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Modelling short-run and long-run predictors of foreign portfolio investment volatility in low-income Southern African Development Community countries

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Orientation: This study examined the main predictors of net foreign portfolio investment volatility in low-income Southern African Development Community (SADC) countries. Based on the World Bank data (July 2014), the selected countries are Zimbabwe, Zambia, Malawi, Lesotho, Madagascar, Mozambique, DRC, Swaziland and Tanzania.

Research purpose: The purpose of this study is to establish the main drivers of net foreign portfolio investment volatility in low-income SADC countries.

Motivation for the study: This study is also motivated by mixed findings in foreign portfolio investment debate on why capital flows are more volatile and difficult to manage in developing than in advanced economies. Although it is acknowledge that developing markets are characterised by the poor quality of financial institutions in economies with weak macroeconomic fundamentals, which ultimately pose a greater risk of sudden stops or reversal of foreign portfolio flows, findings remain inconclusive on what actually drives net foreign portfolio investment volatility in low-income countries.

Research approach/design and method: The Panel Autoregressive Distributed Lag (P-ARDL) model is employed to determine the short- and long-run drivers of such investment volatility in these countries. The study uses quarterly data for the period spanning 2000 to 2015.

Main findings: The findings reveal that all the variables in the model, namely money supply, world output, general prices, real gross domestic product, domestic interest rates and international interest rates, are significant predictors of net foreign portfolio investment volatility. However, positive long-run effects are observed from world gross domestic product, real gross domestic product, prices and money supply, whilst domestic interest rates and international interest rates displayed a negative association in the long run. These findings are consistent with both the economic literature and the empirical literature, which suggest that an increase in interest rates or higher interest rates affects foreign portfolio investment. Similarly, in the short run, all the variables employed in the model are the main predictors of net foreign portfolio investment volatility in low-income SADC countries.

Practical/managerial implications: Policy-makers should embark on policies and programs that promote economic performance in order to attract stable foreign portfolio flows that will lead to stable markets and reduce volatility in the economy. Policy consistency is thus, recommended to attract investors to the region and ensure that stock and bond markets are viable and stable.

Contribution/value-add: Unlike other existing studies, the measure of volatility employed in this is considered superior as it is based on net portfolio flows which reflect changes in an economy's overall current account position. The study informs and advances the current discourse on the causes of capital flow volatility in the field of investment theory and practice.

Keywords: foreign portfolio flows; low-income countries; P-ARDL; volatility; international investment flows; international interest rates; money supply.

Introduction

Over the past three decades, developing economies have become more integrated with global financial markets, largely driven by global trade and capital account liberalisation (Alfaro, Kalemli-Ozcan & Volosovych 2007; Broto, Díaz-Cassou & Erce 2011; Neumann, Penl & Tanku 2009). Indeed, globalisation, which has been the most important feature of the world economy since the 1990s, has been driven by liberalisation of trade and financial flows, resulting in increased cross-border investment flows. However, the surge in global capital flows posed new and serious challenges to the developing world such as foreign portfolio investment volatility. This is heightened by decreased returns and higher inflation rates as well as government policy inconsistencies (Mody, Taylor & Kim 2001). These challenges have continued to attract the interest of investors, economic policy-makers and researchers. Kaltenbrunner and Painceira (2015) and other scholars note that the changing nature of capital flows to developing and emerging markets because of financial integration has exposed these economies to new forms of vulnerability, volatile financial flows and exchange rate fluctuations. This motivated the present empirical investigation of the drivers of variability in foreign portfolio investment flows, particularly in low-income Southern African Development Community (SADC) countries.

Goldstein and Razin (2006) define foreign portfolio investment as the entry of funds into a country when foreigners deposit money in its banks or purchase shares from the country's stock and bond markets. Foreign portfolio investment flows are important because of their links with other macroeconomic parameters in stimulating the economy. Volatility is associated with the behaviour of international investors when they deploy funds for short-term benefit and suddenly withdraw their investment as uncertainty or need arises (Kodongo & Ojah 2012). Accordingly, volatility in this case refers to uncertainty pertaining to the flow of foreign portfolio investment in the economy. However, Ahmed and Zlate (2014) and Waqas, Hashmi and Nazir (2015) define foreign portfolio investment volatility as domestic markets' vulnerability to external shocks, particularly in the event of large and sudden fluctuations and risk uncertainty. Furthermore, capital flow volatility is a period of rapid capital inflows that fuel credit booms and asset price inflation, followed by sudden reversals when exchange rates depreciate, equity prices decline and gross domestic product (GDP) growth slows (Caballero & Krishnamurthy 2006).

This study is also motivated by findings that, because of their nature, capital flows are more volatile and difficult to manage in developing than in advanced economies (Broner & Rigobon 2004). Developing markets are characterised by the poor quality of financial institutions in economies with weak macroeconomic fundamentals, posing a greater risk of sudden stops or reversal of foreign portfolio flows. Broto et al. (2011) and Karimo and Tobi (2013) conclude that sharp and sudden fluctuations in global portfolio flows pose serious challenges and dilemmas to the developing world even though external funding is required for financial and economic development. Global portfolio investment flows have been observed to be highly unstable and vary considerably across types and time, leading to differences in volatility dynamics (Lo Duca 2012). Furthermore, international financial flows to developing economies have shifted from official to private and from debt to equity financing (Makoni 2014). In developing countries, particularly low-income countries (LICs), foreign portfolio flows are thought to play a destabilising role as they suddenly increase, stop or reverse (Broner 2004; Forbes 2012). In contrast, Alfaro et al. (2007) point out that international investment flows are ideal for financial and economic development as they promote efficient global allocation of financial resources. Based on the foregoing and the threat emanating from global portfolio investment flows as a source of funding, this study seeks to increase understanding of the dynamic behaviour of global portfolio flows to low-income SADC countries in order to assist economic policy-makers and portfolio investors to frame appropriate responses.

