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Contents

Abstract

This is the first study to investigate the exchange rate volatility vis-à-vis trade for PNG, one of the only two Pacific Island Countries with a managed floating exchange rate regimes. Using Autoregressive Distributive Lag Model (ARDL) and quarterly time series data from 1995 to 2017, the study finds a positive and significant impact of exchange rate volatility on trade flows in the short-term. However, exchange rate volatility does not affect trade in the long run. Other factors including real exchange rate level, foreign and domestic demand and relative price levels are more likely to influence trade flows in the long run. Policy implications are discussed.

Keywords: PNG, exchange rate volatility, trade

1. Introduction

Since the breakdown of the Bretton Woods system of fixed exchange rate in 1973, much has been said and written about the succeeding floating exchange rate regime and its consequences on various macroeconomic outcomes such as trade. Opponents have argued that high volatility in the exchange rate is likely to result in risk-averse firms slashing production, exports and imports for domestic substitutes, leading to a reduction in the overall trade (Gagnon, 1993; Chowdhury, 1993; Hook & Boon; 2000, & Das; 2003). Proponents contest otherwise that risk-averse firms would, in fact, increase their demand for traded goods amidst an uncertain future instead of reducing volume of trade. The proponents further argue that exchange rate flexibility provides less risk-averse firms with opportunity to earn larger profits (Franke, 1991; Sercu & Vanhulle, 1992; McKenzie & Brooks, 1997; McKenzie, 1998; Doyle, 2001).

On balance, empirical evidence on exchange rate volatility vis-à-vis trade appears mixed at best, suggesting further investigations to better understand the relationship (Clark et al., 2004). At the same time, extant literature seems to have largely ignored the case of a region located on the West of Australia—the Pacific Island Countries (PICs)[1]—small, open, vulnerable, growth and poverty challenged economies. The financial sectors in these economies are also small, bank-centric and not very well developed; in fact, financial development has been relatively slow and mostly inadequate (Jayaraman & Choong, 2012). Given their relatively small share of world trade, most PICs are price takers, making them vulnerable to external shocks. Moreover, since the trade sector comprises a large proportion of domestic economy, shocks from world economy can have large impact on the PICs. Terms of trade shocks, for example, are major contributor to high GDP fluctuations in this region.

The forgoing scenario then makes the exchange rate volatility vis-à-vis trade investigation for the PICs intriguing since literature tends to lean more on the side of a negative relationship. Grier & Smallwood (2007), for example, find evidence of negative and significant relationship between real exchange rate volatility and export growth for six of the nine less developed countries in their sample. Aghion et al (2009) further provided evidence that exchange rate uncertainty impedes productivity growth in countries with low financial development relative to developed financial markets. Bahmani-Oskooee & Gelan (2018) studied this relationship for several African countries and found evidence of negative relationship in some countries. The case of the PICs, however, remain little known. Some studies have investigated the optimal exchange rate regimes in the area (for example, Browne & Orsmond, 2006; Jayaraman, 2004; and Bowman, 2004) but studies on the relationship between exchange rate volatility and trade are scarce. One study by Asafu-Adjaya (1999) on Fiji found a negative relationship between exchange rate variability and export growth.

In the case of Papua New Guinea (PNG), for example, to the best of our knowledge, literature is devoid of any scientific investigation. Yet, trade, like for most economies, remains paramount for the country's growth and development; the country's total trade value as at December 2017 amounted to USD 3.97 billion, representing about 66.4 per cent of the nominal Gross Domestic Product (GDP). Over the period, trade as a share of GDP has declined, on average, from the highs of 80-90 per cent in the earlier years. What makes PNG's, of all PIC's, case even more intriguing is that it, together with Vanuatu, are among the

only two PICs with a managed floating rate regime. It is also the largest of the PICs; its population of about 8 million accounts for over 80 per cent of all PICs put together and also accounts for about 83 per cent of the region's landmass (Chowdhury & Vidyattama, 2007). Immediately after gaining independence from Australia in 1975, PNG adopted a fixed exchange rate regime with its nominal kina exchange rate pegged to a basket of currencies of its major trading partners, more importantly, Australia and the United States. The kina was floated in late 1994 and since then PNG has operated under a managed floating exchange rate regime. In 2014, BPNG shifted to a 'crawl-like' exchange rate arrangement, a soft-peg regime, in response to a foreign exchange shortage and volatility in foreign exchange market price setting mechanism (Habermeier et al., 2009)[2]. The 'crawl-like' arrangement entailed a fixed trading margin of 150 basis points within which retail exchange rates can trade. While these regime shifts effectively reduced the volatility of nominal and real exchange rates, it attracted some criticisms, for example, Nakatani (2018), on its impact on trade flows in PNG as exchange rate became more inflexible.

The foregoing scenario begs the question of how have trade flows in PNG been impacted by the shift of exchange rate regimes. More specifically, how does real exchange rate volatility impact trade flows in PNG, which forms the main issue of investigation for this study. As indicated, this is the first study to systematically do so. The paper extends the traditional models of trade, import and export demand, proposed by Goldstein & Khan (1985) and Bahmani-Oskooee (1986) by including real exchange rate level and volatility to examine the relationship. The study employed Autoregressive Distributive Lag Model (ARDL) with the intention of exploring both short-term and long-run relationships between the variables. Quarterly data was collected from various sources such as the Bank of PNG's Quarterly Economic Bulletin (QEBs), the IMF's International Financial Statistics (IFS) database, and the World Bank's World Development Indicators (WDI) database. The sample period spans over 13 years from 1995Q1 to 2017Q4. The study finds that the influence of exchange rate volatility on trade flows is positive and significant, especially in the short term. In the long-term, trade is impacted by fundamental factors other than exchange rate volatility including real exchange rate and relative price levels and, domestic and foreign income. An increase in real exchange rate level (appreciation)[3] has a negative effect on both import and export demand. An increase in domestic and foreign demand positively influences import and export demand, respectively, while an increase in relative import and export price levels has a negative impact on the demand for imports and exports, respectively.

Based on these findings, some policy implications may be drawn, including the following. Some degree of exchange rate volatility, especially in the short-run appears to be sound economic strategy. Since exchange rate volatility intrinsically complements a higher flexibility in the exchange rate, exchange rate flexibility may foster positive trade flows. Accordingly, there might be some merit in re-visiting direct policy measures such as the exchange rate trading margin which limits the flexibility of the exchange rate. It may also be useful to investigate other determinants of import and export demand including real exchange rate, relative import and export prices and domestic and foreign demand so as to enhance trade flows in PNG in the long term. Depreciation in the real exchange rate or a decline in relative export prices may also be considered.

