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Financial integration and the stability of the financial system in Southern African Customs Union

Abstract

Integration of financial markets increased drastically following the advent of globalization, advancement in technology and modernization of payments systems. Deliberate policies, such as liberalization of the capital account, could have also contributed to this global trend of deepening financial integration. Despite its benefits, the process of financial integration can have serious repercussions such as financial instability. Through contagion, market inter-linkages allow instability in one market to spread easily and quickly to other markets. This paper uses the Kalman Filter to measure the time-varying degree of financial integration in the Southern African Customs Union (SACU). In addition, the same technique is used to assess the impact of such a process of integration on the stability of financial markets in the union. The findings indicate that, despite the segmentation that characterised the SACU financial markets in the mid-1990s, financial integration within SACU has continued to deepen in later periods. Moreover, there is also evidence of integration with the rest of the world in the late 1990s and early 2000s. Consequently, the SACU financial system has been highly sensitive to external shocks which have tended to increase its stochastic volatility. An emerging lesson from the findings is that financial integration should be accompanied by policies that reduce the probability of instability in the union.

Keywords: financial integration, financial stability, Kalman Filter.
JEL Classification: F20, F30, F40, G10.

Introduction

Financial markets across the world have become increasingly integrated. This has been driven by "increased globalization of investment seeking higher rates of return and the opportunity to diversify risk internationally" (Jain and Bhanumurthy, 2005, p. 15) which has been facilitated by increased use of faster and more sophisticated technology (Summers, 2000). The definition of financial integration emphasises two aspects, namely: price equalization for similar assets and the surge in the quantity of actual flows of capital between countries. For example, on the one hand, Edison et al. (2002, p. 750) define financial integration as "the degree to which an economy does not restrict cross-border financial transactions" while on the other hand, Held et al. (1999, p. 189) define the process as the "extent to which the prices of, and returns to, assets are equalized between different national financial markets". Financial integration is seen as a source of many benefits for countries whose markets have embraced the process. For instance, Reddy (2003) points out that financial integration improves the efficiency of monetary policy implementation because integrated markets facilitate easy transmission of price signals by the authorities. Mohan (2005) argues that integrated markets promote the adoption of modern technology and payment systems which should make financial intermediation cheaper. In addition, by increasing access to the pool of international capital, Obstfeld (1994) reasons that financial integration allows transborder borrowing to smooth consumption during adverse shocks. Furthermore, it reduces the costs of collecting, processing and executing transactions and introduces competitive innovation which widens the options of better and sophisticated products (Schneider, 2001).

Table 1 provides the pairwise correlation coefficient between treasury bill rates of the five members of the Southern African Customs Union (SACU)[1] as well the United States (US) of America[2]. The US, which gives preferential treatment to exports of manufactured products from SACU especially textile and clothing, is included to capture the relationship between SACU member countries and the rest of the world. It shows that financial integration within SACU (*intra-SACU* integration) is higher among the common monetary area (CMA) countries[3]. This reflects two characteristics, namely South Africa's (SA) dominance as well as the direct relationship among other CMA countries. The correlation coefficient between SA treasury bill rate and those of other CMA members is higher showing the highest level of financial integration between SA and Namibia (0.99), followed by SA and Lesotho (0.95) while Swaziland (0.88) is the least integrated with SA. The degree of financial integration among the rest of the CMA countries, excluding South Africa, is highest between Lesotho and Namibia (0.95) followed by Lesotho and Swaziland (0.87) and Namibia and Swaziland (0.86). Botswana is weakly integrated with the rest of the SACU countries indicating that it enjoys some degree of monetary policy independence with respect to South Africa.

[1] SACU comprises South Africa, Lesotho, Namibia, Swaziland and Botswana.
[2] For Botswana, the study uses the return on Bank of Botswana certificates as this is the closest instrument to the treasury bill because Botswana only started using treasury bills in 2008. Nevertheless, the return on these certificates still allows for a meaningful comparative analysis.
[3] The CMA which is characterized by the 1:1 peg between the rand and the currencies of other member states, is made up of Lesotho, Namibia, Swaziland and South Africa.

Financial integration with the rest of the world is captured by the correlation between the treasury bill rate between SACU member states and the rest of the world represented by the US. According to this measure, the CMA tends to be more integrated with the US (see Table 1).

Table 1. The Intra-SACU and extra-SACU financial integration

	Botswana	Lesotho	Namibia	SA	Swaziland	US
Botswana	1.00					
Lesotho	-0.60* (0.00)	1.00				
Namibia	-0.53* (0.00)	0.95* (0.00)	1.00			
SA	-0.52* (0.00)	0.95* (0.00)	0.99* (0.00)	1.00		
Swaziland	-0.33* (0.00)	0.87* (0.00)	0.86* (0.00)	0.88* (0.00)	1.00	
US	-0.10* (0.16)	0.42* (0.00)	0.55* (0.00)	0.54* (0.00)	0.42* (0.00)	1.00

Note: * Denotes 5 per cent level of significance and *p*-values are in parenthesis.