Notable cases of the adverse effects of volatile financial flows include the Mexican crisis of 1994–1995, the Asian crisis of 1997–1998 and recently the global financial crisis of 2008–2009 (Ostry 2012). Mercado and Park (2011) stress that short-term financial flows fluctuate significantly and can disrupt the operation of domestic monetary policy and create financial instability that hampers economic growth. Given these threats, investors and economic policy-makers require empirically tested evidence for effective planning and decision-making.

The challenges in managing foreign portfolio flows are a result of the overall surge in the volume of total financial flows and changes in the composition of capital flows as their importance shifts (Becker & Noone 2008). A major concern is that financial flows can be driven by external shocks that are beyond the control of domestic policies. Consensus that volatility is greater and more difficult to manage in developing than developed economies (see Reinhart & Rogoff 2009; Rigobon & Broner 2005) was confirmed during the Asian crisis and the recent global financial crisis. Furthermore, foreign portfolio investment flows were the most volatile component of international capital flows during these crises (Garg & Dua 2014). Gligoric and Jankovic (2013) also pointed out that portfolio and remittance flows have grown dramatically worldwide, particularly in developing countries where they provide a critical source of foreign currency and external funding.

Despite the surges and reversals in foreign portfolio investment flows to developing economies, there is a dearth of research on the drivers and impact of volatility in net foreign portfolio flows, particularly in LICs. The focus of existing studies is the volatility of gross capital flows (net purchases of domestic assets by foreign agents minus net purchases of foreign assets by domestic agents) with respect to major emerging markets (Broner & Rigobon 2004; Broto et al. 2011; Forbes & Warnock 2012; Milesi-Ferretti & Tille 2011; Neumann et al. 2009). However, even in developing countries, domestic investors are increasingly investing abroad as a way of hedging against capital flow volatility (Bluedorn et al. 2013; Obstfeld 2012).

This study makes several contributions to the literature on the variability of global portfolio investment flows. Firstly, the measure of volatility employed is considered superior as it is based on net portfolio flows which reflect changes in an economy's overall current account position. Net foreign portfolio investment flows refer to the difference between net portfolio inflows from international investors buying domestic financial assets, and the net volatility is more powerful and less persistent and has less serial correlation because it is calculated from the absolute values of residuals in line with Broto et al. (2011) and Engle and Rangel (2008), unlike estimates from the rolling window standard deviation or Generalised Autoregressive Conditional Heteroscedasticity (GARCH 1,1) methods. Secondly, this study employs the Panel Autoregressive Distributed Lag (P-ARDL) model, a contemporary panel data analysis approach that can confront and deal with the endogeneity and heterogeneity problems that affected traditional approaches. The study thus informs and advances the current discourse on the causes of capital flow volatility in the field of investment theory and practice.

Thus far, minimal attention has been paid to the short- and long-run predictors of net foreign portfolio investment volatility, particularly in low-income economies. This study seeks to address some of the gaps in the empirical literature on this issue by utilising the Chudik and Pesaran (2013) P-ARDL model.

A brief review of the literature

Foreign portfolio investment flows refer to cross-border investments in both equity and bond markets (Lo Duca 2012) and are regarded as a critical source of private capital for virtually all economies (Karimo & Tobi 2013). Developing economies stand to benefit immensely from a constant supply of stable international financial flows. The benefits to recipient economies include increased liquidity in financial markets and the fact that such financial flows are a source of foreign exchange, instil discipline in capital markets, reduce the cost of capital and bridge the savings-investment gap in developing countries (Karimo & Tobi 2013; Obstfeld & Rogoff 2009). This study is therefore rooted in the portfolio theory of international capital flows suggested by Devereux and Saito (2006). The theory argues that the national currency composition of national portfolios is critical in determining the direction of flow and mobility of international capital.

However, foreign portfolio investment flows are short term in nature and behave unpredictably, exposing recipient economies to high volatility and vulnerability to global financial crises (Kirabaeva & Razin 2012; Rothenberg & Warnock 2006). Excessive portfolio fluctuations increase financial vulnerability and macro-economic instability. Well-informed policy instruments are thus required to promote macro-financial stability in receiving economies. Broto et al. (2011) note that foreign portfolio investment flows are unstable because they are sensitive to domestic conditions in both developed and developing countries. Similarly, Karimo and Tobi (2013) point out that a stable macro-economic environment is a sound predictor of the variability of foreign portfolio flows in the Nigerian economy. Akçelik et al. (2015) thus recommend an appropriate economic policy mix to address the risks associated with foreign portfolio investment vulnerabilities.

Several factors have been linked to foreign portfolio investment volatility. Mercado and Park (2011) found that trade openness significantly drives the volatility of global portfolio flows, whilst an increase in market capitalisation, global liquidity growth and high institutional quality lowers the variability of such flows. Broner and Rigobon (2004) found less convincing evidence on the impact of inflation on portfolio flows but concluded that economic development is a good predictor. On the other hand, Rai and Bhanumurthy (2004) observed that higher domestic inflation pushes returns upwards, inducing international investors to buy more domestic assets and hence exhibiting a positive relationship. This study therefore employs the macro-financial variables affecting low-income economies to explain the variability of foreign portfolio flows.

According to Lo Duca (2012), foreign portfolio flows are subject to informational problems and rational herding behaviour in financial markets as investors seek international diversification opportunities (also see Calvo & Mendoza 2000). A major source of instability that is inherent in foreign portfolio flows arises from the trading activities of fund managers when they enter and leave the market at the same time (Haley 2001). Foreign portfolio stocks and bonds have been observed to be highly liquid, enabling investors to dispose of their assets quickly (Lo Duca 2012). Lo Duca (2012) also highlights that the drivers of capital flows vary across time and cross-sectional units, complicating their estimation. In addition, capital controls have an insignificant effect on the stability of foreign portfolio investment flows (Alfaro et al. 2007; Lo Duca 2012).