The rest of the paper is organised as follows. Section 2 provides the study context, providing an overview of exchange rate policies and trade in PNG. Section 3 provides a brief review of the literature. Section 4 discusses the methods and data. Section 5 provides the empirical results. Section 6 concludes with some policy implications.
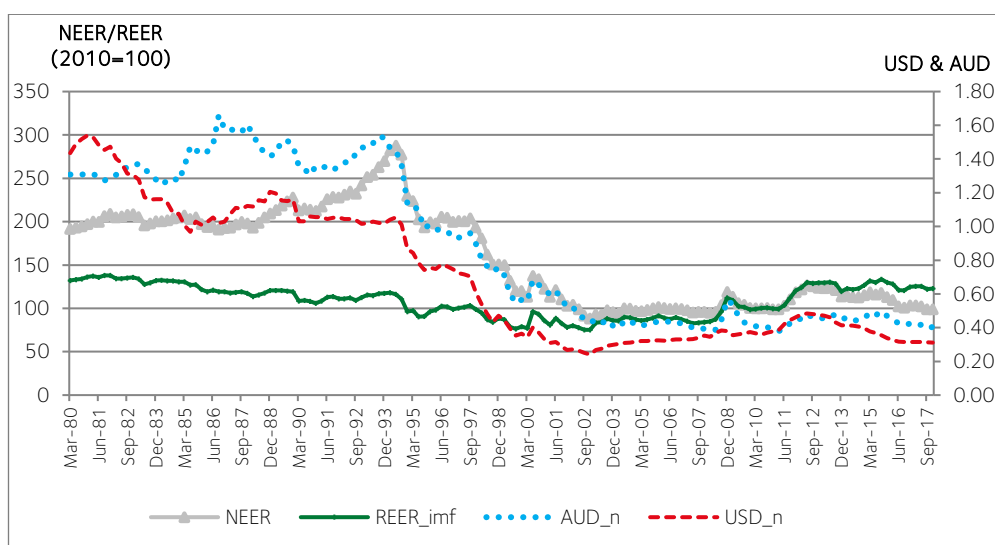
2. Study context: Exchange rate policy and trade flows in PNG

2.1 Fixed exchange rate regime (1975–1993)

After political independence in 1975, PNG, as part of the 'hard kina' macroeconomic policy package, adopted a fixed exchange rate regime which entailed the pegging of its nominal kina exchange rate to a basket of currencies of its major trading partners, more importantly, Australian and US dollars[4]. The hard kina policy which encompassed a combination of exchange rate, monetary and fiscal policies, was formulated on the back of a mix of international and domestic economic conditions at that time. These included government spending constituting a large share of imports, high inflation rates from PNG's major trading partners including Australia, US and Japan, compared to domestic inflation, minimum wages fully indexed to inflation and a relatively low public debt. For the exchange rate policy, exchange rate stability or appreciation was employed to control high imported inflation from PNG's major trading partner countries, from independence up to 1985.

As a result, domestic inflation was maintained well below 10 per cent during the period, although this was achieved at the cost of productivity growth due to the wage indexation policy (Duncan et al., 1998). However, as the domestic and international economic conditions changed after 1985, for example, among others foreign inflation fell relative to domestic inflation, the macroeconomic policies deployed subsequent to 1985 were largely inconsistent with 'hard kina' policy, resulting in economic instability, weak nominal and overvalued real exchange rate which adversely impacted inflation and export growth (Duncan et al., 1998). The deterioration in the fiscal balance of the government especially after 1992 which also added to the worsening macroeconomic situation implied that the government needed adequate international reserves to back its foreign debt. However, insufficient foreign reserves holdings restrained BPNG from protecting the exchange rate from the speculative activities. This resulted in the float of the kina exchange rate in October 1994 (Figure 1).

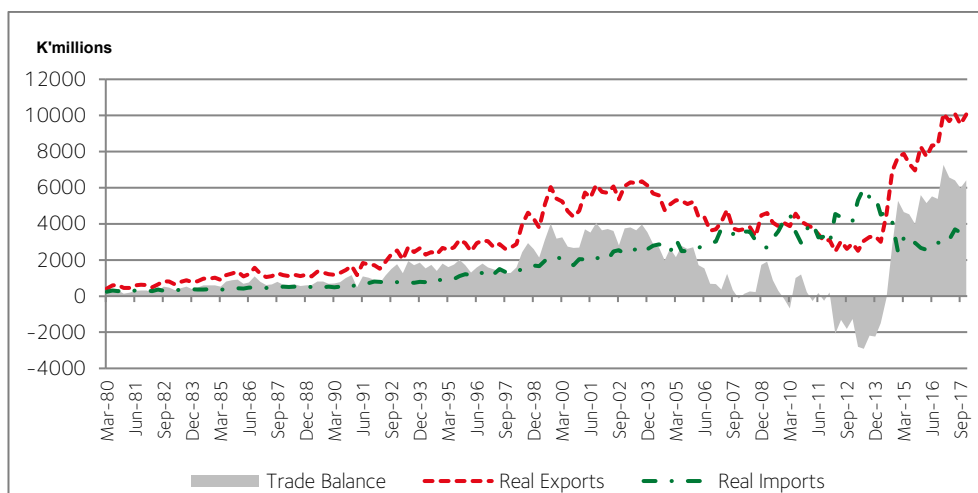Figure 1: PNG nominal and real exchange rates

2.2 Floating exchange rate regime (1994–2013)

The floating of the kina exchange rate resulted in a significant depreciation in the nominal exchange rate, averaging 14.0 per cent annually in two years from mid-1994 to mid-1996, and significantly dropped to an annual depreciation rate of 2.8 per cent in the second half of 1996. The floating of the kina coupled with the liberalisation of wage indexation policy in 1992 meant that the economy became more flexible than it had been since independence. This provided the scope for real wages to fall, stimulating a positive response from employment levels. Although real exchange rate initially declined by around 25 per cent up to mid-1995, subsequent depreciations in the real exchange rate were largely offset by rising domestic inflation fuelled by imported prices. As a result, real exchange rate remained fairly elevated afterwards.

The managed floating exchange rate regime generally assisted growth in the export sector, supported by a broad-based increase in the international commodity prices. This was the period of marked growth in the overall economy which was largely export-driven. Overall level of imports over this period which typically follows aggregate domestic demand conditions also increased. As a result, the country recorded positive trade balances over the large part of the period (figure 2). It was not until the Global Financial Crisis (GFC) of 2008 and 2009 that PNG's export sector was adversely impacted as foreign demand and price for PNG's export commodities fell. In addition, with the transmission of higher imported inflation to domestic economy, real exchange rate remained appreciated. Subsequent to GFC, international export commodity prices recovered, contributing to increased export earnings. This combined with the increased capital inflows associated with the construction of the multi-billion-dollar LNG gas project led to a further appreciation of the exchange rate both in nominal and real terms.

Over the same period, the trade balance turned negative mainly reflecting the significant increase in imports emanating from the LNG project which more than offset the increase in exports. At the end of 2012, the general decline in the international commodity prices had an adverse impact on export revenue, resulting in an increase in the trade deficit. This led to the shortage of international reserves in the foreign exchange market. Meanwhile, the nominal exchange rate also declined thereafter following the imbalance in the foreign exchange market, although the real exchange rate remained broadly elevated as the nominal kina depreciation pressure was partly offset by exchange rate pass-through effect on domestic inflation. There was a turnaround in the trade balance in the second half of 2014 due to the start of LNG exports. However, the earnings from the project was held offshore to meet project liabilities in accordance to the Project Development Agreements (PDAs), resulting in the overall balance of payments to be in deficit thereafter.

