Current Account Deficits and Sustainability: Evidence from South Africa

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Abstract

This paper investigates current account sustainability in South Africa using stationarity and cointegration approaches to assessing intertemporal solvency - where intertemporal solvency implies current account sustainability. The contribution in this paper are four-fold. First, we consider a key emerging market, South Africa, that runs persistent current account deficits that might leave the economy vulnerable to macroeconomic destabilisation. Second, the study utilises both stationarity and cointegration approaches for a consensus in results, where existing literature uses one or the other. Third, this study considers nonlinear methods in its evaluation, and to our knowledge, all studies evaluating South Africa, and most global literature, rely on linear methods. Lastly, we use three specifications of the current account in the cointegration approach for robust results, whereas existing studies tend to use a single specification. Stationarity of the current account to GDP ratio is assessed through linear unit toot tests; ADF, PP, KPSS, DFGLS, ZA unit root tests, and nonlinear KSS (ESTAR) and Sollis (AESTAR) unit root tests. The cointegration approach relies on the linear Engle-Granger, Johansen, Maki, ARDL tests, and nonlinear ARDL (NARDL) tests, on exports - imports, and investments – savings variables. The tests are applied to three data samples for robust results: annual data between 1946-2021, full quarterly data 1960Q1-2021Q4, and short quarterly data 1985Q3-2021Q4. The study consistently finds mean reversion properties through linear unit root tests on annual and full quarterly data. Contrastingly, sustainability cannot be established through linear unit root tests for the short quarterly data but is established through nonlinear KSS (ESTAR) and Sollis (AESTAR) unit root tests. This finding suggests that the current account to GDP ratio of South Africa is a nonlinear but stationary process in the short term. Furthermore, we consistently find cointegration in annual data through the Engle-Granger and Johansen tests, while cointegration is only found when incorporating breaks through the Maki test for quarterly data. Based on the DOLS and ARDL estimators, we are able to find evidence of strong current account sustainability. Still, this result is highly dependent on sample, current account components under consideration, and model specification, with short quarterly data resulting in a non-sustainability conclusion, whereas annual data over a longer time frame gives a sustainability conclusion. Lastly, we find evidence of asymmetric cointegration on utilising the NARDL on short quarterly data, with the conclusion that the current account is sustainable when asymmetries are considered.

J*EL* classification: F32

Keywords; Current account sustainability; Cointegration; Stationarity; Nonlinear methods.

List of Tables

List of Figures

List of Acronyms

ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lag
EMEs	Emerging Market Economies
ECM	Error Correction Model
DFGLS	Dickey-Fuller Generalized Least Squares
DOLS	Dynamic Ordinary Least Squares
ESTAR	Exponential Smooth Transition Autoregressive
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
IBC	Intertemporal Budget Constraint
KPSS	Kwiatkowski, Phillips, Schmidt, and Shin
NARDL	Nonlinear Autoregressive Distributed Lag
OLS	Ordinary Least Squares
PP	Phillips Perron
SARB	South African Reserve Bank
ZA	Zivot Andrews

Contents

1. Introduction

Global imbalances, and more especially persistent current account deficits, have grown to be a topic of interest and concern in academic literature and fields of economics. This interest is fuelled by the relevance of imbalances in numerous contentious topics in economics, where studies highlight the adverse effects of current account imbalances on other economic phenomena of interest. These topics include, among others, currency and financial crises, fiscal deficits, and growing external debt (Adalet & Eichengreen, 2007; Baharumshah et al., 2003; Belke & Dreger, 2011; Catão & Milesi-Ferretti, 2014; Salvatore, 2006; Vamvoukas, 1999), trade protectionism and trade wars (Hubbard, 2006; Liu & Woo, 2018; Sheng et al., 2019), and real estate markets and asset booms (Aizenman & Jinjarak, 2009; Laibson & Mollerstrom, 2010). A prevalent concern on current account imbalances is the sustainability of current account deficits, particularly for emerging market economies that tend to be underesearched in current account literature. It is in light of this, that this study undertakes to assess the sustainability of persistent current account deficits.

Concerns on current account imbalances and the sustainability of current account deficits are warranted, since a growing current account deficit represents an accumulation of liabilities owed to the rest of the world, which cannot be owed in perpetuity and must ultimately be repaid (Hassan et al., 2015). Thus, a dominant strand of literature explains sustainability through solvency and assessing whether the economy meets its intertemporal solvency constraint. Milesi-Ferretti and Razin (1996) suggest a country can be considered solvent if the present value of its future trade surpluses equals the current value of its external liabilities. A country running current account deficits would have to run surpluses in the future to meet obligations arising from the period it ran deficits (Mann, 2002). This highlights the need to run current account deficits for growth-generating investments to realise future surpluses instead of a consumption-driven current account deficit (Klemm, 2013). Otherwise, an ever-growing current account deficit without the associated growth can lead to insolvency and exposes the economy to risks, vulnerabilities and destabilisation that can leave the economy in a precarious economic state.

Such risks, vulnerabilities and destabilisation take various forms. For example, the current account balance (amongst other economic variables) signals an economy's macroeconomic and financial health to domestic and foreign investors. Therefore, a high and persistent current account deficit can paint a gloomy picture of the state of an economy and discourage investment, as investors question a country's debt position and ability to honour external debts – hence posing a question on solvency (Sakyi & Opoku, 2016). Through the effect on investor sentiment and solvency fears, an unsustainable current account deficit can increase a country's risk of bankruptcy by impacting its credibility, creditworthiness, and ability to access capital markets – i.e. an effect on liquidity (Gnimassoun & Coulibaly, 2014; Hassan et al., 2015). Liquidity encompasses whether an economy does not experience sharp reductions of capital inflows financing the deficit, a process termed sudden stops (Edwards, 2007). Liquidity is closely related to and reinforces solvency because an insolvent economy raises fears and concerns that can create illiquidity due to investor sentiments and reactions. Hence, illiquidity and insolvency would further affect an economy's ability to service its external debt liabilities resulting in a debt-ridden economy, which can frustrate its development and growth efforts.

Countries might even hike interest rates to attract capital to finance their current account deficit or preserve existing capital (Hakkio, 1995). However, this similarly contributes to creating an unfriendly domestic environment for local firms who face high borrowing costs, ultimately constraining economic activity and the economy's competitiveness (Cuestas, 2013), i.e., a rise in interest rate appreciates the economy's currency, which dampers exports. In the long run, an economy, subject to its exchange rate regime, might have to devalue its currency to ensure competitiveness. At the same time, interest and debt repayment burdens are placed on future generations, compromising their living standards (Wu, 2000; Wu et al., 1996). Liquidity constraints might encourage reliance on foreign exchange reserves to fund a current account deficit or service external debt. However, this limits how economies can regulate their exchange rates, as depletion or pressure on foreign reserves can lead to foreign exchange crises (Obstfeld et al., 2010).

Additionally, withdrawal of private financing, current account reversals (or a sharp reduction in current account deficits), and sudden stops on the backdrop of unsustainable current account positions might lead to an abrupt trimming of government expenditure (Ghosh & Ramakrishnan, 2006). Such adjustments further impact investment spending and consumption as the current account deficits unwind to facilitate debt repayment. This can depress the economic activities of countries experiencing such reversals. Furthermore, trimming government expenditure impacts the government's provision of services and goods to its citizens to the detriment of their welfare. Lastly, the withdrawal of financing by external investors leaves economies vulnerable to exogenous shocks, like market sentiment of foreign investors, which can destabilise the financial and real sectors of the economy (Baharumshah et al., 2003).

The consequences of withdrawn capital are not just economic since the threat of withdrawal of financing can impact a country's political strategies and national security. For example, the threat of economic sanctions by the United States of America (the US hereinafter) on the United Kingdom (the UK hereinafter) affected the military strategies of the UK and saw it withdrawing from the Suez canal invasion of 1956. This is because the UK was one of the countries in conflict for dominance of the trading sea route, and the US held UK bonds and thus controlled capital flows to the UK (Forbes et al., 2017). Thus, by threatening access to foreign financing, part of which funded the UK's current account, the US could influence the country's military actions in the conflict. The effects of other reversals and sudden stop disruptions include; restricted and adverse impacts on real economic growth and domestic production, currency crises and rapid depreciation to the exchange rate – affecting external debt service, inflationary pressures, a fall in asset prices, and a significant drop in a country's employment rate (Chari & Kehoe, 2003; Edwards, 2004; Hutchison & Noy, 2006).

Although current account reversals and sudden stops can occur for other reasons, for example; the deterioration of the economy encouraging capital flight; more attractive interest rates in industrial economies causing reversals in developing and emerging economies; changes in macroeconomic policies; and a shift in governance lowering investor confidence in the economy; studies find that countries with large persistent and unsustainable deficits are more likely to experience reversals and sudden stops in capital inflows, with the aforementioned consequences (Adalet & Eichengreen, 2007; Milesi-Ferretti & Razin, 2000; Pancaro & Saborowski, 2016). Therefore, an economy with a large and persistent current account deficit is more likely to experience a currency crisis (Edwards, 2002). Hence, understanding current account dynamics and the sustainability of current account deficits is crucial for sound macroeconomic management and financial practice, as unsustainable current account deficits impact economic welfare in various ways.

Despite the need for a sufficient understanding of current account sustainability on the backdrop of the detrimental effects that current account deficits pose for open economies, much of the debates and literature on sustainability have been skewed towards industrialised and developed regions and economies. One such economy of interest is the US. Sustainability concerns for this economy are due to its status in the global economy and the widespread use of the US dollar as a reserve currency. Specifically, concerns are about what the possible unwinding of the country's sizeable and unprecedentedly significant current account deficits would mean for the stability of the global economy (Perelstein, 2009). US current account deficits remain unparalleled in absolute value, reaching $846 billion in 2021 from a moderate surplus of $2.85 billion in 1991.

Similarly, recent current account surpluses run by countries like China bring attention to imbalances, as they are referenced in trade protectionist sentiment and by the political leadership in the US, causing trade tensions. This is due to China's surpluses continuously financing US deficits (Sheng et al., 2019; Taylor, 2012). However, Blanchard and Milesi-Ferretti (2012) argue that economic adjustments around current account surpluses tend to be smoother, less abrupt and disruptive to domestic economies. Hence they generally tend to be of lesser concern in academic literature. Additional countries receiving widespread consideration include OECD and EU countries due to their prominent standings in the global economy (Afonso et al., 2019; Chen, 2011, 2014; Holmes et al., 2010).

While limited coverage has been afforded to emerging markets and developing economies compared to developed countries, East Asian and South American countries, including Mexico, have received some consideration. These economies experienced abrupt current account and international capital flow reversals in the 1990s, where significant current account deficit positions preceded these reversals and crises (Andreosso-O'Callaghan & Kan, 2007; Baharumshah et al., 2003, 2005; Milesi-Ferretti & Razin, 1999). The Mexican and East Asian crises have signified the need for prudent and proactive assessments of emerging and developing market economies.

To bridge this gap, this study aims to contribute to current account sustainability literature by conducting a case study of an emerging market economy. In particular, this study will focus on South Africa. South Africa has run persistent current account deficits from the early 2000s that have widened from moderate current account deficits under 1% of GDP in 2003Q3 to 7% of GDP by 2013Q3. At the time (2013), of the "fragile five[1]" economies, South Africa's current account deficit was eclipsed only by that of Turkey, which registered current account deficits of 5.8% of GDP on an annual basis (against South Africa's annual current account deficit of 5.3% of GDP). Additionally, South Africa had the most significant current account deficit to GDP ratio compared to fellow emerging market trading partners from BRICS[2]. A similar pattern of South Africa running the largest or second largest current account deficit among emerging economies presents itself between 2003 and 2008 and as recently as between 2014 and 2019, based on data from World Bank (2022). Hence, South Africa tends to run one of the largest persisting current account deficits of comparable countries and trading bloc partners.

[1]At the time, these were emerging market countries (Brazil, India, Indonesia, Turkey, South Africa) considered vulnerable to changing global conditions, due to their relatively large foreign financing needs.

[2]BRICS (Brazil, Russia, India, China, South Africa)

South Africa also exhibits macroeconomic destabilisation associated with unsustainable current account deficits. Such characteristics include; high inflationary pressures, episodes of recessions, exchange rate volatility, and volatility in capital flows. Lastly, South Africa has been a recipient of hot money inflows and is over-reliant on external markets for their financing due to limited domestic financing avenues. As such, the country is vulnerable to external sector developments. Hence, current account positions deemed unsustainable can have destabilising macroeconomic effects on South Africa's access to capital flows, financing for its current account deficits, and impact its citizens' economic welfare. These features make South Africa an appropriate case study.

This study makes several contributions to the existing empirical literature. First, an analysis of South Africa contributes to studies on current account dynamics of emerging market economies. As noted earlier, more efforts have been directed at developed economies due to their prominent standing in the global economy. However, for emerging markets, the sustainability of their current account positions is equally important, especially since weak current account positions leave emerging market economies vulnerable to exogenous shocks. Therefore, proactive current account assessments are necessary for sound macroeconomic management.

Tests of intertemporal solvency through cointegration and stationary methods are the predominant method of assessing current account sustainability. However, available studies on developed and emerging economies alike usually fail to reach a consensus on sustainability due to using different testing approaches. For example, Wu et al. (1996) find the US current account unsustainable through cointegration methods, contrary to Taylor (2002)'s finding for the US through stationary tests. Similarly, within the cointegration approach, Holmes and Panagiotidis (2009) find the US current account sustainable through the Johansen cointegration approach, contrary to the unsustainable result found by Wu et al. (1996) using the Gregory-Hansen cointegration test. Additionally, in so far as literature has considered emerging markets, most do so in panel studies (Baharumshah et al., 2005; Lau et al., 2006), and South Africa is no exception to this (Chu et al., 2007; Holmes et al., 2003). While this is welcome, given the increased testing power provided by panel methods (Chen, 2011; Lau et al., 2006), it however offers generalised contexts, especially for policy implications. It can be misleading to generalise emerging market economies research, as country-specific characteristics like institutions and political structures can affect the reactions of economies to external sector developments (Irandoust & Ericsson, 2004). Due to differing economic contexts, fundamentals and environments, there is a need for an individual country study in South Africa to account for its specific economic contexts.

To the best of our knowledge, only three studies have undertaken country-level analysis on South Africa, and all use cointegration methods (none use stationarity methods). Arize (2002) utilises the Johansen cointegration test, whereas Searle and Touna-Mama (2010) use the Engle-Granger test. However, neither of these tests can endogenously detect breaks in the cointegrating relationship of variables; thus, these studies have exogenously determined breaks to improve their model fit. Unfortunately, exogenous detection of breaks leaves results susceptible to bias (Christiano, 1992; Zivot & Andrews, 1992). Stungwa and Mosikari (2023) correct for these with a Maki cointegration analysis, as it endogenously considers structural breaks. However, Stungwa and Mosikari (2023) only rely on annual data spanning a short period of time period (1980 to 2021), which limits their comprehensive view of South Africa's current account. Additionally, annual data might submerge current dynamics that might be assessed easier with higher frequency data. Lastly, none of the studies consider nonlinear dynamics in their evaluation.

To resolve these, we consider both cointegration and stationarity approaches to assessing the intertemporal solvency - hence the sustainability of South Africa's current account. Utilising both approaches is a rigorous attempt at finding a consensus on the sustainability of current account deficits in South Africa. Moreover, we consider a plethora of single-country tests in either approach. The stationarity tests utilised include the ADF, PP, KPSS, DFGLS, ZA, KSS (ESTAR), and Sollis (AESTAR) tests, while the cointegration tests include the Engle-Granger, Johansen, Maki, ARDL, and NARDL tests. The Maki test is utilised to endogenously consider breaks in the cointegrating relationships, while the KSS, Sollis, and NARDL are utilised to consider nonlinear dynamics in relationships. The latter is due to the increasing consideration of nonlinear dynamics in modelling macroeconomic relationships, where the use of these tests in current account literature has been limited. These methods are applied to an annual sample 1946-2021, and quarterly samples 1960Q1- 2021Q4, and 1985Q3 – 2021Q4, where utilising various samples allows for the robustness of results. The stationarity methods are applied to the current account to GDP ratio, while cointegration evaluations are run on export and imports, and savings and investment.

Overall, results suggest current account sustainability is a long-run phenomena, as we tend to find current account sustainability in the annual and long quarterly data, and not the short quarterly sample. However, we find asymmetries to play a significant role in the results found on short quarterly samples. To be precise, stationarity in the 1985Q3-2021 data set is only achieved once nonlinearities are considered, as the process follows nonlinear mean reversion. The rest of the samples are found to follow linear mean reversion. In a similar fashion, cointegration tends to hold for long-run data, with the short quarterly data consistently failing to present with cointegration, regardless of which current account components are considered, or model specifications (for exports and imports). Lastly, there is limited evidence of strong current account sustainability, as the coefficient of cointegration tends to be significantly different from 1, but positive. This is indicative of weak current account sustainability.

The remainder of this paper is divided into seven sections. Section 2 discusses an overview of South Africa's economy, emphasising the country's current account trends and components. Section 3 reviews theoretical frameworks and empirical literature on current account sustainability. Sections 4 and 5 discuss the research methods and data, Section 6 discusses empirical findings, and Section 7 provides the conclusion.