Trichet (2005) argues that financial integration can result in financial stability because it increases competition and improves the efficiency of financial institutions in their operations and allocation of resources. The desire to reap these benefits gave impetus to widespread implementation of capital account liberalization (CAL) in many countries around the world including SACU member states. Nevertheless, financial integration has several risks for integrating economies including the risk of financial instability. Moreover, Pasricha (2009) indicates that for financial integration to be meaningful it must be accompanied by equalisation of prices of identical assets.

This study raises the two research questions: Is there any evidence of deep financial integration among members of SACU? Is there any evidence of stochastic volatility in the union? These research questions are addressed by testing the following hypotheses: First, there is deep intra-SACU financial integration and second, there is no evidence of stochastic volatility in SACU. In testing these hypotheses, the study would attain the following objectives: First, it seeks to determine the time-varying degree of intra-SACU and extra-SACU financial integration. Second, it aims to assess the dynamics of financial stability in the SACU region using stochastic volatility of treasury bill rate. The rest of the paper is structured as follows. Section 1 provides a synthesis of the literature review on the relationship between financial integration and stability and section 2 outlines the methodological approach followed in this study. Section 3 analyzes the data using the tools outlined in section 2 and the final section concludes the paper and offers some policy recommendations.

1. Financial integration and stability: the Nexus

The definition of financial integration that only emphasizes the law of one price loses sight of the fact that identical treatment and equal access to the assets by all agents play a vital role in the process (Baele et al., 2004). Although deeper financial integration does not require identical financial structures across regions, it requires minimal frictions or restrictions to free flow of capital. One of the important gains of financial integration is that it improves financial stability (Babecky et al., 2010). There are few channels that connect financial integration and stability. According to Schmukler (2004) one of the channels works through improvements in the bank supervisory and legal framework as well as market discipline. Financial integration facilitates assimilation of international best-practice in financial regulation and supervision which impacts positively on areas such as securities market legislation, corporate governance and accounting standards (Guiso et al., 2004). Another channel through which financial integration enhances financial stability results from the fact that financial integration introduces foreign entry into local financial markets. Agenor (2003) argues that foreign banks do not pursue lending policies that favour certain sectors of the economy for political gain because they are insulated from government control which often undermines sound lending practices. Furthermore, foreign banks usually come with more sophisticated risk assessment model which enable them to grant credit to creditworthy borrowers and reduce default risk.

The impact of financial integration on financial stability is not always positive. One major adverse effect is the threat of financial crisis which may arise in one country, and spread to all other markets through financial interlinkages. Spicka (2007, p. 4) defines financial crisis as "episodes of high volatility in the financial markets, liquidity problems and insolvency of significant financial market participants that can give rise to real economic effects." Episodes of financial crises are closely associated with financial liberalization. Demirguc-Kunt and Detragiache (1998) observe that countries with libe-

ralized financial systems are more prone to financial crises. Furthermore, Mehrez and Kaufmann (2000) find that lack of transparent government policies, manifested by high levels of corruption, tends to induce banks to increase credit above sustainable levels thereby raising the chances for a financial crisis. This finding underscores the importance of the quality of institutions, especially those that have a direct bearing on the financial system such as rule of law and protection of property rights.

An important mechanism through which financial integration may lead to financial instability is contagion which occurs in an environment in which markets of different countries move together. Karolyi (2003) defines contagion as a phenomenon associated with the propagation of market downside shocks from one country to another. This usually manifests itself through the co-variation in exchanges rates, stock prices and capital flows. Although the causes of contagion are many, they may be grouped into two major types, namely; fundamental-based and irrational contagion. Fundamental-based contagion is associated with a common shock of a local or global nature such as the interest rate policy changes in a dominant economy which may influence capital flows in other countries which are financially integrated with it (Calvo and Reinhart, 1996). Another cause of this type of contagion can be trade links which may transmit shocks from one country to its trade partners (Eichengreen et al., 1996). According to Karolyi (2003), irrational contagion results from co-movements between asset prices in two or more countries that are associated with herd behavior, loss of confidence or other sentiments.

The 2007/08 global financial crisis that emanated in the United States of America (USA) provides an interesting case study of the link between financial integration and stability. This crisis demonstrates how financial integration can result in financial instability due to the fact a crisis spreads from the country of origin to others through inter-linkages between various financial markets facilitated by financial integration. Despite the fact that there have been a number of financial crises in the past such as the Mexican crisis of 1994, the Asian crisis of 1997 and the Russian crisis of 1998, the justification for the focus on the US-triggered global financial crisis hinges on two reasons. First, earlier crises such as the Asian 1997-crisis have already received significant attention and a significant amount of literature is available on them. Second, the global nature of the 2007/08 crisis makes it unique, in the sense that many economies around the world felt its impact and research on its impact on developing countries would increase understanding of the phenomenon of financial crisis.

The 2007/08 global financial crisis is often viewed as a repercussion of bad incentives in the USA mortgage market (Allen and Giovannetti, 2011). This view argues that a shift from orthodox financial intermediation process whereby banks mobilize domestic resources directly, screen borrowers to determine their creditworthiness and extend credit accordingly eroded good incentives. Under orthodox financial intermediation, banks had a good incentive to thoroughly screen borrowers in order to minimise the default risk because they would bear the full risk should borrowers fail to repay. This orthodox financial intermediation process was replaced by a system where brokers became pivotal in screening borrowers and the mortgages were securitized and sold off in bundles or tranches. Hence, the brokers did not bear the losses that could result from the defaults and this created undesirable incentives. Consequently, enormous sub-prime lending ensued. Moreover, rating agencies also began to obtain a substantial proportion of their income from ratings of securitised products. This created bad the incentives for them to over-rate the tranches of toxic assets.