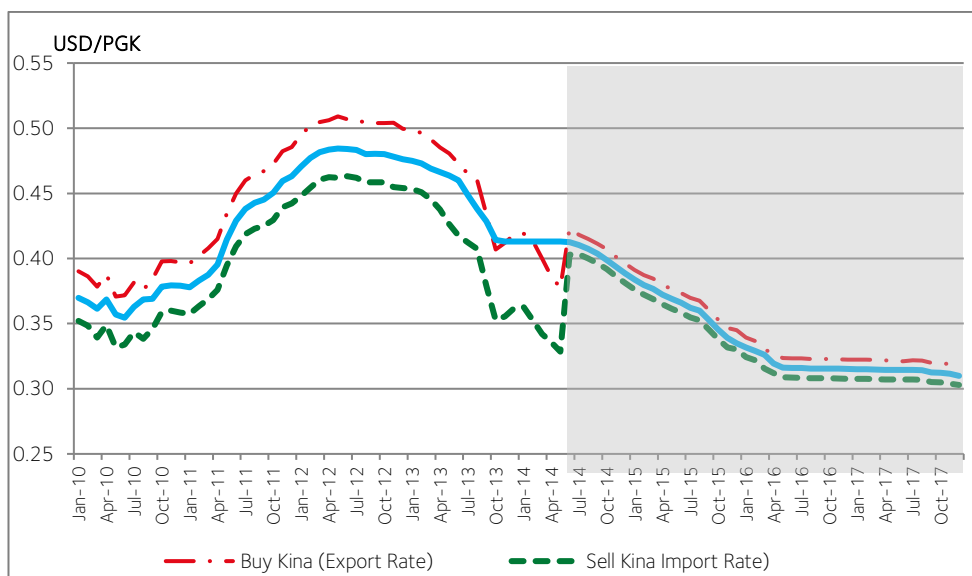Figure 2: PNG real imports, real exports and trade balance

2.3 Crawl-like exchange rate regime (2014–2017)

The accelerated depreciation of kina due to the imbalance in the foreign exchange market after 2012 prompted the Bank to increase its intervention in the foreign exchange market to stabilise the exchange rate, thus, running down on its foreign exchange reserve holdings. This persistent foreign exchange market shortage distorted the relationship between the official interbank foreign exchange rate and the market exchange rates[5]. This distortion of the price setting mechanism of the foreign exchange market implied that exchange rate was not set by market forces but was instead dictated from the supply-side of the market. Consequently, the margins of the market exchange rates also increased significantly reflecting immense downward pressure exerted on exchange rate and rate of depletion of the foreign exchange reserves. This posed a major threat to inflation and overall macroeconomic stability.

As part of the correction to the price setting mechanism and additional support to the stabilisation of exchange rate, the central bank introduced an exchange rate trading margin in the foreign exchange market on the 4th of June 2014. The exchange rate trading margin restricted the authorised foreign exchange dealers to transact with each other within a width of 150 basis points around the official interbank exchange rate. The exchange rate policy caused an immediate *de facto* appreciation of 17.0 per cent in the kina exchange rate, and hence, realigned the market exchange rates with the official interbank exchange rate. The magnitude of the spread was immediately reduced and the pace of depreciation in the nominal exchange rate was largely slowed thereafter (Figure 3). Exchange rate volatility, consequently, was highly reduced reflecting very high stability and rigidity in the kina exchange rate (Figure 4).
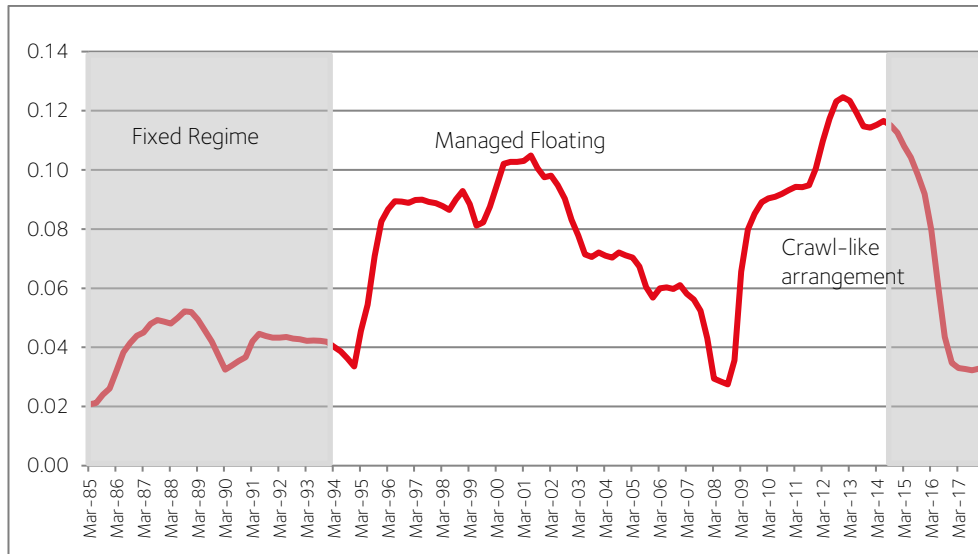
Figure 3: Sell kina, buy kina and interbank (official) USD/kina exchange rates

Exchange rate volatility since political independence closely followed the shifts in the exchange rate regimes. Figure 4 depicts the trend of exchange rate volatility over the different exchange rate regimes PNG experienced since the political independence. Broadly, the fixed exchange rate period was associated with low exchange rate volatility. Immediately after the floating of kina in 1994, exchange rate volatility increased and as a common feature of floating or flexible exchange rate regimes, high exchange rate fluctuations have been prominent during the reign of managed floating regime. This is supported by the fact that kina is highly sensitive to external commodity price shocks given PNG's high commodity export dependency (Kauzi & Sampson, 2009). The decline of the exchange rate volatility since early 2000 to around 2008 largely reflected the period of economic growth and stability, which enabled the Central bank to manage large fluctuations in the exchange rate through its foreign exchange interventions. Exchange rate volatility increased substantially again after 2009 through to early 2014 reflecting the onset of GFC, and subsequent external shocks such as the increased capital inflows from the LNG project and high fluctuations in the commodity prices. The liberalisation of capital accounts by BPNG in 2006 may also have influenced the increased volatility in the exchange rate.

The imposition of the exchange rate trading margin policy reduced high exchange rate volatility and effectively shifted the exchange rate regime from the managed float to 'crawl-like' arrangement (IMF, 2015). The IMF argued that this exchange rate policy restricted much needed flexibility for exchange rate to adjust according to market fundamentals to correct the imbalance in the foreign exchange market (IMF, 2015). On the other hand, the BPNG views this as a market correction and a precautionary measure. Hence, removing the trading margin would otherwise lead to high inflationary pressure and the depletion of foreign exchange reserves which would be drastic for the economy. This necessitates a formal investigation in establishing empirically whether allowing for more flexibility in the exchange rate would assist exports and the overall trade balance, hence, correct for the imbalance in the foreign exchange market. In other words, should exchange rate be allowed to fluctuate according to market fundamentals, which can be volatile in nature? Further, would such exchange rate volatility benefit or have an adverse impact on trade flows?