2. Background

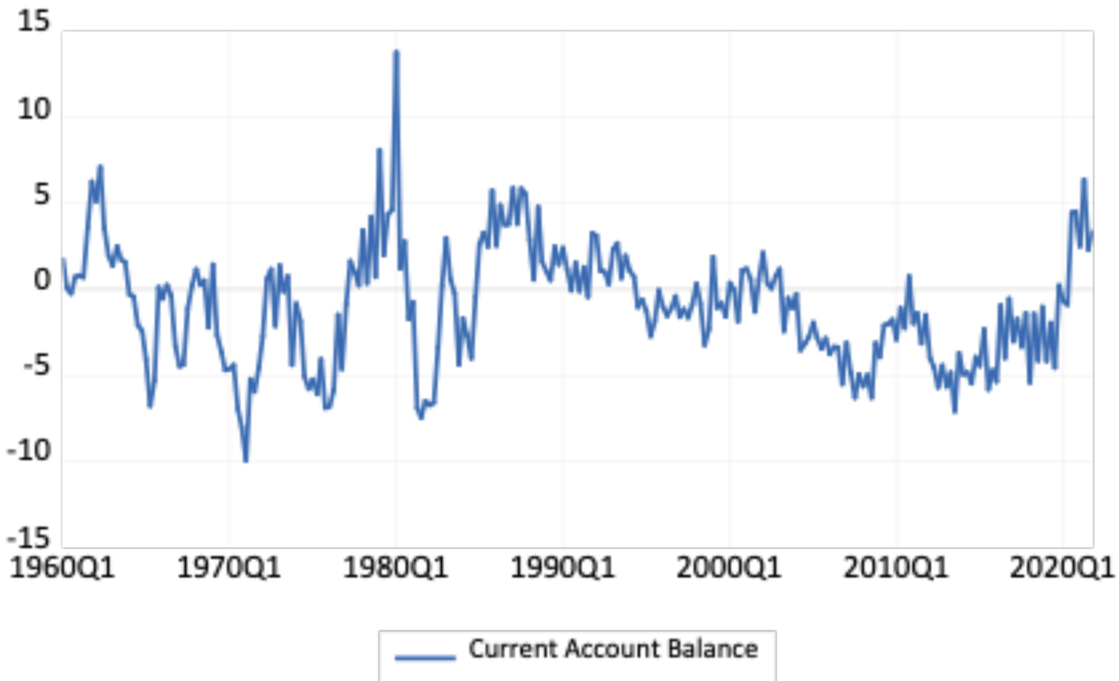
South Africa's current account balance has been declining from surplus since the late 1980s, developing a tendency to remain in the deficit range since the country transitioned to democratic independence in 1994. Indeed, the economy has experienced persistent current account deficits post-1994, moving from moderate deficits of 0.6% of GDP in 1994Q4 to 7.1% of GDP in 2013Q3, as shown in Figure 1. Figure 2 present an evaluation of South Africa's current account balance and the components of its current account over the years. Based on these figures, it is evident that shortfalls in the primary account have driven the country's persistent current account deficits from 2003. However, the size of the current account has depended mainly on how well the trade (goods and services) balance performs, as surpluses in the trade balance have either contracted the current account deficit or turned it into surplus, i.e., when the trade balance turns deficit (surplus), so does the current account.

A closer inspection of the current account and its components in Figure 2 reveals that trade surpluses characterised the period leading to democratic independence in South Africa. This was driven by the growth in the country's manufactured exports (Bell et al., 1999) as the government adopted an export-oriented trade policy regime (Edwards & Schoer, 2001). In addition, austerity measures adopted by the end of 1984 (Harris, 1986) might explain why the economy registered small current account surpluses before attaining democratic independence in 1994, as shown in Figure 1. This current account surplus period was also accompanied by capital outflows from South Africa. Political factors such as sanctions placed on the country due to its apartheid regime made it an unattractive target for investments (Draper & Freytag, 2008).

With the abandonment of apartheid for democratic governance in 1994 and capital account liberalisation in 1995, South Africa saw increased foreign capital flows to its borders. Transitioning from apartheid meant South Africa no longer had the socio-political factors that made the country unappealing to investment[3]. Additionally, the financial liberalisation and reforms following the end of apartheid saw increasing openness in the capital account. Consequently, these led to an increase in inflows that led to the start of South Africa's small

[3]Draper and Freytag (2008) postulate these political factors, and not some utility maximisation processes, were responsible for the country's current account developments in the late stages of the apartheid rule of governance in the country.

Figure 1: Current Account as % of GDP (1960Q1 – 2021Q4)



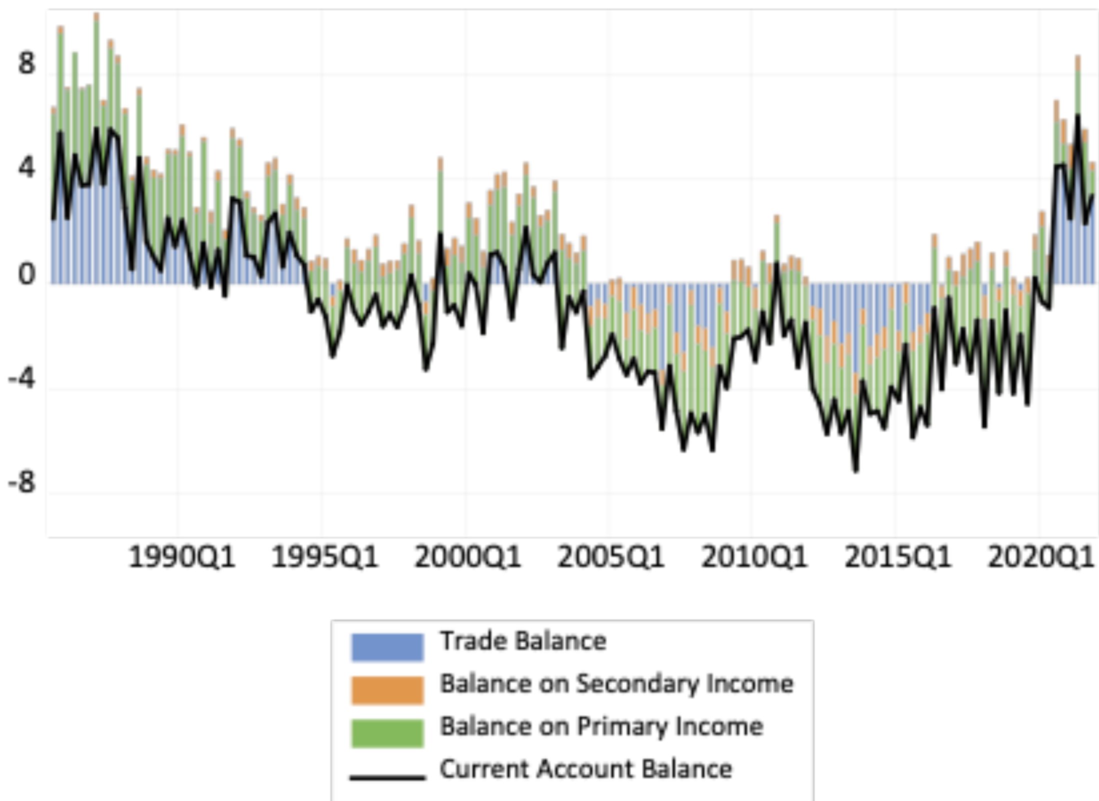
Source: Author's compilation using data from South African Reserve Bank (SARB, 2022)

current account deficits post-1995, as shown in Figure 1.

South Africa would run these small current account deficits, which were of minimal concern until 2001 and 2002 when the country experienced small full-year current account surpluses of about 0.2% and 0.8% of GDP, respectively – breaking the annual current account deficit trend in place since 1994. The current account surpluses over these two years were due to financial contractions from the global economic slowdown in 2001, worsened by the terrorist attacks in the US on the 11th of September 2001 (Draper & Freytag, 2008).

The year 2003 marked the start of South Africa's persistent current account deficits, as shown in Figure 1 and Figure 2. Decomposing the current account balance into its components reveals that South Africa's current account deficits from 2003 are driven by the persistent shortfall in its current account primary incomes. To be precise, because the primary account is persistently in shortfall, the current account has remained in the deficit. However, deteriorations in the trade balance have exacerbated the current account deficit (2003-2008 and 2012-2015), while favourable terms of trade have either contracted the deficit (2009-2011 and 2015-2019) or turned the current account surplus (2020-2021).

Figure 2: Components of the Current Account as % of GDP (1985Q3 – 2021Q4)



Source: Author's compilation using data from South African Reserve Bank (SARB, 2022)

In the presence of persistent and widening shortfalls in the income accounts, the onset of the current deficit in 2003 was due to the reduction in the trade surplus. Reduction in the trade surplus was driven by appreciations in the exchange rates, which dampened exports and encouraged more imports in the face of growing domestic demand (SARB, 2004). This trend would proceed in 2004, resulting in the trade balance slipping into a persistent deficit for the first time in over a decade, as shown in Figure 2. As a result, by 2008Q3, the current account deficit had widened to 6.3% of GDP in contrast to the moderate surplus of 1.2% of GDP in 2003Q1.

The economic slowdown due to the global financial crisis of 2008 led to reduced domestic demand – turning the goods and services balance into a surplus. As a result, the current account deficit narrowed from 6.3% of GDP in 2008Q3 to a moderate surplus of 0.76% of GDP in 2010Q4 through a deficit reversal. This was South Africa's first quarterly current account surplus since 2003Q1. However, this contraction was short-lived, with the current account reverting into a deficit in the next quarter and ultimately reaching unprecedented deficit levels in over two decades at 7.1% of GDP in 2013Q3. This was due to unfavourable terms of trade turning the balance on goods and services into their lowest deficit recorded in more than twenty years at -2.1% of GDP (SARB, 2013). The current account deficit has since contracted due to the surplus from the goods and services account, with the current account deficit reaching 2.5% of GDP in 2019. Furthermore, the rise in prices for commodity exports accompanied by a sharp decline in imports in 2020 and 2021 led to a surplus in goods and services (SARB, 2021a), shifting the current account positions to surplus positions of 2.0% and 3.7% of GDP in 2020 and 2021 respectively.

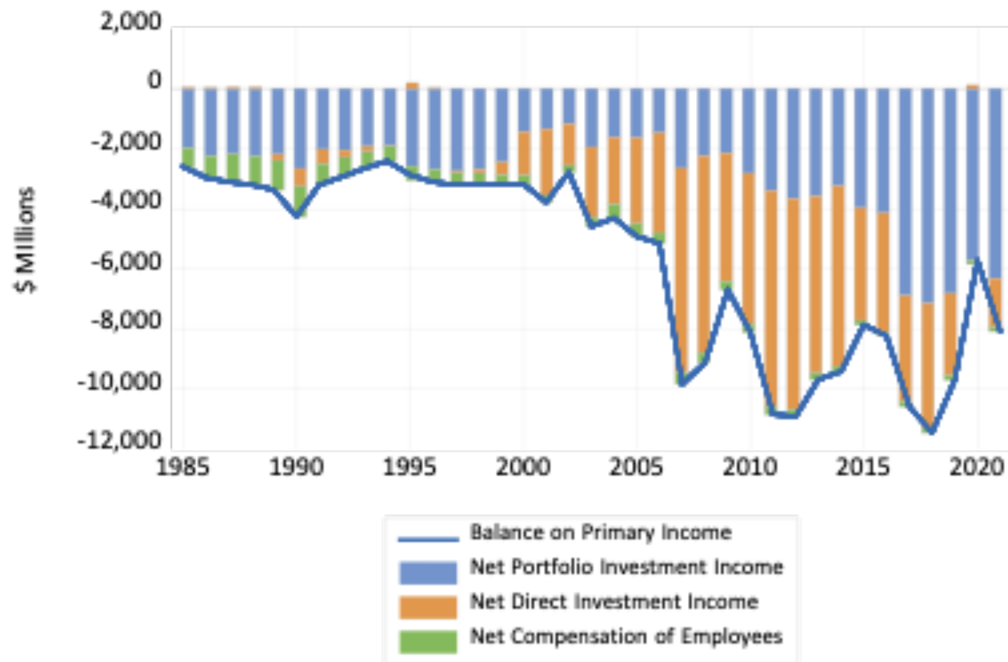
While the dynamics in trade-related components are interesting, given their significant influence on the current account, primary incomes of the current account have significantly ensured the current account remains in the deficit. Primary income comprises of incomes related to employee compensation and investment incomes (direct investment and portfolio investment incomes). Therefore, persistent outflows due to interest and dividend payments (either paid out to direct investors or portfolio investors) have mainly driven the shortfall in the balance of primary incomes. Figure 3 presents a breakdown of the balances in the primary incomes, where notably, between 2000 and 2015, outflows were mainly due to direct investment payments. In other periods, outflows were due to large portfolio payments.

The fragility of a country's current account position is intrinsically tied to the sources of finance for its current account. Current account deficits (surplus) are offset by financial account surpluses (deficits); thus, governments finance current account deficits through foreign capital inflows. South Africa is no exception, as its increasing current account deficits since 2003 have been funded by financial account surpluses fuelled by foreign investment capital inflows. A glance at the breakdown of the different types of capital flowing into South Africa in Figure 4 reveals that portfolio flows and other investments (comprised mostly of bank flows) have been the main driver of South Africa's capital movements since 2009.

However, unlike direct investments, portfolio flows are considered a risky source of financing as their short-term speculative nature makes them more volatile. Figure 4 further highlights this vulnerability with portfolio investments, as around 2008, at the height of the global financial crisis, there was an outflow of portfolio investment due to market-driven sentiment. In contrast, foreign direct investments withstood the economic turmoil and recorded inflows.

Moreover, direct investments are usually desirable as they can contribute to the development of an economy, as the sharing of knowledge, skills and technology can facilitate economic growth. Hence, the vulnerabilities posed by the composition of inflows funding the current

Figure 3: Composition of Primary Incomes of the Current Account (1985 – 2021)



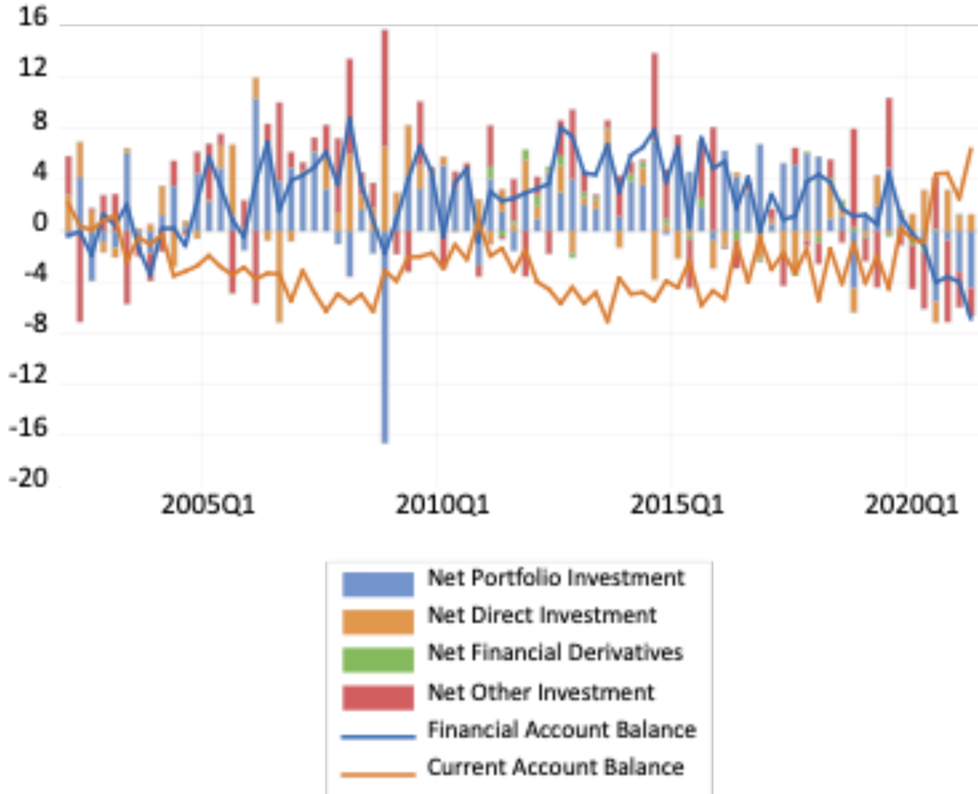
Source: Author's compilation using data from South African Reserve Bank (International Monetary Fund, 2022b)

account deficit in South Africa, where the economy tends to attract more portfolio-related investments, have contributed to concerns about the sustainability of the current account (Searle & Touna-Mama, 2010; Strauss, 2017).

Additionally, the reliance on foreign capital for financing leaves the country vulnerable to debt crises. South Africa's gross debt to GDP ratio increased from 30.7% in 2004 to 51.7% in 2018. This includes an increase in non-resident holdings of national government bonds, which has more than doubled from the less than 20% recorded in 2004 to the 42.8% recorded in 2018 (Arslanalp & Tsuda, 2014; SARB, 2021b). At the same time, the annual GDP growth rate trended downwards from 4.6% in 2004 to 0.1% by 2019, highlighting a generally low growth environment. This leaves the country vulnerable, as its debt levels are rising, whereas a significant portion of its bonds are in foreign hands over a low-growth environment.

With regular unfavourable terms of trade and persistent shortfalls in primary incomes, South Africa's current account balance has remained in the deficit range for most of the 2003 to 2019 period as highlighted, turning surplus in 2020 and 2021 only because of slowed economic activity. This current account deficit has been critical in seeing South Africa's attempts at

Figure 4: Composition of Capital flows as % of GDP (2002Q1 – 2021Q2



Source: Author's compilation using data from South African Reserve Bank (SARB, 2022)

developing its economy, where financing for such exploits has mainly been through foreign portfolio inflows. However, such inflows have proven to be a source of vulnerability as they are fickle, as evidenced by the quick outflows observed in 2008. Furthermore, with periods of rising foreign bond holdings of government debt in a low growth environment, South Africa's national budget is increasingly dependent on foreign inflows, leaving the economy vulnerable to external sector developments. With these increasingly worrisome indicators and the International Monetary Fund (2022a) estimating and projecting South Africa's current account will revert to the deficit range in 2022 and 2023 at 1.2%, and 2.0% of GDP, respectively, an understanding of the sustainability of South Africa's current account remains a question of paramount importance.