Another factor that is believed to have fuelled the financial crisis is the US monetary policy decisions. Allena and Giovalletti (2011) argue that the Federal Reserve Bank's policy of low interest rates following the collapse of the dotcom bubble of 2000 contributed to the crisis. Low interest rates resulted in high demand for housing which in turn led to higher housing prices. Furthermore, low interest rates made it unattractive to save and people found it desirable to borrow even to finance consumption. September 2008 saw the bankruptcy of Lehman Brothers and this compelled markets to carry out a risk-reassessment which ended up with a liquidity shortage and credit crunch. This re-assessment triggered the spread of the effects of the financial crisis to the real side of the economy. Financial integration provided a conduit through which a US financial crisis permeated the rest of the world thereby causing a global financial crisis.

The financial linkages between China and the US enabled Chinese investors to invest huge amounts of funds in mortgage-backed securities. Consequently, this made it easier for the US-triggered crisis could cascade to China. In addition, during the 1997 Asian crisis, the IMF was implored to intervene. IMF policies prescriptions of low government expenditure and high interest rates forced affected countries to build reserves in order to avoid approaching the IMF for relief during future crisis. This strategy created significant global imbalances

which contributed to the bubble (Allen and Giovannetti, 2011). The literature on the transmission channels of the financial crisis identifies two channels, namely: direct channels that work through financial links, and indirect channels that work through real sector inter-linkages (Allen and Giovannetti, 2011). According to the UNCTAD (2009) developing countries grew at the rate of 7 per cent per annum during the 2003 to 2007 period. The growth was at the back of exceptional financing, high commodity prices and receipts of remittances. Therefore, the financial crisis is seen as a consequence of a reversal in three factors, rapid remittance growth, capital flows and international trade. Many countries in Sub-Saharan Africa depended significantly on exports in order to grow their economies. Some of them such as Lesotho benefited from the Africa Growth and Opportunity Act (AGOA) which gave them easy access into the US market. Although this boosted their exports enormously, the dampening demand for exports in the US during the financial crisis seriously hurt exports from these countries with damaging effects on their economic growth. In addition, the credit crunch had a negative effect on trade finance as banks cut back in response to the financial crisis (Aubion, 2009).

Another transmission channel linked to the trade-channel is the vulnerability to terms of trade fluctuations. The fact that Sub-Saharan African countries do not only have a narrow export base but also tend to be undiversified over markets makes it easier for negative shocks emanating from the market of a trade partner to erode their exports. For example, Allen and Giovannetti (2011) indicate that 15 countries in Sub-Saharan Africa earn more than half of their export-revenues from one market, of which nine get more than half of their revenues from exports to Europe. Such high export market concentrations expose Sub-Saharan African countries to adverse swings in the terms of trade. Moreover, a decline in trade in services associated with tourism also provided a corridor for the transmission of the crisis to African countries. The financial crisis compelled residents in developed countries to cut back on luxury goods such as tourism travel to developing countries (Massa and te Velde, 2008).

Remittance flows have also provided a third channel through which the financial crisis spread to developing countries. Ratha et al. (2010, p. 204) highlight the importance of remittances to developing countries and show that in some low income countries, remittance flows "are more than a quarter of GDP". Moreover, remittance flows to developing countries had hovered around an average annual growth rate of 15 per cent during the 1997 to 2007 period. Despite their resilience to the global financial crisis, remittance flows to developing countries grew at a slower pace of 8 per cent in 2008 in contrast to 23 per cent the previous year (Ruiz and Vargas-Silva, 2010). Owing to the role of remittances in the fight against poverty in developing countries, a decline in this source of income can have harmful effects on economic development in these countries.

The fourth transmission channel of the financial crisis is capital flows. According to the World Bank (2009) net capital flows to developing countries slumped from $1,160 billion in 2007 to $727 billion in 2008. The financial crisis also resulted in enormous currency devaluations in developing countries. In addition, FDI flows decelerated from 21 per cent in 2007 to 7 per cent in 2008 (UNCTAD, 2009). Even though Sub-Saharan Africa was not severely hit by reversals in portfolio flows, a high risk aversion and the fluid capital and currency markets-landscape coupled with the reluctance to extend credit reduced the inflows of capital to Sub-Saharan Africa (Allena and Giovannetti, 2011).

2. Methodology

2.1. Description of data and variables. The study uses monthly data obtained from the IMF international financial statistics (IFS) available on the IMF website. The sample spanning January 1994 to June 2011 is used to execute the Kalman Filter model to study the time-varying nature of the degree of financial integration due to the adoption of policies such as CAL as well as assess the dynamics of financial stability in the event of external shocks such as the 1997 Asian crisis and the 2007/08 global financial meltdown. A detailed description of the variables that are used for the estimations are contained in Appendix C.