Figure 4: Real exchange rate volatility in PNG

3. Literature review

Exchange rate volatility and its relationship to trade have been studied at length both at the theoretical and empirical levels. Côté (1994) and McKenzie (1999) conducted a comprehensive survey on the related literature and concluded that from a theoretical perspective, the response of the trade flows to an increase in exchange rate volatility remain ambiguous. They attributed this finding to differing assumptions and models employed in the studies. Empirical literature also displayed the same ambiguity which could reflect undefined theoretical underpinnings, different measures of exchange rate volatility and approaches employed in the empirical studies. In his recent literature survey on the subject, Ozturk (2006) supported these earlier findings and highlighted additional reasons for mixed outcome including different choices of sample periods and status of development, whether developing or developed.

The basic theoretical model was first described by Clark (1973) who used an exporting firm to demonstrate the negative relationship between exchange rate volatility and exports. This simplified model assumes that the firm's profitability depends solely on the variability of the exchange rate and the risk-averse behaviour of the manager. As such, any increase in exchange rate volatility would lead to a decline in production and hence, export, in order to reduce exposure to exchange rate risks. Hooper & Kohlhagen (1978) extended the model to incorporate the response of traded prices and volumes to exchange rate uncertainties with the conclusion basically reinforcing the negative relationship. Various other theoretical studies, such as Ethier (1973) supported this argument that increased exchange rate volatility would lead to a reduction in the trade flows.

These conclusions are largely dependent on various simplified assumptions which mainly include no hedging possibilities either through foreign exchange forwards market or through firms operations to offset the potential adverse effect of exchange rate variations. Hence, these strong assumptions underpinning the baseline theory if removed could potentially alter the anticipated result. For instance, in the advanced economies where forward currency markets are well-developed, firms could enter into forward contracts to hedge against exchange rate risks (Ethier, 1973). Alternatively, multinational firms who have diversified investment portfolio with a wide variety of trade and financial transaction across their countries of operation could offset the negative impact of exchange rate volatility through adjusting to the price and exchange rate variations from different countries of operations and trading partners. Clark et al (2004) presented a thorough review on this literature. Nonetheless, even when some of these assumptions are captured, the support for the negative relationship persists. For example, although Wei (1999) accommodated for hedging, he did not find empirical support for the hypothesis that availability of hedging instruments reduces the impact of exchange rate volatility on trade.

Contrasting these findings, some other theoretical studies such as De Grauwe (1988) argued that increased exchange rate volatility present opportunities for firms to profit, especially if firms possess less risk-averse behaviour. In addition, when theoretical assumption of the inflexibility of the firms to adjust factors of production is relaxed, firms could vary their factor inputs to achieve optimal output in order to profit amidst higher exchange rate fluctuations. For instance, an exporting firm could ramp-up production and export when the prices are high but scale back when the prices drop influenced by the exchange rate fluctuations. Export firms that import intermediate inputs could increase imports when prices fall and increase production when price increase. Pindyck (1982) supported that a higher tendency for prices to fluctuate benefit firms who could utilise that to offset any losses that may result from lower prices. In other words, some of these studies, for example,

Franke (1991) associated trade to stock options that are held by firms, implying that the value of trade is positively correlated to volatility. Further, firms who run large capital spending on production facilities, also known as sunk costs, are more likely to be non-responsive to short term price variations.

Empirical studies also remain inconclusive on the relationship between exchange rate volatility and trade flows. Based on the strong theoretical argument of the risk-averse behaviour of the exporting firms, a large proportion of the empirical literature substantiated the claim that exchange rate uncertainty has negative effect on trade, for instance, Chowdhury (1993), Baak (2004), Clark et al (2004) and Arize et al (2008). Some other studies such as McKenzie & Brooks (1997), Doyle (2001), Bredin et al (2003) and Kassman & Kassman (2005) counteracted the argument by providing evidence that trade flows respond positively to high unexpected variation in exchange rate. However, others including Akhtar & Hilton (1991), McKenzie (1998) and Aristotelous (2001), among others, found ambiguous, insignificant or no relationship between exchange rate volatility and trade.

These mixed empirical conclusions mainly reflect differing theoretical foundations, regions of study, measures of exchange rate volatility, methodologies and sample periods. In recent empirical studies, for example, Aghion et al (2009) validated the claim that the extent of the impact of exchange rate volatility on trade relies on the development status of a country. In particular, the study found that in developed countries where financial markets are well developed, exchange rate volatilities has no effect on trade and growth while in developing economies which are characterised by relatively low levels of financial development, it has adverse implication on trade and growth. Nevertheless, others found opposing results, for instance, Chowdhury (1993) who found adverse impact of exchange rate volatility on trade for the G-7 developed countries and Bahmani-Oskooee (1996), and Arize et al (2000), who studied the subject in the less developed countries. According to Bahmani-Oskooee & Gelan (2017), related studies have not been sufficient to support a consensus on the relationship between exchange rate volatility and trade flows in the case of developing countries.

For the Asia Pacific region to which PNG is part of, studies have been very limited. Baak (2004) investigated the impact of exchange rate and volatility on exports among 14 Asia Pacific Economic Cooperation (APEC) including PNG[6]. Using annual data for the period from 1980 to 2002, the study detected a significant negative impact of exchange rate volatility on the volume of exports. In addition, through sub-sample period analysis, the study concluded that the impact of exchange rate volatility is time-varying. Asafu-Adjaye (1999) explored this relationship for Fiji and found support for the adverse effect of exchange rate volatility on exports, although the relationship was statistically insignificant.

In the case of PNG, there is currently no existing study undertaken specifically about the relationship between exchange rate volatility and trade flows although other related studies on exchange rate and trade has been explored. Aba, Aipi & Irau, (2012a, b,c) in estimating the supply response of PNG's major commodity exports including coffee, oil palm and cocoa, found through qualitative responses from a survey that exchange rate is a major factor influencing the production decision by the commodity growers. Nakatani (2018) focused on the real exchange rate level and its impact on trade flows but not on the exchange rate volatility. He estimated import and export elasticities with respect to changes in the real exchange rate and found support for exchange rate depreciation, in turn, favoured a more flexible exchange rate policy. Similarly, Aipi & Sabok (2015) estimated import demand function for PNG using the traditional import demand model which includes only income and relative price level but did not include exchange rate level or volatility. This study extends traditional import and export demand functions with the inclusion of real exchange rate level and volatility to analyse the impact of exchange rate volatility on trade flows in PNG.