Given the use of the current account as a measure of economic and financial health (amongst other uses), the persistence of South Africa's current account deficits in the presence of the above-noted developments can prove detrimental to the economy. This can be through lowering investor confidence, impacting capital flows to the economy through reversals and sudden stops, which can lead the economy through painful adjustments, as elaborated previously. Hence, there is a need for a current account sustainability assessment for the economy. Accordingly, the following section considers current account sustainability literature to inform our analysis.

3. Literature Review

3.1 Theoretical Framework

The sustainability of current account deficits is best considered through the intertemporal approach to the current account in contrast to two other current account approaches; the elasticities approach and the absorption approach.

The elasticities view emphasises price elasticities demand for exports and imports through exchange rate changes. It mainly highlights the significance of exchange rates in current account adjustments and current account determination (Chuku et al., 2017; Obstfeld & Rogoff, 1995). The main drawback of this approach is that it only considers traded goods in the economy. Hence, it only offers a partial equilibrium view of the current account (Oshota & Badejo, 2015). In contrast, the absorption approach suggests a savings-investment view of the current account. It maintains that the determination of current account balances also depends on an economy's income and expenditure – where these will influence its lending and borrowing decisions (Alexander, 1952; Obstfeld & Rogoff, 1995). Thus, it offers a more inclusive view of the current account than the elasticities approach, as it also considers financial transactions in the determination of the current account. However, the absorption approach does not consider agents' optimising behaviour in evaluating the current account, a drawback that the intertemporal approach accounts for.

The intertemporal view incorporates the main arguments of these different views. It simultaneously considers relative pricing in the current account, recognising the effect pricing has on savings and investment decision-making, and macroeconomic factors in borrowing and lending decisions, as suggested and adopted by the elasticities and absorption approaches, respectively (Obstfeld & Rogoff, 1995). In addition, the intertemporal view considers forward-looking aspects of economic agents' decision-making, which the other two views fail to account for (Gandolfo, 2004). This aspect makes the intertemporal views more appealing than both the elasticities and absorption approaches. Finally, the sustainability question is concerned with the optimisations of current account balances over time and the consequences of agents' decisions on the current account balances. As a result, this study focuses on the intertemporal view, as this view considers the evolution of the current account over time. Alexander (1952) and Gandolfo (2004) provide summaries and derivations for the elasticity and absorption approaches.

Intertemporal frameworks assume economic agents are forward-looking, where their saving, consumption and investment decisions, amongst others, stem from expectations of future periods' economic activity. Expectations include those on the evolution of future productivity growth, real interest rates, and demand, amongst other economic variables (Obstfeld & Rogoff, 1995; Sachs, 1981). Agents care about consumption; therefore, intertemporal optimisation happens through the current account, which is considered a tool for consumption smoothing purposes (Campa & Gavilan, 2011). Investment and consumption can be maintained or smoothed over time (hence, intertemporal) by lending and borrowing from external markets, allowing agents to make utility-maximising decisions. As such, current account deficits or surpluses are a consequence or outcome of the intertemporal optimisation decisions made by households, firms, and governments (Sachs et al., 1981), where such optimisations depend on permanent income fluctuations (Nason & Rogers, 2006; Taylor, 2002). These intertemporal choices and optimisations are restricted by and a result of the interactions of intertemporal budget constraints (IBC) (Sachs, 1981).

Since rising current account deficits imply rising external debt, most studies analyse the theoretical notion of current account sustainability by examining the solvency of the economy through its intertemporal budget constraints (Mann, 2002). Scholars, investors and policymakers alike can utilise the economy's intertemporal budget constraint to assess the macroeconomic health of its current account. The intertemporal budget constraint is similarly based on assumptions of perfect capital mobility and consumption smoothing behaviour (Lanzafame, 2014). A current account deficit (surplus) is sustainable when the IBC is satisfied, as that suggests an economy expects sufficient future current account surpluses (deficits), which can offset its initial net indebtedness (credit position) (Taylor, 2002; Wickens & Uctum, 1993). Such an economy would smooth its consumption, and its current account would typically behave like a stationary variable. If the economy's IBC holds, the current account can be considered mean-reverting, and an equilibrium level of the current account can be achieved. As a result, a country can service the interest on its external debt using trade surpluses (Taylor, 2002). In the absence of impediments to capital flows, like stringent capital controls, the current account would tend to sum to zero over time (Irandoust & Sjöö, 2000). Hence, meeting the IBC is evidence of solvency and, thus, sustainability. On the other hand, violation of the IBC would imply insolvency and lack of mean reversion as an economy will not meet its external debt obligations (Chen, 2011).

Theory adopts two approaches to assess the IBC for current account sustainability. First, analysis can be through directly testing mean reversion and, thus, the stationarity of the current account, as suggested by Trehan and Walsh (1991). Stationarity of the current account would imply intertemporal solvency and, thus, current account sustainability. Alternatively, assessing the long-run relationship or cointegration of components of the current account, as indicated by Husted (1992), can offer insight into the sustainability of the current account. Cointegration between components of the current account implies they will never drift too far apart, ensuring equilibrium in the current account is maintained. As a result, the economy meets intertemporal solvency and thus has a sustainable current account.

3.1.1 Stationarity Approach

Trehan and Walsh (1991) suggest directly assessing the stationarity of the current account for mean reversion properties. This approach relies on analysing the stationarity of the past realisations of the current account, where Trehan and Walsh (1991) suggest that the stationarity of the current account is sufficient to ensure that the intertemporal budget constraint holds. Mean reversion associated with the stationarity of the current account suggests an eventual correction of current account imbalances to their long-run equilibrium path (Lau et al., 2006). Any deviations in current account balances would be considered temporary or transitory; thus, countries with stationary current accounts have no incentive to default on external debt obligations or take corrective measures in the near future (Chen, 2011; Cuestas, 2013; Lau et al., 2006). As such, a historically stationary current account provides an optimistic outlook on the future evolution of the current account and better predicts how the current account will develop, given the stability of its data-generating process.

In contrast, a current account with a unit root lacks mean reversion, and current account shocks would have permanent effects. Moreover, shocks to nonstationary time series can be permanent, changing long-run levels of current accounts and the path to meeting IBC (Lau et al., 2006). Thus, a current account with a unit root would have an explosive debt level, where deficits will tend to increase in the long run. In the absence of economic reforms and interventions, this would lead to excessive debt accumulation (Cuestas, 2013).

Trehan and Walsh (1991) abstract from an open economy's budget constraint in equation 3.1 below;

$$C_t + I_t + G_t + B_t = Y_t + (1 + r_t)B_{t-1} \tag{3.1}$$

where C_t, I_t, G_t, B_t are consumption, investment, government expenditure, and net foreign assets or stock debt, respectively. Y_t is the economy's income while r_t is the world interest rate. Equation 3.1 simplifies to equation 3.2 below;

$$B_t = (1 + r_t)B_{t-1} + Y_t - C_t - I_t - G_t = (1 + r_t)B_{t-1} + NX_t \tag{3.2}$$

Or

$$B_t = (1 + r_t)B_{t-1} + NX_t \tag{3.3}$$

where NX_t is net exports, and $NX_t = Y_t - C_t - I_t - G_t$.

By recursively solving equation 3.3 we get the following forward-looking solution;

$$
\begin{aligned}
&B_t = (1 + r_t)B_{t-1} + NX_t \\
&B_{t+1} = (1 + r_{t+1})B_t + NX_{t+1} \\
&B_{t+2} = (1 + r_{t+2})B_{t+1} + NX_{t+2} \\
&B_{t+2} = (1 + r_{t+2})[(1 + r_{t+1})B_t + NX_{t+1}] + NX_{t+2} \\
&B_{t+2} = (1 + r_{t+2})(1 + r_{t+1})(1 + r_t)B_{t-1} + (1 + r_{t+2})(1 + r_{t+1})NX_t + (1 + r_{t+2})NX_{t+1} + NX_{t+2}
\end{aligned}
$$

Iterating for n periods ahead and making B_{t-1} the subject we get

$$
\begin{aligned}
B_{t-1} = &- \frac{NX_{t+n}}{(1 + r_{t+n})(1 + r_{t+n-1}) \ldots (1 + r_t)} - \frac{NX_{t+n-1}}{(1 + r_{t+n-1}) \ldots (1 + r_t)} - \ldots - \frac{NX_t}{(1 + r_t)} \\
&+ \frac{B_{t+n}}{(1 + r_{t+n})(1 + r_{t+n-1}) \ldots (1 + r_t)}
\end{aligned}
$$

Lastly, assuming the agent's information set available at the beginning of period t is captured by ϕ_{t-1}, Trehan and Walsh (1991) let $R_t = 1 + r_t$ such that $E(R_{t+i} \mid \phi_{t-1}) = R$ for all $i \geq 0$. Thus, the realized gross rate of return $(1 + r_t)$ is denoted by R_t, and its expected value is shown by R. Hence, we get the following intertemporal budget constraint.

$$B_{t-1} = -\sum_{j=0}^{\infty} R^{-(j+1)} E(NX_{t+j} \mid \phi_{t-1}) + \lim_{j \to \infty} R^{-(j+1)} E(B_{t+j} \mid \phi_{t-1}) \tag{3.4}$$

The following transversality or no-Ponzi game condition can be imposed;

$$\lim_{j \to \infty} R^{-(j+1)} E(B_{t+j} \mid \phi_{t-1}) = 0 \tag{3.5}$$

Equation 3.4 implies that an economy's creditors lend to the economy if they expect its future surpluses to equal its foreign debt (Christopoulos & León-Ledesma, 2010) or similarly that foreign debt (credit) must be offset by an economy's expected future surpluses (deficits) (Chen, 2011). However, this implication stands provided the condition in equation 3.5 is satisfied. Equation 3.5 is a long-run budget constraint showing that as t tends to infinity, the present discounted value of future stock assets converges to zero (Taylor, 2002). This is a no-Ponzi game restriction that prevents perpetually rolling over debt but ensures the ultimate repayment of creditors (Karunaratne, 2010). Moreover, this restriction prevents a scenario where debt repayment is made from new external borrowings.

Given the current account as a change in net foreign assets, $CA_t = B_t - B_{t-1}$, stationarity is a sufficient condition for equation 3.5 to hold (Taylor, 2002; Trehan & Walsh, 1991). If the economy experiences positive growth rates, then the stationarity of the current account is sufficient to ensure that the IBC is met (Trehan & Walsh, 1991). Hence, current account sustainability holds if the current account to output ratio is stationary (Chen, 2011), and this requires the stationarity of y_t in equation 3.6 below;

$$y_t = \left(\frac{CA_t}{Y_t} \right) \tag{3.6}$$

where CA_t and Y_t are the current account balance and the economy's income, respectively. Thus y_t is the ratio of the current account balance to income level.

In theory, this implies a perpetual current account deficit remains sustainable and poses no threats of future drastic corrections and adjustments, provided that the obligations do not grow faster than output (Christopoulos & León-Ledesma, 2010; Trehan & Walsh, 1991). Sustainability holds as there is a constant finite debt to GDP ratio in the long run (Chen, 2011). Hence, the current account remains sustainable, provided the current account deficit does not outgrow the expected output (Wu et al., 1996). Failure to find stationarity in a current account plagued with persistent deficits implies a lack of mean reversion, and perpetuation of such behaviour in the future could lead to bankruptcy and disfavour from international capital markets (Christopoulos & León-Ledesma, 2010). The above does not imply that a nonstationary current account will have an imbalance that cannot be corrected. An unexpected intervention or correction can restore the current account to equilibrium (Christopoulos & León-Ledesma, 2010), for example, through adjustments to the exchange rates or investment patterns.

While the stationarity approach focuses on a direct measure of the current account to establish its sustainability, an alternative approach considers the cointegration of the current account components. The intuitive idea behind the cointegration approach is that a long-run relationship between current account components ensures the current account remains in equilibrium.

3.1.2 Cointegration Approach

In contrast to directly assessing the current account's stationarity, Husted (1992) draws from works by Hakkio and Rush (1991b) on fiscal deficits and suggests evaluating the IBC through the cointegration of components of the current account, specifically exports (inflows) and imports net primary and secondary income payments (outflows)[4].A long-run relationship between these variables ensures deviation from equilibrium in the current account will be temporary since its components move together, i.e., the flows never drift too far apart in the long run. As a result, the economy remains intertemporally solvent, and the current account remains sustainable. This contrasts with a lack of cointegration in inflows and outflows, where the resulting divergence can exacerbate the current account deficit.

Husted (1992) proposes a simple economic model that considers a representative agent in a

[4]Imports hereafter refers to a measure adjusted for current account incomes and transfers unless stated otherwise.

small open economy who can freely lend and borrow externally to satisfy their consumption and saving needs, maximising their utility subject to budget constraints. In the absence of government spending, the representative agent suggested by Husted (1992) has the following single-period budget constraint:

$$C_t = Y_t + B_t - I_t - (1 + r_t)B_{t-1} \tag{3.7}$$

where C_t, Y_t, I_t are current consumption, output, and investment expenditure, respectively. r_t is the world's one-period interest rate, B_t is international borrowing and $(1 + r_t)B_{t-1}$ denotes the agent's initial debt representing a country's accumulated foreign debt.

The constraint in equation 3.7 can similarly be rearranged and expressed in international borrowing B_t as follows;

$$-B_t = Y_t - C_t - I_t - (1 + r_t)B_{t-1} \tag{3.8}$$

The trade balance can be represented as $TB_t = X_t - M_t = Y_t - C_t - I_t$ to denote income minus absorption where X_t (income) and M_t (absorption) are exports and imports respectively. Consequently, equation 3.8 simplifies as follows;

$$-B_t = TB_t - (1 + r_t)B_{t-1}$$

$$B_t = -TB_t + (1 + r_t)B_{t-1} \tag{3.9}$$

Through forward iteration and recursive substitution of equation 3.9, the following is derived;

$$
\begin{aligned}
B_t =& -TB_t + (1+r_t)B_{t-1} \\
B_{t+1} =& -TB_{t+1} + (1+r_{t+1})B_t \\
B_{t+2} =& -TB_{t+2} + (1+r_{t+2})B_{t+1} \\
B_{t+3} =& -TB_{t+3} + (1+r_{t+3})B_{t+2} \\
B_{t+3} =& -TB_{t+3} - (1+r_{t+3})TB_{t+2} - (1+r_{t+3})(1+r_{t+2})TB_{t+1} + (1+r_{t+3})(1+r_{t+2})(1+r_{t+1})B_t \\
&\vdots \\
B_{t+n} =& -TB_{t+n} - (1+r_{t+n})TB_{t+n-1} - \ldots - (1+r_{t+n})(1+r_{t+n-1})\ldots(1+r_{t+2})TB_{t+1} \\
&+ (1+r_{t+n})(1+r_{t+n-1})\ldots(1+r_{t+1})B_t
\end{aligned}
$$

Rearranging the last equation and making B_t the subject, we get:

$$
\begin{aligned}
B_t =& \frac{TB_{t+n}}{(1+r_{t+n})(1+r_{t+n-1})\ldots(1+r_{t+1})} + \frac{TB_{t+n-1}}{(1+r_{t+n-1})\ldots(1+r_{t+1})} \\
&+ \ldots + \frac{TB_{t+1}}{(1+r_{t+1})} + \frac{B_{t+n}}{(1+r_{t+n})(1+r_{t+n-1})\ldots(1+r_{t+1})}
\end{aligned}
$$

Lastly, iterating forward into an infinite time horizon, i.e., as n approaches infinity, the following expression for the economy's intertemporal budget constraint is derived;

$$
B_t = \sum_{i=1}^{\infty} \mu_i TB_{t+i} + \lim_{n\to\infty} \mu_n B_{t+n} \tag{3.10}
$$

where

$$
\mu_i = \prod_{j=1}^{i} \left(\frac{1}{1+r_{t+j}} \right)
$$

The economy's intertemporal budget constraint in equation 3.10 suggests the economy's external lending (borrowing), B_t, equals the discounted value of its future trade surpluses (deficits), $\sum_{i=1}^{\infty} \mu_i TB_{t+i}$, provided the second right-hand term is zero (Husted, 1992). In this case, the economy would remain solvent. Intuitively, the present value of future external debts of a solvent country tends to zero in the long run, i.e., $\lim_{n\to\infty} \mu_n B_{t+n} = 0$ (Gnimassoun & Coulibaly, 2014). Setting $\lim_{n\to\infty} \mu_n B_{t+n} = 0$ is a no-Ponzi game condition. Two non-optimal scenarios arise if the limit is non-zero, violating the economy's IBC. A non-zero limit where $\lim_{n\to\infty} \mu_n B_{t+n} < 0$ could result in a scenario where external debt borrowings exceed the present value of its future trade balances. In this instance, the economy bubble finances its debt as it relies on more loans to refinance its existing external debt (Husted, 1992). The economy would operate under a Ponzi scheme and tend to roll over its debt. Alternatively, under a non-zero limit where $\lim_{n\to\infty} \mu_n B_{t+n} > 0$, the present value of the economy's future trade balances could exceed the country's external debt. This is similarly not optimal, as the economy makes Pareto inferior decisions (Husted, 1992). Theoretically, assessing sustainability requires investigating whether the limit in equation 3.10 sums to zero.

Husted (1992) assumes the world interest rate is stationary and then expresses the IBC in exports and imports for a testable model that analyses the cointegration between these two components of the current account. A cointegration relationship between exports and imports implies the co-movement of the two variables, hence a long-run equilibrium. Exports and imports would not permanently diverge or drift apart, consequently satisfying the agent's intertemporal budget constraint and suggesting that the current account is on a sustainable path. The temporary divergence could be due to, for example, productivity gaps or technological shocks (Irandoust & Ericsson, 2004), consequently implying the lack of cointegration due to the persistence of these shocks, if not the effect of policy distortions in the economy (Irandoust & Sjöö, 2000). Cointegration is vital to this assessment as it allows the bubble term in the no-Ponzi restriction to go to zero (Quintos, 1995).