Furthermore, variability in exchange rates and a decline in returns as well as high inflation considerably increase the instability of foreign portfolio flows (Çulha 2006; Kodongo & Ojah 2012; Waqas et al. 2015). Choong et al. (2010) stress that the relationship between stock markets and global portfolio flows relies heavily on the level of stock market development. On the other hand, Carrieri, Errunza and Majerbi (2006) argue that the focus should be on real exchange rate fluctuations as opposed to nominal exchange rate volatility because the real exchange rate eliminates inflation and is a superior indicator of net foreign portfolio investment volatility. Empirical evidence also shows that there is an inverse relationship between exchange rate and portfolio flows (Bleaney & Greenaway 2001; Ersoy 2013; Waqas et al. 2015).

Based on the theory of portfolio investment, foreign investors are attracted by high interest rates as they reduce borrowing costs and the foreign investor will invest until interest rates are equalised across the world. However, this theory becomes problematic when risk, uncertainty and volatility are introduced (Waqas et al. 2015). In terms of high volatility, investors prefer to go short term, but as the environment becomes uncertain they withdraw their investment (Kodongo & Ojah 2012). On the other hand, stock market performance attracts capital flows and tends to stabilise portfolio flows, thereby attracting interest from both domestic and international investors as well as economic policy-makers (Ferreira & Laux 2009; Karimo & Tobi 2013). At micro-economic level, the effects of portfolio flows on financially constrained firms' access to finance exceed the negative effects of volatility in portfolio flows (Knill & Lee 2014), and they remain beneficial even during crisis periods (Beck, Demirgüç-Kunt & Levine 2009).

Neumann et al. (2009) and Daude and Fratzscher (2008) concluded that high industrial productivity stabilises the variability of foreign portfolio flows. This is evident in advanced economies with high and stable output production. However, Mody, Taylor and Kim (2001) obtained mixed results regarding this relationship, whilst De Vita and Kyaw (2008) suggest that output and industrial production are important pull factors in explaining foreign portfolio investment volatility.

Finally, a positive association has been identified between foreign direct investment (FDI) and foreign portfolio investment volatility, as an increase in FDI boosts market confidence and attracts stable foreign portfolio flows (Gözgör & Erzurumlu 2010; Waqas et al. 2015). However, Levchenko and Mauro (2007) indicate that during crisis periods, foreign portfolio investment is neither consistent nor persistent compared to other capital flows. Moreover, Ferreira and Laux (2009) observed that foreign portfolio investment volatility is positively related to financial liberalisation.

Whilst several approaches have been identified to measure historical volatility, the estimation process is not straightforward (Broto et al. 2011; Neumann et al. 2009). These approaches include GARCH (1,1), rolling window standard deviation, exponential weighted moving average (EWMA) and the Spline-GARCH model. Broto et al. (2011) concluded that the residuals derived from the panel model approach produced superior results to the GARCH (1,1) and the rolling window standard deviation methods because of its robust nature. Therefore, in line with Salisu and Isah (2017) and Broto et al. (2011), the reduced form volatility estimation is given below:

$$V_{ct}^2 = \frac{1}{4}\sum_{j=1}^{4}\left|R_{ctj}\right| \qquad \text{[Eqn 1]}$$

where j represents each quarter of year t and R_{ctj} is the annual average of the absolute value of quarterly residuals.

Traditional approaches such as the rolling window method are not suitable for this study as they lose observations at the beginning of the sample. Moreover, volatility is highly persistent as it depends on previous periods, leading to problems of endogeneity and serial correlation (Broto et al. 2011). In addition, these approaches give the same weight to recent and previous flows, thereby normalising the volatility dynamics and leading to volatility underestimation during a shock and overestimation thereafter. Finally, the EWMA is a symmetrical model where large negative capital flows have the same impact as large positive ones. Hence, it merely smooths the squared time series and fails to capture capital flow volatility dynamics.

Based on Broto et al. (2011), the residuals approach offers long horizon forecasts of volatility which depend on economic fundamentals and deliver the volatility estimates anticipated in a newly opened market.

According to Broto et al. (2011), the absolute values of residuals are produced by an autoregressive integrated moving average (ARIMA) model as developed by Caporello and Maravall (2003). A suitable ARIMA model is estimated for each country and type of capital flow on a quarterly basis. In this study, the absolute values of residuals are generated using the EViews program in line with Schwert (2015). This program was used because of its ability to create a new series from an existing one (i.e., lag values). In this study, a new series is established from the one period lag values of the original series (AR1 process), making it possible to estimate the regressions and generate the absolute values of the residual values.

In summary, the literature seems to suggest that there is a lack of consensus on the key factors driving foreign portfolio investment volatility. The empirical literature cites a number of reasons for this, including differences in samples or data used, different research methods and the time varying behaviour of the drivers of volatility because of changes in investors' tastes and preferences (Alfaro, Kalemli-Ozcan & Volosovych 2004; Lo Duca 2012). The next section discusses the methods used in this study.

Data sources and research methodology

Data sources

The study utilises quarterly unbalanced panel data spanning a period of 16 years from 2000:Q1 to 2015:Q4. The choice of the study period and the cut-off dates were influenced by the availability of data on foreign portfolio investment flows in low-income SADC countries. The main data sources are the World Bank Data Bank, the International Monetary Fund's (IMF) International Financial Statistics, Bloomberg and the central statistical centres of the respective countries' central banks. Based on the World Bank data (July 2014), the selected countries are Zimbabwe, Zambia, Malawi, Lesotho, Madagascar, Mozambique, DRC, Swaziland and Tanzania.