4. Methodology and data

4.1 Model specification

This paper draws on the empirical literature to model the impact of real exchange rate and its volatility on trade in PNG. Following Goldstein & Khan (1985) and Bahmani-Oskooee (1986), the models of import and export demand functions are specified with the inclusion of real exchange rate both in terms of level and volatility. This is an extension to the traditional models which encompasses only income and relative price levels. The import and export demand functions are specified as follows:

$$lrim_t = \alpha_0 + \alpha_1 ly_t + \alpha_2 lipr_t + \alpha_3 ler_t + \alpha_4 lvol_t + \varepsilon_{1t} \tag{1}$$

$$lrex_t = \beta_0 + \beta_1 lyf_t + \beta_2 lxpr_t + \beta_3 ler_t + \beta_4 lvol_t + \varepsilon_{2t} \tag{2}$$

Where, the dependent variables, $lrim_t$ and $lrex_t$ are real import and export calculated as the nominal import and export values divided by import and export prices, respectively. Import price is measured as the import-weighted price index of PNG's six major trading partner countries 7. Unit export value of PNG's trading partners is taken as import prices of PNG's major trading partners due to unavailability of data. Export price index is the unit value of PNG's exports. ly_t and lyf_t are real domestic and foreign incomes, respectively, reflecting domestic and foreign demand. Real domestic income ly_t is represented by the real GDP whilst the real foreign income lyf_t is computed as the export-weighted real GDP of PNG's major trading partner countries. $lipr_t$ and $lxpr_t$ are relative import and export prices. Relative import price $lipr_t$ is measured as the ratio of foreign price, measured as the import-weighted Consumer Price Index (CPI) of PNG's major trading partners, to domestic CPI.

Relative export price is the ratio of PNG's export price index to its trading partners' trade-weighted export price index. Due to unavailability of the export price index for PNG's major trading partners, their import price index is applied; hence, the variable is equivalent to terms of trade. Real exchange rate ler_t is the trade-weighted real effective exchange rate constructed as the nominal effective exchange rate adjusted by inflation differential of PNG and its major trading partners. It reflects the real exchange rate fluctuations and the level of export competitiveness of PNG relative to its main trading partners. Exchange rate volatility $lvol_t$ is measured as the moving standard deviation of the logarithm of real effective exchange rate. ε_{1t} and ε_{2t} are the error terms of the import and export demand functions, respectively. All the variables in equations 1 and 2 are in logarithmic (log) form; hence, the interpretation of the estimated coefficients of the results would be in elasticity.

Equation 1 implies that PNG's aggregate demand for import is a function of its aggregate domestic income, relative import price and real exchange rate level and volatility. On the other hand, equation 2 suggests that PNG's export demand is dependent on the income level of its major trading partner countries, the relative price level of PNG's exports to its trading partners and real exchange rate level and volatility. Since the main motivation of this investigation is to examine the relationship of exchange rate level and its volatility, and trade, these models are simplified, leaving out some of the variables which can be significant to trade such as trade openness, export diversification and import substitution effects.

The traditional theoretical models of trade which encompasses income and price as explanatory variables for both import and export volume functions set the prior expectation for the relationship of relative prices and income, and import and exports (Goldstein & Khan, 1985). Accordingly, a positive relationship is expected for income variable, both domestic and foreign, in relation to import and export while a negative relationship is expected for the relative price variable and import and export. That is α_1 and β_1 is expected to be greater than 0 while α_2 and β_2 is expected to be less than 0. A positive relationship is anticipated for real exchange rate and imports while an inverse relationship is expected for real exchange rate and exports, that is, α_3 is greater than 0 while β_3 is less than 0. For exchange rate volatility, both theoretical and empirical literature indicated mixed expectation of its relationship to both imports and exports. Therefore, priori expectation for the signs of the coefficient of exchange rate volatility, α_4 and β_4 can be greater than or less than 0. This ambiguous relationship between exchange rate volatility and trade will be explored in this study for the case of PNG.

Measure of Exchange Rate Volatility

The question of the appropriate measure of exchange rate volatility is one that is unresolved among researchers. One of the main disagreements has been on the use nominal and real exchange rate. Whilst some preferred the use of nominal exchange rate on the argument that it is the rate that is used for actual trades, others defended the use of real exchange rate relying on the theoretical argument that it affects trade through price competitiveness. Few others support that the use of either rates would not make much difference (Huchet–Bourdon & Korinek, 2011). Since we are interested in establishing the real effects of exchange rate volatility on real imports and exports, we employ the real effective exchange rate in this study.

The second disagreement is the use of different measures of exchange rate volatility itself. In general, there is no consensus to the most appropriate measure of exchange rate volatility. However, most studies have employed some sort of a measure of variance in their analysis to reflect the risks and uncertainty associated with the fluctuations in the exchange rate. The most widely used measure of volatility is the standard deviation of the moving average of the logarithm of real exchange rate. Other typical measures of exchange rate volatility employed in various studies include the moving standard deviation of the percentage change in the exchange rate, and the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model generated volatility (Huchet-Bourdon & Korinek, 2011). This study employed the standard volatility measure, the moving standard deviation of the logarithm of real exchange rate which is defined in equation 3.

$$Vol_t = \left[\frac{1}{m} \sum_{i=1}^{m} \left(er_{t+i-1} - er_{t+i-2} \right)^2 \right]^{\frac{1}{2}}$$ (3)

Where, er_t is the real exchange rate and m is the number of observations or periods which ranged between 4 to 20 quarters for quarterly series. According to Clark et al (2004), 4 quarter or 1 year moving average of the standard deviation of the exchange rate can be referred to as a short-term volatility measure while 20 quarter or 5 year moving average can be perceived as a long-term volatility measure. The study employed the long term volatility measure based on the argument that the short-term measure is irrelevant for trade (De Grauwe, 1988). De Vita and Abbott (2004) further argued that long term measures tend to produce significant and interpretable results compared to the short-term volatility measure.

4.2 Data

This study employed quarterly data from 1995Q1 to 2017Q4 which featured the two recent exchange rate regimes, the managed floating exchange rate regime (1995-2013) and the 'crawl like' exchange rate regime (2014-2017). The data is mainly sourced from the Bank of PNG's Quarterly Economic Bulletin (QEB), the IMF's International Financial Statistics (IFS) database, and the World Bank's World Development Indicators (WDI) database. Figure 5 shows the trends of the variables employed in the study.

Figure 5: Trend of all model variables

4.3 Estimation Method

The Autoregressive Distributive Lag approach (ARDL), also known as the bounds test approach is employed to first establish if there exist cointegration between real imports and exports and their corresponding explanatory variables. Pesaran et al (2001) proposed this method as an alternate to the two main approaches for cointegration including the Engle & Granger (1987) two-step residual based procedure which tests for the null of no cointegration and the Johansen (1991,1995) system-based reduced rank regression method. The main advantage of the use of ARDL over the other two methods is that it allows for flexibility in the use of both I(0) and I(1) variables whereas the two methods strictly require all the variables to be I(1). Further, ARDL generally provides unbiased estimates of the long-run model and validates the t-statistics even when some of the explanatory variables are endogenous (Harris & Sollis, 2003). Although it is often argued that pre-unit root testing of variables is irrelevant in the ARDL approach, unit root tests are conducted

following the argument that if not checked, variables could be I(2) or above which could potentially lead to the generation of spurious results (Frimpong & Oteng-Abayie, 2006).