The equation for testing this long-run relationship is as follows;

$$X_t = a + bM_t^* + e_t \tag{3.11}$$

where M_t^* represents the import of goods and services plus interest payments on net debt, while X_t is the economy's exports, and the flows are expressed relative to gross national or domestic product (Husted, 1992). For cointegration, X_t and M_t^* from equation 3.11 are nonstationary I(1) processes, i.e. stationary in first differences. Furthermore, e_t is a stationary I(0) process (Hakkio & Rush, 1991b; Husted, 1992).

The study on fiscal sustainability by Quintos (1995) extends solvency conditions. It suggests that given a positive initial external debt, if $b = 1$ in equation 3.11, there is strong current account sustainability as the economy's IBC will be satisfied. In this case, the economy has a consistent finite foreign debt to GNP ratio. Intuitively, a unity result is a testament to the strength of exports and imports. Quintos (1995) further adds that if $0 < b < 1$, the economy's constraint still holds, but current account sustainability can be considered weak, i.e., a weaker long-run relation between exports and imports. There would be a weak form of current account sustainability as the economy has an incentive to default on external debts (Fountas & Wu, 1999). The less than unity outcome would be inconsistent with a finite debt to GNP ratio. In this scenario, an economy might find it challenging to rely on external markets to finance its debt. Hakkio and Rush (1991b) suggest likewise based on government finance. Policy implications might include raising interest rates to market (Quintos, 1995) its risky debt. If $b > 1$, the economy is in a surplus position, and interest-inclusive expenditures on imports grow slower than the economy's exports (Gnimassoun & Coulibaly, 2014). Lastly, the current account is deemed unsustainable if cointegration does not hold, as the difference between exports and imports grows without restriction. However, it must be noted that the critical condition for meeting intertemporal solvency remains the presence of a cointegrating relationship between imports and exports and not the unity condition (Husted, 1992). Perhaps this might be why studies are less concerned about testing for the unit condition in empirical studies (Arize, 2002).

Intuitively, the presence of cointegration means debt obligations (imports) and revenue income (exports) follow each other. As a result, debts can always be paid by generated income, maintaining the difference between inflows and outflows, as any deviation from this can be considered temporary. In this way, deficits are temporary, and surpluses can be expected later on to restore equilibrium (Irandoust & Ericsson, 2004); hence, there is mean reversion in the development of the current account. Numerous studies, for example, Arize (2002), Wu et al. (2001) abstract from the IBC approach as followed by Husted (1992), where sustainability or meeting the IBC is determined by analysing the co-movement of some of the current account components.

As noted by Liu and Tanner (1996) and Chen (2011), directly assessing the current account ratio for stationarity, as suggested by Trehan and Walsh (1991), has three advantages over the cointegration approach by Husted (1992). Firstly, the stationarity approach is stronger than the cointegration approach, as it imposes a cointegration vector of [1, -1] between exports and imports. Secondly, the cointegration approach requires that the interest rate be stationary, whereas Trehan and Walsh (1991) prove this need not be the case. Lastly, the stationarity approach remains valid without requiring exports and imports to be random walks (Liu & Tanner, 1996). We apply both cointegration and stationary IBC frameworks to assess sustainability despite the advantages of stationarity approaches over cointegration approaches for two reasons. Firstly, the cointegration approach allows for varying measures of current account sustainability, a feature that typically lacks in the stationarity approach. This allows for an assessment of the strength of sustainability, as suggested by Quintos (1995). This contrasts with the stationarity approach that only offers a dichotomous yes or no answer to the presence of sustainability. Secondly, using both methods allows for an opportunity to find a consensus on these approaches and the sustainability of the current accounts run by South Africa. This is motivated by studies finding conflicting results depending on the elected approach of analysis.

Consequently, based on the above theoretical review, the functional form for empirical analysis based on directly assessing stationary as suggested by Trehan and Walsh (1991) is as specified in equation 3.6, i.e. $y_t = \left(\frac{CA_t}{Y_t}\right)$. The ratio y_t is expected to be negative since the current account deficit is a negative flow. However, sustainability is measured based on stationarity; priori expectations are that the current account to GDP ratio is a stationary I(0) process for sustainable current accounts.

Sustainability assessments based on cointegration approaches will depend on imports and exports relative to GDP. The functional form for the empirical analysis is thus as specified in equation 3.11, i.e., $X_t = a + bM_t^* + e_t$, where X_t and M_t^* are stationary at first difference, and the two variables are cointegrated. Additionally, interest rates are assumed to be stationary following Husted (1992).

3.2 Empirical Literature Review

Based on the above theoretical review, stationarity or cointegration approaches can be utilised to assess the mean reversion properties of the current account. Mean reversion of the current account implies intertemporal solvency and, hence, the current account's sustainability. However, findings from the literature on the sustainability of current accounts using either approach have been mixed. This section thus evaluates key studies and identifies the gaps in the literature.

3.2.1 Stationarity Approach

Stationary test approaches have enjoyed usage given their simplicity, testability and theoretical links to the current account. For example, if the current account to output ratio is stationary, it validates the intertemporal view of the current account (Wu, 2000). Furthermore, it confirms the ability of the current account to serve as a buffer for consumption smoothing purposes (Lau et al., 2006). Similarly, mean reversion makes it easier to extrapolate the evolution of the current account based on past realisations of the current account.

Taylor (2002) analyses the sustainability of a group of developed economies using the Augmented Dickey-Fuller (ADF) unit root test by Said and Dickey (1984). The study relies on the time series properties of the current account to GDP ratios of these countries, with annual data approximately between 1870 and 2002. Countries considered in the study include Australia, Canada, France, Germany, Italy, Japan, and the US. The ADF test finds the current account of all countries in the study to be stationary at levels, i.e. the countries' individual ratios are I(0), as the ADF test rejects the null of a unit root against a stationary alternative in all the series. This finding implies the current account balances of these countries satisfy their intertemporal budget constraints and that the current accounts of these countries are on a sustainable path over the period.

Taylor (2002)'s study evaluates data that spans at least a century for most countries. However, the result does not imply that the current accounts of these countries experienced continuous periods of sustainability over the whole sampled period. Indeed, Taylor (2002) finds that some countries' current accounts experienced periods of disruptions. Still, these were short-lived and restricted in amplitude; hence, they were too limited to bring about the nonstationarity that would prevent the countries from satisfying their long-run IBC. The importance of the sampling period becomes significant once we consider contributions by, for example, Gundlach and Sinn (1992) and Jansen (1996), that consider data from periods that are subsamples of the 1870 to 2002 time frame considered by Taylor (2002).

Gundlach and Sinn (1992) exploit data between 1950 and 1988, while Jansen (1996) considers data between 1952/53 and 1991. Both studies utilise data that corresponds with subsamples of the period considered by Taylor (2002). While Gundlach and Sinn (1992) corroborate the findings by Taylor (2002) using the ADF for Australia, France and Italy, they find contrasting results for Canada, Germany, Japan, and the US. Similarly, Jansen (1996) supports Taylor (2002) 's findings for Australia, Germany, France, Japan and the US but differs on findings for Canada. The different results might coincide with the short-lived disturbances mentioned by Taylor (2002), which only seemed insignificant to the overall conclusion of their study due to the more extended period they considered. The sensitivity to data point selection is further demonstrated by the contrasting conclusions reached for Germany, Japan and the US by Gundlach and Sinn (1992) and Jansen (1996) despite their data selection periods differing by around three years.

Lastly, Gundlach and Sinn (1992)'s study finds fewer countries have stationary current account ratios post the breakdown of the Bretton Woods system in 1972. This was because countries had current account targets under the Bretton Woods system and stifled net international capital flows. However, the Bretton Woods system was succeeded by a system of flexible exchange rates, which made it easier for net international capital flows to respond to investment opportunities. Additionally, over the latter system, current account targets were less of a priority (Gundlach & Sinn, 1992). This result highlights the importance of considering macroeconomic developments when assessing the current account sustainability result for more insights on the dynamics of the current account, specifically highlighting the importance of the exchange rate regime in the developments of the current account.

Studies further consider the Phillips and Perron (1988) (PP) unit root test to resolve conflicting results found in their ADF, as the PP outperforms the ADF, especially when using low-frequency data (Choi & Chung, 1995). These studies include; Gundlach and Sinn (1992), whose findings uphold the nonstationary result in Japan, Germany, and the US found by their ADF test; Matsubayashi (2005) who finds stationarity hence sustainability in the US current account using quarterly data between 1965 and 1998; Chen (2011) who finds a unit root in quarterly data from Australia between 1970 and 2009 as well as in New Zealand between 1983 and 2009.

Liu and Tanner (1996) utilise the PP test, in addition to the ADF, on quarterly data between 1970 and 1990 for Canada, Germany, Japan, the UK and the US. These countries' current accounts are unsustainable due to the presence of a unit root in their data. The study further considers the Kwiatkowski et al. (1992) (KPSS) stationarity test, which in contrast to the ADF and PP tests, has a null of stationarity against an alternative of a unit root. The KPSS finds conflicting results as it suggests all countries have a stationary current account except for Canada and Germany. However, Liu and Tanner (1996) further consider the effect of breaks in the data and re-evaluate the presence of unit roots using the ADF and PP tests with discrete breaks. This is motivated by evidence suggesting traditional specifications of unit root tests tend to misclassify stationary processes as unit root processes in the presence of structural breaks. As a result, these tests would tend to mistake the effect of structural breaks as data following a unit root process (Perron, 1989), impairing the ability of tests to ascertain the true data-generating process of a series. As a result, Liu and Tanner (1996) overturned their initial ADF and PP findings, concluding that Germany, Japan and the US had current accounts on a sustainable path in the presence of discrete breaks. Evidence, albeit weaker, also suggests the UK and Canada had sustainable current accounts using both tests. The evaluated breaks correspond with domestic policy shifts in the US around 1983, while breaks for the rest of the countries correspond with the coordinated devaluation of the US dollar around 1984, appreciating the countries' respective currencies between 1985 and 1986, thus leading to a revaluation of their current accounts. Similar to Gundlach and Sinn (1992), the breaks included by Liu and Tanner (1996) are not endogenously determined by the unit root tests.

For emerging and developing economies, Lau et al. (2006) examine the sustainability of the current accounts of Asian-5 countries (Indonesia, Korea, Malaysia, the Philippines and Thailand) using the ADF and KPSS tests. The study further considers the Dickey-Fuller Generalized Least Squares (DFGLS) test by Elliott et al. (1992), which tests a unit root null against a stationary alternative. The sample comprises nominal current account per output quarterly data extrapolated from annual series between 1976-2001 for East Asian countries that experienced large current account deficits before the 1997/1998 Asian financial crises. These countries experienced large capital inflows before the currency crisis, and current account surpluses post the crisis period. The study splits data into pre-crisis and whole period samples. The first avoids currency-related effects, while the entire period includes these effects by also considering post-crisis data. The data split attempts to prevent the sensitivity of results to sampling periods (Lau et al., 2006).

Over the whole sample, Lau et al. (2006) finds evidence of nonstationary current accounts, as the ADF and DFGLS tests fail to reject the null of a unit root, while the KPSS test rejects the null of a stationary current account. To avoid biases in results due to crisis-induced breaks, the study tests pre-crisis data separately with the same tests. It reaches a similar conclusion found over the whole sample. The considered countries had current accounts following a unit root process regardless of the sampling period, which suggests these countries had current accounts that were on an unsustainable path. This finding is corroborated by Yan (1999), who similarly finds these countries in violation of their intertemporal budget constraints before the crisis.

However, the ADF and PP tests are often scrutinised for their limited statistical power, especially in small samples. This would impact the ability of these tests to detect mean reversion properties, especially where convergence to equilibrium is slow (Lau et al., 2006). Furthermore, the tests perform poorly in the presence of breaks in the data-generating process of a series. To address the shortcomings of linear univariate unit root tests, as well as resolve conflicting findings on the sustainability of current accounts, stationarity analysis of the current account balance has evolved in two ways. One strand of literature considers the use of panel unit root tests to benefit from time series properties of data and cross-sectional variations in data, for example, Lau et al. (2006) and Wu (2000). The other strand of literature considers nonlinear based unit root tests, suggesting that traditional linear-based tests yield conflicting results due to misspecifications of the data generating processes in the current account balances, for example, Chortareas et al. (2004) and Clarida et al. (2007).

Wu (2000) utilises the increase in testing power offered by panel unit root tests over univariate linear tests like the ADF. They examine the current account to GDP ratios of 10 OECD and G7 countries using quarterly data between 1977 and 1997 through the Im et al. (2003) (IPS) panel unit root test. The study abstracts from individually assessing unit root tests of countries using the ADF, then for countries where it fails to find stationarity in their current accounts, Wu (2000)proceeds by applying the IPS test. The panel members found to have unit roots based on the ADF, including the UK, Italy, Germany, Japan, and the US. However, they are found to have a stationary current account based on the IPS and thus do not violate their IBC. The study does not include Spain in the panel because the country has a stationary account based on the ADF. Lastly, Wu (2000) advises abstracting from univariate methods like the ADF and utilising panel methods if the ADF fails to reject the null of a unit root.

In this regard, Kalyoncu (2006) considers the sustainability of 22 OECD countries, abstracting from the ADF before utilising the IPS test on annual data between 1960 and 2002. The ADF finds stationarity in countries including the UK, Italy, and Spain. Consequently, they are dropped from the panel analysis. The IPS overturns ADF results, finding the likes of Germany, Japan, and the US to have sustainable current accounts due to rejecting the IPS null of a joint unit root (Kalyoncu, 2006).

Similarly, upon finding nonstationarity in current accounts of Asian-5 countries through ADF and DFGLS unit root tests, Lau et al. (2006) analyse these countries' current accounts through panel unit root tests. The study utilises the IPS and, for confirmation of results, uses panel unit root tests by Harris and Tzavalis (1999) (HT) and Breitung (2001) (UB). The HT and UB panel unit root tests similarly have a null of nonstationary for the panel. Hence the rejection of their null would imply that the current accounts of panel members are stationary, thus consistent with their countries' IBCs. The study finds that pre-Asian financial crisis subsample data (1976Q1-1996Q4) and whole sample data (1976Q1 – 2001Q4) follow mean reversion, implying that the countries' current accounts were on a sustainable path even before the financial crisis. This finding contrasts with linear univariate tests -

which had suggested the pre-crisis and whole period data followed nonstationary processes. The study further considers post-currency crisis data (1997Q1 to 2001Q4) with panel unit root tests to capture the impact of both the crisis and capital outflows. The analysis of this post-currency crisis period was previously omitted when using conventional unit root tests due to power concerns, as the sample period was small. However, the analysis becomes possible due to higher-powered panel unit root tests. The panel unit root tests find that these Asian countries had sustainable current accounts post the currency crisis.

However, the IPS, HT and UB panel unit root tests have a distinctive drawback. They test the joint null that all members in the panel follow a unit root process. This null makes it challenging to learn which members follow a stationary process when the joint null is rejected, as well as understand which members follow a unit root process. Furthermore, the joint null can be rejected by the test if at least one member in the panel follows a stationary process, despite the rest of the members following a unit root process (Taylor & Sarno, 1998), i.e. where a panel has a mixture of I(0) and I(1) members. As a result, it may be misleading to conclude all panel members have a stationary series based on the rejection of the joint null (Chang et al., 2005). This might lead to misleading results when considering whether individual countries' current accounts follow stationary or unit root processes.

Studies like Wu (2000) and Kalyoncu (2006) attempt to correct the drawback of utilising panel tests with a joint null hypothesis. This is done through pretesting all countries' current accounts with the ADF and admitting only series following an I(1) process to the panel. However, the final results still require scrutiny as admission to the panel is contingent on a test already found to have statistical power issues.

To circumvent the restrictions imposed by the joint null, studies like those of Baharumshah et al. (2005), Holmes et al. (2003) and Holmes (2006) assess current account stationarity in panel form through the Seemingly Unrelated Regression Augmented Dickey-Fuller (SURADF) test by Breuer et al. (2002). In contrast to tests that assess the joint null of a unit root, the SURADF has the advantage of testing individual hypotheses for each panel member. It does not impose uniformity in constructing its null and alternative hypothesis, thus allowing for heterogeneity amongst panel members and for inferences to be made on the stationarity of the individual members in the panel data (Breuer et al., 2002). Thus, the SURADF has the advantage of identifying which countries have nonstationary current accounts, as opposed to providing a general conclusion about the stationarity of the panel as a whole (Holmes, 2006).

To allow for heterogeneity among panel members, Holmes (2006) exploits OECD quarterly data for 11 countries between 1980 and 2002 by testing individual countries with the ADF.

Furthermore, the study utilises the IPS and the SURADF to benefit from the power gains of panel tests. The ADF finds stationarity for two countries, Australia and Japan, whereas the IPS rejects the null of a joint unit root in favour of data following a stationary process. However, the IPS test does not inform on the individual dynamics of each member's current account. Consequently, Holmes (2006) assesses the data with the SURADF and finds that only four countries, Australia, the UK, Belgium, and Japan, have stationary current accounts, while the rest, including the US, Germany and Italy, have nonstationary current accounts. Results from the SURADF suggest a sizeable number of countries might be why the null of a unit root in the IPS was rejected by Wu (2000), as they had previously found stationarity and hence sustainability in the current accounts of OECD countries using the IPS.

