Monetary policy spillovers in the SACU area[#]

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Abstract: Considering that South Africa is the largest economy in the Southern African Customs Union (SACU), it is most likely that monetary policy shocks from South Africa could spill over to the smaller members of SACU, which are Botswana, Lesotho, Namibia, and Swaziland (the so-called BLNS countries). The BLNS countries are dependent on South Africa and have their monetary policy actions linked to those of South Africa. This means that one of the major challenges that BLNS countries could face when attempting to maintain price and economic stability is the spillover of monetary policy shocks from South Africa. This paper, therefore, examines the extent of South African monetary policy spillovers to the BLNS countries through investigating whether or not South African inflation spills over to the inflation of other SACU countries and how the monetary authorities in the BLNS countries react to South African policy interest rates. These spillovers are crucial because monetary policy is one of the key elements of macroeconomic policy and its effective conduct of the policy is critical to the economic performance and prospects of a country. Methodologically, we employ the SVAR analysis and the Diebold-Yilmaz spillover method. The findings indicate that South African monetary policy spillovers are a significant source of fluctuations in the monetary policy variables of the BLNS countries. Furthermore, a South African monetary policy shock significantly affects interest rates and inflation in the BLNS countries in a homogenous manner and largely the same way as within South Africa. The main contribution of the paper is the assessment of the cross-country responses to policy spillovers.

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1. INTRODUCTION

Monetary integration is one of the major points of focus for African countries. Integration takes several arrangements that include the formation of a free trade area, creation of customs union, a common market as well as an economic union, which involves monetary and fiscal integration. According to McCarthy (2012), full monetary integration is one of the highest forms of integration. Key characteristics of monetary integration are:

a. Fixed exchange rates of currencies of the member countries with respect to each other;
b. The existence of full convertibility of currencies in the region;
c. Assignment of the responsibility for exchange rate policy to the region, and
d. Assignment of the instruments of monetary policy to the region, implying that a regional central bank is established.

Several African regional integration arrangements, such as SADC (Patroba and Nene, 2013), ECOWAS (Fwangkwal, 2014) and CFA franc zone (McCarthy, 2012), are aiming to become a full monetary union, which is when there is complete monetary integration in the region. Moreover, some of the SADC member countries, South Africa, Botswana, Lesotho, Namibia, and Swaziland, are part of the Southern African Customs Union (SACU). The SACU region incorporates the Common Monetary Area (CMA), the oldest monetary integration arrangement still in existence (McCarthy, 2012). The CMA consists of four of the five SACU countries, South Africa, Lesotho, Namibia and Swaziland, and its main characteristics are (McCarthy, 2012; Wang, Masha, Shirono and Harris*,* 2007):

a. Lesotho, Namibia, and Swaziland (LNS) have their national currencies pegged at par with the South African rand and the rand circulates freely in the LNS countries alongside the LNS currencies i.e. the Lesotho Loti, Namibian dollar, and the Swaziland Lilangeni. Although Botswana is not part of the CMA, the value of the Pula is set against a currency basket in which the rand carries a weight of about 60 - 70%;

b. Lesotho and Namibia central banks foreign reserve requirement of setting the total reserves equal to the amount of currency in circulation;

c. There is a free flow of funds within the CMA;

d. LNS countries have access to South African money and capital markets, and

e. There is a *de facto* monetary policy set by the South African Reserve Bank throughout the CMA.

The features listed above indicate that the main characteristic limiting the CMA from becoming a full monetary union is that the member countries have national central banks that are responsible for their monetary policies. This raises the question of whether or not monetary policy should be completely centralised in the SACU region, which is an upgrade of the current CMA to a SACU monetary union. A regional central bank for the SACU region is expected to insulate policy formulation from the influence of national policies and this could help curb inflation and ensure price stability (McCarthy, 2012).[1] However, this implies a loss of monetary policy autonomy for member countries and a restriction of their policy space (McCarthy, 2012: 5).

If the SACU region establishes a regional bank, it means that there will be one authority responsible for formulating monetary policy and ensuring macroeconomic stability for all South Africa and the BLNS countries. According to Wang, Masha, Shirono and Harris, (2007) the net benefits of setting up a regional central bank depend on how well the member countries react to macroeconomic spillovers. Due to economic and financial linkages among the SACU countries, the prevalence of the transmission of shocks among member countries is high. Considering that South Africa is the largest economy in the region it is most likely that the policy shocks from South Africa could spill over to the other smaller SACU countries, Botswana, Lesotho, Namibia and Swaziland (BLNS). Therefore, in an attempt to establish the feasibility of a regional central bank in the SACU region, it is important to investigate the extent of South African macroeconomic policy spillovers to the BLNS countries as well as establish whether or not the impact of SA macroeconomic policy is the same in all BLNS countries.

[1] There is a possibility of the regional central bank failing to provide the stability needed in the region as highlighted the performance of the European Central Bank and the Bundesbank, who have struggled to insulate the European countries from economic shocks and instability.

Furthermore, the main factors influencing the policy response process include the impact of symmetric or asymmetric shocks on the member countries and the effectiveness of the regional central bank policy in cushioning the impact of asymmetric shocks as well as facilitating the adjustment process (Wang *et al,* 2007: 29). The response of the BLNS countries to South African macroeconomic spillovers would give an indication on whether or not the SACU central bank will be ideal for the SACU member countries.

South African spillovers are considered because South Africa is the dominant country in the SACU region with the BLNS countries largely dependent on South Africa. This was established in the previous chapter on the SA dominance hypothesis. Furthermore, as a consequence of the harmonised monetary and exchange rate policies of the SACU countries, the monetary policy conduct in South Africa may have implications for the BLNS countries. This means that one of the major challenges that BLNS countries could face when attempting to maintain price and economic stability is the spillover of monetary policy shocks from South Africa. This paper, therefore, focuses on the extent of South African monetary policy spillovers to the BLNS countries.

In light of the above discussion, the main objective is to investigate the feasibility of the SACU region having a centralised Southern African central bank by analysing the extent and effects of South African monetary policy spillovers to the BLNS countries. The main objective is addressed through the following secondary objectives:

i. Use a Phillips curve relationship to establish whether or not South African inflation spills over to the inflation of other SACU countries.
ii. Use a Taylor-type monetary reaction function to assess how the monetary authorities in the BLNS countries react to South African policy interest rates.
iii. To establish whether or not there is interest rate pass-through from South Africa to the other SACU countries.

Monetary policy spillovers are the focus of the study because monetary policy is one of the key elements of macroeconomic policy and, hence, the effective conduct of the policy is critical to economic performance and prospects of a country.

According to Seleteng (2016), economists regard the main objectives of monetary policy as price stability and stable economic growth. To achieve this objective, monetary authorities focus on using one or more of the different monetary policy instruments such as setting a policy rate, controlling the money supply or managing an exchange rate (Taylor, 1995). Monetary policy is transmitted from short-term interest rates, to exchange rates and long-term interest rates, and finally to real GDP and inflation. However, this is not the end of the transmission because there is a feedback mechanism whereby the movements in real GDP and inflation are transmitted back to the short-term interest rate through a policy rule or reaction function (Taylor, 1995; Leeper, Sims and Zha, 1996).

Consequently, the monetary policy spillover analysis in this paper will assess both the direct and indirect paths of the South African monetary policy to the BLNS economies. The direct and indirect effects of monetary policy are represented by three monetary policy equations; the Phillips curve, the Taylor rule as well as the interest rate pass-through. The three monetary policy equations used for the spillover analysis stem from the argument by Leeper *et al*. (1996) that separating the regular response of policy to the economy from the response of the economy to policy is a more accurate measure of the effects of policy changes. In this study, the indirect channel of the Taylor rule represents the response of policy to the economy whilst the direct channel of the Phillips curve and interest rate pass-through represent the response of the economy to policy.

The focus of this chapter is on the monetary policy spillovers. Apart from contributing to the academic literature on monetary integration and policy spillovers in the SACU region, this paper adds value to the previous studies by assessing cross-country responses to policy spillovers. Moreover, the paper contributes by identifying the impact of South African monetary shocks on the BLNS countries. This response to South African spillovers will show the extent of monetary integration among the SACU countries. Consequently, this will provide an indication of how the SACU countries react to policy shocks currently and after the establishment of a regional central bank (Harvey and Cushing, 2015). Therefore, establishing a SACU regional bank would only be a good strategy if the SACU member countries have a similar reaction pattern to policy, economic and external shocks.

The remainder of the paper is organised as follows: Section 2 reviews literature on having a regional central bank, as well as the spillover effects of monetary policy while section 3 outlines the methodology that is used in the paper. Section 4 discusses the empirical results of the analysis and the final section draws conclusions.

2. LITERATURE REVIEW

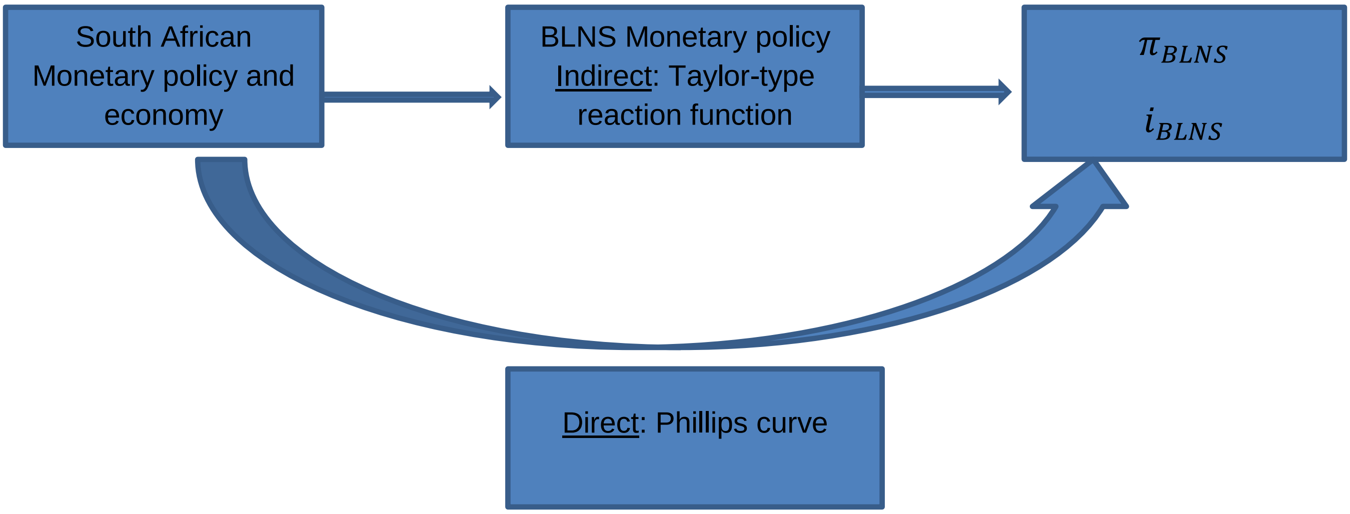
Most African countries are pursuing full monetary integration, with the aim of having a regional central bank and a single currency. However, none of the regions has managed to meet the macroeconomic convergence criteria necessary for full monetary integration. The Common Monetary Arrangement (CMA) as part of the Southern African Customs Union (SACU) region is highly integrated and has the potential for large policy spillovers among the member countries. The issue of spillovers in an integrated region points toward the need for economies to coordinate their policies to better deal with domestic and foreign economic shocks among member countries. This raises the question of how much monetary policy coordination exists among the SACU countries, given the extent of monetary policy spillovers in the region. Furthermore, monetary policy coordination contributes to macroeconomic convergence of member countries, which is a key criterion for determining whether the SACU countries should have a regional central bank or not.

In setting up a SACU central bank, one of the major policy challenges that member countries should consider is the spillover effects of monetary policy shocks in this region. Therefore, this chapter focuses on the extent of the dominant South African monetary policy spillovers on the BLNS countries to establish the feasibility of setting up a regional SACU central bank. A discussion of the literature on the extent of monetary policy spillovers is presented below.

Harvey and Cushing, (2015) and Alesina, Barro, and Tenreyro, (2002) show that an investigation of the degree and nature of the monetary policy spillover effects can be used to determine the feasibility and desirability of setting up a regional central bank. When member countries are affected by shocks, they need to have similar reactions to such shocks to ensure that the same monetary policy can address shock recovery similarly across the region.

Most monetary policy spillover studies that have been done focus on the spillover effects of US monetary policy on large advanced economies, emerging Asian economies, and Latin American economies. The following literature review on monetary policy spillovers focuses on direct and indirect monetary policy spillovers (see Figure 1 below).

Figure 1 - Monetary policy impact channels



Indirect monetary policy spillover refers to a situation where the South African monetary policy affects the BLNS inflation rate and output via the BLNS monetary policy; whereas direct monetary policy spillover refers to a case where the South African monetary policy affects BLNS inflation rate and output directly and not via the BLNS policy variable.

2.1. Phillips curve

The Phillips curve is a direct channel of the monetary policy spillover and it came about from the observation by A. W. Phillips in1958, of an inverse relationship between money wage changes and the unemployment rate. This finding by Phillips (1958) suggested that policymakers could exploit the tradeoff to reduce unemployment at a small cost of additional wage inflation.[2] By the late 1960s, early 1970s US data provided mixed evidence to support the original Phillips curve and this led to the development of the expectations-augmented Phillips curve.