2.2. Analytical techniques. In this study, the Kalman Filter is used to measure the changing degree of financial integration and the dynamics of financial stability in SACU. This is done by estimating and assessing the time-varying financial integration parameter $\beta_{i,t}$ in equation (1) below and the financial parameter λ_1 in equation (5) below. The Kalman Filter is a recursive iterative procedure that updates the minimum mean square linear estimate of the state variables at each time *t*. The choice of this technique is justified by the nature of the research problem. The objective is to measure financial integration and stability at each point in time throughout the sample. Other studies such as Korajczyk (1996), Franzoni (2001) and Hooy and Goh (2006) use the ordinary least square (OLS) rolling regression technique to produce time-varying coefficients for financial integration. Yeoh, Hooy and Arsad (2010) argue that even though the coefficients obtained from a rolling regression vary with each rolling window, they are assumed to be con-

stant over the fixed window period. Therefore, the change in the degree of financial integration which may occur during the fixed rolling window is missed. Moreover, OLS rolling regression is sensitive to outliers. These "abnormal" values would affect the estimated coefficients over the entire window length. Hence, unlike the OLS rolling regression, the Kalman Filter technique yields more robust time-varying coefficients by capturing the variability at each time period as new data is incorporated in the calculations (see Appendix A for details on this technique).

Model 1. Modelling financial integration in SACU.

The paper adopts the Kalman Filter technique used by Haldane and Hall (1991) to measure financial integration in SACU. The model is specified in state-space form with the following signal equation:

$$lnr_{i,r} - lnr_{SA,t} = \alpha_{i,t} + \beta_{i,t}(lnr_{SA,t} - lnr_{US,t}) + \varepsilon_t,$$
$$\varepsilon_{i,t} N(0, V) \quad (1)$$

The state equations are specified as follows:

$$\alpha_{i,t} = \alpha_{i,t-1} + \xi_t \quad E\left[\log(p_t^2)\right] N(0, Q)$$

$$\beta_{i,t} = \beta_{i,t-1} + \mu_t \quad \mu_{\tilde{t}} N(0, V), \quad (2)$$

where $r_{SA,t}$ represents the treasury bill rate of a dominant economy in the SACU, that is, South Africa, while $r_{US,t}$ refers to the treasury bill rate of an external dominant economy represented by the United States of America (US). $r_{i,t}$ stands for the treasury bill rate of country i in the SACU area at time t. Equation (2) makes it possible to measure the degree of financial integration in the SACU region, as well as determine which anchor treasury bill rate is more important at the particular point in time between the South African and US rates. Equation (1) is transposed in $r_{i,t}$ to get:

$$r_{i,t} = (1 - \beta_{i,t})\, lnr_{SA,t} + \beta_{i,t}\, lnr_{US,t} - \alpha_{i,t} - \varepsilon_{i,t}. \quad (3)$$

It can be seen from equation (3) that as $\beta_{i,t}$ decreases in value towards zero, the individual country treasury bill rate would be increasingly determined by the South African treasury bill rate suggesting a high *intra-SACU* financial integration. Conversely, as $\beta_{i,t}$ approaches unity, the US influence dominates. In order to ascertain whether there is evidence of financial integration among members of SACU, the study tests the following hypothesis:

$$H_0: \beta_{i,t} = 0. \quad (4)$$

Model 2. Modelling financial instability in SACU.

A different specification of the Kalman Filter model is used to measure stochastic volatility of the treasury bill rate for all SACU countries over the sample period. In this case, stochastic volatility is estimated to measure the evolution of financial instability over the sample period. The study measured time-varying volatility for the SACU region with a specific objective of assessing the impact of external shocks such as the 2007/08 global financial crisis. The Kalman Filter is applied to a state-space model that is derived from the stochastic differential equation which is usually used to model the instantaneous risk free rate of interest (see Appendix B for details). Francois-Eric and Raymond (2010) specify the state-space model as follows:

$$\log(r_t^2) = -1.27 + \eta_0 + h_t + \xi_t, \quad (5)$$

$$h_t = \lambda_0 + \lambda_1 h_{t-1} + \varepsilon_t, \quad (6)$$

where $\log(r_t^2)$ is the log of the square of the treasury bill rate at time t and h_t is the conditional volatility. Equation (5) is an observation (signal) equation and equation (6) is a measurement (state) equation. The Kalman Filter model follows a three-stage procedure which involves forecasting, updating and estimation of parameters. The study estimates the state-space model given in equations (5) and (6) and tests the hypothesis defined by:

$$H_0: \lambda_0 = 0. \quad (7)$$

3. Data analysis

3.1. Time-varying financial integration in SACU. *3.1.1. Unitroot test results.* The study employs two unit-root tests to study the time-series properties of the treasury bill rate data that was used to estimate the Kalman Filter model. The two tests are the Augmented Dickey Fuller (ADF) and the Philips-Peron (PP) tests. The tests tend to complement each other well to increase the robustness of the results because they are individually often criticized for low power. The findings show that all variables are integrated of the first order i.e. I (1) stationary (see Appendix D). As a result, they are used in their first differences in the estimations.

3.1.2. Discussion of results. Table 2 reports the results for the average coefficients for the entire sample period for the estimations using both level data and first differences. The results for first differences are not significant at 10 percent level of statistical significance. However, in terms of magnitude, the average β for Lesotho and Namibia is close to zero. This indicates that financial integration between Lesotho and Namibia and South is very high. The average β is a little higher compared to zero for Swaziland and Botswana, but still remains far away from unity. Moreover, the hypothesis that $\beta_{i,t} = 0$ cannot be rejected at 10 percent level of statistical significance. It can, therefore, be concluded

that there is evidence of deep financial integration within SACU. Nevertheless, this study focuses on the evolution of financial integration over time captured by time-varying β reported in Figure 1.