In developing and emerging markets, Baharumshah et al. (2005) find conflicting results when assessing current accounts of 12 Asian countries between 1970 and 2002 using the IPS, UB, and HT against the SURADF. The IPS, UB and HT tests reject the null of joint unit roots, consistent with Lau et al. (2006)'s panel analysis of some of the countries under consideration using similar tests. However, the SURADF by Baharumshah et al. (2005) finds only three of the twelve countries have unit roots at the 10 per cent significance level. Chu et al. (2007) and Holmes et al. (2003) consider African markets using the IPS and SURADF tests in their analysis. Chu et al. (2007) assess 48 countries and reject the joint unit root null using the IPS. However, the SURADF from the study finds stationarity in only 37 countries under consideration. Holmes et al. (2003) considers 26 countries wherein the IPS similarly rejects the joint null of a unit root. However, their SURADF finds stationarity in only 21 countries (eight more countries compared to an individual country assessment using the ADF). Thus, on moving from individual country assessments using the ADF to a more robust panel unit root test that accounts for heterogeneity, Holmes et al. (2003) is able to find evidence in favour of a sustainable current account in more countries.

The SURADF allows for gains in testing power over traditional unit root tests like the ADF. It further provides for the analysis of individual country dynamics in panel analysis, unlike the IPS, HT and UB tests discussed above. However, Ford et al. (2006) stress the bias of the SURADF to panel member inclusion. In particular, Ford et al. (2006) analyse the exchange rate behaviour of OECD countries using the SURADF but construct different panels with overlapping members and find that country-specific results differ depending on what other members are included in the panel. This makes SURADF results sensitive to member selection, as a stationarity result will depend on what other members are added to the panel before analysis. As a result, arbitrarily selecting countries in constructing a panel might lead to misleading results as the SURADF may not allow for robust results (Ford et al., 2006). This drawback is further demonstrated by results found by Chu et al. (2007), whose SURADF analysis finds a unit root in current accounts by Algeria, the Republic of the Congo, Morocco, Uganda and Zambia, in contrast to a finding of stationarity for the same countries found by Holmes et al. (2003). Thus, while panel data improves testing power over traditional tests, it either fails to inform on individual country dynamics, e.g., the IPS test or provides results that are not robust to the creation of panels before analysis, e.g., the IPS and the SURADF test.

As noted by Maddala and Kim (1998) when commenting on purchasing power parity (PPP) studies, panel tests generally test a different hypothesis than that of interest in most studies, thus offering limited recourse in improving the testing power of unit root tests and consequently fail to resolve low testing power issues identified in unit root test;

> *"Whether it is the use of panel data unit root tests in investigations of PPP or growth and convergence, the first question is: what are the hypotheses of interest? Consider the case of PPP and test of the long run validity of the PPP hypothesis in the form of testing for a unit root in the real exchange rate. One may be interested in testing whether the hypothesis of the PPP holds for the Japanese Yen against US dollar (JY/US) exchange rate. In this case, what is of relevance are the data on this exchange rate. It is no use to be told that we reject the validity of the PPP even in the long run for the JY/US but that if we throw in a large number of countries and use the panel data unit root test, we do not reject the PPP hypothesis for the JY/US exchange rate. The hypotheses under consideration in the two cases are different" (Maddala & Kim, 1998).*

This assertion implies panel tests would have a limited practical benefit where research interests pertain to specific countries. On the other hand, they might be beneficial for assessing a group of countries with mutual interests, for example, the sustainability of current accounts in a monetary region or a trading block. However, Maddala and Kim (1998) further opine it would still be challenging to derive summary statistics from panel-based analysis, for example, on how long it takes for PPP deviations to be corrected.

The conventional stationarity approach to sustainability that has so far been reviewed utilises linear specified unit root tests like the ADF, PP and DFGLS. However, a strand of literature argues that the failure to find a consensus in these tests is due to their inability to incorporate nonlinearities in the adjustment of the current account (Chortareas et al., 2004). The default assumptions of linearity in the stationarity process have several implications for empirical testing.

If the current account follows a linear process, then adjustments in the current account are expected to be symmetric around the current account's long-run equilibrium (Clarida et al., 2007). There would be no distinction between speeds of adjustments below or above the current account. The speed of adjustment would be uniform and independent of the magnitude of displacement from equilibrium. Hence, adjustments to equilibrium would be indifferent to whether deficits are large or relatively small (Clarida et al., 2007).

However, if nonlinear processes govern adjustments, the size of the current account deficit would matter. Indeed, current account deficits might have thresholds beyond which market forces and government policy interventions might induce or force faster corrections and mean reversions to the current account (Clarida et al., 2007). The implication would be asymmetric adjustments of current accounts, as agents and policymakers may react less aggressively to current account movements around these threshold levels, beyond which rapid adjustments to current accounts can be expected (Clarida et al., 2007). Hence, if current account responses are nonlinear, this might affect the mean reversion properties of the current account. Tests from linear unit root approaches would suffer from reduced testing power due to such nonlinearities, resulting in falsely concluding that the current account is nonstationary when it might be stationary (Chen, 2011; Topalli & Dogan, 2016). Whether a country is found to meet its IBC through a stationarity current account can depend on whether a linear or nonlinear modelling approach is used, where either, if correctly specified, can still sufficiently capture the dynamics of the current account to answer questions on sustainability (Christopoulos & León-Ledesma, 2010). It is important to note that sustainability requires a stationary account, regardless of whether the current account follows a linear or nonlinear process (Chen, 2014).

Against this backdrop, the empirical literature has evolved to consider nonlinear dynamics in the evolution of current account balances and their mean reversion properties. Christopoulos and León-Ledesma (2010) assess US quarterly data between 1960 and 2008. Conventional unit root tests, the ADF and DFGLS, unanimously fail to reject the null of a unit root in the economy's current account to GDP ratio, implying the current account is unsustainable. However, the study proceeds by testing for and finding nonlinearities in the data using the RESET test by Ramsey (1969), Arai et al. (2004) test, and the Granger, Terasvirta, et al. (1993) test, where the latter test favours the exponential smooth transition autoregressive (ESTAR) specification. The presence of nonlinearity suggests that the linear unit root tests used might be mistaking nonlinearity as the presence of a unit root. Hence, the nonlinear ESTAR unit root test by Kapetanios et al. (2003) (KSS) and Kiliç (2003) is applied, and it finds mean reversion properties in the US current account. The test considers a null of a linear nonstationary process against an alternative of a nonlinear stationary process. Thus, on accounting for nonlinear mean reversion, the US current account is found to be sustainable, contrary to findings from linear unit root tests (Christopoulos & León-Ledesma, 2010). The ESTAR tests used by Christopoulos and León-Ledesma (2010) emphasise the importance of the size of the current account in mean reversion of the current account (Cuestas, 2013), i.e., size nonlinearities.

Raybaudi et al. (2004) suggest economies must adhere to their long-run budget constraints but might experience periods when the current account behaves like a nonstationary variable. This can be due to the stochastic properties of the series suffering from structural breaks resulting from changing macroeconomic policies over time. To address this, the study uses a Markov switching unit root test or the switching augmented Dickey-Fuller (MS-ADF) by Hall et al. (1999). The method analyses the sustainability of current accounts through different regimes, where the current account can be stationary and where it can be nonstationary. It further allows for both the analysis of global stationarity over the entire series (common with conventional unit root tests) and local stationarity (for the various regimes) (Takeuchi, 2010). In so doing, the methods allow for temporary deviations of the current account from an optimal path, regardless of what causes such variations, while still conceding the long-run budget constraint could be met (Raybaudi et al., 2004). Hence, it allows for subsamples of unsustainability in a current account that could otherwise be sustainable in the long run. These short-run deviations from optimal paths or nonstationary regimes can inform policy, ensuring the economy meets its IBC in the long run. For example, suppose the regimes where the current account is nonstationary are frequent and prolonged. In that case, this can signal that an economy runs a higher risk of failing to meet its long-run IBC, and authorities can implement necessary interventions (Raybaudi et al., 2004). If regimes when the current account is I(1) are persistent, this can be considered a red signal that the current account is unlikely to meet its long-run budget constraint. The appeal of the approach is in how closely it analytically models reality. As Takeuchi (2010) notes, countries do not quickly go bankrupt but can have periods where their debt levels can become worrisome, both of which require consideration. It further provides more insight into the state of the current account and its development, as opposed to only providing a dichotomous yes or no response to whether the current account is sustainable. Through this method, the dichotomous answer can still be found by checking for global stationarity.

Raybaudi et al. (2004) analyse the current account sustainability of Argentina, Brazil, the US, the UK, and Japan individually using quarterly data. The study reaches conflicting conclusions about sustainability based on the ADF and KPSS tests. However, in accounting for the possibility of different regimes with the Markov switching approach, the study finds that only data from Argentina (1992-2001) and the US (1970-2002) had red signals and persistent regimes of unsustainability. This would suggest the two countries were at risk of not meeting their long run budget constraints.

Similarly, Chen (2011) follows the MS-ADF approach adopted by Raybaudi et al. (2004) to assess eight OECD countries' quarterly data between 1970 and 2009. The study considers nonlinear methods, as it finds conflicting stationarity results using the ADF, PP and KPSS tests. Chen (2011) proceeds to test for nonlinearities following Psaradakis and Spagnolo (2002), and then applies the MS-ADF testing approach. Except for Belgium, the study finds that the long run budget constraint was unlikely to hold for Australia, New Zealand, Spain, Portugal, Finland, Hungary and the Czech Republic. This finding implies sustainability concerns for these countries are warranted once nonlinearities are accounted for.

The stationarity approach to assessing current account sustainability has enjoyed widespread usage due to its simplicity. However, results from linear univariate unit root tests have been mixed; hence studies have either used panel methods or nonlinear unit root tests for gains in testing power. However, in contrast to directly assessing the stationarity of the current account, like Trehan and Walsh (1991), some studies follow Husted (1992) and use the cointegration approach. The cointegration approach evaluates long-run relationships between components of the current account, where the presence of cointegrating relations implies intertemporal solvency hence current account sustainability.

3.2.2 Cointegration Approach

A cointegrating relationship between components of the current account, predominantly exports and imports inclusive of current account incomes and transfers, implies the two variables do not drift apart in the long run and converge to long-run equilibrium. This convergence would ensure that the economy meets its IBC, as a result, the current account would remain sustainable.

Studies utilising this approach include Husted (1992), who analyses US data between 1967 and 1989 using Engle and Granger (1987) tests. The test fails to find cointegration, which suggests the US violated its intertemporal budget constraint. This further implies the US had an unsustainable current account over the sampled period. However, structural breaks determined *a priori* following Perron (1989) are found to cause the unsustainability result in the whole sample as the study finds cointegration between 1967 and 1983. Furthermore, Husted (1992) finds that despite the current account deficit level rising post the 1983 breakpoint, US exports and imports are cointegrated with a coefficient insignificantly different from unity. This implies the current account was on a sustainable path when accounting for structural breaks in the data, despite a mean change in the level of the current account deficit.

Husted (1992) bases the study on cointegration tests by Engle and Granger (1987) using quarterly nominal exports and imports of goods and services relative to gross national product (GNP). However, Engle-Granger tests are restrictive as they do not allow for breaks in the cointegrating relationship. Husted (1992) attempts to correct for this but bases their conclusion on an exogenously determined structural break. However, exogenously determining breaks requires pretesting data and thus makes tests susceptible to data mining and bias (Christiano, 1992; Zivot & Andrews, 1992). Furthermore, a cointegration test precedes testing coefficients for unity. However, Engle-Granger regression results in standard errors that are inappropriate to test for this hypothesis due to autocorrelation and heteroskedasticity (Arize, 2002). Thus the method used only allows for testing the presence of long-run relationships or sustainability without allowing for a reliable measure of the strength of sustainability.

To account for the shortfalls in the approach by Husted (1992), Fountas and Wu (1999) extend the analysis of the US using similar data. Their extension allows for endogenously determined structural breaks in the cointegrating relationship. First, they apply the Phillips and Perron (1988) (PP) unit root test and find exports and imports to be I(1) processes before proceeding to test for long-run relationships between the two variables. Thereafter, they use the Zivot and Andrews (1992) (ZA), and Gregory and Hansen (1996) (Gregory-Hansen) tests to assess cointegration. The ZA unit root test can be used as a cointegration test, provided a cointegration parameter of 1 is imposed on the import measure in the regression equation (Fountas & Wu, 1999). The ZA finds no long-run relationship between exports and imports. The study then applies the Gregory-Hansen cointegration test as it allows for breaks in individual data series and breaks in the cointegration equation of the data. However, the latter test places less restrictions on cointegration parameters, unlike the ZA test, which imposes unity. Similarly, the Gregory-Hansen test fails to find cointegration between exports and imports. Contrary to findings by Husted (1992), this implies the US violated its intertemporal budget constraint; hence its current account was on an unsustainable path. The difference in the results of the two studies highlights the importance of endogenously determining breaks when modelling cointegrating relationships.

Wu et al. (1996) analyse quarterly data from US and Canada between 1973Q4 and 1994Q4. Consistent with Fountas and Wu (1999), the study fails to find cointegration in US data despite accounting for breaks through the Gregory-Hansen test. In contrast, the study finds a significant cointegrating relationship for Canada. Consequently, Wu et al. (1996) apply the dynamic ordinary least squares (DOLS) by Stock and Watson (1993) for Canada to check if the import coefficient is significantly different to 1. DOLS estimates are preferred to the ordinary least squares (OLS) estimates, as OLS suffer from simultaneity bias. The study concludes that current accounts in Canada are unsustainable as the coefficient on the import variable is significantly different to 1. However, given the postulation by Quintos (1995), Canada's current account can be considered weakly sustainable as there is cointegration, and the coefficient on the import variable is positive but less than 1.

Wu et al. (1996) also consider the Johansen cointegration test due to the superior testing properties the procedure has over the commonly used Engle-Granger test. The Johansen approach performs better when compared to the Engle-Granger, with results that are more efficient, unbiased and symmetrical (Gonzalo, 1994; Phillips, 1991). Additionally, the procedure allows for the identification of multiple cointegrating relationships. However, the test does not accommodate endogenous breaks in its analysis, unlike the Gregory-Hansen, which can impact its ability to detect cointegration (sustainability). Indeed, the Johansen results find no cointegration in data from the US and Canada. The result for Canada is overturned upon using the Gregory-Hansen test. The difference in results between these tests highlights the importance of utilising various methods, as the no cointegration result of the Johansen test for Canada is easily overturned when considering endogenous breaks through the Gregory-Hansen test. Apergis et al. (2000) similarly acknowledge the importance of breaks when evaluating Greece, as the Johansen test fails to find cointegration in the data whereas the Gregory-Hansen test does. Consequently, Greece is found to have a strong sustainable current account as the coefficient on imports is unity. Apergis et al. (2000) rely on the DOLS test to establish the unity result. Additional failures of both the Johansen and Engle-Granger tests in Canada and the US are noted by Wu et al. (2001), who fails to find cointegration through both methods in G7 countries.

Despite these failures in the Johansen cointegration test, some studies are able to establish cointegration on utilising it. These include the study by Holmes and Panagiotidis (2009), who finds evidence of cointegration on US quarterly data between 1960 and 2007 but fails to find a significant coefficient of unity. Bodman (1997) similarly finds the persistent current account deficit in Australia sustainable when analysing quarterly data between 1965 and 1993. Bodman (1997) finds consistent results when using the maximum eigenvalue and the trace tests within the Johansen cointegration method. This latter study corroborates the findings of Bahmani-Oskooee (1994), who similarly finds cointegration in Australia using quarterly data between 1966 and 1990 on the Engle-Granger test.

For emerging and developing markets, Baharumshah et al. (2003) consider current account sustainability through the cointegration approach using annual data from Malaysia, the Philippines, Indonesia and Thailand between 1961 and 1999. The study further considers a subsample between 1961 and 1997, which coincides with the pre-Asian crisis of 1997. The subsample results would inform whether current account sustainability tests would have been able to detect the Asian crisis[5]. Unit root tests reveal exports and imports are I(1) variables, and consequently, the study utilises the Johansen and Gregory-Hansen tests. The Johansen test finds cointegration in Thailand and Indonesia over the whole sample, whereas cointegration is only present for Malaysia over the subsample. To consider the effect of breaks, the study applies the Gregory-Hansen test and reaches a similar conclusion. It further finds a result of cointegration in the full sample for the Philippines. The latter result is reasonable, as by failing to account for structural breaks, the Johansen test would be biased towards failing to reject the null of no cointegration for the Philippines (Baharumshah et al., 2003). The study further utilises the DOLS method to estimate long-run equilibria, i.e., to verify the strength of sustainability in these economies. The study applies the DOLS method where cointegration is present due to its favourable performance in small samples and finds that Malaysia has a strong sustainable current account prior to the crisis (sub-sample), with a coefficient insignificantly different from unity. The rest of the countries' current account deficits are weakly sustainable over the whole sampled period (Baharumshah et al., 2003).

Taken as a whole, the results of Baharumshah et al. (2003) support the view that unsustainable deficits can be considered predictors of the Asian crisis, given the failure to find sustainability in the subsample for all countries except Malaysia. Furthermore, the results are consistent with the theory; by depreciating their currencies, Thailand, the Philippines and Indonesia are able to achieve sustainability in a weaker sense and move towards intertemporal solvency (Baharumshah et al., 2003). In contrast, Malaysia fails to achieve sustainability post the crisis, as it maintained a fixed exchange rate regime post the crisis, which hampered the ability of current account balances to adjust to the sustainable path it maintained before the crisis. This highlights the importance breaks have on the sustainability of the current account – especially those that coincide with major economic events. These conclusions must however be taken with caution as there is a short period post the crisis, with only two years of additional data. Nonetheless, it also informs on how sensitive analysis is due to sampling periods – as an additional two years of data are sufficient to

[5]The selection of the subsample is done *a priori*, as the Gregory-Hansen test used in the analysis is unable to detect structural breaks near the end of the sample period.

overturn all of the countries' results.

Lau and Baharumshah (2003) study Malaysia with two extra years' worth of data. Similarly, Malaysia has a strong sustainable account between 1961 and 1997 based on the Gregory-Hansen and DOLS methods. However, the study finds Malaysia has a weakly sustainable current account between 1961 and 2001. These results contrast with its analysis of stationarity of the current account variable, as the ADF, PP and KPSS suggest it follows a unit root process.