[2] However, this is not what Phillips had in mind. He wanted to show that pursuing lower unemployment only was possible with higher inflation.

According to Russell *et al* (2013), ‘modern’ Phillips curves are ‘expectation’ based and they incorporate an inflation equation, which is specified as follows:

$$\pi_t = f(\pi_t^e, z_t)$$

Where π_t is the inflation rate in period t; π_t^e is the expected inflation conditional on available information and z_t is a control variable. The control variable, z_t, is represented in a number of ways in the literature including the unemployment rate, the unemployment rate gap, the output gap, real marginal costs, income share of labour, and the markup of prices over unit labour costs (Russell *et al*, 2013).

The three common theories of the Phillips curve relation are the Friedman and Phelps (F-P) Phillips curve, the New-Keynesian Phillips curve (NKPC) and the hybrid model. The expectations-augmented Phillips curve of Friedman (1968) and Phelps (1967) [F-P Phillips curve] assumes adaptive expectations on inflation where expected inflation is measured as a geometrically declining distributed lag of all past rates of inflation, with the coefficients of past inflation adding up to one. This is an indication that the F-P Phillips curve is a backward-looking inflation model.

The NKPC assumes rational expectations, with no repeated erroneous expectations errors. In addition, the NKPC model provides optimizing microeconomic foundations for the Phillips curve, which are answers to two of the perceived shortcomings of the F–P Phillips curve (Gordon, 2009). According to the NKPC theory, inflation expectations respond to current and anticipated changes in policy, which is a representation of a forward-looking expectations model. However, one of the drawbacks to the NPKC model is that if agents are rational and forward-looking, then reducing inflation is costless (Fuhrer and Moore, 1995; Roberts, 1997; and Gali and Gertler, 1999, Gali, 2008). This is inconsistent with the general observation that anti-inflation policies are associated with large costs to aggregate output.

The third theory of the Phillips curve is the hybrid Phillips curve, which is a convex combination of the F-P Phillips curve and the NKPC. This hybrid model incorporates both the forward-looking and backward-looking behavior on expectations and does not have explicit optimising micro-foundations compared to the NKPC. All the above models have been empirically tested in literature and a brief overview of these follows in the discussion below.

Literature shows that there are mixed results on the applicability of the different versions of the Phillips curves. This means that there are mixed findings on the direct monetary policy channel in the literature. Loungani and Swagel (2001), Ball and Mazumder (2015) and Esu and Atan (2017) estimate the expectations-augmented Phillips curves for developing countries, the US and Sub-Saharan African countries respectively. Using the output gap as a measure of economic activity, Loungani and Swagel (2001) found support for the expectations-augmented Phillips curve. Conversely, using the unemployment variable as a measure of economic activity, Ball and Mazumder (2015) found support for the expectations-augmented Phillips curve whilst Esu and Atan (2015) rejected the validity of the expectations-augmented Phillips curve.

Furthermore, Linde (2005), Yazgan *et al* (2005) and Leshoro (2011) estimate the hybrid NKPC for the US, Turkey, and Kenya respectively. Yazgan *et al* (2005) and Leshoro (2011), using output variables, found evidence of the NKPC relation, whereas Linde (2005) rejected the validity of the NKPC model. The validity of the hybrid NKPC has been supported by most inflation dynamics in different countries. Using the output gap as a measure of economic activity, Linde (2005) for the US, Basarac *et al* (2011) for European transition economies and Milucka (2014) for the Czech Republic all found support for the hybrid NKPC relations. Gali and Gertler (1999) and Gali *et al* (2001) also found support for the hybrid NKPC versions in the US and the Euro area respectively, using real marginal cost as a measure of the economic activity. Using capacity utilisation as a measure of economic activity, Jensen (2010) tested the applicability of the hybrid NKPC in the Euro area and found support for the hybrid NKPC relation.

In addition, a few researchers investigated the validity of the open economy hybrid NKPC. These include Paloviita (2008) for the Euro area and Sahu (2013) for India. These authors used the output gap as a measure of economic activity and they found support for the open economy hybrid NKPC. The open economy relations are extensions of the hybrid NKPC versions that incorporate foreign variables as possible determinants of inflation in the domestic economy. This is evidence of spillovers from one country to another.

Lastly, non-linear versions of the Phillips curve have also been investigated in literature where there is a possibility of asymmetric relationships between inflation and economic activity. Clark *et al* (1996); Schaling, (1998), Ewing and Seyfriend, (2003) and Kobi and Gabsi, (2017) found support for a valid nonlinear Philips curve relationship. There is also Phillips curve literature where all three common versions of the Phillips curve (traditional, NKPC and hybrid NKPC) have been estimated and the model with the best fit chosen. In investigating which Phillips curve has the best fit, Russell (2013), Schebe *et al* (2005) and Melihovs *et al* (2007) find that the hybrid NKPC version is the best version to explain the inflation dynamics in developed and developing economies. The literature discussed above shows that the most applicable direct channel of monetary policy is presented by the hybrid NKPC.

The Phillips curve studies for the SACU countries are discussed below. There is limited research on the Phillips curve relevance to the BLNS countries and it shows that there is mixed evidence on the support of the Phillips curve. There is support for the Phillips curve in South Africa (Nkomo, 1999; Fedderke and Schaling, 2005; Phiri, 2016), in Botswana (Sediakgotlha, 2017) and in Namibia (Shifotoka, 2015). However, there is also literature indicating that the Phillips curve is not applicable to South Africa (Chicheke, 2009; Burger, P and Marinkov, 2006; Hodge, 2002; Dadam and Viegi, 2015; Leshoro and Kollamparambil, 2016) and in Namibia (Ogbokor, 2005). The most common measure of economic activity used in the estimation of the Phillips curve relation in the SACU region is the output gap. Following the literature above, the output gap is the economic activity measure used in this study.

In more detail, Nkomo, (1999) and Shifotoka (2015) find support for the traditional Phillips curve in South Africa and in Namibia respectively, whilst Chicheke (2009) and Ogbokor (2005) reject the validity of the traditional Philips curve in South Africa and Namibia respectively. Furthermore, Fedderke and Schaling (2005) in South Africa support the applicability of the NKPC version, whilst Dadam and Viegi (2015) do not support the validity of the NKPC in South Africa. Du Plessis and Burger, R (2006), Phiri (2016) and Sediakgotlha (2017) support the validity of the hybrid NKPC for South Africa and Botswana, whereas Leshoro and Kollamparambil (2016) reject the validity of the hybrid NKPC in South Africa.

Lastly, a few Phillips curve studies of South Africa found support for the nonlinear specification of the Phillips curve and these include Nell (2006) and Ngalawa and Komba (2017).

The existence of Phillips curve relations in a country has implications to monetary policy in that the monetary authorities are guided on what the important determinants of inflation are. According to Shahbaz (2012), the main implication of evidence supporting Phillips curve is that central bankers, monetary policymakers and researchers are able to determine how best to stabilise the price level by controlling inflation as well as establishing an unemployment rate or economic growth consistent with low inflation (Shahbaz, 2012). Where there is evidence of a non-linear Phillips curve, it means that monetary authorities need to take account of the asymmetry in the conduct of monetary policy (Clark *et al,* 1996).

In addition, there is limited literature on the use of the Phillips curve to analyse monetary policy spillover effects across countries. However, because the Phillips curve has a long empirical pedigree and is generally accepted as a strong empirical regularity (Bayoumi and Vitek, 2013), a form of the Phillips curve will be used in this article. Although the Phillips curve has mainly been used to examine the inflation dynamics of a single country without accounting for spillover effects from other countries, a few studies have investigated the spillover effects through the Phillips curve relation.

In the SACU region, Nchake (2012) examines how prices in Lesotho react to the South African monetary policy as well as establish the extent of market integration between Lesotho and South Africa. The author finds that South African monetary policy plays a significant role in the inflation behavior Lesotho and that the Lesotho retail market is highly integrated with the South African markets. Similar to the findings in Chapter one, Gaomab II (1998) finds a strong positive influence of South African inflation on Namibian inflation. Ndzinisa (2008) estimates three equations of monetary policy (Phillips curve, Taylor rule, and the IS equation) to assess the efficacy of monetary policy on economic growth in Swaziland. Using the Engle-Granger cointegration technique, Ndzinisa (2008) finds that Swaziland inflation is largely affected by the movement in South African consumer price index and also finds that price differentials between Swaziland and South Africa have an effect on Swaziland real GDP.

The implication of the existence of Phillips curve spillovers in the SACU region is that there is evidence of a direct monetary policy spillover from South Africa to Lesotho, Namibia and Swaziland.

For the non-SACU region, Osorio and Unsal, (2011) present a quantitative analysis of inflation dynamics in Asia using a global VAR that incorporates the role of regional and global spillovers in driving Asia's inflation. The authors find evidence of significant demand-driven inflation spillovers from China to the other countries in Asia. Additionally, Weiguo and Yang (2012) examine the impact of US monetary policy shock on Chinese real output and inflation. Using structural VAR (SVAR) methodology and the Johansen cointegration test, Weiguo and Yang (2012) find that US monetary policy shocks spillover to Chinese real output and inflation. Similarly, Netsunajev and Winkelmann (2014) find evidence of US inflation expectation spillovers to the Euro area. This further highlights the existence of a direct monetary policy channel among the non-SACU countries. In the discussion above, these direct monetary policy shocks originate from a dominant country (or large economy) in a particular region and they spill over to other countries.

Some of the available literature examines monetary policy spillover effects by estimating either a structural model or a dynamic general equilibrium model, which incorporates the Phillips curve as one of the equations. This is incorporated in the discussion below. Following the literature discussed above, this article estimates a form of the Phillips curve to assess the direct monetary policy spillovers from South Africa to the BLNS countries. The function will be of the following form:

$$\pi_j = f(\pi_j^e, \pi_{SA}, \hat{y}_j, \hat{y}_{SA})$$

Where π_j is the inflation rate in the BLNS country j; π_j^e is the expected inflation (which is proxied by lagged inflation); π_{SA} is the inflation rate in South Africa; $\hat{y}_j$ is the output gap for the BLNS country j and $\hat{y}_{SA}$ is the South African output gap. In particular, the South African output gap and inflation rate are included in the models of each of the BLNS countries as a measure of the spillover effect.

2.2. Interest rate pass-through

Another direct channel of monetary policy is the interest rate pass-through, which shows how the monetary policy rate is transmitted to the short-term and long-term interest rates. Traditionally, from the perspective of monetary policy, interest rate pass-through refers to a transmission of a change in the central bank policy rate to aggregate domestic demand and output via retail interest rates. This is indicated by the magnitude, degree, and speed of reaction of short-term interest rates to changes in the policy rate.

The interest rate pass-through literature has three main branches. One branch focuses on the interest rate pass-through of market interest rates to retail bank rates based on similar-maturity terms (De Bondt, 2002). Another branch is the pass-through of monetary policy rate on retail rates, which has been termed the monetary policy approach (Sander and Kleimeier, 2004). Lastly, a branch that combines the two approaches mentioned above, where it initially looks at the transmission of policy rates to market rates and then look at the transmission of market rates to retail rates (Berstein and Fuentes, 2003). The focus of this study is on the modified monetary policy approach where the South African monetary policy is transmitted to the monetary policy rates of the BLNS countries, which is a direct channel of monetary policy spillovers.

Economists have extensively studied the interest rate pass-through. The IRPT literature shows that the pass-through tested is either from the money market rates to the long-run rates (Toolsema, Sturm and De Haan, 2002) as well as from the policy interest rate to the short-term and long-term interest rates, referred to as the monetary policy approach (De Bondt, 2005). The monetary policy approach is one of the channels of monetary policy in which the monetary policy can affect the economy and it is the pass-through tested in this study. The degree of pass-through indicates the effectiveness of the monetary policy transmission (De Bondt, 2002; Horvath, Kreko and Naszodi, 2004).

Some of the studies reported compare the nature and degree of interest rate pass-through among the Euro countries to establish the effect of the common monetary policy in the Euro area (Heinemann and Schuler, 2002; De Bondt, 2005; Hofmann, 2006; Sorensen and Werner, 2006; Creel, Hubert and Viennot, 2013; Borstel, Eickmeier and Krippner, 2015). The main findings are that the transmission mechanism of policy interest rates to the long-term rates differs across countries which imply weak convergence of monetary policy transmission in the European Monetary Union (Beckmann, Belke, and Verheyen, 2012; Toolsema *et al*, 2002). This finding implies that the common monetary policy of the ECB may be seriously hampered by this heterogeneous pass-through in the Euro area. In other words, cross-country differences in the interest rate pass-through could complicate the implementation of a single monetary policy in the countries forming the Euro area (Mojon, 2000).