Table 2. Financial integration in SACU

Country	Levels		First differences	
	α	β	α	β
Lesotho	0.0306* (4.4758)	-0.0213* (4.4758)	-0.0002 (-0.098)	0.0044 (0.2705)
Namibia	-0.0009 (-0.2456)	-0.0009 (-0.2456)	5.57E-05 (0.0517)	0.0047 (0.4638)
Botswana	0.3682* (5.3912)	0.3682** (5.3912)	-0.0028 (-0.4064)	0.0308 (0.6412)
Swaziland	0.0703* (6.0509)	0.0703* (6.0509)	-0.0008 (-0.3388)	0.0169 (0.8568)
Log likelihood	991.614		1747.355	
AIC	-9.368		-16.645	
SIC	-9.240		-16.517	
No. of obs	210		209	

Notes: * and ** denotes significant at 1% and 5% levels of significant and *z*-statistics are in parenthesis. Convergence was achieved after 500 iterations using the Marquardt maximum likelihood method.

Figure 1 shows that β is negative prior to 1996 which indicates that both intra and extra-SACU financial integration was weak during this period. This indicates a degree of financial segmentation during the period likely due to the political uncertainty that marred the region, especially the hegemonic economy of South Africa, prior to 1994. Nevertheless, the post-1996 period saw an improvement because the value of β hovers very closely between zero and one i.e., $0 < \beta < 1$, this suggests a high degree of financial integration characterised by three episodes over the period 1996 to 2011.

The first episode spans the period 1996-2001. During this time all members of SACU, with the exception of Namibia, are more financially integrated with the US than with South Africa because the value of the β approaches unity. This is the time when most SACU countries implemented CAL. For example, Botswana introduced limited relaxation of the capital account in 1998 which was followed by full convertibility of the capital account in 1999. Botswana manifests the highest degree of integration with the US than the rest of the countries and only begins to converge to SACU in 2003. SACU member-countries which are also members of the common monetary area (CMA) manifest the lowest degree of financial integration with the US. It can be noted that Namibia is consistently integrated with South Africa, followed by Lesotho and then Swaziland. Moreover, the introduction of CAL in Lesotho in 2003 does not appear to have deepened financial integration between Lesotho and the rest of the world. This is because by this time, Lesotho had already converged to the CMA-club in 2002.

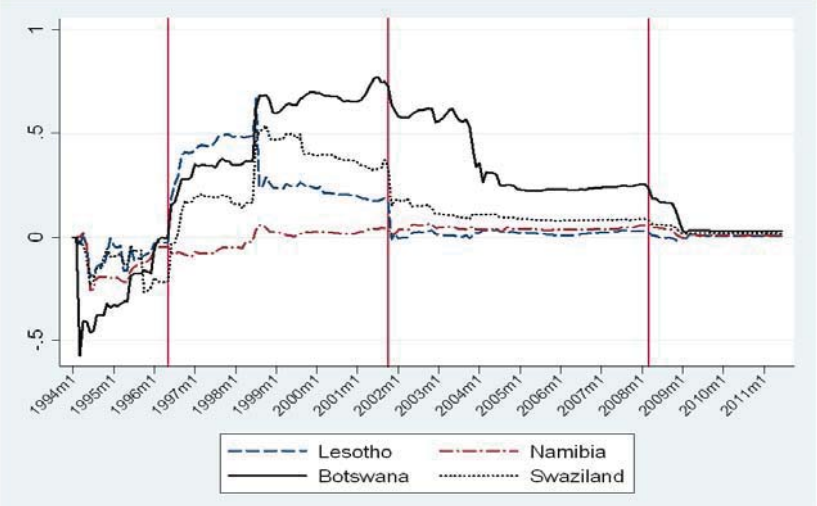

Fig. 1. Intra- and extra-SACU financial integration

The second episode covers the period 2002 to 2008. During this time, the integration among the members of the CMA gets deeper and Botswana also converges significantly towards this group particularly from 2003. The third episode covers 2009 to 2011. Figure 1 reveals that the level of financial integration

in the entire SACU deepened following the 2007/08 global financial crisis that emanated from the US. The β converges very closely to zero and highlights that financial integration within SACU intensified significantly during this period.

3.2. Financial stability in SACU. The results for the estimation of stochastic volatility of members of SACU are reported in Table 3. The results reject the hypothesis defined by $\lambda_1 = 0$. The average value of thecoefficient of volatility is significant at 1 percent level of significance which shows evidence of high stochastic volatility in the union. Since the focus of this study is on the dynamics of volatility over the sample period. Figure 2 reports results for the time-varying value of stochastic volatility for all the coun tries in SACU.