Estimating net foreign portfolio investment volatility

An important part of the data used in this study is the determination of net foreign portfolio volatility estimates for net portfolio flows for each individual LIC. The study employs the absolute values of residuals as guided by Engle and Rangel (2008) and successfully utilised by Broto et al. (2011). This approach produces superior results compared to the traditional GARCH (1,1) and the rolling window standard deviation method. According to Broto et al. (2011), the absolute values of residuals are produced from an ARIMA model calculated by the automatic procedure of TRAMO-SEATS for Windows (TSW) developed by Caporello and Maravall (2003) of the Bank of Spain. However, in this study, the absolute values of residuals are produced using the EViews program as demonstrated by Professor G.W. Schwert (2015). EViews' ability to create a new series from an existing one (i.e. lag values) makes it ideal. A new series is established from the one period lagged values of the original series (AR1 process), making it possible to estimate the regressions and generate the absolute values of residual values.

After generating the absolute values of residuals, the quarterly variance of net foreign investment flows is estimated from the quarterly averages of the absolute values of monthly residuals (R_{ctj}). As stated in the literature review and based on Broto et al. (2011), the reduced form volatility estimation equation is as follows:

$$v_{ct}^2 = \frac{1}{4}\sum_{j=1}^{4}\left|R_{ctj}\right| \qquad \text{[Eqn 2]}$$

where j represents each quarter of year t and R_{ctj} is the annual average of the absolute value of quarterly residuals.

According to Broto et al. (2011), the residuals approach offers robust estimates of historical volatility relative to the values generated by GARCH (1,1) and rolling window standard deviation. The residuals approach also allows for long-term forecasts of volatility to be based on economic fundamentals and delivers the variability estimates anticipated in a recently liberalised economy.

Estimation technique

The objective of this study is to ascertain and explain the main predictors of foreign portfolio investment volatility in low-income SADC countries. It follows Rafindadi and Yosuf (2013), Hegerty (2011), Al Mamun, Sohog and Akhter (2013) and Mohaddes and Raissi (2014) in utilising Chudik and Pesaran's P-ARDL model (2013). The choice of this model was driven by several advantages it has over conventional short- and long-run estimation techniques.

The P-ARDL model is chosen primarily because of its flexibility with small sample studies. This approach accommodates variables that are of different order of integration, that is, it can handle I(0) and I(1) variables but not I(2). According to Giles (2013), ARDL is a contemporary technique for investigating long- and short-run dynamics. In addition, the P-ARDL model enables different variables to be assigned different lags in the same system (Giles 2013; Hegerty 2011). Furthermore, it is simple to set-up, implement and interpret as it involves a single equation, but at the same time powerful enough to accommodate more than two lags and six variables (Giles 2013; Oluseye & Gabriel 2017). Moreover, the Chudik and Pesaran (2013) P-ARDL model is ideal for panel analysis as it accounts for cross-sectional dependency (CSD) and allows for one or two structural breaks when carrying out unit root tests. Finally, it is powerful in estimating the long- and short-run parameters of the model (Dritsakis 2011; Shin et al. 2014).

Now suppose that the P-ARDL regression model for low-income SADC countries is given by:

$$\begin{aligned}\Delta Y_{it} &= \delta_{i0} + \delta_1 \Delta X_{it-1} + \delta_2 \Delta X_{it-2} + \delta_3 \Delta X_{it-3} + \ldots\ldots \\ &+ \delta_p \Delta X_{it-p} + \omega_1 y_{it-1} + \omega_2 y_{it-2} + \omega_3 y_{it-3} + \ldots\ldots. \qquad \text{[Eqn 3]} \\ &+ \omega_q y_{it-q} + \varepsilon_{it}\end{aligned}$$

where Y_{it} is a vector of (kx1) vector representing net foreign portfolio investment volatility, i represents the low-income SADC countries, Δ captures first difference operator, X_i and y_i are the lagged independent variables for every i = 1 …………….p and q, $\delta_1 - \delta_p$ denote the short-run co-efficiency of the model explaining short-run relationships, $\omega_1 - \omega_q$ correspond to the long-run relationship and e_{it} represents the vector of noise term.

Ethical consideration

This article followed all ethical standards for a research without direct contact with human or animal subjects.

Empirical analysis and interpretation of results

This section begins the empirical analysis of the methodology employed and the interpretation of results using P-ARDL. The aim is to establish the main drivers of net foreign portfolio investment volatility in low-income SADC countries. The role of foreign portfolio investment flows in financing stagnant economies and large budget deficits in developing countries cannot be ignored. Furthermore, it is important to note that net foreign portfolio investment flows into low-income SADC countries will assist in equilibrating overall savings and investment in the region (Friedman 1986) in order to stimulate economic growth. In line with Al Mamun et al. (2013), Rafindadi and Yosuf (2013) and Gerni et al.'s (2013) empirical studies, we adopt Chudik and Pesaran's (2013) P-ARDL model using quarterly data spanning 16 years from 2000 to 2015. Based on Kutu and Ngalawa (2016), the P-ARDL model is ideal for this study because it accounts for CSD, accommodates one or two structural breaks when conducting unit root tests and is suitable for panel analysis (Chudik & Pesaran 2013).

Panel Autoregressive Distributed Lag unit root results

The study tests for the presence of unit roots to determine the stationarity of the data set using the Levin, Lin and

Chu (LLC), Im, Pesaran and Shin (IPS) and Augmented Dickey–Fuller (ADF) tests at individual intercept and individual intercept and trend. All three methods of unit root testing are used so as to compare and validate the results, thereby ensuring consistency. This is in line with Moon and Perron (2004), Demetriades and Fielding (2012) and Ishibashi (2012). At 5% significance level for the benchmark, the findings show that after first differencing, all the variables in the model are stationary at order one, that is, I (1). Whilst the LLC unit root test shows that inflation (CPI), world output (WGDP) and international interest rates (FFR) are not stationary at I(1), both the IPS and ADF results show otherwise and indicate that these variables are stationary at I(1). This is a majority result that is hence adopted for the study. Furthermore, the unit root test results are consistent with Kutu and Ngalawa (2016). This satisfies Sari, Ewing and Soytas (2008) and Katircioglu's (2009) conditions for running an ARDL model. According to these scholars, ARDL can be used with a mixture of I(0) and I(1) variables as well as fractionally integrated order or irrespective of their order of integration. This means that this approach can be applied to data or variables whether they are only I(0), I(1), a mixture of I(0) and I(1), mutually co-integrated or regardless of their order of integration but not I(2). Furthermore, Pesaran, Shin and Smith (2001) point out that the dependent variable must be I(1). As shown in Table 1, the dependent variable is I(1) and hence, satisfies the Pesaran et al. (2001) condition for running an ARDL model.