Furthermore, Aziakpono, Kleimeier, and Sander (2007) use the interest rate pass-through to examine the extent of integration among the SADC countries and they define increased monetary integration among countries as a situation where various countries have similar transmission mechanisms of monetary policy rates to short-term bank rates. Part of their study finds evidence of interest rate pass-through of South African monetary policy rate to the other SADC countries' national short-term rates. This finding raises the question of how the SA monetary policy rate passes through to the BLNS countries' monetary policy rates. Another study on African countries by Misati, Nyamango, and Kamau (2011) examines the degree of pass-through of monetary policy interest to retail interest rates and finds incomplete pass-through of Kenyan monetary policy interest rates to other retail rates.

In a monetary union setup, Heinemann and Schurler (2002) test interest rate pass-through in the EMU and they find that higher financial market integration increases the degree and speed of interest rate pass-through. In addition, interest rate pass-through establishes the effectiveness of a regional central bank or a single monetary policy within a group of countries. Egert and MacDonald (2006) also seek to answer the question of how the common monetary policy of the European Central Bank (ECB) monetary policy is transmitted within the CEE countries. Crespo-Cuaresa *et al* (2006) and Egert and MacDonald (2006) find low interest rate pass-through among a group of Central and Eastern Europe (CEE) countries, using a multivariate VAR framework.

According to Aziakpono *et al* (2007), if the pass-through from policy rates to retail interest rates leans towards homogeneity across countries, then there is monetary integration in the region and a regional central bank would be more effective. Moreover, a shift to a regional central bank may contribute to macroeconomic convergence, thereby reducing the heterogeneity across countries.

Some regions have a dominant country that *de facto* formulates the monetary policy of that region. An example is the SACU region, where South Africa dominates the smaller SACU countries (Botswana, Lesotho, Namibia, and Swaziland - BLNS). In these countries, domestic interest rate pass-through is small compared to the interest rate pass-through from the dominant central bank rate to the national interest rates (Aziakpono *et al,* 2007). This means that the domestic interest rates align themselves more to central bank rates of a dominant country and could lead to a more homogeneous interest-rate pass-through as well as increased monetary integration. The pass-through methodology in this study is similar to the one by Aziakpono *et al,* (2007) who model pass-through as a VAR process with a focus on the interest rate pass-through of the South African central banks to the other countries' bank rates.

The general conclusion from the literature above is that a majority of countries exhibit incomplete and heterogeneous pass-through and that the interest rate pass-through can be influenced by macroeconomic conditions (Egert and MacDonald, 2006). The main implication of heterogeneity in monetary transmission across countries is that it may seriously impede the effectiveness of the common monetary policy of a regional central bank. Moreover, the financial crisis as well as the sovereign debt crisis hampered pass-through in the Euro area and for the Central and Eastern European (CEE) countries.

Pertaining to spillover analysis, the literature on the interest rate pass-through focuses on the spillover of monetary policy with interest rate pass-through being one of the components investigated (Albaghi, Leiva-Leon, and Saravia, 2015; Sanchez-Ordonez, 2017; Potjagailo, 2017; and Edwards, 2017). In evaluating the effect of US policy actions on economic fundamentals of Latin American emerging markets, Albaghi *et al* (2015) and Edwards (2017) find significant evidence of US interest rate spillovers to the Latin American economies. Moreover, Edwards (2015) looks at Asian countries and finds that the significant US policy rate pass-through is higher in Latin American economies than in Asian ones, which could be an indication of higher integration between the USA and the Latin American economies. Similarly, Bernoth and Konig (2016) find evidence that US interest rates spill over to Euro rates. For emerging Asian economies, Belke, Dubova, and Volz (2017) examine the long-term interest rate spillovers from Eurozone and US to emerging Asian economies. The authors find significant pass-through and the degree of pass-through varies across countries. In addition, Miyajima, Mohanty, and Yetman (2014) find that the US policy rate spills over to Asian economies via the long-term interest rate.

The European countries have also been a subject of monetary policy spillover analysis where the transmission mechanism of the European Central Bank's monetary policy is a cause for concern for the EU countries. Potjagailo (2017) find significant interest rate pass-through spillovers and the degree of pass-through is higher for countries that are financially integrated. These significant pass-through spillovers have an implication for domestic monetary policymaking, in that interest rates are one of the effective monetary policy transmission mechanisms. The interest rate pass-through spillovers tend to be higher where economies are highly integrated. Therefore, monetary and financially integrated economies should consider the effects of foreign monetary policy actions in their domestic economic conditions.

Following the literature discussed above, the analysis of the direct monetary spillover effect using the interest rate pass-through involves testing relationships between central bank policy rate of a dominant economy and monetary policy rates of smaller economies. In particular, this article intends to test whether or not the BLNS monetary policy rates react to changes in the South African central bank policy rate. The monetary reaction function analysis discussed in the following section incorporates the interest rate pass-through.

2.3. Monetary policy reaction function

Taylor (1995) highlights that the indirect transmission of monetary policy links the movements in real GDP and inflation back to the short-term interest rate through a policy rule or a reaction function. A monetary reaction function for a central bank indicates the response of the policy rate to economic variables and establishes the goals that influence the actions of the central bank (Setlhare, 2004).

The most common policy reaction function is the Taylor rule, as suggested by Taylor (1993) and it is useful when examining the conduct of monetary policy. A simple Taylor rule describes an interest rate feedback policy that is a linear function of both the deviation of actual inflation from target inflation and the output gap and is as follows:

$$i_P = f(\hat{\pi}, \hat{y})$$

Where i_P is the policy interest rate or the short-term interest rate; $\hat{\pi}$ is the inflation gap between the inflation rate and the target inflation and $\hat{y}$ is the output gap between level of output and the potential output.

According to Taylor (1993: 200), "the monetary authorities are assumed to adjust their interest rate in response to either the deviations of the money supply from its target, deviations of the exchange rate from its target or the weighted deviations of the inflation rate and real output from their targets". Moreover, Taylor (1993) asserts that an interest rate rule is preferable to an exchange rate rule or a money supply policy rule. Using a multi-country model for the G7 countries, Taylor (1993) finds that the most preferable interest rate rule in the G7 countries is the one that places positive weight on both the price level and real output. However, the sizes of the weights depend on the economic conditions in each country.

In addition, Taylor rules have been modified to include additional variables such as exchange rates, money supply, private sector credit, and foreign policy variables; and are referred to as Taylor-type functions. The Taylor-type functions are the most common policy rules used in literature and they describe interest rate setting behavior by central banks with some autonomy over monetary policy. The main monetary policy goals are price stability and economic growth and these enter as determinants of the policy rate in the Taylor rule. Therefore, the Taylor-type rule is a form of a central bank's monetary policy reaction function that indicates the response of a country's policy rate to changes in inflation and output gap, as well as any additional variables that central banks would consider as important variables for monetary policy conduct.

This article estimates a Taylor-type reaction function to measure the indirect monetary policy spillovers in the SACU region. A substantial literature has accumulated on Taylor-type rules and reaction functions and its discussion follows.

Monetary reaction function literature indicates the extensive use of Taylor-type rules in evaluating the monetary policy transmission mechanisms in both developed and developing countries. McNees (1992), Clarida, Gali and Gertler (1998), Mehra (1999) and Roskelley (2016) estimate the Taylor-type reaction functions for the US and they all find support for the Taylor-rule relation. Their results also indicated that a forward-looking Taylor rule best fits the US data. Moreover, Moura and de Carvalho (2010) find support for the Taylor rule in Latin American economies.

For the Euro region and New Zealand, Boeckx (2011) and Santacreu (2005) find evidence of the Taylor rule. De Brouwer and O'Regan (1997) find support for a Taylor-type monetary reaction function in Australia. Girardini, Lunven, and Ma (2012) and Ping and Xiang (2003) find evidence for the Taylor rule in China. In addition, Rotich, Kathanje, and Maana (2007) and Arbatli and Moriyama (2011) examine the conduct of monetary policy for Kenya and Egypt, respectively. Their findings provide support of Taylor rule that incorporates both backward-looking and forward-looking behavior. However, there are studies that find no support for the original Taylor rule relation with either inflation or the output gap insignificant. In their analysis, Huang and Shen (2001) indicate that only inflation is significant in a Taylor rule function for Taiwan, whilst the output gap is insignificant. Similarly, Sanchez-Fung (2000) and Inoue and Hamori (2009) find an insignificant output gap for the Dominican Republic and India respectively.

For the SACU countries, most of the Taylor rule literature shows that the monetary policymakers incorporate the spillover component of monetary policy in their reaction functions (see Table A-2.3b). Setlhare (2014), Bleaney and Lisenda (2001) and Motlaleng and Tshekega (2008) estimate a Taylor-type reaction function for Botswana which includes a South African interest rate and they all find a significant Taylor-type function. Additionally, Kganetsano (2007) and Munyengwa (2012) estimate a Taylor-type reaction function for Botswana that includes South African inflation and finds evidence of the Taylor rule in Botswana.

Matlanyane (2005) develops a macro-econometric model for Lesotho and finds that the nominal Treasury bill rate of Lesotho is linked to national real economic activity, inflation, and SA interest rates. Namibian studies show that monetary policy decisions of South Africa spill over to Namibia through the interest rate and the exchange rate

(Uangata and Ikhide, 2002; Fleermuys, 2010; Kamati, 2014). Uangata and Ikhide (2002) and Kamati (2014) find that Namibian inflation and the Namibian output gap are significant in explaining changes in interest rates. However, Fleermuys (2010) shows that there is an insignificant relationship between the interest rate and the output gap in Namibia.

With regard to foreign variables added to the Taylor rule, Setlhare (2004) and Munyengwa (2012), find that the exchange rate and the South African interest rate are significant variables for the conduct of monetary policy in Botswana, whilst Bleaney and Lisenda (2001) and Gaotlhobogwe *et al* (2008) find that the exchange rate is insignificant. Matlanyane (2012), Uangata and Ikhide, (2002), Fleermuys (2010) and Kamati (2014) show that South African interest rates are significant variables in explaining changes in interest rates in Lesotho and Namibia. The significance of the South African interest rate in the estimated monetary reaction functions is an implication of the existence of policy spillovers from a dominant economy to smaller closely integrated economies.

South African data fits the Taylor-type reaction functions well (Aron and Muellbauer, 2002; Ortiz and Sturzenegger, 2007; Naraidoo and Raputsoane, 2010; Woglom, 2003; Ncube and Tshuma, 2010). To determine spillovers to South African monetary policy, Aron and Muellbauer (2002), Ncube and Tshuma (2010) and Woglom (2003) include the US interest rate and the real exchange rate as explanatory variables in the SA monetary reaction function. The authors found the additional variables to be significant in the Taylor specification. A few studies have made an attempt at estimating non-linear Taylor-type reaction functions and these studies include Naraidoo and Raputsoane (2010) and Ncube and Tshuma (2010) for South Africa, Davradakis and Taylor (2006) and Boinet and Martin (2008) for the UK, Assenmacher-Wesche (2006) for the US as well as Surico (2007) for the European central bank. Non-linear Taylor rules mean that there are asymmetric responses of interest rates to inflation and output gap (Naraidoo and Raputsane, 2010).

Therefore, the literature shows that a Taylor-type monetary reaction function fits the data well for most countries, unlike the original Taylor rule.

There is considerable literature on monetary policy spillovers using a Taylor-type monetary reaction function and a brief discussion of the spillover effects literature follows. Most of the studies that use Taylor-type reaction functions refer to the reaction functions as open economy Taylor-type rules (Arbatli *et al*, 2011 and Clarida, Gali and Gertler, 1998). There is limited literature on the indirect monetary policy spillovers in the SACU region. Bleaney and Lisenda (2001) estimate a Taylor-type reaction function for Botswana, incorporating a South African interest rate as one of the independent variables. They find that the South African interest rates are not significant in Botswana's reaction function. However, by examining the conduct of Botswana monetary policy through a Taylor-type monetary reaction function, Setlhare (2004) and Motlaleng and Tshekega (2008) find a statistically significant South African interest rate. Furthermore, Kamati (2014) show that South African interest rates are significant in explaining the Namibian interest rates. The existence of South African spillovers has implications for monetary policy conduct of Botswana and Namibia because their central banks need to consider the SA interest rate behavior when setting the domestic policy rates.

Most spillover studies of the monetary policy reaction function look at the effect of the US interest rate on the interest rate of other countries (Clarida *et al*,1998); Ramos-Francia (undated); Gray, 2012; Caceres *et al,* 2016). These studies find that US policy rates spill over to smaller economies through their monetary policy reaction functions. Clarida, Gali, and Gertler (1998) estimate monetary policy reaction functions for the G3 countries (Germany, Japan, and the US) and the E3 countries (UK, France, and Italy). They find statistically significant but quantitatively small spillovers across these countries.

There is a limited number of monetary policy spillover analyses for the SACU region, using Taylor-type monetary reaction functions. The estimated monetary reaction function in this article models the short-term policy interest rates of the BLNS countries as a function of BLNS inflation rates, the South African inflation rate, the BLNS output gaps, the South African output gap, and the South African monetary policy rate.