Sawada (1994)'s analysis similarly highlights the sensitivity of the results to the sampling period, as it finds Thailand to have a sustainable current account between 1955 and 1990, seven years short on data leading to the crisis. The study finds this result through the Engle-Granger approach. It further finds Chile to violate its intertemporal budget constraint. The Chilean result is corroborated by Herzer and Nowak-Lehmann (2006), who similarly fails to find cointegration through the Engle-Granger test but finds it through the Gregory-Hansen test. Finally, based on the cointegration result from the Gregory-Hansen, the study applies the DOLS method and finds that Chile has a strong sustainable current account.

Sahoo et al. (2016) analyse the sustainability of current account deficits in a comparative study between India and China using annual data from 1980 to 2014. The study uses the Bayer and Hanck (2013) cointegration method to examine the long-run relationship between exports and imports. However, as the test fails to consider structural breaks, Sahoo et al. (2016) further consider the ARDL bounds testing approach by Pesaran et al. (2001) to ensure the robustness of estimates. Both trade flows are found to be I(1) processes, and cointegration tests unanimously find that China has a sustainable current account balance while India does not. The failure to find adherence to the IBC in India corroborates the findings by Nag and Mukherjee (2012), who uses the Gregory and Hansen (1996) cointegration test. However, these findings contrast with those by Holmes et al. (2011), who find sub-samples of cointegration or sustainability in India's IBC between 1950 and 2004. On using the Johansen (1998) and Breitung (2002) cointegration tests, the study by Holmes et al. (2011) splits Indian data into regimes that coincide with the liberalisation of India's economy, where the post-liberalisation period (the late 90s onwards) is consistent with sustainability. The Breitung (2002) test allows for nonlinearity between exports and imports. The sensitivity of results to method selection is further highlighted by Garg and Prabheesh (2021), who similarly finds that accounting for structural breaks results in a cointegrating relationship in India when using the test by Johansen et al. (2000). Garg and Prabheesh (2021) consider quarterly data from 1998Q1 to 2017Q4 in their analysis.

Some studies assess the cointegration of current account components through panel tests.

This is to circumvent short data spans that impede analysis using pure time series only and to benefit from the cross-sectional pooling of data. Nonetheless, panel analysis drawbacks highlighted in the stationarity approach remain relevant. Panel cointegration tests similarly fail to advise on which members contribute to the joint results of rejecting cointegration, where results are sensitive to member selection.

Wu et al. (2001) adopt a panel cointegration approach suggested by Pedroni (2004) and Kao (1999) to assess G7 countries (US, France, Germany, Italy, Canada, Japan) using quarterly data from 1973 to 1998. The UK is excluded due to having an import variable that is not I(1). The study fails to find cointegration for these countries through the Engle-Granger and Johansen tests, proceeds with the panel cointegration tests, and finds that current account balances in these countries are sustainable. This is consistent with the panel unit root testing approach by Wu (2000) for G7 countries. In addition, the study finds a cointegrating coefficient of unity between these variables – evidence of strong form sustainability.

Baharumshah et al. (2005) analyse the sustainability of a panel of East Asian countries (Malaysia, Philippines, Singapore, Taiwan, South Korea and Japan) with annual data between 1970 and 2000 by panel cointegration methods. Exports and imports are measured in real terms as a percentage of gross domestic product (GDP). The study uses IPS unit root tests, which reveal the existence of a unit root, before utilising the cointegration procedure by Pedroni (2004) and Pedroni (1999). The DOLS approach adapted for panel analysis by Kao and Chiang (2001) is then used to estimate long-run relationships. The study finds that pre-Asian financial crisis sampled data (1970 - 1997) was in violation of their intertemporal budget constraints. This is partly attributed to pre-crisis policies in these countries, including pegged exchange rate systems, that affected the ability of the current account to adjust to external shocks. However, some crises-affected countries recorded surpluses following currency depreciations and changes to interest rates, among other variables. Indeed, post-crisis data is consistent with sustainability (Baharumshah et al., 2005). This suggests the need to carefully monitor balances for proactive macroeconomic intervention, as a forced policy change facilitated restoration to the sustainable path. Lastly, this implies current account balances can be used to predict financial crises. However, the pre-financial crisis sample is inconsistent with the panel stationarity test results previously discussed for Asian countries by Lau et al. (2006), whose conclusion was sustainability. This highlights the need to rely on multiple tests for sustainability conclusions, as different methods lead to different conclusions.

Evidently, for any given country, the sustainability result depends on the approach used in the analysis. This could be a unit root test on a current account measure or assessing the cointegration of the components of the current account. In either one of the approaches, specifications can be linear or nonlinear. However studies in both approaches tend to utilise linearly specified models and tests. While there is increasing attention towards nonlinear unit root tests in assessing current account sustainability (Chen, 2011, 2014; Christopoulos & León-Ledesma, 2010; Raybaudi et al., 2004), to the best of our knowledge, fewer studies (Holmes et al., 2011; Kouadio & N'Guessan, 2021) attempt to assess current account sustainability through nonlinear cointegration methods. However, nonlinear considerations are similarly important in cointegration analysis, since linear cointegration tests might have limited capabilities of finding cointegration in the presence of nonlinearities.

Furthermore, the above studies highlight the effects of the sampling period on unit root and cointegration tests, where a lack of consensus in studies can also be attributed to the difference in chosen sampling periods. Limiting factors for developing and emerging markets tend to include data availability – where studies are restricted in the analysis due to data spanning relatively short periods, where reliance on short samples can mask long-run sustainability. These factors have resulted in notable conflicting results in the literature on determining the sustainability of countries' current accounts. It has also inevitably seen more rigorous evaluations of developed economies than emerging economies. However, given the growing prominence of the developing and emerging markets in the global economy, it is imperative that all countries are evaluated, given the growing integration of the global economy and its financial systems. This includes countries running persistent deficits like South Africa, whose economic disruptions due to unwieldy deficits can impact the well-being of its citizens, as well as global investors who routinely seek investments in emerging markets economies, as previously highlighted.

3.2.3 Empirical Literature: South Africa

Indeed, there exists a plethora of studies evaluating current account sustainability through stationarity and cointegration methods. However, despite this extensive empirical literature, South Africa remains under-researched despite running persistent current account deficits. Thus, there is a need to bridge this research gap.

To our knowledge, two studies consider South Africa through stationarity methods but do so as part of their panel analysis. Holmes et al. (2003)'s panel analysis of African markets includes South Africa for the periods 1960 to 2000, whereas Chu et al. (2007) does the same but for the period 1980 to 2004. Both studies utilise the stationarity approach and find South Africa's current account balance to be sustainable based on the IPS panel unit root test rejecting the null of a joint unit root and the studies' SURADF rejection of a unit root in South Africa. However, as discussed, panel-based tests mask individual country results as they tend to generalise results to all panel members. Furthermore, panel results are sensitive to member selection – this might cast doubt on the applicability of the tests' conclusions to South Africa's individual country dynamics.

To our knowledge, three country-level studies by Stungwa and Mosikari (2023), Searle and Touna-Mama (2010) and Arize (2002) focus on South Africa but are restricted to the cointegration approach. Searle and Touna-Mama (2010) consider a country study analysis of South Africa's current account using quarterly data between 1987Q1 and 2010Q1. The study adopts the cointegration approach and utilises the Engle-Granger test. ADF and PP unit root tests find exports and imports are nonstationary, finding both series to be I(1). Subsequently, the cointegration test – where OLS residuals are tested using the ADF and PP, supports cointegration in South Africa's current account. The study finds cointegration between exports and imports, however, the coefficient on imports is significantly different from unity. While the study concludes this is evidence of an unsustainable current account, this is evidence of weak current account sustainability suggested by Quintos (1995). However, Searle and Touna-Mama (2010) are able to find a unity result in line with strong current account sustainability on accounting for breaks in the cointegrating relationship. The study suggests two break dates, 1994Q1 and 2003Q2, determined exogenously and verified using the Chow (1960) test. These breaks are then included in the Engle-Granger regression equation using dummy variables.

The first break in 1994Q1 corresponds with the country's "institutional shifts". While the study does not define these, we assume it implies the country's transition towards democratic independence due to the abandonment of the Apartheid system of governance. This allowed for more integration with the global economy, thus an increase in current account flows. The latter break in 2003Q2 corresponds with the influx of portfolio flows and FDI due to an increase in nonresidents investing in the economy's shares and government bonds, as South Africa was viewed as a lucrative investment destination due to favourable credit ratings (SARB, 2003). This deteriorated the country's net foreign asset position (Searle & Touna-Mama, 2010).

The study by Searle and Touna-Mama (2010) has various weaknesses. First, the identification of breaks is selected independent of the analytical model, i.e., breaks are determined and imposed instead of being selected endogenously, and this might bias the study's results. Our study corrects for this by considering the Maki cointegration method due to its ability to endogenously detect breaks, hence limiting biases in the study's results and conclusion. Hence, if these breaks are important in the long-run relationship between variables, the Maki cointegration test is expected to detect them.

Second, the study relies on an OLS method to derive long-run estimates used to measure the strength of sustainability, i.e., using OLS estimates from the regression whose residuals are used to test for cointegration in the Engle-Granger test. While this allows for the derivation of super-consistent estimates, the associated standard errors are not (Herzberg, 2014). As a result, the statistical significance of the coefficients becomes questionable, and hypothesis tests become invalid (Arize et al., 2015). Additional studies noting endogeneity and simultaneity bias issues with the OLS include Apergis et al. (2000), Baharumshah et al. (2003), and Herzer and Nowak-Lehmann (2006). We correct for this by relying on DOLS for robust long-run estimates where cointegration has been established through the Engle-Granger, Johansen and Maki tests.

Third, the study regresses exports on imports and does not consider the regression of imports on exports. This is a method weakness of the Engle-Granger test, as it requires one to specify a dependent variable, the effect of which can impact whether a cointegrating relation is found. This is even more relevant where literature specifies more than one equation to assess the relationship between variables, i.e., Searle and Touna-Mama (2010) regress exports on imports, but studies including Herzer and Nowak-Lehmann (2006) regress imports on exports. We discuss this drawback in more detail in this paper's method section. However, to correct for this drawback, we consider an additional model that regresses imports on exports for robustness. Lastly, there is evidence suggesting that alternative methods, for example, the Johansen cointegration test, have superior properties in comparison to the Engle-Granger, hence can lend more definitive evidence on the relationship between exports and imports in South Africa. We correct for this last drawback by utilising different cointegration methods, including the Engle-Granger, Johansen, ARDL and Maki tests.

Stungwa and Mosikari (2023) consider South Africa through the Maki cointegration test to accommodate the possibility of multiple structural breaks. The study finds the presence of a weak long run relationship from annual data between 1980 and 2021. Stungwa and Mosikari (2023) resolve one of the limitations found in the study by Searle and Touna-Mama (2010), as they account for endogenous breaks through the Maki cointegration test. However, three issues emerge from this study. First, as demonstrated by Lau and Baharumshah (2003), cointegration results can be sensitive to time span selection, as 2 years' worth of data were significant to overturn results in Malaysia. Stungwa and Mosikari (2023) rely on annual data of a relatively shorter time span, and we correct for this by relying on a longer annual time span running from 1946 to 2021 for a comprehensive view of South Africa's current Account. Second, Stungwa and Mosikari (2023) only consider annual data, despite motivations that higher frequency data has the potential to reveal dynamics that might be masked by low frequency data (Zhou, 2001). We correct for this by additionally considering two quarterly data sets running from 1960Q1 to 2021Q4, and 1985Q3 to 2021Q4, the motivations of which we expand on the data section of this study. Lastly, Stungwa and Mosikari (2023) do not consider nonlinearities in their cointegration analysis, which we consider by including a NARDL analysis.

Arize (2002)'s country study considers South Africa alongside 49 other countries using quarterly data between 1973Q2 and 1997Q3 through the Johansen cointegration method, i.e., this is a multi-country study and not a panel analysis. The Johansen test has the advantage of identifying the presence of cointegration regardless of which variable is chosen as the dependent variable (although this study theoretically specifies a regression of imports on exports). The study finds evidence for cointegration in South Africa, suggesting the economy does not violate its intertemporal budget constraint and hence has a current account on a sustainable path. However, this study does not consider current account incomes and transfers, and is thus restricted to assessing trade flows. This can cast doubt on the true state of the current account balance and whether it is indeed sustainable given the significant impact the primary account, for instance, has played in the current account deficits registered in South Africa. We correct for this by considering an expanded measure of the import variable, as discussed in this paper's data section.

Against this background, the empirical strategy employed in this study consists of assessing current account sustainability in South Africa using cointegration and stationarity approaches. This allows for a more rigorous and robust conclusion on whether the current account deficits experienced by South Africa are consistent with intertemporal solvency and are thus sustainable. Both approaches are used for completeness and to check for a consensus on the sustainability of South Africa's current account deficits. The stationarity approach will abstract from linearity tests to assess whether there are linearities in the current account to GDP series. After that, we will consider the ADF, PP, KPSS, DFGLS, and ZA unit root tests. If nonlinearities induce a lack of stationarity, possibly due to model misspecifications from nonlinearities, we will consider the KSS (ESTAR) and the asymmetric exponential smooth transition autoregressive (AESTAR) by Sollis (2009) (Sollis) unit root tests. For the cointegration approach, if the pair of variables are individually I(1), we consider the Engle-Granger, Johansen, and Maki cointegration tests. A cointegration result from these tests would imply current account sustainability. To measure the strength of sustainability, we will rely on the DOLS technique for efficient estimates. We will additionally consider the ARDL bounds test for assessing long-run relationships of all variables, given the test's ability to consider variables of mixed I(0) and I(1) orders of integration. Additionally, the ARDL model will be used to determine the strength of current account sustainability (long run elasticities). We will also consider the NARDL, which has similar requirements as the ARDL but additionally considers asymmetries in long-run relationships. Lastly, depending on preliminary tests applicable for all methods, the data utilised will be annual data from 1946 to 2021, quarterly data from 1985Q3 to 2021Q4, and quarterly data from 1960Q1 to 2021Q4.

4. Research Methods

In light of empirical studies demonstrating how current account sustainability results depend on the utilised testing method, this study considers multiple stationarity and cointegration methods in its empirical analysis. Stationarity tests are applied based on equation 3.6 which shows the current account to GDP ratio. An alternative approach utilises cointegration tests relying on the model specified in equation 3.11 which tests the long-run relationship between current account components i.e., exports and imports (current account incomes and transfers inclusive) in our baseline model. Stationarity of the current account balance and the presence of a long-run relationship between current account components similarly imply intertemporal solvency and, hence current account sustainability.

4.1 Stationarity Approach

The development of unit root tests has seen tremendous interest in macroeconomic literature. First, the conventional Ordinary least squares (OLS) method for establishing economic relationships assumes variables have time-invariant means and variances. However, this feature is usually absent in macroeconomic variables (Nelson & Plosser, 1982), as economies undergo growth and development over time. This implies that using OLS to model macroeconomic relationships might produce misleading results, hence the need to pretest variables for unit roots before analysis. For example, alternative methods like cointegration become more appropriate for variables with unit roots (Shrestha & Bhatta, 2018). Second, the presence of unit roots in some variables may invalidate long standing economic theories like intertemporal approaches to the current account and purchasing power parity relations.

Against this backdrop, studies, for example Dickey and Fuller (1979), Said and Dickey (1984) and Phillips and Perron (1988), have been devoted to creating methods meant to detect the presence of unit roots for utilisation in pre-testing data before establishing macroeconomic relations or to inform on the validity of theories. Due to this widespread usage, we skip the formulation of traditional and popular unit root methods used in this study, except for general tests and those necessary to demonstrate the issues in current account analysis.

Stationarity in the current account (measured as the current account to GDP ratio) implies intertemporal solvency hence current account sustainability. The literature that utilises unit root tests to determine sustainability of the current account is split between linear unit root tests (Lau et al., 2006; Matsubayashi, 2005; Taylor, 2002) and nonlinear unit root tests (Chen, 2011; Christopoulos & León-Ledesma, 2010; Cuestas, 2013). The starting point for linear unit root tests includes Dickey and Fuller (1979)'s pioneering work which relies on an AR(1) model:

$$y_t = \phi y_{t-1} + e_t \tag{4.1}$$

where y_t is the series of interest (in our case, the current account to GDP ratio), and e_t $i.i.d \mathcal{N}(0, \sigma^2)$.

Establishing the presence of a unit root requires examining ϕ. The null hypothesis of the test is the presence of a unit root, where $\phi = 1$, against a stationary alternative where $|\phi| < 1$. However, to formally test for this, Dickey and Fuller (1979) transform 4.1 to the more convenient model presented below:

$$\Delta y_t = \theta y_{t-1} + e_t \tag{4.2}$$

where $\theta = \phi - 1$. Thus, testing the null that $\phi = 1$ against the alternative that $|\phi| < 1$ in equation 4.1, is equivalent to testing for the null (H_0) that $\theta = 0$ against the alternative (H_A) that $\theta < 0$ in equation 4.2.

Failing to reject H_0 implies the presence of a unit root in y_t (current account to GDP ratio), while rejecting the null in favour of H_A implies stationarity and that the variable is a mean reverting variable. The results from the hypothesis test utilise critical values provided by Dickey and Fuller (1979) and Dickey and Fuller (1981).

A notable drawback of Dickey-Fuller tests is that e_t is assumed to be independently and identically distributed, which makes the test inappropriate when errors are serially correlated (Maddala & Kim, 1998). In this scenario (where errors are autocorrelated), the true size of the test (probability of making a Type I error) is higher than the nominal size used (Brooks, 2008).