Table 4. Stochastic volatility model

SACU member state	λ_1	Root *MSE*	*z*-statistic	*p*-value
Botswana	7.752*	0.879	8.822	0.000
Lesotho	7.715*	0.757	10.193	0.000
Namibia	7.746*	0.761	10.178	0.000
SA	7.652*	0.771	9.924	0.000
Swaziland	7.812*	0.769	10.164	0.000
Log likelihood	-1938.414	Akaike info criterion		18.556
Parameters	10	Schwarz criterion		18.716
Diffuse priors	5	Hannan-Quinn criter		18.621

Notes: * Denotes significant at 1 per cent level. Convergence was achieved after 500 iterations using the Marquardt maximum likelihood method.

The results for the estimation of time-varying stochastic volatility are presented in Figures 2 and 3 for the CMA and SACU, respectively. It can be observed that the CMA countries are sensitive to external shocks. In Figure 2, there are about seven instances where volatility increased for all the four member countries of the CMA as reflected by the humps of the stochastic volatility curves. The first one is noted in July 1997 where volatility increased to reflect the impact of the Asian crisis. Radelet and Sachs (1998) indicate that the Asian crisis was caused by a haphazard and partial liberalisation process followed by the affected countries and not necessarily their financial openness. This observation underscored the importance of a gradual and well-guided process of CAL instead of an abrupt and disorderly approach. The second instance is observed in August 1998. This period corresponded to the devaluation of the *ruble* by the Russian government and defaults on domestic debt which precipitated a financial crisis in the country. The third one is a mild increase noted in September 2001. This reflected the mild effect of the negative economic effects of the 9/11 attacks in the US which resulted in massive insurance loses.

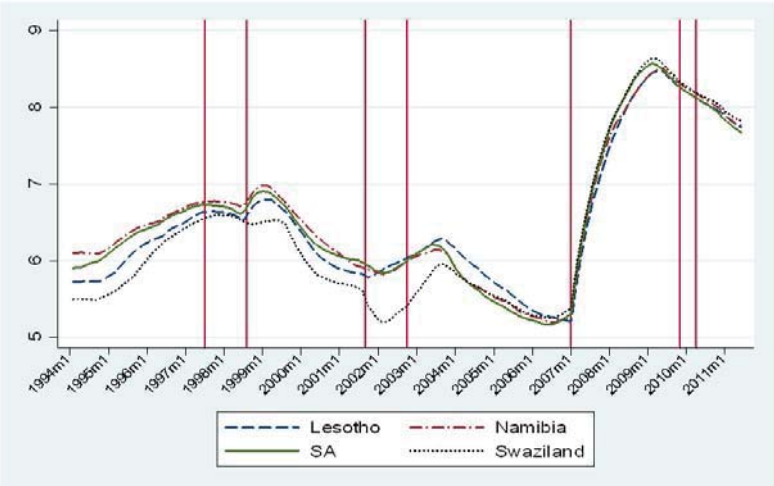

Fig. 2. Stochastic volatility in CMA

The fourth event occurred in October 2002 when significant declines in stock prices were realised in stock exchanges in the US, Canada, Asia and Europe reaching their levels during the Asian financial crisis in 1997. The fifth event is quite pronounced because it triggered the largest increase in volatility in all SACU countries (see Figure 3). This is the period of the 2007 global financial crisis that emanated from the US as a result of subprime lending and credit default swaps and swept across the world even reaching the SACU region. This crisis in particular highlighted the importance of a good and effective regu-

latory and supervisory apparatus which should be harmonized across integrating countries. Following this drastic increase in volatility, things improved in 2009. However, the sixth event is marked by a small rise in volatility in November 2009 during the Dubai debt standstill. The last event is the European sovereign debt crisis which also had a mild effect on stochastic volatility in SACU as reflected by the small rise in April 2010. The CMA turns out to be the mossusceptible to external shocks indicating that the deeper the level of financial integration in a region, the higher the risk of financial instability arising from external shocks. In general, Botswana is an outlier in SACU as Figure 3 attests. This country's stochastic volatility increased with those of the other SACU member countries only in two instances, namely: the 9/11 attack in the US (2001) and the 2007 global financial crisis. This may suggest that the public debt management in Botswana is better than in the other countries or that there is a lower debt dependency in this country.