Therefore, following the literature discussion above, the reaction function will be of the following form:

$$i_{Pj} = f(\pi_j, \pi_{SA}, \hat{y}_j, \hat{y}_{SA}, i_{PSA})$$

Where i_{Pj} is the policy interest rate of each of the BLNS countries, j; π_j is the inflation rate of the BLNS country j; π_{SA} is the South African inflation rate; $\hat{y}_j$ is the output gap of the BLNS country j; $\hat{y}_{SA}$ is the South African output gap and i_{PSA} is the South African policy interest rate. This reaction function above not only includes the South African interest rates (as indicated by SACU literature) but also incorporates the South African inflation rate and output gap to assess the monetary policy spillover effects of South Africa to the BLNS countries. The significance of the South African policy rate highlights the interest rate pass-through spillover from South African to the BLNS countries. The main and novel contribution of this spillover analysis is the introduction of the South African inflation rate and the South African output gap in the monetary reaction functions of the BLNS countries. Another contribution is that this study will contribute to the empirical literature by using 'cross-border' monetary policy spillover analysis for the SACU countries to establish the need to centralise the monetary policymaking to the South African Reserve bank for all the SACU countries.

Most of the literature on monetary policy spillovers examines the transmission mechanism of the foreign policy rate to the macroeconomic and financial conditions of the domestic economy. The United States is the common foreign country as it is considered "…to be the world's largest economy by the size of its GDP and is the centrepiece of the international financial system" (Garcia and Bolanos, 2017:3). The common finding is that the US monetary policy significantly spills over to the monetary policy in emerging market economies (Miyajima *et al*, 2014; Tillmann, 2016; Anaya, Hachula and Offermanns, 2017; Ramos-Francia, no date; Gray, 2012; Chen, Mancini-Griffoli and Sahay, 2014); to countries in the Pacific Basin (Edwards, 2015) and to Asian economies (Miyakoshi and Jalolov, 2005; Sutherland, 2010). Sanchez-Ordonez (2017) find a significant and high degree of international spillover of the US monetary policy rate to the Colombian policy rate. Moreover, Fic (2013) examines the impact of unconventional monetary policy measures adopted in developed economies on developing economies and find that the US monetary policy has an impact on developing economies.

Such spillovers of foreign monetary policy decisions are a key concern, particularly, to smaller emerging economies and, therefore, some form of monetary policy coordination is necessary (Sanchez-Ordonez, 2017). Furthermore, there is evidence of the spillover of US monetary policy shocks to other macroeconomic variables such as inflation, economic growth and private sector credit (Canova, 2005: Chen *et al*, 2014). The results indicate that the US monetary policy has large and significant spillover effects on several macroeconomic variables in the Latin American economies and that the interest rate channel is a key channel of US monetary policy spillovers, while the trade channel plays a negligible role.

The impact of the monetary policy on these economies varies with the extent of their exposure to the US economy as well as their trade and financial linkages. For example, Chen *et al* (2014) find that there are significantly smaller monetary policy spillovers to emerging market economies if they have higher real GDP growth, stronger external current account position, lower inflation as well as a lower share of local debt held by foreigners. The evidence of asymmetric spillovers across emerging market economies means that the degree and nature of spillovers depend on the country-specific characteristics.

For the Euro area, Kucharcukova, Claeys, and Vasicek (2016) and Potjagailo (2017) investigate the spillover effects of the ECB's monetary policy to assess the readiness of the EU countries outside the Euro area (Czech Republic, Hungary, Poland, Denmark, Sweden, and the UK) in joining the Eurozone. The authors find significant spillover effects of the monetary policy shocks to European countries outside the Euro area. Vespignani (2015) examines the international transmission of US, Japanese and Chinese monetary shocks to the Euro area and find that there are significant spillover effects of monetary policy on the Euro area.

Some of the available literature examines monetary policy spillover effects by estimating either a structural model or a dynamic general equilibrium model, which incorporates the Phillips curve, the interest rate pass-through, and a Taylor-type reaction function as one of the equations. This includes Laxton and Prasad (2000) who analyse the international spillover effects of US shocks to major industrial economies.

The authors estimate a Phillips curve relationship for the industrial economies where inflation is a function of the output gap and the US output gap. Their results show that the US output gap spills over to inflation in other countries.

Furthermore, Haberis and Lipinska (2015) use a standard small open economy Keynesian model to show that monetary policy strategies in a large foreign economy affect monetary policy in a small domestic open economy. The authors include a Phillips curve as one of the equations in the model and this Phillips curve presents inflation as a function of the domestic output gap, lagged inflation, the foreign output gap, and foreign inflation. These foreign variables are measures of the monetary policy spillovers from the foreign economy to the domestic economy.

In addition, Hayo and Niehof (2013) analyse the effects of monetary policy spillovers on financial markets and the feedback from financial markets to the real economy. They extend the NKPC by accounting for spillover effects from US monetary variables to Canadian real variables and from US real variables to Canadian monetary variables. Hayo *et al* (2013) find evidence of spillover effects of the US monetary policy to the Canadian economy. Furthermore, Vymyatnina (n.a) construct a small inter-country forward-looking econometric model based on the NKPC for Russia, Belarus, and Kazakhstan.

Vymyatnina (n.a.) models inflation as a function of expected future inflation, the domestic inflation rate, the inflation rate from other countries and the domestic output gap. The results show that inflation in Belarus responds to Russian monetary policy changes as indicated by the significant coefficient of the Russian inflation and Russian output gap. In addition, Dekle and Hamada (2014) investigate how Japanese expansionary monetary policy affects the US and whether or not Japanese expansionary monetary policy has positive spillover effects on the US. The authors use VAR models that include an estimation of the Philips curve with inflation in the US expressed as a function of the US output gap, the Japanese output gap, and inflation. Dekle and Hamada (2014) find that Japanese output gap has a positive effect on US inflation, although the effect is economically small.

A few studies for African countries include Kronick (2014) for Sub-Saharan countries, Seleteng (2016) for the Common Monetary Area countries, Setlhare (2014) for Botswana, Matlanyane (2005) for Lesotho, Fleermuys (2010) for Namibia as well as Aron and Muellbauer (2002) for South Africa. Seleteng (2016) investigates the spillover of South African repo rate to macroeconomic variables in the CMA. Using panel vector autoregression (PVAR) methodology, Seleteng (2016) find that a shock to the South African repo rate significantly affects CMA lending rates, inflation, and economic growth. The discussion of some of the spillover studies for the SACU countries is in the section presenting the empirical literature of Taylor rules.

3. METHOD

The monetary policy spillover in this paper refers to the significant transmission of South African monetary policy variable onto the BLNS monetary policy and economic variables, i.e. a significant reaction of the BLNS policy rate and economic variables to changes in the South African policy rate (Sanchez-Ordonez, 2017: 4). The changes in the policy rate are expected to filter throughout the economy by affecting financial and macroeconomic activity. This means that central banks can use their policy interest rates to move the economy towards achieving macroeconomic goals such as full employment, price stability, and economic growth.[3] Traditionally, the macroeconomic goal variables are the inflation rate, economic growth or gross domestic product (GDP) and the long-term interest rate. Therefore, the spillover analysis in this chapter refers to the investigation of the role of South African (dominant country) monetary policy and goal variables and the exchange rate in the monetary transmission dynamics of BLNS countries (smaller countries).

Given that monetary policy affects its goal variables indirectly, the transmission of the monetary policy to these variables is through various channels. Common channels include the interest rate channel, the credit channel, the exchange rate channel and the asset price channel (Mishkin, 1996).

[3] However, the previous chapter showed that the BLNS countries' policy variables are dominated by the South African monetary policy variables, and are, therefore, partially dependent on South African actions

The interest rate channel refers to the changes in market interest rates, brought about by a change in the policy rate, which then leads to changes in investment patterns and the output. The expected reaction to an increase in the monetary policy rate is as follows:

$$\uparrow policy\ rate\ \rightarrow\uparrow market\ interest\ rates \Rightarrow\uparrow cost\ of\ borrowing \rightarrow \\ \downarrow investment\ and\ consumpton \rightarrow\downarrow output$$

The credit channel focuses on the transmission of monetary policy through the changes in the supply of loans/credit offered by banks. According to Mishkin (1996), the bank-lending channel focuses on changes in the financial environment for smaller firms. The expected reaction to an increase in the monetary policy rate is as follows:

$$\uparrow policy\ rate\ \rightarrow\uparrow market\ interest\ rates\ \rightarrow\downarrow bank\ reserves\ and\ bank\ deposits\ \rightarrow \\ \downarrow available\ bank\ loans\ \rightarrow \\ \downarrow investment\ spending\ and\ consumer\ spending \rightarrow\downarrow output$$

The exchange rate channel refers to the transmission of monetary policy actions via the exchange rate, where a change in the policy interest rate affects the value of the domestic currency, then the net exports and lastly, output. The more open a country is, the more effective is the channel. The expected reaction to an increase in the monetary policy rate is as follows:

$$\uparrow policy\ rate\ \rightarrow\uparrow market\ interest\ rates \rightarrow\uparrow foreign\ capital\ inflows\ \rightarrow \\ \uparrow appreciation\ of\ the\ domestic\ currency\ \rightarrow\downarrow competitiveness \rightarrow \\ \downarrow net\ exports \rightarrow\downarrow output$$

In the asset price channel, monetary policy is transmitted through asset prices

$$\uparrow policy\ rate\ \rightarrow\uparrow market\ interest\ rates \rightarrow\downarrow equity\ (share) prices \rightarrow \\ \downarrow investment\ spending\ and\ consumer\ spending \rightarrow\downarrow output$$

The significance and applicability of these channels differ across countries due to the varying depths of financial systems, different economic structures, and economic activities.

There are several methods used in literature to investigate international monetary policy spillovers. These include the

- global vector autoregression (GVAR) framework (cf: Dekle and Hamada, 2015; Georgiadis, 2016 and Fadejeva, Feldkircher and Reininger, 2017);
- time-varying parameter factor-augmented VAR (FAVAR) (cf: Kazi, Wagan and Akbar, 2013 and Liu, Mumtaz and Theophilopoulou, 2014);
- full information maximum likelihood (FIML) method (cf: Cho and Moreno, 2003), the small 3 equation macro model (cf: Gordon, 2005);
- a structural vector autoregression (SVAR) framework (cf: Dungey and Fry, 2003; Sousa and Zaghini, 2004; Vespignani, 2015);
- SVAR with block exogeneity (SVARX) (cf: Canova, 2005; Mackowiak, 2007; Catao, Laxton and Prasad, 2008; Sato, Zhang and McAleer, 2011; Allegret, Conharde and Guillaumin, 2012 and Sanchez-Ordonez, 2017).

The alternative methods listed above are not used in this paper because of the sample size limitation and limited availability of macroeconomic data in the smaller SACU countries.

The methods used in this paper are the structural vector autoregression (SVAR) framework and the Diebold-Yilmaz (DY) spillover analysis. The use of the SVAR method is to analyse short-run dynamic interactions among the monetary policy variables in the SACU region and indicate the effects of policy shocks. The SVAR method is useful for this study because it takes a theory-guided approach at economic data where restrictions are compatible with a number of theories (Gottschalk, 2001). Furthermore, the Diebold-Yilmaz approach is used because it provides a spillover index that measures the contribution of the South Africa monetary policy shocks to the BLNS countries. The index also condenses and summarises information from the variance decompositions, into more focused and easily interpretable spillover measures (Cotter, Hallam, and Yilmaz, 2017). These two methods combined will help capture and quantify the linkages between the South African monetary policy and the BLNS countries.

3.1. Structural Vector Autoregression

For fully exploring the spillovers of South African monetary policy to the BLNS countries, this study uses a structural vector autoregression (SVAR). Sims (1980) introduced the VAR methodology, which is a common framework used in the empirical literature of international monetary policy spillovers. The SVAR approach is chosen for the study because it is useful in exploring the implication of a given theoretical view for the dynamic behavior of the variables of interest (Gottschalk, 2001). According to Sousa and Zaghini (2007: 404), the SVAR approach is a powerful tool for investigating the dynamic interactions because it "controls for the linkages between variables which allows for providing an appropriate assessment of the contribution of monetary shocks to output and inflation". However, the SVAR method has its own drawbacks which include the notion that "economic shocks recovered from an SVAR do not resemble the shocks measured by other mechanisms, and may reflect variables omitted from the model. Also, the results of many SVAR exercises are sensitive to the identification restrictions" (Fernandez-Villaverde and Rubio-Ramirez).

The main applications of SVAR models include impulse-response analysis of time series variables to a given one-time structural shock, and quantification of the average and cumulative contributions of a particular structural shock to fluctuations of a variable over time (Kilian, 2011). Furthermore, an impulse-response function traces the reaction paths of variables to an unexpected structural shock and is useful in assessing the transmission of shocks to economic variables in a system of variables. The variance decomposition analysis is useful in identifying the important sources of fluctuations of a variable (Kilian, 2011). A structural form equation of the VAR model of each of the BLNS economies can be written as (Pfaff, 2008 and Sanchez-Ordonez, 2017):

$$A_0 y_t = A(L) y_t + \varepsilon_t \qquad (1)$$

Where y_t is a $n \times 1$ vector of variables, A_0 is a $n \times n$ matrix that specifies the contemporaneous relationships between variables, $A(L)$ is a $n \times n$ lagged coefficient matrix and ε_t is a $n \times 1$ vector of structural disturbances that are assumed to be white noise. The strategy adopted in the paper is to include the variables that account for the direct and indirect channels of monetary policy transmission.