The existence of a cointegration between the variables would imply that a long-run equilibrium relationship exists between the variables and that any disturbances that results in disequilibrium in the relationship in the short-run would be corrected in the long-run. The error correction terms measure this short-term adjustment of the long-term equilibrium relationship. With the employment of the ARDL model, both the short-term and long-term relationship between the variables can be modelled.

The short-run dynamics is incorporated into the long-run equation by specifying the equations in an error correction representation. The inclusion of short-run dynamics into the model would assist correct the problem of endogeneity between the explanatory variables (Pesaran & Pesaran, 1997). Equations 1 and 2 can be represented as a conditional ARDL-error correction form respectively, as follows:

$$\Delta lrim_t = \alpha_0 + \sum_{i=1}^{p1} \alpha_{1i}\Delta ly_{t-i} + \sum_{i=1}^{p2} \alpha_{2i}\Delta lipr_{t-i} + \sum_{i=1}^{p3} \alpha_{3i}\Delta ler_{t-i} + \sum_{i=1}^{p4} \alpha_{4i}\Delta lvol_{t-i}$$
$$+ \delta_0 lrimp_{t-1} + \delta_1 ly_{t-1} + \delta_2 lipr_{t-1} + \delta_3 ler_{t-1} + \delta_4 lvol_{t-1} + \delta_5 dum_{im} + \varepsilon_t$$

$$\Delta lrex_t \underset{(5)}{=} \beta_0 + \sum_{i=1}^{p1} \beta_{1i}\Delta lyf_{t-i} + \sum_{i=1}^{p2} \beta_{2i}\Delta lxpr_{t-i} + \sum_{i=1}^{p3} \beta_{3i}\Delta ler_{t-i} + \sum_{i=1}^{p4} \beta_{4i}\Delta lvol_{t-i}$$
$$+ \sigma_0 lrex_{t-1} + \sigma_1 lyf_{t-1} + \sigma_2 lxpr_{t-1} + \sigma_3 ler_{t-1} + \sigma_4 lvol_{t-1} + \sigma_5 dum_{ex} + \xi_t$$

Where, Δ is the difference operator, p is the number of lag length, ε_t and ξ_t are white noise error terms while α_0 and β_0 are constants of respective equations. All the variables are specified in equations 1 and 2. $\alpha_{1i} \dots \alpha_{4i}$ and $\beta_{1i} \dots \beta_{4i}$ represent the short-term coefficients of the real import and export, respectively, while $\delta_0 \dots \delta_4$ and $\sigma_0 \dots \sigma_4$ are long-term coefficients representing long-term relationships normalised by δ_0 and σ_0. The error correction terms which reflect the linear combination of the lagged level of all variables in each of the equation are represented by the second line of each equation. δ_5 and σ_5 are coefficients of dummy variables, dum_{im} and dum_{ex} which captures the structural break periods induced by the PNG LNG project on real imports and exports, respectively. The LNG construction started around 2011 to 2013 whilst the initial LNG export period started around the second quarter of 2014 with a ramp-up to production into 2015.

5. Empirical results

5.1 Unit Root Test

Prior to the estimation of the long-run relationship or cointegration between the variables, it is formal that the test of stationarity is done to establish the order of integration for each variable. The graphical analysis of the variables indicates that some variables are stationary at levels, that is, I(0), while others, mainly those that have trends could be stationary at a higher order of integration that is, I(1) or I(2). The formal unit root test of Augmented Dickey Fuller (ADF) is subsequently employed to establish the stationarity of the variables. The ADF test-statistics derived using the Swartz Information Criteria (SIC) are presented in Table 1. The results confirmed that all the variables are I(1) except relative import price, which is I(0) at 5 per cent level of significance when ADF is run including a constant and without a trend. This reflected the structural break of the relative import price starting 2003, whereby the relative import price after a sharp decline from prior period, remained fairly stable up until 2017.

Table 1: Augmented Dickey Fuller Unit Root Test Results

Variable	Levels		First Difference	
	Constant	Trend	Constant	Trend
lrim	–2.44	–3.07	–12.04***	–12.12***
	(–2.58)	(–3.16)	(–3.50)	(–4.06)
lrex	–1.35	–1.60	–9.67***	–9.66***
	(–2.58)	(–3.16)	(–3.50)	(–4.06)
ly	1.08	–1.50	–2.58	–5.08***
	(–2.58)	(–3.16)	('–2.59)	(–4.07)
lyf	1.51	–2.86	–7.60***	–8.12***
	(–2.58)	(–3.16)	(–3.50)	(–4.06)
lipr	–3.18**	–2.00	–7.82***	–8.35***
	(–2.89)	(–3.16)	(–3.50)	(–4.06)
lxpr	–1.28	–2.25	–7.43***	–7.41***
	(–2.58)	(–3.16)	(–3.50)	(–4.06)
ler	–1.06	–2.34	–8.58***	–8.54***
	(–2.58)	(–3.16)	(–3.50)	(–4.06)
lvol	–2.52	–2.53	–4.93***	–4.93***
	(–2.58)	(–3.16)	(–3.50)	(–4.06)

Note: ***,**,*statistical significance at 1%,5% & 10%. Figures in brackets are corresponding t-statistics.

5.2 ARDL estimates

The empirical results of the ARDL model are presented in Table 2 for both import and export demand functions. The table shows the estimated long-run and short-run coefficients of the explanatory variables in the respective models, estimated coefficients of the error correction terms and selected diagnostic tests. The maximum lag length was set to 2 for the dependent and the independent variables for both import and export demand models. Based on the Akaike Information Criteria (AIC), the optimal models selected are ARDL (2, 0, 0, 0, 2) and ARDL (2, 1, 1, 0, 1), respectively, for import and export demand functions. Since F-statistics of the Wald 'bounds' tests of cointegration for both

import and export demand functions are higher than the upper critical values at 1 per cent level of significance, respectively, it can be inferred that there exist long–run equilibrium relationships between imports and exports, and their respective dependent variables. The long-run equilibrium relationships are also confirmed as the coefficients for the error correction terms for both functions are negatively signed and significant, reflecting a mean reverting process (Arize et al, 2017). Residual diagnostic tests on the models including the serial correlation Lagrange Multiplier (LM) test, tests of heteroscedasticity and the Cusum stability test show that the models are void of serial correlation problem, errors are homoscedastic, and the models are generally stable. This gives confidence that the coefficients of the estimation are plausible. The models explained over 93 per cent and 95 per cent respectively of the variation in the import and export demand. Since all the variables are in logarithms, the results are explained in terms of elasticity, that is, income and price elasticity and exchange rate level and volatility elasticity relative to real import and exports.