To resolve this drawback, Said and Dickey (1984) "augment" the Dicker-Fuller test equation 4.2 by including lagged values of the dependent variable, thus resolving autocorrelation in the error term. In contrast to changing the regression equation in 4.1 as the Augmented Dickey-Fuller does, Phillips and Perron (1988) make non-parametric adjustments to the Dickey-Fuller test statistics to automatically correct for autocorrelation and heteroskedasticity in the error term (Brooks, 2008). As in the Dickey-Fuller test, deterministic components, i.e., constant, or constant and trend, can be included in the augmented Dickey-Fuller and Phillips-Perron test equations. Additionally, the latter two tests similarly consider the null of a unit root against a stationary alternative.

The Dickey-Fuller and Phillips-Perron tests are often criticised for low testing power, especially in small sample data and when the series is stationary with a near-unit root process i.e., when ϕ in equation 4.1 is close to 1 (Brooks, 2008). Thus, Elliott et al. (1992) advance the augmented Dickey-Fuller test in the Dickey-Fuller generalized least squares test (DFGLS); where the ADF regression is estimated using GLS-detrended data. Through Monte Carlo experiments, Elliott et al. (1992) find GLS-detrended data performs better in the presence of the aforementioned conditions when compared to the standard ADF approach.

Mean reversion in the current account suggests intertemporal solvency, hence a sustainable current account. Such mean reversion is established through unit root tests as discussed above. However, the unit root tests discussed thus far assume the current account adjusts linearly, hence the tests are linearly specified. This is despite theoretical arguments suggesting otherwise for example, Christopoulos and León-Ledesma (2010) and Clarida et al. (2007); where the consequence of utilising linear unit tests in the presence of nonlinearity in the data can include falsely concluding the current account is unsustainable when it in fact might be sustainable. In this regard, it is imperative to consider nonlinear unit root tests.

Indeed, the linear unit root tests considered above might fail to establish stationarity if the series is indeed stationary but nonlinear. To account for this shortfall, we consider two more methods that account for size and sign nonlinearities. Size nonlinearities consider the effect the absolute deviation of the current account from equilibrium has on the sustainability result. Sign nonlinearities consider the different impacts the sign of a shock on the current account might have on mean reversion properties of the current account.

To consider size nonlinearities i.e., asymmetric speed of adjustment towards equilibrium, this study utilises the exponential smooth transition autoregressive (ESTAR) model proposed by Kapetanios et al. (2003). The test assesses a null of a unit root against an alternative of a globally stationary nonlinear (ESTAR) process. By doing so, the variable of interest can be characterised as a two regime process; where the variable follows a unit root (unsustainable current account) in the inner regime but is a stationary process (sustainable current account) in the outer regimes (Cuestas, 2013), and the switch between these regimes is smooth. This rules out the possibility of a globally nonstationary result due to nonstationarity in the inner regime when the variable is in fact globally stationary. Kapetanios et al. (2003) utilise a smooth transition autoregressive model of order 1:

$$y_t = \alpha y_{t-1} + \phi y_{t-1} G_t(\theta, y_{t-d}) + e_t \tag{4.3}$$

where y_t is the series of interest i.e., current account to GDP ratio; e_t $i.i.d\mathcal{N}(0, \sigma^2)$; and the exponential transition function bounded between 0 and 1 is as shown below:

$$G_t(\theta, y_{t-d}) = 1 - \exp(-\theta y_{t-d}^2) \tag{4.4}$$

From the exponential transition function shown in equation 4.4, $d \geq 1$ is the delay parameter and $\theta \geq 0$ determines the speed and smoothness of transition. Hence, from equation 4.3 and 4.4 the ESTAR model can be given by:

$$y_t = \alpha y_{t-1} + \phi y_{t-1} \left[1 - \exp(-\theta y_{t-d}^2)\right] + e_t \tag{4.5}$$

By imposing that $\phi = 0$ and $d = 1$, the expression in 4.5 can be reparametrized into

$$\Delta y_t = \phi y_{t-1} \left[1 - \exp(-\theta y_{t-1}^2)\right] + e_t \tag{4.6}$$

where y is the demeaned or detrended variable of interest, $e_t \sim$ i.i.d. $\mathcal{N}(0, \sigma^2)$, and $[1 - \exp(-\theta y_{t-1}^2)]$ captures nonlinear adjustments. The null hypothesis is that $H_0 : \theta = 0$ and the alternative hypothesis is $H_A : \theta > 0$.

However, it is impractical to test for the null, as it is difficult to identify ϕ under the null. Hence, Kapetanios et al. (2003) compute a first-order Taylor series approximation, and utilise the auxiliary regression that follows:

$$\Delta y_t = \beta y_{t-1}^3 + \text{error} \tag{4.7}$$

where $H_0 : \beta = 0$ and $H_A : \beta < 0$, and the estimate of β, $\hat{\beta}$ is estimated through OLS.

The specification in equation 4.7 can be augmented with lags of the dependent variable Δy_t, following Said and Dickey (1984)'s approach in the augmented Dickey-Fuller test, to account for serially correlated errors. However, these errors are assumed to enter the model in a linear fashion (Kapetanios et al., 2003). Lastly, relevant critical values for the t-statistics of the test are provided by Kapetanios et al. (2003).

To consider sign nonlinearities, this study further utilises the asymmetric exponential smooth transition autoregressive (AESTAR) model proposed by Sollis (2009). While studies by Kapetanios et al. (2003) and Sollis (2009) both test for deviations from equilibrium, the KSS test only considers symmetric effects under the null, whereas the Sollis (2009) test is able to make a distinction between symmetric and asymmetric effects (i.e., in addition to considering the size, the Sollis (2009) further informs on the effect the sign of disequilibrium has on the stationarity of a variable).

The AESTAR model is as follows:

$$\Delta y_t = G_t(\theta_1, y_{t-1})[S_t(\theta_2, y_{t-1})\phi_1 + (1 - S_t(\theta_2, y_{t-1}))\phi_2]y_{t-1} + e_t \tag{4.8}$$

where y_t is the current account to GDP ratio, e_t $i.i.d\mathcal{N}(0, \sigma^2)$ and

$$G_t(\theta_1, y_{t-1}) = 1 - \exp(-\theta_1 y_{t-1}^2) \quad \text{where } \theta_1 \geq 0 \tag{4.9}$$

$$S_t(\theta_1, y_{t-1}) = [1 + \exp(-\theta_2 y_{t-1})]^{-1} \quad \text{where } \theta_2 \geq 0 \tag{4.10}$$

Sollis (2009) similarly utilises a Taylor expansion:

$$\Delta y_t = \beta_1 y_{t-1}^3 + \beta_2 y_{t-1}^4 + \text{error} \tag{4.11}$$

where the test for unit roots in equation 4.11 requires testing the null, $H_0 : \beta_1 = \beta_2 = 0$ by means of an F-test (Cuestas, 2013).

Due to mixed results from the stationarity approach, literature has further considered the cointegration approach to establish intertemporal solvency and current account sustainability. The cointegration approach relies on establishing long run relationships between components of the current account, in this case exports and imports, where the co-movement of these variables allows for intertemporal solvency hence current account sustainability. Thus, considering the cointegration approach is warranted for a more robust conclusion on the sustainability of South Africa's current account deficits.

4.2 Cointegration Approach

Cointegration analysis is preceded by unit root testing exports and imports to ensure an appropriate testing method is utilised. Where regressors are both I(1), the Engle-Granger, Johansen or Maki cointegration tests are suitable to use. The autoregressive distributed lag model is more appropriate when variables are both I(1) or a mix of I(0) and I(1) variables.

4.2.1 Engle-Granger Cointegration Test

Indeed, to test for a relationship between two macroeconomic variables, Engle and Granger (1987) begin by testing variables for unit roots. In a bivariate setup, where variables of interest are y_t and x_t both variables must be difference stationary, i.e., individually follow an I(1) process. Ordinarily, a linear combination of these variables will similarly follow an I(1) process. However, if a linear combination of these variables is stationary, i.e. if a linear combination of these variables is I(0), then the variables can be considered cointegrated (Engle & Granger, 1987). This is a result of y_t and x_t following the same stochastic processes and trends that cancel out when the two variables are combined. Such a cointegrating relationship is synonymous with the existence of a long-run equilibrium relationship between y_t and x_t.

To demonstrate this, consider a static regression of the two variables in equation 4.12 below:

$$y_t = \beta_1 x_t + e_t \tag{4.12}$$

where e_t is the residual term, y_t and x_t are the variables of interest and are both I(1). Equation 4.12 can be rearranged as follows:

$$e_t = y_t - \beta_1 x_t \tag{4.13}$$

If e_t is a stationary I(0) process, then by definition $y_t - \beta_1 x_t$ would similarly follow a stationary process, i.e. $y_t - \beta_1 x_t$ I(0), as the statistical properties on the left-hand side of equation 4.12 must equal those on the right-hand side.

A practical test of the Engle-Granger approach requires estimating equation 4.12 through a least squares regression equation and deriving the resultant residual series or the equation's estimated errors, i.e. deriving $\hat{e_t}$. A unit root test, usually the ADF, is then applied to $\hat{e_t}$, where the null of a unit root corresponds with the null of no cointegration against an alternative of cointegration (stationarity of the residuals). Rejecting the null in the unit root test implies rejecting the null of no cointegrating relationship, in which case variables can be considered to have a long-run relationship. Conversely, if $\hat{e_t}$ follows a unit root process, the null of no cointegration cannot be rejected, suggesting the absence of a long-run relationship between the two variables. In this latter case, y_t and x_t are nonstationary but are independent. Engle and Granger (1987) and Engle and Yoo (1987) provide applicable critical values for the unit root test on the residual series.

The Engle-Granger technique enjoys widespread usage due to the high intuition inherent in the procedure. However, it has its drawbacks. Firstly, the test is unable to determine multiple cointegrating relations. This becomes an issue where one attempts to model the relationship between more than two variables. Secondly, the test requires one to identify a dependent variable in the initial regression equation. For example, depending on which variable is selected as the dependent variable, the regression to generate the residuals for the relationship between the two variables might be specified as equation 4.14 or 4.15 below:

$$y_t = \beta_1 x_t + v_t \tag{4.14}$$

$$x_t = \beta_1 y_t + u_t \tag{4.15}$$

where residuals from equations 4.14 and 4.15 can be denoted as $\hat{v}$ and $\hat{u}$ respectively.

It is possible to find that $\hat{v} \sim \mathrm{I}(0)$ while $\hat{u}$ follows a nonstationary process, and vice versa. For large samples, this becomes a non-issue. However, results might differ in practice and for small sampled data (Pesaran, 2015). For example, both equations 4.14 and 4.15 might be estimated, but findings remain uncertain if residuals from the two estimations yield different results. Such a finding is counterintuitive given the definition of cointegrating relationships, i.e., finding a linear combination of the variables that is stationary, as one would expect findings to be invariant to the ordering of variables in the specification. This might lead to uncertainty as to whether y_t and x_t follow the same stochastic trends and are cointegrated. While specification typically follows economic literature, this drawback becomes relevant in instances where theory and empirical studies might not provide one particular model specification for cointegration or perhaps differing models. For example, while Husted (1992)'s model specification regresses exports on imports, Arize (2002)'s specification regresses imports on exports. Nonetheless, the counterintuitive difference in results when establishing a long-run relationship, as in equation 4.14 or equation 4.15, results from the Engle-Granger method's estimation procedure.

Despite these drawbacks, this study abstracts from the Engle-Granger method for three reasons. Firstly, the analysis in this paper considers the cointegration of two variables.

Thus, the inability of the Engle-Granger technique to model more than two relationships does not impact the paper's analysis. Secondly, an additional robustness check is included that considers both specifications of the relationship between the study's variables i.e., in addition to regressing imports on exports, a robustness check of regressing exports on imports is included. This allows for a more definitive conclusion on the relationship between these variables and the current account sustainability question. Lastly, the Engle-Granger method is appealing due to its simplicity, hence it is utilised as it offers an intuitive starting point for the paper's analysis

Nonetheless, a significant critique of the Engle-Granger test is that it offers less efficient and biased results in comparison to the Johansen cointegration method (Gonzalo, 1994; Phillips, 1991). Consequently, the paper proceeds by considering the Johansen cointegration method to assess current account sustainability due to its superior properties.

4.2.2 Johansen Cointegration Test

Indeed, the dynamic system based Johansen cointegration test, while especially beneficial in a multivariate analysis, still offers superior properties to the Engle-Granger even in a bivariate setup. The Johansen test can be estimated through the following equation:

$$Y_t = \mathbf{A}Y_{t-1} + \mu_t \tag{4.16}$$

where $\mathbf{A}$ is a $n \times n$ matrix of parameters, Y_t is a vector of I(1) variables i.e., $Y_t = (Y_{1,t}, Y_{2,t}, ..., Y_{n,t})'$ and $\mu_t = (\mu_{1,t}, \mu_{2,t}, ..., \mu_{n,t})'$. By subtracting Y_{t-1} from both sides of 4.16, we get

$$\Delta Y_t = \pi \Delta Y_t + \mu_t \tag{4.17}$$

where $\pi = \mathbf{A} - \boldsymbol{I}$ is an $n \times n$ matrix of parameters.

The Johansen approach requires examining the rank of the π matrix, to detect cointegration and determine the number of cointegrating relationships in the data. In our bivariate case, where $n = 2$ variables, the rank will take on values from 0 to 2. If rank$(\pi) = 0$, then no linear combination of the 2 variables is stationary i.e., there is no cointegration. If rank(π) = 1, there is a linear combination of the variables that is stationary, and the matrix π contains 1 cointegrating vector. However, if rank(π) = $n = 2$ i.e., rank equals the number of variables, then the variables in the system are I(0) (Hjalmarsson & Österholm, 2007), in which case the Johansen test might be an inappropriate test for establishing long run relationships.

The Johansen test provides two test statistics, for hypothesis tests on rank(π) = r, where critical values for both test statistics are provided in Johansen and Juselius (1990):

$$\lambda_{\text{trace}}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{4.18}$$

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \tag{4.19}$$

where r is the number of cointegrating relationships, T is the sample size, and $\hat{\lambda}_i$) is the ith ordered eigenvalue from the π matrix.

The trace test in equation 4.18 jointly tests the null that the number of cointegrating vectors is less than or equal to r. The alternative either considers an unspecified number of cointegrating vectors, or a general alternative that there are more than r. However, the max test conducts separate tests for each eigenvalue, with the null that the number of cointegrating vectors is r against an alternative that the number of cointegrating vectors are $r+1$. Testing is sequential, i.e., first test the null that $r = 0$ (no cointegrating vectors). If this null is not rejected, testing ends here and it can be concluded there is no cointegration between the evaluated variables. If the null is rejected, the null changes to test $r = 1$, and so on, until the null is no longer rejected.

A critical drawback of the tests considered thus far is their inability to consider the effects of endogenous breaks when testing for cointegrating relationships. This hampers the ability of these tests to produce reliable results, as breaks might impact long run relations between variables, i.e., in the presence of breaks, the Johansen and Engle-Granger tests will perform poorly and might fail to detect long run relationships. Additionally, the consideration of exogenous breaks on the aforementioned cointegration tests might bias results. To account for the possibility of breaks, this study proceeds by considering the Maki cointegration test for its ability to endogenously accommodate breaks in the long run relationship between variables

4.2.3 Maki Cointegration Test

Maki (2012) suggests a cointegration model that allows for a maximum of 5 structural breaks, where breaks are endogenously detected by the cointegration test. The absence of structural break considerations in other cointegration tests, including the Engle-Granger and Johansen tests, might bias results if a break in the relationship between variables exist (Gregory et al., 1996). The test for cointegration requires evaluating the following models:

Model 1: Break in intercept without trend (level shifts)

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta x_t + \epsilon_t \tag{4.20}$$

Model 2: Break in intercept with trend (level shifts with trend)

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \gamma t + \beta x_t + \epsilon_t \tag{4.21}$$

Model 3: Break in intercept and coefficients but model has a trend (regime shifts)

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \beta x_t + \sum_{i=1}^{k} \beta_i x_t D_{i,t} + \epsilon_t \tag{4.22}$$

Model 4: Break in intercept, coefficients and trend (trend and regime shifts)

$$y_t = \mu + \sum_{i=1}^{k} \mu_i D_{i,t} + \sum_{i=1}^{k} \gamma_i t D_{i,t} + \beta x_t + \sum_{i=1}^{k} \beta_i x_t D_{i,t} + \epsilon_t \tag{4.23}$$

where y_t and x_t are our I(1) variables; μ_i, β_i, γ_i denote breaks in the intercept, coefficient (or regressor), and the trend; $D_{i,t}$ is our structural break dummy that takes on the value of 1 in the presence of a break and 0 otherwise i.e., $D_{i,t}$ takes a value of 1 if $t > T_{Bi}(i = 1, \dots, k)$ and 0 otherwise; T_{Bi} denotes the time period of the break and k is the maximum number of breaks.

Notably, models with $k = 1$ and $k = 2$, correspond with the methods by Gregory and Hansen (1996) and Hatemi-j (2008), which evaluate 1 and 2 breaks respectively. However, the Maki test is superior to these tests as it considers more breaks in long run relationships – which avoids misspecifications when the number of breaks is unknown. The null hypothesis of the Maki test is the absence of cointegration, against an alternative of cointegration with i breaks, where $i \leq k$.

The Engle-Granger, Johansen, and Maki cointegration tests require all variables under consideration to be integrated of first order i.e., I(1). Therefore, the tests are not applicable where variables have different orders of integration. To accommodate this possibility, we also consider the ARDL model, due to its ability to consider variables of mixed I(0) and I(1) orders of integration. This will allow us an opportunity to evaluate variables that would otherwise be ineligible for the tests discussed thus far.