The direct channel is represented by the Phillips curve (PC) and the interest-rate pass-through (IRPT), whilst the indirect channel is represented by the monetary policy reaction function (MPRF).

Following Raghavan, Silvapulle and Athanasopoulos (2012) and Burger *et al,* (2012) the variables in the VAR are ordered in such a way that the policy target variables (output and inflation) come before the policy instruments. Hence, the VAR ordering of the variables is as follows:

Botswana → $[\hat{y}_{SA} \quad \pi_{SA} \quad i_{SA}^{p} \quad \hat{y}_{B} \quad \pi_{B} \quad i_{B}^{p}]'$ (2)

Lesotho, Namibia and Swaziland → $[\hat{y}_{SA} \quad \pi_{SA} \quad i_{SA}^{p} \quad \pi_{k} \quad i_{k}^{p}]'$ (3)

Where π_j are the inflation rates for South Africa and Botswana, π_k is the inflation rate for each of the LNS countries; e SACU country , $\hat{y}_j$ is the output gap of the SACU country j, and i_{Pj} is the policy interest rate of each of the countries. The estimated SVARs for each of the BLNS countries will include the South African monetary policy variables to capture the international monetary policy spillovers. Sanchez-Ordonez (2017) asserts that, firstly, a reduced form VAR is estimated and then identifying restrictions imposed on contemporaneous variables to be able to extract the coefficients of the SVAR model.[4]

In line with studies on monetary policy transmission mechanism, two main methods of identifying restrictions are the Cholesky decomposition and the structural decomposition (Tsangarides, 2010). The Cholesky decomposition places restrictions on contemporaneous structural parameters (matrix A_0), by using a recursive structure. This is sensitive to the different ordering of variables. The Cholesky ordering sometimes produces unrealistic restrictions and economically meaningless solutions if not founded on economic theory (Sanchez-Ordonez, 2017; Kilian, 2011).

[4] Identifying restrictions is a process of disentangling structural innovations from the reduced-form innovations i.e. orthogonalisation of the reduced-form errors.

Moreover, a recursive ordering is likely to be invalid for small and more open economies (Cushman and Zha, 1997) and "may not be appropriate when identifying the simultaneous contemporaneous relationships between policy instruments and money market variables" (Raghavan *et al*, 2012: 3847).

Alternative identification restrictions, such as the non-recursive structure, are more ideal for representing small economy models like the BLNS countries. Therefore, following Ordonez-Sanchez (2017), Raghavan *et al* (2012), Mackowiak (2007) and Leeper *et al* (1996), the identified SVAR models in this paper use a non-recursive restriction of the contemporaneous parameters in the matrix A_0. Economic monetary policy equations representing the indirect and direct spillovers (PC, IRPT, and MPRF respectively) guide the restrictions imposed. The variables included in the SVARs are GDP, inflation, policy interest rate.

Since the BLNS countries are relatively small and open to South Africa, their variables are expected to have little or no effect on the South African economy. Therefore, the ordering of variables starts with the SA variables since they affect the BLNS countries contemporaneously, while the inverse is unlikely to be true. The South African variables appear first in the SVAR model and are included in each of the BLNS SVARs to measure the monetary policy spillovers.

After estimating the SVAR models, the impulse response function and variance decomposition analysis provide the speed of adjustment to the shocks and the magnitude of the shocks for various economies (Sato, Zhang, and McAleer, 2011: 1354). To assess the monetary spillovers, we use impulse-response functions of a one-standard-deviation monetary policy shock on output, inflation, the monetary policy rate[5]. The SVARs will, via, the impulse responses trace the responses of BLNS policy and macroeconomic goal variables to SA monetary policy shocks. Furthermore, the forecast error variance decompositions are used to examine the relative importance of the monetary policy shock for fluctuations in each variable and they indicate the forecast error variance of output, inflation, and the discount rate at different horizons that can be explained by the monetary policy shock.

[5] The inclusion of the lending rate and the effective or rand dollar exchange rate did not improve results and, therefore, these variables were excluded from the estimated SVAR.

3.2. Diebold-Yilmaz (DY) spillover measures

The spillover index analysis is based on the approach introduced by Diebold and Yilmaz (2009, 2012). Diebold and Yilmaz (2012) define the spillovers as the share of the forecast error variances of one variable contributed by the other variable(s). According to Cotter, Hallam, and Yilmaz (2017), the DY spillover method summarises variance decomposition information from the SVAR, into a set of relevant and easily interpretable spillover measures. The main advantages of using the DY spillover index in this study are that (Lee, Liao, Huang and Huang, 2015):

i. It provides magnitude as well as the direction of the policy spillover

ii. It measures the effects of shocks to SA monetary policy on the BLNS variables as well as the net contribution of SA monetary policy to the BLNS monetary policies. It also provides the time-varying magnitudes of spillovers using the rolling window estimation

iii. It also provides the time-varying magnitudes of spillovers using the rolling window estimation

The DY spillover analysis has largely been applied to measure the spillovers in financial markets (cf. Louzis, 2013; Alter and Beyer, 2014; Yarovaya, Brzeszczynski, and Lau, 2016). However, limited research exists on the application of the DY spillover analysis to the real side of the economy, for example, Antonakakis and Badinger (2012, 2014), Yilmaz (2009), Giglio, Kelly, and Pruitt (2016), Cotter *et al* (2017) as well as Cronin (2018). This study contributes to the spillover literature above by quantifying the international monetary policy spillovers among the SACU countries using the Diebold and Yilmaz (2012) framework. Also, the forecast error variance decompositions are derived from the SVAR framework (section 3.1 above), instead of the generalised VAR framework of Diebold and Yilmaz (2012).

The SVAR model produces variance decompositions that are used in the construction of the spillover measures. Suppose that from the VAR framework, the *H*-step ahead forecast error variance decomposition is denoted by $\phi_{ij}(H)$. The total spillover index measures the contribution of spillovers of shocks across all countries to the total forecast error variance and can be defined as:

$$TS(H) = \frac{\sum_{i,j=1,i\neq j}^{N} \phi_{ij}(H)}{\sum_{i,j=1}^{N} \phi_{ij}(H)} \times 100 \quad (6)$$

Given that the focus of this study is to examine the spillovers from South Africa to the BLNS countries, the directional spillovers will also be calculated. These refer to the spillover effects transmitted by SA to the BLNS country, j**,** denoted as:[6]

$$DS_{SA\to j}(H) = \frac{\sum_{j=1,}^{N} \phi_{jSA}(H)}{\sum_{i,j=1}^{N} \phi_{SAj}(H)} \times 100 \quad (7)$$

Considering that a unidirectional SVAR model is specified, the directional spillover index is also unidirectional. Furthermore, the directional spillovers calculated in this paper are slightly different from the ones presented by Diebold-Yilmaz (2012) because they focus only on the contribution of a subset of variables, which is the contribution of the South African variables to the BLNS country variables.

The directional spillovers focus on the South African spillovers via the three monetary policy equations representing the direct channel (Philips curve and interest rate pass-through) and indirect channel (monetary policy reaction function). A Phillips curve represents a relationship between inflation and output of the BLNS country and South African inflation and GDP are included to capture the spillovers from South Africa. The calculation of the South African spillovers through each of the BLNS Phillips curves is calculates as the proportion of the contribution of SA inflation and output to BLNS inflation.

Interest rate pass-through represents the proportion of South African monetary policy interest rates that is transmitted to rates for the BLNS country. The SA spillovers through each of the BLNS interest rate pass-through equations are calculated as the proportion of the contribution of SA monetary policy to the BLNS monetary policy.

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[6] Note that there is another form of directional spillovers which refers to those spillover effects received by South Africa from the BLNS country, $\boldsymbol{j}$**,** defined as: $DS_{SA\leftarrow j}(H) = \frac{\sum_{j=1,i\neq j}^{N} \phi_{ij}(H)}{\sum_{i,j=1}^{N} \phi_{ij}(H)} \times 100$. However, this directional spillover is not relevant for this study because the smaller SACU countries do not have a significant influence on South Africa.

The indirect spillovers, measured through the monetary policy reaction function, show how the BLNS country monetary policy rates react to changes in their output and price levels, with SA inflation and output included capturing the spillovers. The spillovers are defined as the proportion of the contribution of SA output, inflation and policy rate to the BLNS policy rate.

4. RESULTS

The variables used in the study are on a quarterly basis and range from 1960Q1 to 2016Q4, depending on the availability of the data. The source of the data is the IMF IFS database. Gross domestic product (GDP) represents a measure of output and only South Africa and Botswana have GDP time series available quarterly. Lesotho, Namibia, and Swaziland (LNS countries) GDP time series are on an annual basis. Because of this, only South African GDP is included in the SVAR models of the LNS countries as a measure of output for both South Africa and the LNS countries. The argument to use SA GDP as a proxy for Lesotho, Namibia and Swaziland GDPs is because the LNS countries GDPs are significantly linked to SA GDP and a detailed explanation is provided in the appendix. The data available and the period of availability is also provided in the appendix.

Inflation is calculated as the quarter to the same quarter of the previous year percentage change in the log of a consumer price index (CPI). This method of calculating inflation brought the problem of serial correlation in the SVAR models because of overlapping quarters. However, this problem was eliminated by including more lags in the model. Inflation is the target of the monetary policy conducted by the central bank. Moreover, the discount and Treasury bill (TB) rates are nominal short-term interest rates used as proxies for the monetary policy rate. The interest rates and inflation rates are in percentages. GDP is detrended using the Hodrick-Prescott filter to estimate the output gap[7] (e.g. Dungey and Fry, 2003).

[7] Following method used by Kaiser and Maravall (1999), observations were extended by 3 years (12 observations for quarterly data) at the beginning and the end of the sample in an attempt to deal with the end-of-sample problem of the HP filter method.

Before estimating the SVARs, an optimal lag was determined using the information criteria. The Akaike Information Criteria (AIC) and the Schwarz Information Criteria (SC) identified the appropriate lag length to be between 1 and 8 lags for all the four SVAR models. The preferred lag lengths were then selected based on the minimum information criteria and the absence of serial correlation in the SVAR model.

4.1. Identification

In order to identify the structural shocks in an SVAR, some restrictions were placed on contemporaneous relationships. These restrictions are motivated by the need for a parsimonious specification as well as a stable model that fares well in terms of the diagnostic checks. As mentioned earlier, economic theory and the three monetary policy equations (the Phillips curve, interest rate pass-through and the monetary policy reaction function) guide the SVAR restrictions. This means within the estimated SVAR, some of the equations resemble the three equations mentioned above. The output gap is expected to have a positive relationship with inflation, which is a Phillips curve relation. If existent, the interest rate pass-through is expected to be positive in reaction to a change in the South African policy rate. Lastly, from the monetary reaction function, the policy rate is expected to have a negative response to a change in inflation and a positive response to a change in the output gap.

The process of selecting the contemporaneous restrictions involved eliminating the insignificant contemporaneous coefficients until only the significant ones remained. Therefore, the identified contemporaneous matrices for the BLNS countries are presented below. The subscripts B, L, N, S, and SA refer to Botswana, Lesotho, Namibia, Swaziland, and South Africa respectively, A_0 represents the matrix of contemporaneous coefficients and X is the vector of variables included in the SVARs. Considering that South Africa is the dominant economy and the source of the policy spillovers, its variables are ordered first in the SVAR model of all the BLNS countries. The restrictions show that the monetary policy rate reacts to contemporaneous output and inflation (domestic and foreign). However, researchers such as Kim (2001) and Sanchez-Ordonez (2017) argue that foreign output and inflation do not enter contemporaneously into the SVAR model of monetary policy transmission analysis.

Based on literature and the three monetary policy equations, different SVAR specifications (with different combinations of variables – R/$ exchange rate, lending rate) were tried and tested and the best of the restrictions were adopted.[8] The best SVAR models included only the monetary policy rate as well as the policy target variables (inflation and the output gap).

The Botswana SVAR is presented below and consists of six variables, and these are the output gap, inflation, and the monetary policy rate for South Africa and Botswana.

$$\text{Botswana} \rightarrow A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 \\ b_{41} & 0 & 0 & 1 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 \end{bmatrix}; X = \begin{bmatrix} \hat{y}_{SA} \\ \pi_{SA} \\ i_{SA}^{p} \\ \hat{y}_{B} \\ \pi_{B} \\ i_{B}^{p} \end{bmatrix}$$

The estimation period is 1995Q3 – 2017Q4 (n = 90) and the best model with no serial correlation is at 6 lags. The contemporaneous restrictions imposed for the Botswana SVAR model are that the South African output gap and inflation are expected to contemporaneously affect the SA policy rate and Botswana inflation and policy rates. The contemporaneous effects to the Botswana inflation come from the South African inflation, the South African policy rate, and Botswana output gap. Lastly, the contemporaneous restrictions for the Botswana policy rate (proxied by the discount rate) show that the Botswana policy rate is expected to respond to all the other variables contemporaneously.