Table 2: Estimated Import and Export Demand Models using ARDL

Import Model		Export Model	
ARDL(2, 0, 0, 0, 2)		ARDL(2,1,1,0,1)	
Variable			
Long-run relationships			
ly	1.1***	lyf	3.38***
	(2.71)		(9.54)
lipr	-0.51**	lxpr	-1.29***
	(-2.26)		(-9.74)
ler	-1.82***	ler	-0.95***
	(-3.86)		(-3.37)
lvol	-0.33	lvol	-1.96
	(-0.24)		(-1.30)
Short-run relationships			
Δ(lrim(-1))	-0.17**	Δ(lrex(-1))	-0.15*
	(-2.04)		(-1.89)
Δ(ly)	1.80**	Δ(lvol)	6.45***
	(2.38)		(2.88)
Δ(lipr)	1.01*	Δ(lvol(-1))	-6.38***
	(1.75)		(-2.96)
Δ(lvol)	3.39**		
	(1.81)		
dumim	0.38***	dumex	0.34***
	(6.83)		(6.18)
$ECT_{im}(-1)*$	-0.44***	$ECT_{ex}(-1)*$	-0.36***
	(-7.49)		(-7.43)
c	3.14***	c	1.12***
	(7.51)		(7.46)
F-statistics	10.67***(5.06)	F-statistics	10.52***(5.06)
R-squared	0.93	R-squared	0.95
Adj R-squared	0.92	Adj R-squared	0.94
BG-LM Test	0.0503	BG-LM Test	0.0639
BG-Heterosced	0.0933	BG-Heterosced	0.2687
Cusum_Stability	Stable	Cusum_Stability	Stable
t-stat-ect(-1)	-7.49***(-4.6)	t-stat-ect(-1)	-7.43***(-4.6)

Notes: ***,**,*statistical significance at 1%,5% & 10%. Sample period 1995-2017. () brackets indicate the t-statistics of the estimated coefficients

5.3 Discussion

The import demand model results show that in the long-run, exchange rate volatility is insignificant in explaining demand for imports, although the sign of the coefficient is negative implying an inverse relationship. Other factors including domestic income, relative price, and real exchange rate are significant in explaining movements in import demand in the long-term. In particular, a 1 per cent increase in domestic income would result in an increase in real imports by 1.1 per cent, a 1 per cent increase in the relative import price would result in a 0.51 per cent decline in the real imports and a 1 per cent increase in real exchange rate level would lead to a 1.82 per cent decline in imports.

The long-run positive relationship of domestic income and the negative impact of relative price level on import demand fulfilled prior theoretical expectations. This also confirms past empirical evidence for PNG, although the magnitude of the elasticity differed. For example, the income elasticity with respect to imports of 1.1 estimated in this study compares to 0.69 found by Aipi & Sabok (2015), 1.86 by Senhadji (1998) and 0.13 by Nakatani (2018). However, the negative relationship of real exchange rate and import is conflicting to both theory and past empirical finding, although is consistent with a recent study. The negative import elasticity with respect to real exchange rate is supported by Chowdhury & Yabom (2018) who found a negative response of real imports to an appreciation shock to real exchange rate while Nakatani (2018) found the import elasticity to be positive and within the range of 0.8 and 1.1. These differing results compared to Nakatani (2018) could reflect the varying specifications employed in the studies including the number and proxy of variables, the sample periods and the econometric approaches. Further, since PNG's mineral sector is enclaved from the rest of the economy, exchange rate movement may have insignificant impact on total import demand, though it may affect the non-mineral sector import demand. However, although Chowdhury & Yabom (2018) employed the non-mineral sector imports, they found that its response to a depreciation shock remains negative but statistically insignificant.

In the short term, the relationship between exchange rate volatility and import demand is elastic and significant. A 1 per cent increase in real exchange rate volatility would lead to a 3.4 per cent increase in imports. Other variables impacting import demand in the short-term include one quarter lag value of imports, changes in domestic income and relative import price. In particular, a 1 per cent increase in imports in past quarter would result in a 0.17 per cent decline in real imports in the current period, a 1 per cent increase in domestic income would lead to a 1.8 per cent increase in import demand while and a 1 per cent increase in relative import price would result in a 1.1 per cent increase in imports. The dummy variable dum_{im} which reflected the construction period of the PNG LNG project, especially between 2011 and 2013, had a significant positive impact on the level of import demand in the economy.

The short-term positive and highly elastic relationship between exchange rate volatility and import demand may possibly reflect that importing firms in PNG, especially risk-averse firms, increase their demand for imports amidst an increase in exchange rate volatility in the short-term as a precautionary measure for an uncertain future. Alternatively, for firms with less risk-averse behaviour, an increase in exchange rate volatility in the short-term presents them with an opportunity to maximize their profits through increased imports and production. The coefficient for the error correction term for the import demand of 0.44 is negative and significant, implying that about 44 per cent of the disequilibrium in import demand caused by

a past quarter's shock is corrected in the current quarter. This also confirms the existence of the long-run equilibrium relationship between import demand and its determinants.

The model results for the export demand functions are reported in the right column of Table 2. The results show that in the long-run, exchange rate volatility is an insignificant determinant of export demand, although the sign of the coefficient is negative implying an inverse relationship. Export demand is influenced mainly by other fundamental factors including foreign income, relative export price and real exchange rate level. The signs of coefficients of these variables are as anticipated. In particular, a 1 per cent increase in foreign income would result in a 3.38 per cent increase in export demand whereas a 1 per cent increase in relative export price and real exchange rate would result in a 1.29 per cent and 0.95 per cent declines in export demand, respectively.

The highly elastic and significant positive relationship between foreign income and real exports in the long-term imply that exports are to a larger extent dependent on external demand conditions relative to other determinants. Higher foreign demand, especially in PNG's major exporting countries, would result in an increased demand for PNG's exports. The elastic and negative relationship of the relative price of exports imply that an increase in domestic export price relative to foreign export price level would discourage demand for PNG's exports and induce substitution of PNG's exports for other competitors. This is further corroborated by the inverse relationship of the real exchange rate and export demand. An increase in the real exchange rate would imply that PNG exports become relatively expensive to its competitors resulting in a substitution of PNG's exports for the competitors'. This could also be viewed from the supply-side whereby depreciation in the real exchange rate would encourage production and export as exporter's price in domestic currency increases. The findings above are broadly supported by the past studies including Nakatani (2018) and Aba et al (2012a,b,c), although the magnitude of the elasticity somewhat differed. For example, whilst this study found export elasticity with respect to real exchange rate to be negative and inelastic at 0.95, Nakatani (2018) found the export elasticity to be lower and negative at around 0.4 and 0.5 to 0.7, respectively, for overall and agriculture related exports. Aba et al (2012a,b,c) found relative price to be an insignificant determinant whilst income for trading partners proved to be significant in explaining the movements in key agricultural commodity exports for PNG including coffee, cocoa and oil palm. In addition, Aba et al (2012a,b,c), although did not include real exchange rate as explanatory variable in their models, qualitatively established that it is a significant factor in explaining the supply response of the respective agricultural commodities.

In the short-term, however, the relationship between exchange rate volatility and exports is significant and highly elastic. A 1 per cent increase in current exchange rate volatility would lead to a 6.45 per cent increase in exports. Other short-term determinants of export demand include one quarter lag of exports and real exchange rate volatility. A 1.0 per cent increase in the one quarter lag of exports would result in a 0.15 per cent decline in exports while a 1 per cent increase in one quarter lag of real exchange rate volatility would result in a 6.38 per cent decline in exports. The dummy variable reflecting PNG LNG exports dum_{ex} had a significant and positive impact on the level of real export.