TABLE 1a: Levin, Lin and Chu, Im, Pesaran and Shin and Augmented Dickey–Fuller unit root tests.

Variables	Levin, Lin and Chu (individual intercept)			Levin, Lin and Chu (individual intercept and trend)		
	Order of integration	*t** statistics	*p*	Order of integration	*t** statistics	*p*
CPI	I(1)	4.656	1.000	I(1)	6.451	1.000
FFR	I(1)	2.279	0.989	I(1)	4.022	1.000
M2	I(1)	−1.648	0.050**	I(1)	0.259	0.602
RGDP	I(1)	−1.771	0.038**	I(1)	−0.299	0.382
INT	I(1)	−2.269	0.012***	I(1)	−0.9799	0.164
NFPI	I(1)	−11.85	0.000***	I(1)	−10.977	0.000***
WGDP	I(1)	17.178	1.000	I(1)	24.158	1.000

CPI, inflation; FFR, international interest rate; M2, money supply; RGDP, real gross domestic product; INT, domestic interest rate; NFPI, net foreign portfolio investment; WGDP, world output; IPS, Im, Pesaran and Shin; ADF, augmented Dickey–Fuller.

'*', '**' and '***' represent statistical significance at 10%, 5% and 1%, respectively.

TABLE 1b: Levin, Lin and Chu, Im, Pesaran and Shin and Augmented Dickey–Fuller unit root tests.

Variables	IPS unit-root test (individual intercept)			IPS unit-root test (individual intercept and trend)		
	Order of integration	*t** statistics	*p*	Order of integration	*t** statistics	*p*
CPI	I(1)	−5.710	0.000***	I(1)	−5.197	0.000***
FFR	I(1)	−4.662	0.000***	I(1)	−2.738	0.003***
M2	I(1)	−7.425	0.000***	I(1)	−6.295	0.000***
RGDP	I(1)	−7.702	0.000***	I(1)	−6.478	0.000***
INT	I(1)	−5.937	0.000***	I(1)	−4.333	0.000***
NFPI	I(1)	−16.206	0.000***	I(1)	−15.624	0.000***
WGDP	I(1)	−19.029	0.000***	I(1)	−18.303	0.000***

CPI, inflation; FFR, international interest rate; M2, money supply; RGDP, real gross domestic product; INT, domestic interest rate; NFPI, net foreign portfolio investment; WGDP, world output; IPS, Im, Pesaran and Shin; ADF, augmented Dickey–Fuller.

'*', '**' and '***' represent statistical significance at 10%, 5% and 1%, respectively.

TABLE 1c: Levin, Lin and Chu, Im, Pesaran and Shin and Augmented Dickey–Fuller unit root tests.

Variables	ADF–Fisher Chi-square unit root-test (individual intercept)			ADF–Fisher Chi-square unit root-test (individual intercept and trend)		
	Order of integration	*t** statistics	*p*	Order of integration	*t** statistics	*p*
CPI	I(1)	74.371	0.000***	I(1)	64.078	0.000***
FFR	I(1)	52.253	0.000***	I(1)	31.269	0.027**
M2	I(1)	90.970	0.000***	I(1)	70.232	0.004***
RGDP	I(1)	97.404	0.000***	I(1)	74.075	0.000***
INT	I(1)	75.600	0.000***	I(1)	54.777	0.000***
NFPI	I(1)	246.136	0.000***	I(1)	212.052	0.000***
WGDP	I(1)	297.230	0.0000**	I(1)	254.503	0.000***

CPI, inflation; FFR, international interest rate; M2, money supply; RGDP, real gross domestic product; INT, domestic interest rate; NFPI, net foreign portfolio investment; WGDP, world output; IPS, Im, Pesaran and Shin; ADF, augmented Dickey–Fuller.

'*', '**' and '***' represent statistical significance at 10%, 5% and 1%, respectively.

The test for cross-sectional dependency

Notwithstanding the postulation that the Chudik and Pesaran (2013) P-ARDL model accounts for CSD, and the alternative standard augmented Dickey–Fuller (ADF) test proposed by Pesaran (2007) to remove the impact of CSD, the study first conducts a chow test to ascertain whether the data for the SADC countries can be pooled. The findings are supportive of pooled regression for these countries. Thereafter, the Pesaran cross-sectional dependence (Pesaran CD) test is used to test whether the error term or residuals are correlated across units. The benchmark hypotheses that are tested for CSD are as follows:

- $H0:\beta=1$, there is no correlation of the residuals (error term).
- $H1:\beta\neq 1$, there is correlation of the residuals (error term).

The results show a *t*-statistic value of 21.791 is greater than the Pesaran table value at 5%; hence, the study fails to reject the null hypothesis of no correlation of the residuals but rejects the alternative hypothesis that correlation of the residuals exists in the model. Accordingly, the Pesaran CD test conducted on the P-ARDL regression model does not show the presence of CSD or common factors affecting the cross-sectional units in the SADC countries. This is similar to Pesaran (2007) and Gow, Ormazabal and Taylor (2010) who corrected for CSD in their respective studies.