The Lesotho SVAR model includes five variables and these are the South African output gap as well as the inflations, and the monetary policy rates for South Africa and Lesotho. The estimation period is 1987Q1 – 2018Q3 (n = 127) and the best model with no serial correlation is at 6 lags. The chosen restriction is presented below:

$$\text{Lesotho} \rightarrow A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ 0 & b_{52} & b_{53} & b_{54} & 1 \end{bmatrix}; X = \begin{bmatrix} \hat{y}_{SA} \\ \pi_{SA} \\ i_{SA}^{p} \\ \pi_{L} \\ i_{L}^{p} \end{bmatrix}$$

[8] These are available if requested.

The contemporaneous restrictions in the Lesotho SVAR indicate that the Lesotho policy rate is expected to react to contemporaneous South African inflation and monetary policy rates, and the Lesotho inflation rate. Moreover, the Lesotho inflation rate is likely to respond contemporaneously to all the South African variables (output gap, inflation, and monetary policy rate.

In addition, the SVAR model for Namibia includes the output gap for South Africa and the inflation and monetary policy rates for South Africa and Namibia. The estimation period is 2004Q4 – 2018Q3 (n = 56) and the best model with no serial correlation is at 6 lags.

$$\text{Namibia} \rightarrow A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & 0 & 1 & 0 \\ b_{51} & b_{52} & b_{53} & 0 & 1 \end{bmatrix}; X = \begin{bmatrix} \hat{y}_{SA} \\ \pi_{SA} \\ i_{SA}^{p} \\ \pi_{N} \\ i_{N}^{p} \end{bmatrix}$$

The contemporaneous restrictions for the Namibia SVAR indicate that contemporaneous South African GDP and inflation rate are expected to affect the Namibian inflation and policy rate. The SVAR model for Swaziland also includes five variables, which are the South African output gap as well as inflation and the monetary policy rate for South Africa and Swaziland. The estimation period is 1976Q3 – 2018Q3 (n = 169) and the best model with no serial correlation is at 6 lags.

$$\text{Swaziland} \rightarrow A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ 0 & b_{52} & b_{53} & b_{54} & 1 \end{bmatrix}; X = \begin{bmatrix} \hat{y}_{SA} \\ \pi_{SA} \\ i_{SA}^{p} \\ \pi_{S} \\ i_{S}^{p} \end{bmatrix}$$

For the Swaziland SVAR, the South African output gap is expected to have a contemporaneous effect on the South African inflation and the monetary policy rate and the Swaziland monetary policy rate. The South African inflation rate contemporaneously affects SA and the Swaziland policy rates, and Swaziland inflation. In all the BLNS models, these restrictions indicate that SA variables can contemporaneously affect the BLNS variables but not vice versa.

This means that the SA variables do not react within the contemporaneous period to changes in any of the BLNS variables. This is what is expected given that South Africa is dominant in the SACU region as verified in the previous chapter.

As highlighted above, the SVAR model restrictions are based on the monetary policy equations, with the policy rate equation representing the monetary policy reaction function and the interest rate pass-through, as well as the inflation equation representing the Philips curve equation.[9] In addition, given that the restrictions above are non-recursive, the BLNS SVAR models became over-identified. The LR test was used to test the validity of this over-identification restriction and Table 1 presents the results of these tests below.

Table 1: LR test and diagnostic checks

Country	LR Chi-square	Portmanteau test p-value	LM test p-value
B	2.7455 (0.2534)	0.352	0.943
L	2.0101 (0.1563)	0.512	0.3669
N	2.3006 (0.3165)	0.125	0.5669
S	0.1508 (0.6978)	0.463	0.326

Note: 1. LR test → H_0 is that the restrictions are valid and the values in brackets are the p-values of the Chi-square statistic for the LR test for over-identification; 2. Portmanteau and LM tests → H_0 is that the estimated SVAR model has no serial correlation; 3. → H_0The p-values are reported.

The results above show that the restrictions for all the SVAR models are valid and that the residuals are uncorrelated and normally distributed. The AR roots analysis also shows that the estimated SVAR models are stable because all the roots have a modulus that is less than one. Therefore, these tests mean that the impulse-responses and variance decompositions from the SVARs are valid.

4.2. Impulse response analysis

In this section, the paper presents the impulse response functions of output, inflation, and the policy rate of the BLNS countries to orthogonal shocks to the South African monetary policy.[10]

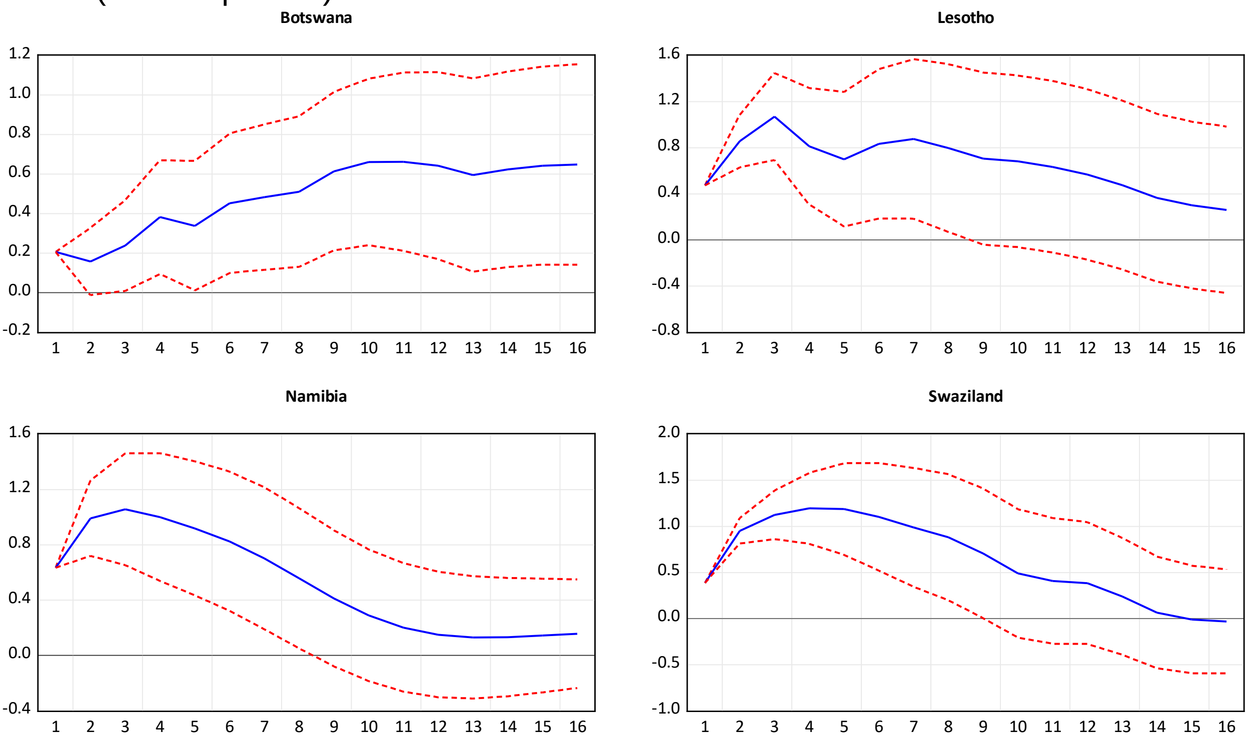
[9] The GDP equations, representing the IS function, are also included to capture a complete the monetary transmission mechanism.

[10] The impulse-response functions of South African variables to their own variables and the BLNS country variables are presented in Appendix A2 and they show that the monetary policy actions of the BLNS countries are insignificant in the South African economy. Moreover, the impulse response functions of South African variables to their own variables show a significant Philips curve relation and a monetary policy reaction function.

The impulse response function refers to a response of the BLNS variables to a positive one-unit shock to SA variables i.e. sizes of the shocks are measured by one unit change of the errors.

This means that one-unit shocks to the monetary policy rate and inflation rate are measured as a one-percentage point change whilst a one-unit shock to output is a one percent change. The main impulse to consider is the increase in the discount rate that represents a contractionary monetary policy. Any significant responses of BLNS variables to this monetary policy shock are an indication of direct monetary policy spillovers from SA to the BLNS country. Moreover, the impulses to SA output and inflation are also considered as an indication of indirect monetary policy spillovers. Figure 2 below shows that BLNS policy rates have a significant positive response to a South African monetary policy shock.

Figure 2: Response of BLNS monetary policy rates to a South African monetary policy shock (MPRF spillover)



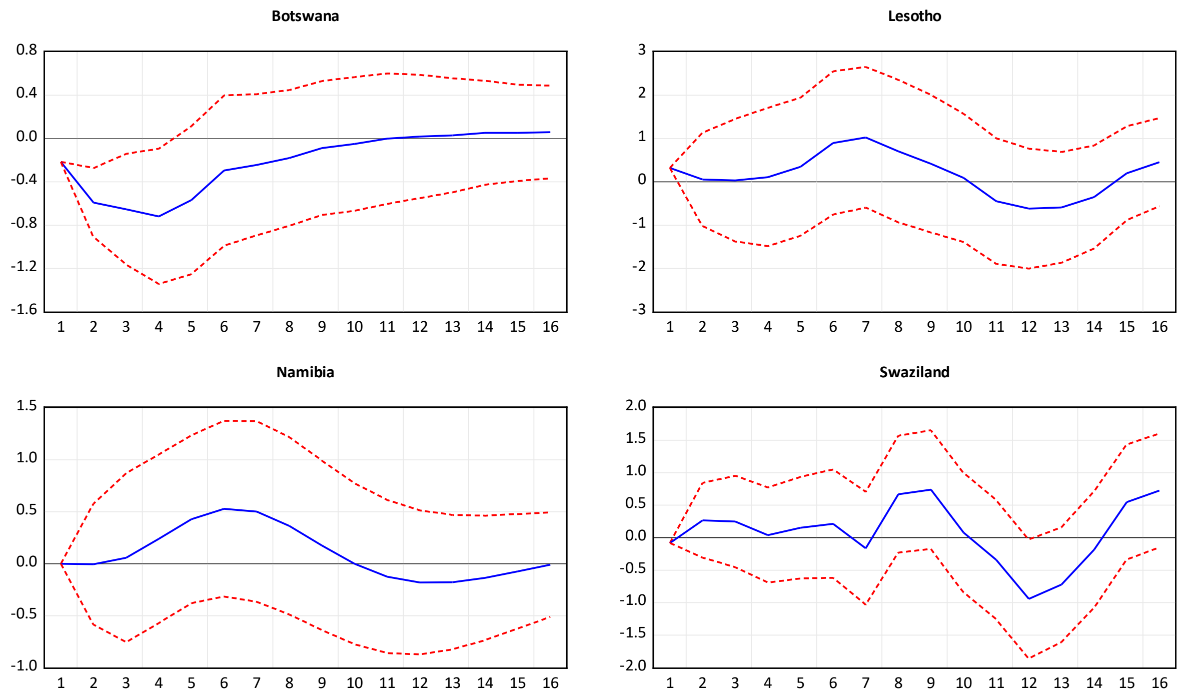
Lesotho, Namibia and Swaziland policy rates have the most significant positive reactions to a South African monetary policy shock and these reactions are prolonged to more than 6 quarters for all three countries. A one-percentage-point shock to the South African monetary policy causes a 0.63 percentage point change in the Namibian monetary policy rate in the first quarter, a 0.39 percentage point change in the

Swaziland rate and a 0.5 percentage point change in the Lesotho policy rate. The impulse responses for these three countries peak three quarters after the monetary policy shock at an average of 1 percentage point change. This is expected considering that the BLNS central banks closely follow the actions of the SA central bank.

The positive response of the BLNS policy rates is evidence of monetary policy spillovers from South Africa to the other SACU countries through the interest rate pass-through as well as evidence of the South African monetary policy dominance in the SACU region. The BLNS policy rates react the same way South African rates react to its own monetary policy. This means that South African monetary policy is a relevant monetary policy for Botswana, Lesotho, Namibia, and Swaziland and is responsible for setting the monetary policy in the region.