The high elasticity of the real exchange rate volatility for both the current and one quarter lag period in the short-term with differing signs is unanticipated. This is not unique to the study as past related studies have found mixed and inconsistent results for the short-term compared to the longer horizon (Huchet-Bourdon & Korinek, 2011). Nonetheless, it can be deduced broadly that in the short-run, risk-averse exporters would increase demand for

exports in the current period in fear of higher exchange rate volatility in the future which could be detrimental to the value of their exports. In addition, the trading partners' demand for PNG's exports would increase as they would perceive higher exchange rate volatility as an opportunity to profit from. Increased exchange rate volatility in the current quarter would induce exporters to respond positively to exports in the current quarter. This would mean that the volume of exports in the subsequent quarter would decline. The coefficient for the error correction term for the export demand of 0.36 is negative and significant, implying that about 36 per cent of the disequilibrium in export demand caused by a past quarter's shock is corrected in the current quarter. This also confirms the existence of the long-run equilibrium relationship between exports and its determinants.

5.4 Robustness check

For robustness checks, co-integration methods, Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) which corrects for potential simultaneity (Stock & Watson, 1993) and endogeneity bias and serial correlation (Phillips & Hansen, 1990) were applied to estimate the long-run relationships between real import and exports and their respective demand factors. The results presented in Table 3 generally show consistency with the results derived from the ARDL model. However, one noticeable difference in the estimated model is that real exchange rate volatility in the export demand model is significant at 5 per cent level of significance. This imply that in the long-run, volatility in the real exchange rate would have an adverse effect on export demand, but its impact on import demand would be insignificant. This result, however, was run on the models without inclusion of lags, especially in the DOLS model. With the inclusion of additional lags, the variable becomes insignificant which is consistent with the ARDL model.

Table 3: Estimated Import and Export Demand Models using FMOLS & DOLS

Import Demand Model			Export Demand Model		
Variables	FMOLS	DOLS (0,0)	Variables	FMOLS	DOLS (0,0)
ly	0.57**	0.85**	lyf	3.21***	3.19***
	–1.99	–2.47		–15.25	–12.23
lipr	–0.89***	–0.75***	lxpr	–1.12***	–1.11***
	(–5.8)	(–4.23)		(–15.63)	(–12.37)
ler	–1.15***	–1.49***	ler	–1.04***	–0.99***
	(–3.49)	(–3.71)		(–5.65)	(–4.49)
lvol	0.74	1.13	lvol	–1.89**	–2.17**
	–0.71	–1.03		(–2.16)	(–2.16)
dumim	0.61***	0.64***	dumex	0.49***	0.30**
	–6.44	–5.66		–4.51	–2.4
c	11.28***	9.23***	c	3.59***	3.59***
	–4.47	–3.03		–6.4	–5.01
R-squared	0.86	0.89	R-squared	0.84	0.88
Adj R-squared	0.85	0.88	Adj R-squared	0.83	0.87
Lc-Statistic	1.28***	0.03	Lc-Statistic	0.50***	0.04

6. Conclusion and policy implications

This study investigated the notion of a negative relationship between real exchange rate volatility and trade flows in the case for PNG, in light of the recent shift in the exchange rate regime from managed float to *de facto* 'crawl-like' arrangement. The study found that real exchange rate volatility has a positive and significant effect on trade flows in the short-run but no relationship in the long run. In the short-run, exchange rate volatility has a positive effect on both real exports and imports, though a similar-sized negative lagged effect on exports may potentially negate the positive effects on exports. Nonetheless, trade broadly would increase in the short-run. In relation to the long run relationship, exchange rate volatility does not have any impact on both imports and exports. Other factors including domestic and foreign demand, relative import and export prices and real exchange rate levels were found to have prominent influence on trade flows. In particular, domestic demand has a positive impact on imports whilst relative import price and real exchange rate level negatively affects it. On the other hand, exports are influenced positively by external demand, but negatively by relative export price and real exchange rate level. The study concludes that the view that exchange rate volatility is associated with negative trade flows does not necessarily hold for PNG especially in the short-term.

In terms of policy implication, allowing some degree of volatility in the real exchange rate, especially in the short-term may be beneficial to trade as it could assist stimulate both export and import demand, although the effect of exports may be offset by past exchange rate uncertainty. In addition, efforts should also be focused on other key determinants of import and export demand including real exchange rate level, relative import and export prices and domestic and foreign demand in order to stimulate trade flows in PNG in the long term. Following the Marshall Learner Condition, it can also be deduced that depreciation in the real exchange rate may encourage exports, hence, improve trade balance especially in the long-run. This means that exchange rate policies with some degree of exchange rate flexibility may be beneficial to trade in the case for PNG. This is supported by the findings of Nakatani (2018) who argued for a more flexible exchange rate as it is beneficial to trade flows for PNG. Chowdhury & Yabom (2018) also found that depreciation in the real exchange rate could induce an increase in real exports. Direct exchange rate policy measures such as the exchange rate trading margin, although may be beneficial especially in foreign currency crisis-like situation to anchor inflation expectations and prevent significant foreign reserve depletion, it can largely reduce exchange rate volatility and limits the flexibility of the exchange rate. This could have negative consequences for trade flows and economic growth if sustained.

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Notes

1   Pacific Island Countries (PICs) comprise of Papua New Guinea, Fiji, Solomon Island, Vanuatu, Tonga, Samoa, Cook Island, Niue, Tokelau, Nauru, Kiribati, Tuvalu, Micronesia, and New Caledonia.

2   While IMF (2015) classified PNG's exchange rate regime as the 'crawl-like' arrangement, the Bank of PNG in its Monetary Policy Statement (2014) argued otherwise that the imposition of exchange rate trading margin did not change PNG's exchange rate regime which remains managed floating. For the purpose of the study, this paper takes the classification as 'crawl-like' arrangement, although appreciating that it was not an intended official shift of regime.

3   PNG's exchange rate is directly quoted, that is, price of domestic currency is measured in terms of foreign currency (foreign currency per kina), therefore an increase would imply an appreciation in the exchange rate.

4   See Garnaut and Baxter (1984) for detailed discussion on the Hard Kina policy in PNG.

5   Market exchange rates are the buy and sell kina exchange rates. Sell kina exchange rate is the rate at which domestic currency, kina, is sold for foreign currency, particularly for US dollars whilst buy kina exchange rate is the rate at which foreign currency, particularly US dollars is used to buy domestic currency, kina.

6   APEC economies included in the study included Australia, Canada, Chile, Indonesia, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Philippines, Singapore, Thailand and the United States.

7   These six major trading partner countries include Australia, Japan, United States, Singapore, New Zealand and China. Average trade shares of these countries from 2014 to 2017 constitute more than 80 per cent of the total trade, 70 per cent of the imports and 60 per cent of the export trade share.