The Panel Autoregressive Distributed Lag determination

To ensure robust and efficient results, this study utilises the unrestricted likelihood ratio test for the lag lengths and conducts various lag selection criteria to determine the optimum lag for the P-ARDL model. The various orders of lags conducted for the model are the sequential modified likelihood-ratio test statistic (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz

Bayesian information criterion (SBIC) and Hannan-Quinn information criterion (HQIC). The P-ARDL is conducted for eight (8) lags order. The results in Table 3 show that the SBIC selects lag two (2), whilst the LR, FPE, AIC and HQIC select lag three (3). The benchmark hypothesis for choosing the optimum lag is to select the lag that gives the minimum criteria. As presented below, lag 3 gives the minimum criteria for the value of the LR, FPE, AIC and HQIC which is now the optimal lag length for the variables in the system. Therefore, lag 3 is chosen for the P-ARDL model; this is consistent with Olarewaju, Sibanda and Migiro (2017) and Nowak-Lehmann et al. (2011). The choice of lag 3 allows the model to be dynamic and robust and prevents shortening of the data set. This is in line with the order of lags selected by Ali, Irum and Ali (2008) and Raza, Shahbaz and Nguyen (2015).

Determining the strength of the model selection criteria

As indicated in Table 2 where the LR, FPE, AIC and HQIC select lag three (3), the AIC gives the smallest number amongst them. The benchmark hypothesis is that the smaller the number, the better the model for selecting optimal lag length. In order to determine the strength of the AIC over other criteria (LR, FPE and HQIC) that chose 3 lag for model selection in the regression, this study employs the criteria graph to determine the top 16 different P-ARDL models based on the benchmark analysis that the lower the value of the criteria, the better the model. The ARDL (4, 4, 4, 4, 4, 4, 4) model seems to be superior to the others.

The Panel Autoregressive Distributed Lag model

In the estimation of the main predictors of net foreign portfolio investment flows in low-income SADC economies, the results from the P-ARDL show that in the long run, all the variables in the model are statistically significant in explaining net foreign portfolio investment volatility in SADC countries (see Table 3). In particular, the findings reveal that world GDP, real GDP, money supply (M2) and prices (CPI) have a positive long-run impact on net foreign portfolio investment volatility in these economies, whilst global interest rates (FFR) and domestic interest rates (INT) have a negative impact on net foreign portfolio investment flows in the low-income SADC countries. The reason is that as world GDP grows, foreign investors may sometimes invest in other countries' stock and bond markets for speculation and in an attempt to diversify and expand their horizons. This relationship is consistent with economic theory (an increase in money supply will have a positive impact whilst an increase in interest rates will have a negative impact) and empirical evidence such as that provided by Kolodko (2006). The positive relationship amongst world GDP, real GDP, money supply and prices is an indication that an increase in these variables will lead to an increase in net foreign portfolio investment volatility in SADC countries.

TABLE 2: Lag length determination and selection for the Panel Autoregressive Distributed Lag model.

Lag	LogL	LR	FPE	AIC	SBIC	HQIC
0	−2543.125	NA	7.04e-05	10.304	10.363	10.327
1	−1026.793	2983.651	1.874	4.375	4.851	4.562
2	−833.634	374.612	1.052	3.793	4.684*	4.143
3	−31.623	283.289*	1.358*	1.740*	5.129	3.070*
4	−788.470	86.313	1.067	3.808	5.116	4.322
5	−613.947	328.597	6.411	3.301	5.025	3.978
6	−472.825	261.718	4.421	2.929	5.069	3.769
7	−292.631	329.082	2.601	2.399	4.955	3.402
8	−191.702	181.469	2.121	2.189	5.162	3.356

LR, likelihood-ratio; FPE, final prediction error; AIC, Akaike information criterion; SBIC, Schwarz Bayesian information criterion; HQIC, Hannan–Quinn information criterion.
'*', '**' and '***' represent statistical significance at 10%.

TABLE 3: The Panel Autoregressive Distributed Lag regression model.

Variable	Coefficient	Std. error	*t*-statistic	Prob.*
Long run equation				
LOGFFR	−0.043	0.049	−0.872	0.014
LOGWGDP	1.641	1.042	1.575	0.009
LOGRGDP	0.312	0.031	10.014	0.000
LOGM2	0.360	0.240	1.494	0.027
LOGCPI	0.008	0.010	0.777	0.063
INT	−0.000	0.000	−2.117	0.003
Short run equation				
COINTEQ01	−0.090	0.130	−9.918	0.000
D(LOGNFPI(-1))	0.178	0.119	1.488	0.038
D(LOGNFPI(-2))	−0.107	0.081	−1.332	0.014
D(LOGNFPI(-3))	−0.241	0.096	−2.511	0.013
D(LOGFFR)	0.042	0.123	0.342	0.033
D(LOGFFR(-1))	−0.017	0.078	−0.216	0.029
D(LOGFFR(-2))	0.270	0.088	3.068	0.002
D(LOGWGDP)	−1.230	2.459	−0.500	0.017
D(LOGWGDP(-1))	−4.658	2.213	−2.105	0.036
D(LOGWGDP(-2))	−9.220	1.992	−4.629	0.000
D(LOGRGDP)	0.636	0.275	2.318	0.021
D(LOGRGDP(-1))	0.024	0.199	0.122	0.003
D(LOGRGDP(-2))	0.762	1.017	0.749	0.054
D(LOGM2)	0.336	0.823	0.408	0.003
D(LOGM2(-1))	0.771	0.952	0.809	0.019
D(LOGM2(-2))	2.569	1.408	1.824	0.069
D(LOGCPI)	1.628	1.864	0.873	0.033
D(LOGCPI(-1))	3.926	2.279	1.722	0.006
D(LOGCPI(-2))	2.632	1.992	1.321	0.017
D(INT)	−0.026	0.012	−2.199	0.029
D(INT(-1))	0.033	0.018	1.771	0.078
D(INT(-2))	−0.005	0.006	−0.889	0.075
C	0.002	0.016	0.099	0.021

ARDL, autoregressive distributed lag.
Dependent variable: D(DLOGNFPI); Method: ARDL; Sample: 2001Q2 2015Q4; Model selection method: Akaike info criterion (AIC); Selected model: ARDL (4, 3, 3, 3, 3, 3, 3).