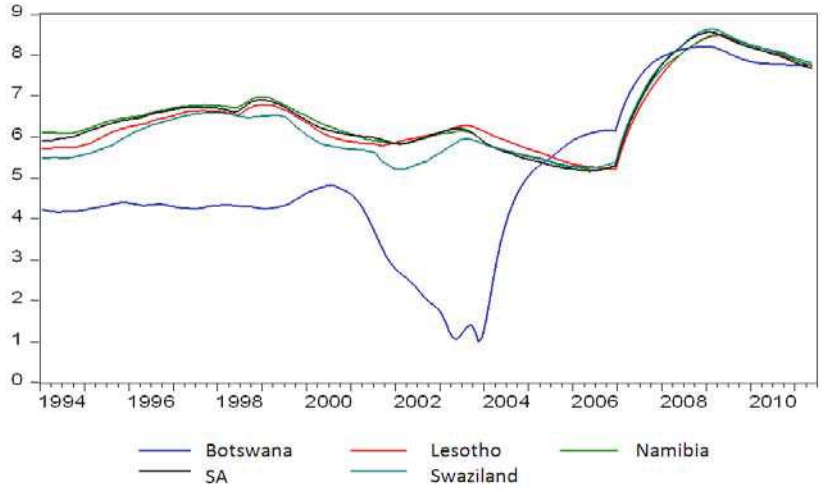

Fig. 3. Stochastic volatility in SACU

Conclusions

Key findings and policy implications. The study set out to test two hypotheses; the first one is that there is no intra-SACU financial integration, and the second one is that there is no evidence of financial instability, captured by stochastic volatility, in the region. The results provide evidence of intra-SACU financial integration which has actually deepened over the years especially in the aftermath of the 2007/08 global financial crisis. The depth of financial integration is highest within the CMA. There is also some evidence of *extra-SACU* financial integration particularly in the late 1990s and early 2000s. The pre-1996 period is characterised by financial market segmentation likely due to the political uncertainty that affected South Africa the strongest member of SACU, prior to 1994. The second hypothesis is rejected at 1 percent level of significance. This provides evidence of significant effects of external shocks on stochasticvolatility in the union indicating that such negativeshocks in crease financial instability. The CMA turns out to be the most susceptible to external shocks indicating that the deeper the level of financial integration in the region, the higher the risk of financial instability arising from external shocks. The results have two key implications for policy. *First*, the example of the political ostracism of South Africa before 1994 shows that political stability is crucial for deeper financial integration. *Second*, countries that embrace financial integration should formulate and implement sound macroeconomic, regulatory and supervisory polices to mitigate any adverse impact of financial integration on financial stability.

Agenda for future research. Given that there is evidence of time-varying financial integration and stochastic volatility, it is important to investigate the causal relationship between financial integration and instability in the context of SACU. This study proposes this as an area for future research.

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Appendix A. Kalman Filter

The Kalman Filter technique suggested by Haldane and Hall (1991) and specifies a state-space model with the following signal equation:

$$lnr_{i,r} - lnr_{SA,t} = \alpha_{i,t} + \beta_{i,t}(lnr_{SA,t} - lnr_{US,t}) + \varepsilon_t, \qquad \varepsilon_{i,t}\, N(O,V) \tag{8}$$

The state equations are specified as follows:

$$\alpha_{i,t} = \alpha_{i,t\text{-}1} + \xi_t \quad \tilde{\xi}_t\, N(0,\, Q),$$

$$\beta_{i,t} = \beta_{i,t\text{-}1} + \mu_t \quad \mu_{\tilde{t}}\, N(0,\, V). \tag{9}$$

We can write the above system of equations in vector notation as:

$$Y_t = \tilde{\delta}\, Z_t + \tau_t, \tag{10}$$

$$Z_t = AZ_{t\text{-}1}\ \tilde{A} + k_t. \tag{11}$$

Z_t is a vector of unobserved time-varying parameters $[a_t, \eta_t]$ which is determined by the state equation, δ is a vector of the constant and A is an identity matrix which can take a number of forms that represent an autoregressive process of the first order. The error terms are identically independently distributed (*IID*):

$$\tau_t \times IID \times (0,\, \sigma^2) \text{ and } K + IID \times (0,\, Q). \tag{12}$$

α_t and η_t vary over time according to a random walk process. The Kalman Filter defines Z_t as a vector of state variables at time t and P_t as a covariance matrix of the state vector. Thus based on data available at time $t-1$, the best estimate of Z_t i.e. $Z_{t/t\text{-}1}$ and its corresponding mean square error (MSE) are defined as:

$$Z_{t/t\text{-}1} = AZ_{t/t\text{-}1}, \tag{13}$$

$$P_{t/t\text{-}1} = AP_{t\text{-}1}\,\tilde{A}\ + Q. \tag{14}$$

On the basis of equation (13), the one-step-ahead prediction of the state variables is the product of the transition matrix A and Z_t. The one-step-ahead prediction error of the measurement μ_t and its MSE ϕ_t is calculated as:

$$\mu_t = Y_t - \tilde{\delta}\, Z_{t/t\text{-}1}, \tag{15}$$

$$\phi_t = \delta\, P_{t/t\text{-}1}\ \tilde{\delta}\ + \sigma^2. \tag{16}$$

Once Y_t has been observed, the one-step-ahead of the state variables is calculated by taking into account new information as it becomes available. The μ_t contains new data about Z_t beyond the information contained in $Z_{t/t\text{-}1}$. Therefore, the state variables and their corresponding MSE can be calculated as:

$$Z_t = Z_{t/t\text{-}1} - P_{t/t\text{-}1}\,\tilde{\delta}\,\phi_t^{-1}\,\delta\ \mu_t, \tag{17}$$

$$P_t = P_{t/t\text{-}1} - P_{t/t\text{-}1}\,\tilde{\delta}\,\phi_t^{-1}\,\delta\ P_{t/t\text{-}1}. \tag{18}$$

The Kalman Filter performs the iterative process from equations (13) through (18). The error terms τ_t and k_t are assumed to be normally distributed and the following sample log likelihood is used to estimate the unknown parameters of the system of equations:

$$\log L = \frac{nT}{2}\log 2\pi \sum_{t=1}^{T}\log\left|\phi_t\right| - \frac{1}{2}\sum_{t=1}^{T}\mu_t\phi_t^{-1}\mu_t. \quad (19)$$