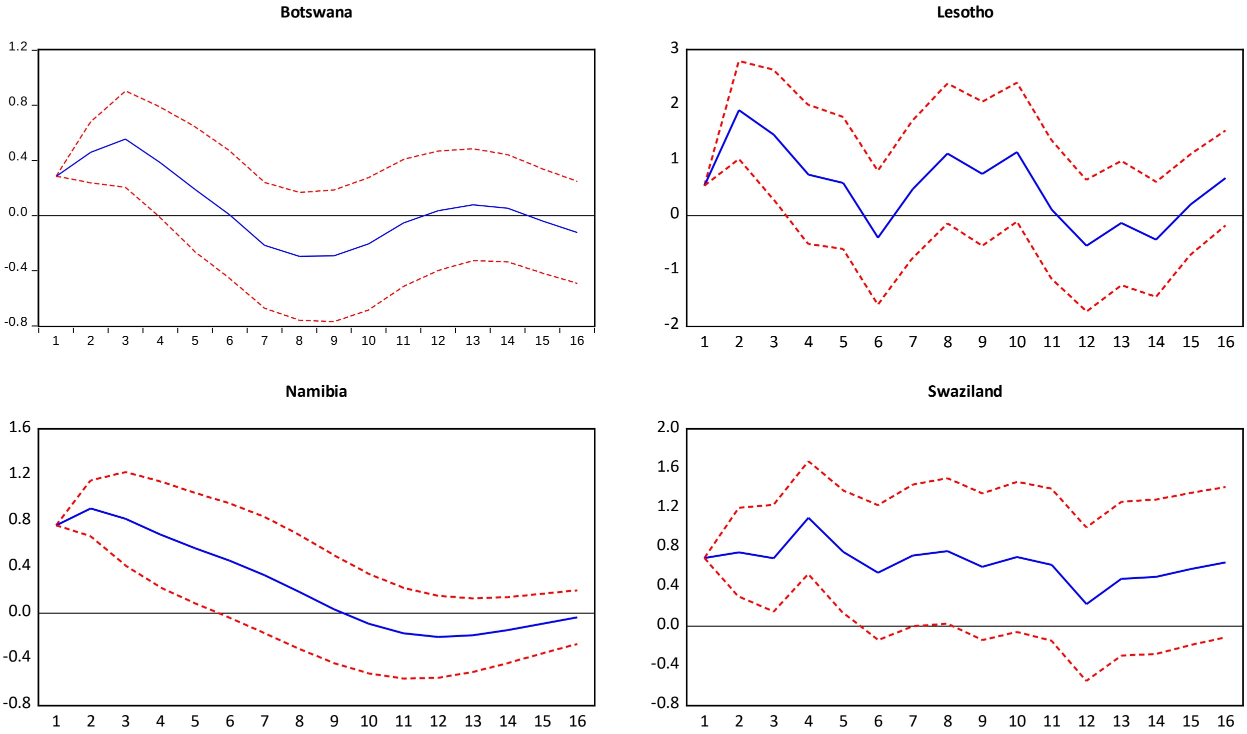
Considering that the main objective of the central banks of the SACU countries is price stability, the impulse response functions of the BLNS inflation rates to a SA monetary policy shock are observed. Figure 3 below shows a significant response of Botswana and Lesotho inflation to a South African monetary policy shock. In all the SVARs, there is an insignificant reaction of the South African inflation to its monetary policy shock. The impulse response functions of South African variables to other South African variables are available on request.

Figure 3: Response of BLNS inflation rates to a South African monetary policy shock



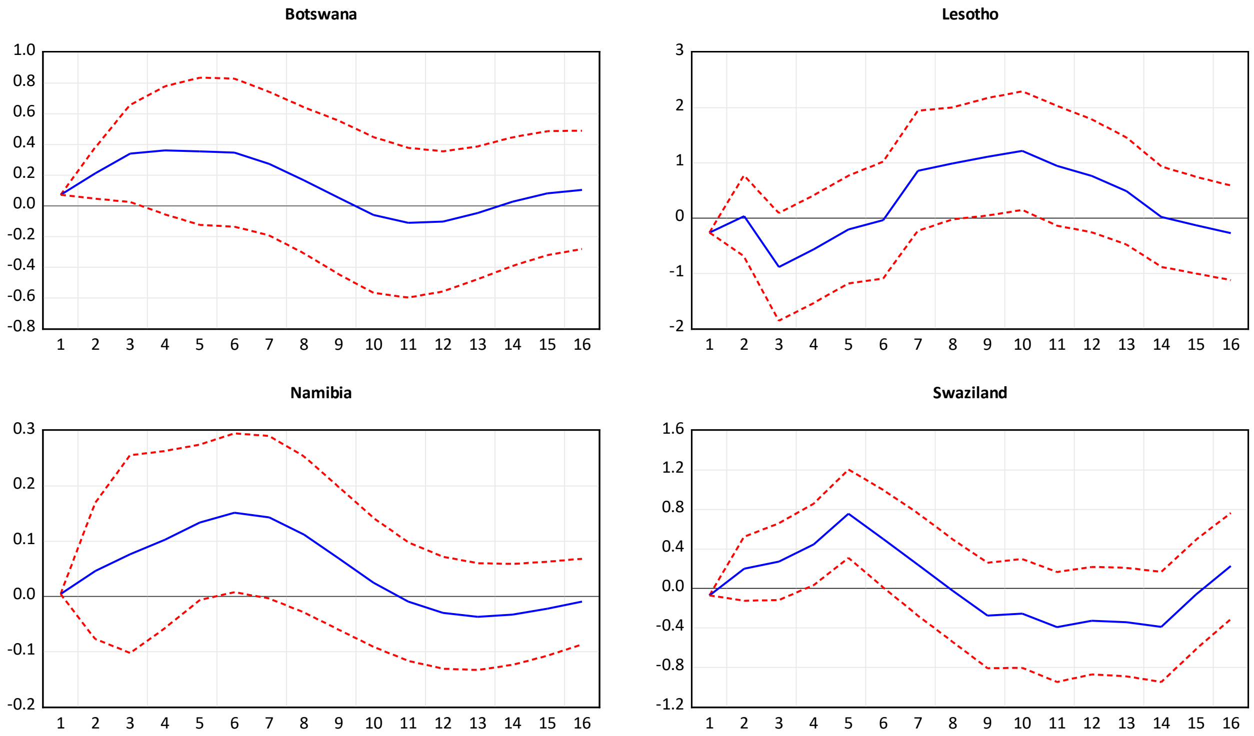
A shock to the South African monetary policy triggers a decline in Botswana inflation, which lasts for nearly 4 quarters. The response in the first quarter is a 0.2 percentage point decline in the Botswana inflation rate and it peaks at a 0.72 percentage point decline in the fourth quarter. However, Lesotho, Namibia and Swaziland inflation rates have an insignificant reaction to a contraction in the South African monetary policy rate. Additional monetary policy spillovers are evident from the impulse response functions of BLNS inflation to SA inflation and output shocks. These show evidence of spillovers through a Phillips curve relation.

Figure 4: Response of BLNS inflation rates to a South African inflation shock (PC spillover)



All BLNS inflation rates have a significant positive reaction to a South African inflation shock, which is instantaneous and wears off after 4 quarters for Botswana and Lesotho and 5 quarters for Namibia and Swaziland. A one-unit shock in the SA inflation rate leads to a peak response of 1.9 percentage points in the Lesotho inflation, 1.1 percentage points for Swaziland, 0.91 percentage points for Namibia and 0.55 percentage points for Botswana. This is an indication of the presence of the South African inflation spillovers to the BLNS inflation variables. Moreover, monetary policy spillovers are also investigated by looking at the Phillips curve relationship between inflation and output. Figure 5 below displays the impulse response functions of the BLNS inflation rates to a shock in the South African output.

Figure 5: Response of BLNS inflation rates to a South African output shock (PC spillover)



There is evidence of Phillips curve spillovers for Botswana, Lesotho and Swaziland where the inflation rate has a significant positive response to a South African output shock. The Botswana response is instantaneous, with a 0.07 percentage point in the first quarter, which peaks to a 0.34 percentage point response in the third quarter. Lesotho and Swaziland inflation rates react to a SA output shock with a lag. A significant response of about 1.10 percentage point change for Lesotho inflation is observed between the ninth and the eleventh quarter, and a significant response of about 0.7 percentage point change between the fourth and the sixth quarters for Swaziland. This result means that SA monetary policy contributes to meeting the monetary goals of Botswana, Lesotho and Swaziland of stabilising prices and output. However, Namibian inflation does not react to a shock in the South African output.

Figures 6 and 7 below represent monetary policy spillovers via the monetary policy reaction function, which are spillovers of SA inflation and output on the BLNS policy rates. Lesotho, Namibia and Swaziland policy rates have a significant reaction to a South African inflation shock.

A one percent shock in SA inflation causes a 0.07 percentage point response to Lesotho policy rate in the first quarter and this response path peaks at 0.46 in the third quarter. The responses of Namibian and Swaziland inflation rates also peak at about 0.33 percentage point, in the third quarter. Furthermore, all the BLNS policy rates have a significant reaction to South African output shocks. The responses become insignificant between the sixth and ninth quarters, with Swaziland having the longest significant response function. A one percent shock in SA output causes, in the first quarter, a 0.18 percentage point response to Botswana policy rate, a 0.07 percentage point response to Lesotho policy rate, a 0.014 percentage point response to Namibia policy rate and a 0.06 percentage point response to Swaziland policy rate. The response paths for the BLNS countries peak at 0.25, 0.42, 0.115 and 0.06 percentage points respectively. These results show that South African inflation and output shocks have significant positive effects on the monetary policy rates of the BLNS countries, with the effects wearing off after the 3rd quarter for the inflation shock and 6 quarters for the output shock.

Figure 6: Response of BLNS policy rates to a South African inflation shock (MPRF spillover)

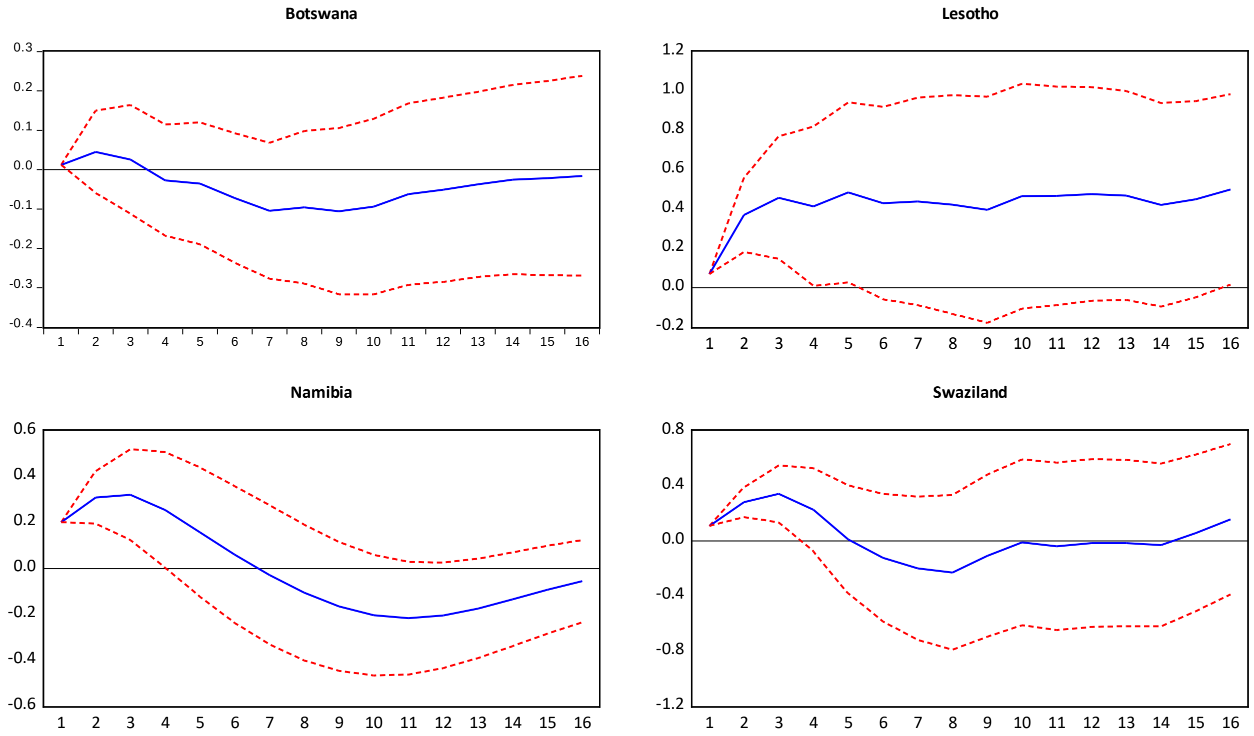
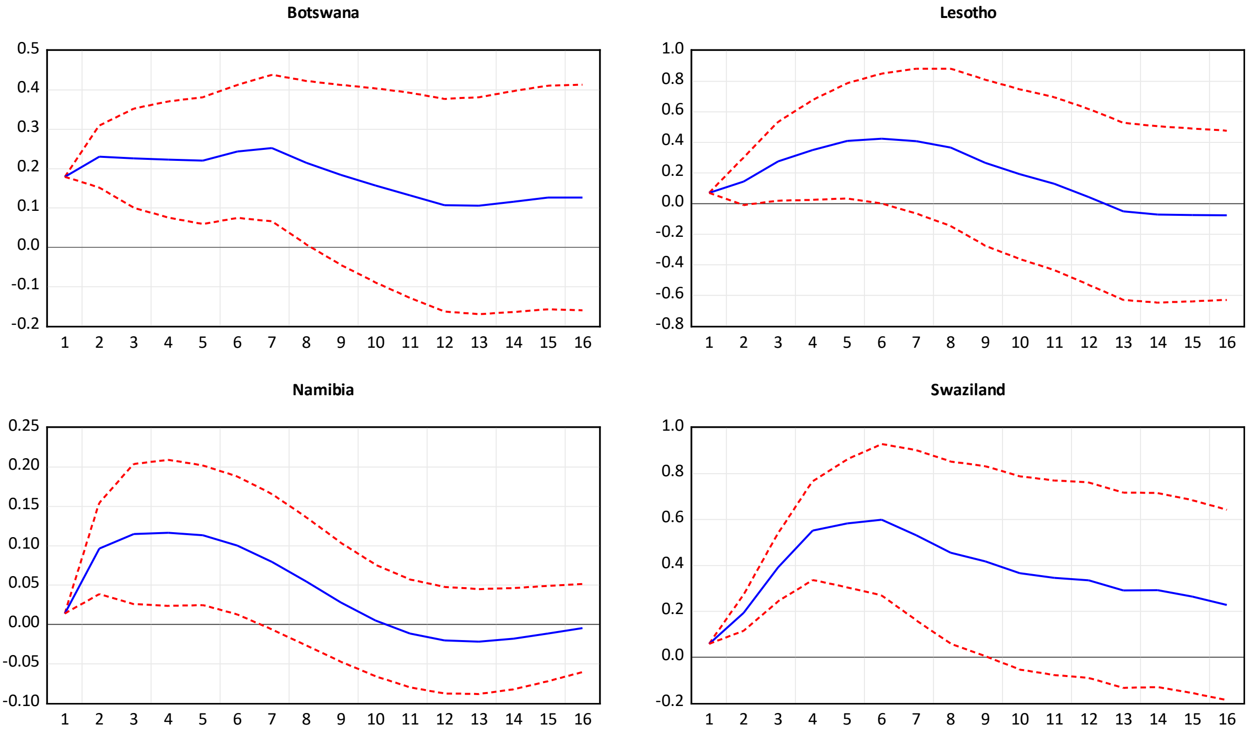