Conversely, interest rates have a negative impact on net foreign portfolio investment flows in the low-income SADC countries. This can be inferred to mean that a contractionary policy has an adverse effect on net foreign portfolio investment in these countries. This relationship is supportive of economic theory and Neumeyer and Perri's (2005) empirical evidence.

As far as the short run is concerned, the coefficients of all the explanatory variables were found to be statistically significant; hence, indicating that at 5% and 10%, all the variables in the model serve as the main predictors of net foreign portfolio investment flow volatility in SADC countries. The results demonstrate that, in the short run, all the variables are major drivers of net foreign portfolio investment volatility in these LICs.

F-statistic	1.230	Prob. *F* (11,022)	0.306
Obs* *R*-squared	13.352	Prob. Chi-Square (12)	0.311

'*', '**'and '***' represent statistical significance at 10%, 5% and 1%, and, respectively.

FIGURE 1: Heteroscedasticity test: Breusch–Pagan–Godfrey.

F-statistic	1.283	Prob. *F* (2,220)	0.121
Obs* *R*-squared	2.069	Prob. Chi-square (2)	0.125

'*', '**'and '***' represent statistical significance at 10%, 5% and 1%, respectively.

FIGURE 2: Breusch–Godfrey serial correlation LM test.

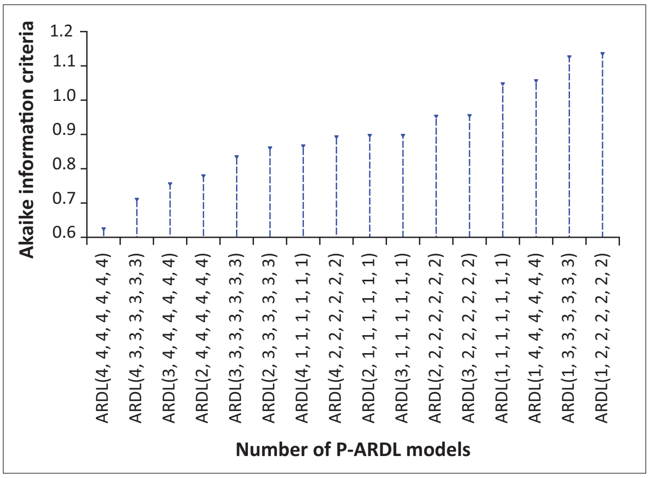


FIGURE 3: Possible number of panel ARDL (autoregressive distributed lag) models using the Akaike Information Criteria.

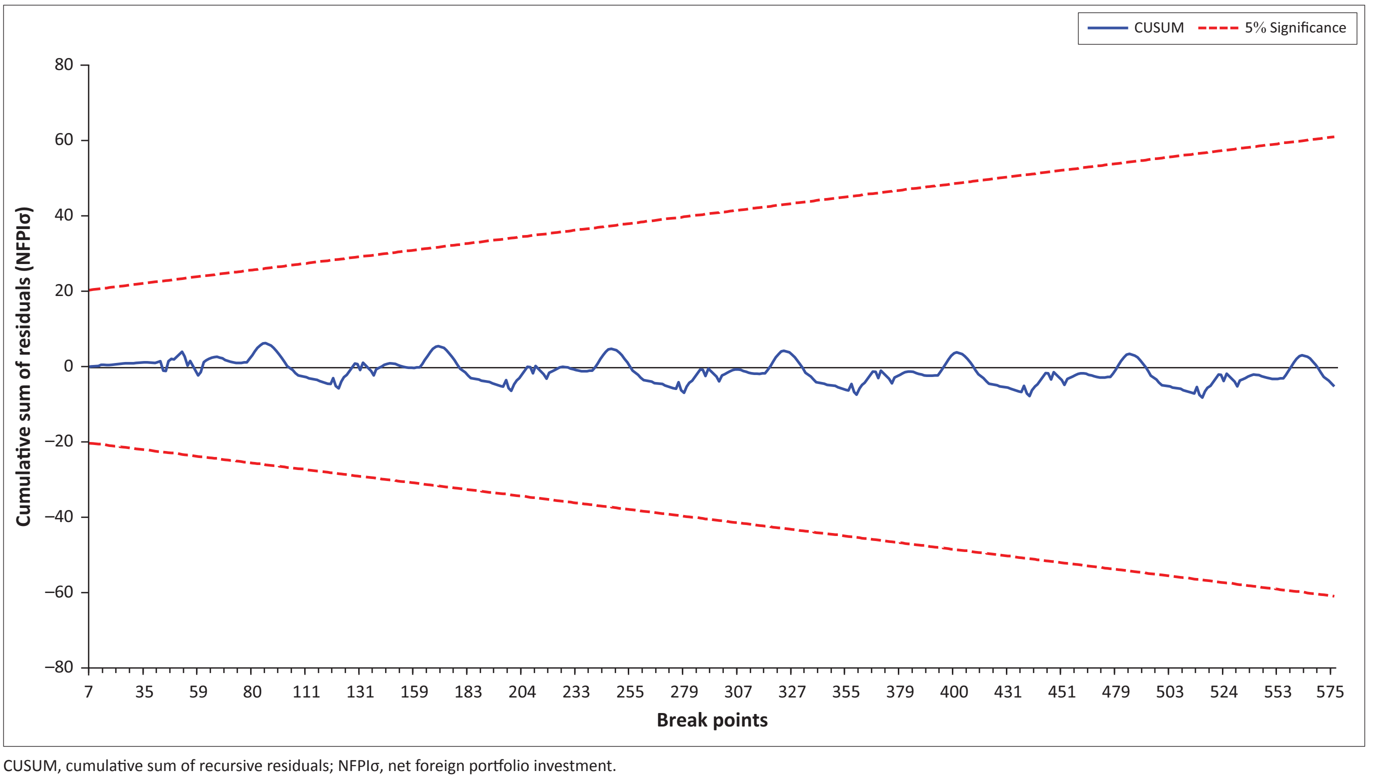
Diagnostic and reliability tests

In order to determine the reliability of the P-ARDL model, the study tests for heteroscedasticity, serial correlation and stability of the model. The benchmark null hypotheses tested for the model are as follows:

- $H0: \beta = 1$, there is no heteroscedasticity and serial correlation in the model.
- $H1: \beta \neq 1$, there is heteroscedasticity and serial correlation in the model.