Appendix B. Derivation of a state-space

One of the important aspects of the Black and Scholes (1973) model is that of unconditional volatility which was based on the assumption of constant volatility of the return of a financial asset over time. The concept of unconditional volatility led to the use of the conventional standard deviation of stock returns as an empirical measure of their volatility. Francois-Eric and Raymond (2010) note that over time, it became clear that the variance of returns varies with time. The Kalman Filter is one of the methods that can be used to estimate this conditional or stochastic volatility. The theoretical departure point is to model the instantaneous risk free rate of interest r_t as a stochastic differential equation (SDE) represented in equation (20):

$$d(\log(r)) = \frac{dr}{r}\mu dt + \sigma(t)\, dz_t. \quad (20)$$

Mills (1999) show that the stochastic process in equation (20) can be written in discrete form as follows:

$$r_t = \mu + \sigma_t p_t, \quad (21)$$

where $p_t = \frac{(r_t - \mu)}{\delta_t}$ and follows a standard normal distribution. $r_t = \Delta\log(r_t)$. The conditional variance of r_t is variable over time and is defined by:

$$Var\left(\frac{r_t}{\sigma_t}\right) = Var(\mu + \sigma_t p_t) = \sigma_t^2. \quad (22)$$

The conditional standard deviation of r_t is σ_t and this can be used to define the conditional volatility of r_t, this can be called h_t. According to Mills (1999) the distribution of the conditional volatility h_t. is a lognormal distribution. It is defined as:

$$h_t = \log(\sigma_t^2) = \lambda_0 + \lambda_1 h_{t-1} + \varepsilon_t, \quad (23)$$

where, $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$. Equation (23) can be written for r_t. This can be done by combining equation (21). Since, $h_t = \log(\sigma_t^2)$ then the conditional standard deviation becomes $\sigma_t = \sqrt{e^{h_t}} = e^{\frac{h_t}{2}}$, thus r_t can be expressed as:

$$r_t = \mu + p_t\, e^{\frac{h_t}{2}}. \quad (24)$$

Mills (1999) assumes that $\mu = 0$ since the daily mean return and the intra-day returns of stocks and currencies tends to average zero. Equation (24) is linearized by taking the square of r_t and taking its natural logarithm to get:

$$r_t^2 = p_t^2\, e^{h_t}, \quad (25)$$

$$\log(r_t^2) = \log(p_t^2) + h_t. \quad (26)$$

Since $p_t \sim N(0,1)$, then the distribution of $\log(p_t^2)$ is a logarithmic chi-square (X^2) distribution with $E\left[\log p_t^2\right] = -1.2704$ and $var\left[\log p_t^2\right] = \frac{\pi^2}{2} = 4.93$. Francois-Eric and Raymond (2010) show that for small samples the parameters of this distribution tend to deviate from the mean value of -1.27 and variance of 4.93, and in order to incorporate these facts into the model, they add and subtract $E\left[\log(p_t^2)\right]$ in equation (26) to get:

$$\log(r_t^2) = E\left[\log(p_t^2)\right] + h_t + \left\{\log(p_t^2) - E\left[\log(p_t^2)\right]\right\}. \quad (27)$$

Equation (27) can be simplified and written as follows:

$$\log(r_t^2) = \eta_0 - 1.27 + h_t + \xi_t, \quad (28)$$

where $\xi_t \sim X^2(-1.27, 4, 93)$ and $\xi_t \sim X^2(-1.27, 4.93)$ $\xi_t = \log(p_t^2) - E(\log(p_t^2))$.

The constant η_0 is added to account for the deviation from -1.27 as such a tendency is observed in small samples. Putting this information together, Francois-Eric and Raymond (2010) specify the state-space model by combining equations (28) and (23), to arrive at:

$$\log(r_t^2) = -1.27 + \eta_0 + h_t + \xi_t, \tag{29}$$

$$h_t = \lambda_0 + \lambda_1 h_{t-1} + \varepsilon_t. \tag{30}$$

Equation (29) is an observation (signal) equation and equation (30) is a measurement (state) equation. The estimation of the Kalman filter follows a three-stage procedure which involves forecasting, updating and estimation of parameters. E-views 7 was used to perform the estimation.

Appendix C

Table 1A. The definition of variables

Variable	Definition
SABO	The differential between the treasury bill rate of SA and Botswana
SALE	The differential between the treasury bill rate of SA and Lesotho
SASWA	The differential between the treasury bill rate of SA and Swaziland
SANA	The differential between the treasury bill rate of SA and Namibia
SAUS	The differential between the treasury bill rate of SA and US computed using the interest rate parity condition
r^2	The square of the treasury bill rate

Appendix D

Table 2A. Unitroot test results (first differences)

	ADF		*PP*		Decision
	Critical value	*t*-stat	Critical value	Adj. *t*-stat.	
*SA**	-4.003	-8.562	-4.003	-8.537	I(1)
*SABO**	-4.003	-9.220	-4.003	-6.973	I(1)
*SANA**	-4.003	-12.241	-4.003	-15.697	I(1)
*SASWA**	-4.003	-12.687	-4.003	-15.927	I(1)
*SALE**	-4.003	-14.122	-4.003	-17.834	I(1)
*SAUS**	-4.003	-11.731	-4.003	-10.835	I(1)

Notes: * Denotes stationary at 1% level of significance.