Figure 7: Response of BLNS policy rates to a South African output shock (MPRF spillover)



In summary, a South African contractionary monetary policy shock leads, in all BLNS countries, to a significant increase in the policy interest rates. These interest rates largely track the South African monetary policy rate, particularly, the LNS countries. This is an indication of significant financial integration between South African and the BLNS financial markets. Given that symmetric response to external shocks is one of the prerequisites of establishing a centralised central bank, the finding that the BLNS economies respond similarly to the South African monetary policy shocks builds the case towards setting up a SACU central bank. Moreover, these impulse response functions indicate evidence of direct and indirect monetary policy spillovers from South Africa to the other SACU countries. In addition, these results tentatively show the conclusion that the shocks to the South African monetary policy rate, inflation and output are transmitted to the BLNS monetary policy rates and inflation rates.

4.3. Variance decomposition and Diebold-Yilmaz spillover analysis

In an attempt to quantify and summarise the international spillovers, the Diebold-Yilmaz (DY) spillover measures are calculated using the variance decompositions from the SVAR models above.

The variance decompositions are based on the 12-step ahead forecasts (i.e. 12 quarters) and only the values of the selected quarter are reported. Table 2 below presents the variance decompositions of inflation and policy rates of the four BLNS countries from a South African monetary policy shock. Only the variance decompositions relating to spillovers are reported in Table 2, the rest of the variance decompositions are presented in the Appendix. The spillovers from South African variables are defined here as contributions of South African variables to the forecast error variance of the BLNS country variables.

Table 2 – Variance decompositions

To → From ↓	Cty	GDP (SA)	Inflation (SA)	IR (SA)	GDP (B)	Inflation (BLNS)	IR (BLNS)
GDP (SA)	B	66.066	7.888	9.089	3.087	4.848	9.021
	L	83.238	3.815	2.588		3.961	6.397
	N	76.395	5.346	9.240		2.451	6.568
	S	86.529	1.623	5.939		2.481	3.429
Inflation (SA)	B	18.777	58.934	7.835	6.350	2.873	5.230
	L	27.535	35.263	4.108		29.614	3.479
	N	10.082	71.420	4.544		0.722	13.232
	S	16.778	74.568	3.229		0.384	5.041
IR (SA)	B	26.151	11.414	45.099	2.452	1.168	13.716
	L	20.331	3.462	47.671		12.053	16.483
	N	19.246	18.820	51.348		2.250	8.336
	S	46.703	4.081	38.437		8.568	2.211
Inflation (BLNS)	B	1.262	30.219	13.162	10.656	32.945	11.756
	L	13.047	13.273	3.269		66.944	3.467
	N	7.384	48.076	2.980		26.293	15.268
	S	13.364	24.806	7.465		44.239	10.125
IR (BLNS)	B	17.262	3.537	14.604	29.168	5.816	29.612
	L	7.640	14.555	25.864		4.430	47.510
	N	13.783	21.399	47.889		4.116	12.813
	S	32.688	2.616	35.677		11.670	17.350
GDP (B)	B	14.590	3.937	5.901	70.541	2.706	2.325

Note: Compiled by author

The variance decomposition analysis shows that a South African monetary policy shock accounts for about 14 percent of the fluctuations in the Botswana policy rate, 16.5 percent of the fluctuations in the Lesotho policy rate, 8 percent of the fluctuations in the Namibian policy rate and about 2 percent of the fluctuations in the Swaziland policy rate.

The evidence of the spillover effect of the South African monetary policy via the interest rate pass-through is, as expected, an indication of the significant dependence and integration of the LNS countries on the South African financial sector. The South African monetary policy shock contributes a small percentage (about 1 – 12 percent) to the variations in the BLNS prices. There is also evidence of the contribution of South African monetary policy to BLNS prices via South African prices. The South African inflation rate accounts for 2.9 percent to Botswana inflation, 29.6 percent to Lesotho inflation, 0.7 percent to Namibian inflation and 0.3 percent to Swaziland inflation. Lastly, the South African output shocks contribute between 3 and 9 percent to the variations in the BLNS policy rates and between 2.4 and 5 percent to the variations in the BLNS inflation rates.

The variance decomposition analysis confirms the findings from impulse response functions that the SA monetary policy shocks influence the BLNS monetary policies through their significant contributions to the fluctuations in BLNS inflation and policy rates. Furthermore, the results from the variance decomposition analysis are then summarised through the calculation of the DY spillover measures for the Phillips curve relation (PC), and monetary policy reaction function (MPRF). These spillover measures are presented below. Table 3 below shows that about 66 percent of the South African monetary policy spills over to Namibian inflation via inflation and output, about 50 percent, 38 percent, and 20 percent spills over to Botswana, Swaziland, and Lesotho prices respectively.

Table 3 – Philips curve Spillover measures

To ↓ From →	**GDP (SA)**	**Inflation (SA)**	**Inflation (own)**	**Spillover Index (%)**
Inflation (B)	4.848	30.219	32.945	49.59
Inflation (L)	3.961	13.273	66.944	20.47
Inflation (N)	2.451	48.076	26.293	65.77
Inflation (S)	2.481	24.806	44.239	38.15

Note: Author's calculations
Botswana GDP has about 2.71 percent contribution to Botswana inflation and is not included in the table to condense the table.

Furthermore, there is evidence of SA monetary policy spillovers through the monetary policy reaction function indicated in Table 4 below. The spillover index to the BLNS policy rates ranges from 35 to 83 percent, with Botswana having the lowest spillover index and Namibia the highest index.

Table 4 – Spillover measures via MPRF

To ↓ From →	GDP (SA)	Inflation (SA)	Policy rate (SA)	Inflation (own)	Policy rate (own)	Spillover index (%)
Policy rate (B)	17.262	3.537	14.604	5.816	29.612	35.40
Policy rate (L)	7.640	14.555	25.864	4.430	47.510	48.06
Policy rate (N)	13.783	21.399	47.889	4.116	12.813	83.07
Policy rate (S)	32.688	2.616	35.677	11.670	17.350	70.98

Note: Author's calculations
Botswana GDP has about 29.2 percent contribution to the Botswana policy rate and is not included in the table to condense the table.

These results show that the main source of fluctuations of Lesotho, Swaziland, and Namibia policy rates is due to SA policy spillover effects, which account for more than 48 percent of the variations.

Overall, shocks to the SA discount rate spill over to the BLNS policy and non-policy variables directly via the Phillips curve relationship and the interest rate pass-through equation and indirectly via the monetary policy reaction function. The monetary policy spillover is strongest for lending rates and discount rates in the LNS countries. The contribution of SA non-policy variables (inflation and output) to the BLNS country prices and interest rates implies that there are other spillover effects from South Africa that are not due to monetary policy shocks. This implies that more consideration is needed from the BLNS countries when setting their monetary policies, apart from considering the SA monetary policy.

In addition, results which emerge from the DY spillover measures is that South Africa is the net transmitter of monetary policy spillovers in the SACU region to Botswana, Lesotho, Namibia, and Swaziland, through the policy rate, inflation, and output. Moreover, there are significant monetary policy spillovers from SA to BLNS countries, highlighting a high degree of integration between financial systems as well as the strong role of monetary interdependencies in the SACU countries with the effects of the SA monetary policy dominating the region.

5. CONCLUSION AND POLICY IMPLICATIONS

Building on the research by Aziakpono (2007) and Ikhide and Uanguta (2010) on the SACU countries, the purpose of this study is to investigate the magnitude and importance of South African monetary policy spillovers to the BLNS countries using quarterly data on the policy rate, inflation, and GDP. This is a relevant study because there is limited empirical evidence known to the policymakers in the BLNS countries with respect to the degree and magnitude of the South African monetary policy spillovers to these economies. Methodologically, we employ the SVAR impulse-response functions, variance decomposition analysis, and an adapted VAR-based spillover index by Diebold and Yilmaz (2012). These methods, particularly, the Diebold-Yilmaz index, is well suited for the investigation and have rarely been used in the international monetary policy spillover analysis in the SACU region.

Generally, the findings are that the South African monetary policy spillovers are an important source of fluctuations in the policy and non-policy variables of the BLNS countries. This suggests a high level of financial linkage and dependence of BLNS countries on South Africa's financial systems as well as openness and capital mobility among the SACU countries. Furthermore, a South African monetary policy shock significantly affects interest rates and inflation in the BLNS countries in a homogenous manner and largely the same way as within South Africa. Therefore, this common spillover effect of the South African monetary policy to the other SACU countries points towards the feasibility of setting up a regional central bank in the SACU region. The finding that the LNS countries follow the monetary policy of South Africa also support the feasibility of setting up a SACU central bank. However, there are other factors to consider as well which would contribute to making the regional central bank feasible and these include stable economic growth and an effective fiscal policy (Bawumia, 2002).

Lastly, the findings from this paper have an important policy implication that South African monetary policy shocks significantly spillover to the BLNS countries, although slightly less intense for Botswana. The large magnitude of spillover effects obtained in this study point towards the feasibility of setting up a supranational monetary policy as well as the importance of establishing macroprudential stabilisation policies (Antonakakis and Badinger, 2014).

Appendix

Data

Sample information

Variable (country)	Date	Sample size
GDP (SA)	1960Q1 – 2018Q4	236
GDP (B)	1994Q1 – 2018Q4	100
Policy rate (SA)	1960Q1 – 2018Q4	236
Discount bank rate (B)	1976Q3 – 2018Q4	170
TB rate (L)	1980Q1 – 2018Q4	103
TB rate (N)	1991Q3 – 2018Q4	110
Discount rate (S)	1976Q3 – 2018Q4	170
Inflation (SA)	1961Q1 – 2018Q4	232
Inflation (B)	1975Q1 – 2018Q3	177
Inflation (L)	1974Q1 – 2018Q3	179
Inflation (N)	2003Q1 – 2018Q3	63
Inflation (S)	1966Q1 – 2018Q4	212

GDP argument

The LNS GDP growth rates are related to SA GDP growth rate as presented in the tables below.

Correlations between SA GDP growth rate and LNS GDP growth rates

Variables		Correlation	p-value	n
SA	**L**	0,971	0,000	53
	N	0,927	0,000	31
	S	0,960	0,000	51

The correlation coefficients in the table above show that the South African GDP growth rate is highly correlated with the LNS GDP growth rates and the correlations are statistically significant. Given that the sample size is small (n = 31 to 51), the Spearman rank correlation coefficient is used instead of the ordinary correlation coefficient. After establishing the correlations, the Johansen Fisher cointegration test was used to determine whether or not South African GDP is cointegrated with the LNS GDP. The panel form of the test was used because the sample sizes for the individual LNS GDPs are small. The LNS GDPs were pooled together and then tested for cointegration with SA GDP.

Johansen Fisher panel cointegration test between SA GDP and LNS GDPs

Trace test	p-value	Lag	Trend assumption
82.763	0.000	1	Intercept (no trend) in the cointegrating equation and test VAR

In addition to the cointegration test, panel causality tests were also performed and the results show that SA GDP does Granger cause LNS GDP.

Causality tests between GDP growth rates

Causality test*	Null Hypothesis:	F-Statistic	p-value
Granger Causality	DLGDP_SA does not Granger Cause DLGDP	12.2835	0.0006
	DLGDP does not Granger Cause DLGDP_SA	1.23592	0.2685
	Null Hypothesis:	**Zbar-Stat.**	**Prob.**
Dumitrescu Hurlin Panel	DLGDP_SA does not homogeneously cause DLGDP	4.26250	2.E-05
	DLGDP does not homogeneously cause DLGDP_SA	-0.49462	0.6209

Note: * - test performed at 1 lag.