The results in Figure 1 and 2 show that there is no heteroscedasticity and serial correlation in the model. Figure 3 shows possible number of panel ARDL models using the Akaike Information Criteria. The probability values in the two tables confirm the model to be free from heteroscedasticity and serial correlation. The stability graph also shows the stability test of the model. The line capturing the study's data passes within the 5% confidence interval; hence, the model is stable. Therefore, the null hypothesis of stability is accepted for the model.

Figure 4 shows that the CUSUM statistics are well within the critical bounds, signifying the stability of all the coefficients in the error correction model. This finding is in line with Halicioglu (2005) and shows that there is a stable long-run relationship between the dependent and independent variables in the model.



CUSUM, cumulative sum of recursive residuals; NFPIσ, net foreign portfolio investment.

FIGURE 4: Stability test for the autoregressive distributed lag model.

TABLE 4: The Panel Autoregressive Distributed Lag co-integration test (Wald test).

Test statistic	Value	Degree of freedom	Probability
F-statistic	5.219	(2, 227)	0.006
Chi-square	10.439	2	0.005

ARDL, autoregressive distributed lag.

TABLE 5: The Panel Autoregressive Distributed Lag error correction term.

Variable	Coefficient	Std. error	*t*-statistic	Prob.
ECT	−0.733	0.117	6.239	0.000

ECT, error correction term.

The Panel Autoregressive Distributed Lag co-integration results

The default parameter estimate of the short-run coefficient (COINTEQ01) with the coefficient value of −0.090 and probability value of 0.000 is an indication of disequilibrium in the past that can be corrected in the future. The negative coefficient means disequilibrium, whilst its significant probability value confirms the possibility of reverting to equilibrium in the long run with a high speed of adjustment. This is as expected and indicates the existence of long-run co-integration amongst the variables (otherwise there would be no co-integration). Furthermore, a P-ARDL co-integration test is conducted to validate the model and the result. As shown in Table 4 below, the *F*-statistics show a *p*-value of less than 0.05. Therefore, the study rejects the null hypothesis of no co-integration and fails to reject the alternative hypothesis that there is a long-run co-integration relationship amongst the variables in the model. The *F*-statistic value of 5.219 is greater than the upper band of the Pesaran critical value of 3.01 at 5% level (Pesaran & Pesaran 1997:478). This again shows evidence of a long-run co-integration relationship amongst net foreign portfolio investment volatility and the other variables in the model.

The Panel Autoregressive Distributed Lag error correction term

In further validating the existence of long-run equilibrium that was revealed in the Diagnostic and reliability tests section, Table 5 shows the results of the error correction term (ECT). The negative sign of the ECT coefficient shows the existence of disequilibrium in the short run and convergence of the system in the long run. The ECT value of −0.733 suggests a relatively high speed of adjustment from short-run disequilibrium to the restoration of equilibrium in the long run of net foreign portfolio investment volatility. This is in line with the results revealed by the default parameter of (COINTEQO1) as shown in Table 3. These results are consistent with Waliullah and Rabbi (2011) and Banerjee, Dolado and Mestre (1998) on the existence of a stable long-run relationship.

Conclusions

This study examined the main predictors of net foreign portfolio investment volatility in low-income SADC countries using a P-ARDL model with quarterly data spanning the period 2000 to 2015. All the variables in the model were statistically significant in the short and long run, and hence, they determine net foreign portfolio investment volatility in these countries. The results are consistent with theory and empirical studies such as Akinlo (2004), Glytsos (2005), Ramirez (2006), and Kolodko (2006), amongst others. It was found that prices, real GDP, world GDP and money supply have a positive long-run effect on net foreign portfolio investment volatility in the SADC countries. Conversely, interest rates have a negative impact on net foreign portfolio investment volatility in these countries. This finding is in line with general expectations, economic theory and empirical evidence as indicated in Neumeyer and Perri (2005).

Furthermore, the P-ARDL model provides some evidence of the existence of co-integration between foreign portfolio investment volatility and the other variables in the model. Co-integration exists when the relationship between two time series' variables exhibits a constant pattern in the long run. These findings are in line with empirical studies such as Giuliano and Ruiz-Arranz (2009), Yang (2008) and Li and Liu (2005), amongst others. Moreover, the results revealed a significant negative value of the ECT and a comparatively high speed of adjustment of 73% at which disequilibrium in the short run can be restored back to equilibrium in the long run. These findings are supportive of Kutu and Ngalawa (2016), Waliullah and Rabbi (2011) and Banerjee et al. (1998) who contended that a highly significant ECT is evidence of the existence of a steady long-run relationship amongst the variables employed in any model.

Policy-makers should embark on policies and programs that promote economic performance in order to attract stable foreign portfolio flows that will lead to stable markets and reduce volatility in the economy. Failure to ensure stable markets and viable investment opportunities would attract speculative and unstable foreign portfolio investment flows that will adversely affect the economic growth of the SADC economies from which escape may be difficult. Overall, it can be concluded that all the variables employed in the system serve as significant predictors of net foreign portfolio investment volatility in both the short and long run in low-income SADC countries. Economic policy consistency is therefore recommended in order to attract stable investment flows to the region.

It is recommended that future researchers compare the predictors of gross and net portfolio investment volatility, find other means of estimating volatility and include other key variables missed in this study.

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The authors have declared that no competing interests exist.

Authors' contributions

Both authors contributed equally to this work.

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