4.2.4 Autoregressive Distributed Lag

Indeed, the dynamic single equation ARDL method by Pesaran et al. (2001) is suitable when all variables are I(1) or when variables are of mixed orders of integration i.e., I(0) and I(1). This contrasts with the Engle-Granger and Johansen cointegration tests which are strictly for I(1) variables. An additional advantage of the ARDL is its dynamic nature. The method incorporates lags of the dependent and independent variables, allowing for an assessment of temporal dependencies and adjustments over time. The ARDL specification of two variables, y and x, is provided in equation 4.24 below:

$$\Delta y_t = \alpha_0 + \delta_1 y_{t-1} + \delta_2 x_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + \sum_{i=1}^{p} \phi_i \Delta x_{t-1} + \mu_t \tag{4.24}$$

where Δ and μ represent the first difference of the variables and the error term respectively. To establish a long run relationship between the variables, the ARDL test considers the null and alternative hypotheses below:

$$H_0 : \delta_1 = \delta_2 = 0$$
$$H_A : \delta_1 \neq \delta_2 \neq 0$$

The null hypothesis is specified as the non-existence of a long run relationship, thus failure to reject the null implies there is no long run relationship between the variables under consideration. In contrast, rejecting the null in favour of the alternative hypothesis, H_A, suggests there is cointegration between the variables considered. The ARDL reaches a conclusion based on an F-statistic presented between two critical bounds, the lower I(0) and upper I(1). An F-statistic below the lower bound results in failure to reject the null i.e., no long run relationship, while an F-statistic above the upper bound provides evidence for the alternative hypothesis i.e., the presence of a long run relationship. However, if an F-statistic is between the lower and upper bounds, then the result is inconclusive.

Shin et al. (2014) extends the ARDL and formulates a nonlinear ARDL (NARDL) method with the same requirements as the ARDL. The test equation is presented in equation 4.25, and the intuition is that y may react differently to positive impacts of x^+ than it would to negative impacts of x^-. An extended derivation of the model and its description can be found in Shin et al. (2014).

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta y_{t-i} + \sum_{i=0}^{q} \alpha_2 \Delta X^+_{t-i} + \sum_{i=0}^{q} \alpha_3 \Delta X^-_{t-i} + \delta_1 y_{t-1} + \gamma_1 X^+_{t-1} + \gamma_1 X^-_{t-1} + \mu_t \quad (4.25)$$

5. Data

5.1 Sampling Periods

After identifying relevant unit root and cointegration methods for assessing current account sustainability, we apply them to South Africa. This paper exploits 2 data samples that comprise of annual and quarterly data sourced from the South African Reserve Bank(SARB, 2022). The selected quarterly period runs from 1960Q1 to 2021Q4, while annual data is from 1946 to 2021. These form our baseline results, and the starting point of both samples is determined by data availability.

Using data sets of different frequencies allows for a more robust conclusion on the sustainability of the current account, and offers various advantages over using one data set. Firstly, the annual data set covers a longer time frame than the quarterly data set. A data set with a longer time frame can allow for the dissipation of shocks to the current account, if any, when using the stationarity approach. This would allow for the testing of long run sustainability which may not be possible when relying on a data set spanning a shorter time period. Similarly, cointegration is a long-run phenomenon (Hakkio & Rush, 1991a), which might be better modelled using data that span longer periods. Hence, restricting the analysis to limited quarterly data might impede the study's ability to observe long-run trends.

However, despite the advantage of a long time span, an extremely long dataset might submerge subsample periods of interest. This might make it difficult to proactively assess disturbances that have the potential to destabilise current accounts in the short run. Moreover, due to the number of data points available in annual data (from 1946 to 2021), it becomes difficult to consider subsamples of annual data without compromising on the testing power of tests. Indeed, higher frequency of quarterly data compared to the yearly series over the same time span can increase the power of the tests used (Zhou, 2001). The previously evaluated studies of Taylor (2002), Gundlach and Sinn (1992), and Jansen (1996) motivate this selection of various time frames. While Taylor (2002)'s study showed sustainability over decade long data, the subsample period selections of the same data by Jansen (1996) and Gundlach and Sinn (1992) reveal periods of unsustainability in the current accounts of various developed economies. Furthermore, Gundlach and Sinn (1992) highlight the effects of the change in current account sustainability standings of countries due to the effect of changes in their exchange rate regime, which are masked by data that spans relatively long periods in the study by Taylor (2002). In this regard, the long quarterly sample (1960Q1-2021Q4) is selected based on data availability (the longest quarterly sample available), to equally measure long run sustainability alongside the annual sample, but with more dynamics that might be submerged by annual data. We additionally consider a short quarterly sample (1985Q3-2021Q4), to measure short run sustainability and the economy's most recent current account dynamics. The starting point corresponds with the period South Africa adopted a dual exchange rate regime.

5.2 Selected Variables

The empirical estimation of the stationarity approach relies on the ratio of the current account balance to gross domestic product ($CAGDP$), following Taylor (2002). The cointegration approach requires decomposing the current account balance into current account receipts and payments. Following Brissimis et al. (2012), the exports of goods and services variable (EX) measure the country's receipts, while the imports of goods and services minus net factor incomes and net unilateral transfers (IM) measure the country's payments. Net factor incomes are calculated as the difference between primary income receipts and primary income payments, while net unilateral transfers are the difference between current transfer receipts and current transfer payments. The latter two flows are considered for two reasons. Firstly, their inclusion is consistent with the definition of the current account; hence their exclusion would reduce the current account to the trade balance. Secondly, primary and secondary incomes significantly contribute to South Africa's persistent current account deficit, as the country generally posts trade balance surpluses. Hereafter, this study adopts a definition of imports that is inclusive of income components of the current account unless specified otherwise.

For robustness, alternative specifications of the current account are considered in the cointegration approach. The current account can be considered as the difference between savings and investments. Hence, a cointegration analysis between savings and investments can lend insight on the sustainability of the current account as is the case with the cointegration analysis between exports and imports (Herzberg, 2014). In this regard, we follow Sinha (2002) and gross domestic savings is used to measure savings (S), while gross fixed capital formation is used to measure investment (I).

All aforementioned ratios and variables are calculated based on flows measured at current Rand prices. Additionally, export, import, savings and investment variables are expressed as a percentage of GDP for scaling purposes.

6. Empirical Results

After identifying relevant data and methods, this paper proceeds to test for current account sustainability. This aim is achieved by employing the different unit root and cointegration methods for a robust conclusion.

6.1 Descriptive Statistics

First, we perform a descriptive analysis of our key variables; exports, imports, investments, savings and the current account to GDP ratio as presented in Table 6.1.1. This allows us to get preliminary insights on the data we are using and the South African economy. Descriptive statistics reveal that on average, imports exceed exports as a percentage of GDP. This implies South Africa relies more on external goods, services and pays more in factor incomes, than it generates from its own exports and its factors of production. As a result, the current account has experienced an average deficit of 1.8% of GDP annually. Descriptive statistics across all samples additionally reveal that on average South Africa invests more than it saves. This similarly speaks to the fragility of the current account, as the economy might rely on external resources for its domestic investments – leaving it too vulnerable to investor sentiment. Considering that the mean can be influenced by extreme values, we also examine the median of all key variables. The median reveals trends similar to that of the mean.

6.2 Stationarity Approach

The stationarity of the current account to GDP ratio in levels is consistent with intertemporal solvency and hence sustainability of the current account. Consequently, a popular method of assessing current account sustainability is applying unit root tests to the current account variable. Due to studies using either linear or nonlinear specifications in unit root testing, a pivotal starting point would be testing the current account for nonlinearities. Failure to detect nonlinearities would imply traditionally linear unit root tests are adequate to assess current account sustainability. However, if nonlinearities are present in the data generating process of the current account, this would validate the use of nonlinear unit root tests to assess current account sustainability (Chen, 2011; Christopoulos & León-Ledesma, 2010).

Table 6.1.1: Descriptive Statistics

		Mean	Median	Maximum	Minimum	Std Dev
Annual (1946 - 2021)	EX	24.7	24.7	32.3	18.4	3.2
	IM	26.5	26.3	37.3	17.6	4.4
	I	19.3	18.4	29.2	13.1	3.9
	S	18.4	17.2	33.4	7.0	4.8
	CAGDP	-1.8	-1.5	5.3	-16.0	3.8
Quarterly (1960Q1 - 2021Q4)	EX	24.7	24.5	38.6	17.2	3.6
	IM	25.7	25.2	40.0	16.4	4.3
	I	19.5	18.5	31.7	12.4	4.3
	S	19.1	18.0	36.9	10.4	5.0
	CAGDP	-1.0	-0.9	12.8	-10.0	3.4
Quarterly (1985Q3 - 2021Q4)	EX	25.2	25.8	33.7	17.2	3.5
	IM	26.2	25.9	40.0	16.4	5.0
	I	17.0	16.8	23.2	12.4	2.3
	S	16.2	15.4	27.1	10.4	3.2
	CAGDP	-0.9	-1.1	6.4	-7.1	3.0

Notes: As defined and explained in section 5.0, EX = Exports, IM = Imports (adjusted for current account incomes and transfers), I = Investments, S = Savings, CAGDP = Current account balance to GDP ratio.

Consequently, the linearity of the current account to GDP ratio is evaluated through; the neural network test by Granger, Terasvirta, et al. (1993); the white neural network test by Lee et al. (1993); and the nonlinearity test by Tsay (1986). The results of these tests are presented in Table 6.2.1.

Results in Table 6.2.1 show that the annual data sample (1946 - 2021) does not exhibit nonlinearities. The null hypothesis that the current account to GDP ratio follows some linear processes cannot be rejected, as the p-value is consistently above the 10 per cent level of significance. In contrast, the considered tests suggest that both samples of quarterly data might follow some nonlinear process, as the considered tests reject the null of linearity at the 10 per cent significance level.

Limited studies consider nonlinear methods; hence a comparative analysis of these nonlinearity results within current account literature is limited. However, studies by Raybaudi et al. (2004), Chen (2011) and Christopoulos and León-Ledesma (2010) which advocate for nonlinear methods in current account sustainability literature base their implementation of nonlinear unit root tests on findings from these linearity tests. They find nonlinearities in data from countries including the US, Australia, Spain, Portugal, New Zealand Belgium. In contrast, Chen (2011) fails to reject linearity in the Czech Republic and Finland. All of these studies utilise quarterly data in their analysis.

It is important to reiterate that the presence of nonlinearities affects the sustainability conclusion only through determining the appropriate model specification (Chen, 2014). In other words, the tests in Table 6.2.1 can only advise on whether a linear or nonlinear unit root test should be applied. After that, relevant conclusions on the current account's sustainability can be made based on findings from the implemented linear or nonlinear unit root test.

Table 6.2.1: Nonlinearity tests on Current account to GDP ratio

	Variable	Teraesvirta	White	Tsay
Annual (1946-2021)	CAGDP	0.89	0.88	0.76
Quarterly (1960Q1-2021Q4)	CAGDP	0.00*	0.01*	0.06***
Quarterly (1985Q3-2021Q4)	CAGDP	0.05**	0.06***	0.04**

Notes: values represent p-values, where ***, **, * represent significance at 10%, 5% and 1% levels, respectively. CAGDP is the current account to GDP ratio. The tests consider a null of linearity against an alternative of nonlinearity (Psaradakis & Spagnolo, 2002).

Failing to reject the null of linearity in annual current account to GDP ratio suggests linear unit root tests might be more appropriate for this sample. In contrast, linearity tests suggest nonlinear unit root tests might be more appropriate for quarterly data. However, we still consider linear-based unit root tests for quarterly data, as this allows for a comparison in results between linear and nonlinear specified unit root tests.

First, we consider the ADF and PP unit root tests due to their widespread usage in the literature. The ADF and PP test the null of a unit root against a stationary alternative. However, the ADF and PP tests tend to be biased against the non-rejection of the nonstationary null. Consequently, the KPSS test which considers a null of stationarity against a nonstationary alternative is also considered. Utilising tests that evaluate a null of a unit root and those considering a null of stationarity usually allows for confirmatory analysis of results (Maddala & Kim, 1998). If unit root tests reject the null of a unit root, and stationarity tests fail to reject the null of stationarity, then results are consistent and confirmatory[6] . Similarly, results can be confirmatory if unit root tests fail to reject their null of a unit root, while stationarity tests reject their null of stationarity in favour of nonstationary alternatives. Otherwise, results can be considered inconclusive.

Intuitively problems arise if results are inconclusive since confirmatory analysis does not

[6]Tests with a null of a unit root are considered unit root tests, whereas tests with a null of stationarity are referred to as stationarity tests.

suggest which of the conclusions would be more appropriate. Furthermore, confirmatory analysis for the ADF and PP through the KPSS has been notably criticised by Maddala and Kim (1998) as seeking confirmation from a test with low power problems that similarly plague the ADF and PP unit root tests. Instead, they suggest utilising more powerful unit root tests to confirm results. Caner and Kilian (2001) similarly critique the use of these unit root and stationarity tests as complementary, suggesting it might be misleading. In this regard, the stronger powered DFGLS unit root test is considered in addition to the ADF, PP and KPSS.

The ADF and PP unit root tests reject the null of a unit root in the current account to GDP based on annual data, as presented in Table 6.2.2. The KPSS offers conflicting results, as the presence of stationarity depends on the test specification. However, the higher-powered DFGLS supports stationarity regardless of test equation specification, as it rejects the null of a unit root at the 5 per cent level of significance. Thus, South Africa has a sustainable current account between 1946 and 2021, validating the ability of the current account to serve as a buffer for consumption smoothing purposes.

Quarterly based samples provide contrasting results to the annual results as presented in Table 6.2.2. The linear unit root tests suggest the full quarterly sample (1960Q1-2021Q4) is stationary at level. This contradicts our nonlinearity test results as we typically expect the presence of nonlinearities to induce a unit root or nonstationary result in current account data consistent with findings by Chen (2014) and Christopoulos and León-Ledesma (2010). However, it could be that the nonlinearity present in the full sample quarterly data does not affect the stationarity properties of the data over the period, hence the finding that CAGDP is I(0). While the PP test suggests stationarity in the short quarterly sample (1985Q3-2021Q4), the ADF and higher powered DFGLS suggest otherwise, finding evidence of a unit root in the sample. Additionally, the KPSS rejects the null of stationarity in the short quarterly sample. Hence, for the short quarterly result, it might be that the data presents with nonlinearities that do in fact induce nonstationarity, or there could be breaks in the data that are mistaken for unit roots.

Overall, the results over the three samples suggest the presence of sustainability when using relatively longer samples, due to the stationarity result in the annual series and longer quarterly series. In contrast, the shorter quarterly series generally suggests the current account is unsustainable. The sustainability results based on annual and full quarterly samples are consistent with stationarity findings of Chu et al. (2007) and Holmes et al. (2003), who test South Africa alongside other African economies in their panel analysis. As previously discussed, panel results are sensitive to member selection and it is possible to

Table 6.2.2: Unit root and stationarity tests on the Current account to GDP ratio

	ADF		PP		DFGLS		KPSS	
	C	C+T	C	C+T	C	C+T	C	C+T
Annual (1946 - 2021)	-3.53**	-3.57**	-3.12**	-3.28***	-2.10**	-3.14**	0.27	0.17**
Quarterly (1960Q1 - 2021Q4)	-4.66*	-4.70*	-6.28*	-6.33*	-3.59*	-4.48*	0.23	0.13***
Quarterly (1985Q3 - 2021Q4)	-2.40	-1.96	-4.28*	-5.39*	-1.35	-2.14	0.79*	0.21**

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. C represents test equations that include a constant term only, while C+T include a constant and a trend. ADF, PP and DFGLS test a null of a unit root against a stationary alternative. A significant result implies stationarity, hence a sustainable current account. The KPSS tests a null of stationarity against a unit root alternative. A significant result implies the presence of a unit root, hence an unsustainable current account.

incorrectly conclude that a country has a stationary series due to the countries included alongside the country of interest in a panel. Hence, our country study results based on these two samples lend support to stationarity findings on South Africa by Chu et al. (2007) and Holmes et al. (2003), implying their results for South Africa might not be biased by panel member selection.

The failure to reject the null of a unit root on quarterly data between 1985Q3 and 2021Q4 through the ADF and DFGLS, as well as the rejection of the null of stationarity by the KPSS, contrary to theory, might be due to structural breaks. Indeed, some studies find that accommodating breaks in unit root tests reverses the prior conclusion that current accounts follow a unit root process, for example, Liu and Tanner (1996) using data from industrialised countries. To consider this possibility, the Zivot and Andrews (1992) (ZA) unit root test is implemented. The test is preferred as it endogenously determines a one-time structural break, avoiding the need to pre-test data. In this way, results from the ZA are less likely to suffer from data mining biases, unlike utilising the Perron (1989) unit root tests, which requires having *a priori* knowledge about the data's breaks i.e., breaks are exogenously determined. The ZA operates within the framework of linear regression models, hence is still considered a linear unit root test. It extends the ADF but differs with it due to its ability to accommodate breaks in the data generating process of the series (Herzberg, 2014).

Results for the ZA unit root test are presented in Table 6.2.3, and the test fails to reject the null of a unit root against stationarity with a break, regardless of the test specification. This finding suggests that stationarity cannot be achieved even when considering endogenous breaks in the evolution of the current account. As a result, the ZA further validates the ADF, DFGLS, and the KPSS in suggesting the current account is a nonstationary process. Hence, South Africa runs an unsustainable current account balance between 1985Q3 and 2021Q4. Results further reject the null of a unit root in levels for the annual and full quarterly samples, corroborating the finding that both series are stationary in levels as presented in Table 6.2.2. Thus, the ZA emphasises the intertemporal solvency of the current account and its sustainability based on the annual and full quarterly samples.

Table 6.2.3: Zivot-Andrews unit root test on Current Account to GDP ratio

	C	TB	C+T	TB
	Level			
Annual (1946-2021)	-5.01**	2003	-4.81***	2003
Quarterly (1960Q1-2021Q4)	-5.46*	1976Q3	-5.83*	1976Q3
Quarterly (1985Q3-2021Q4)	-2.69	2016Q2	-3.47	2015Q3

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. C represents test equation that includes a constant term only, while C+T includes a constant and trend. TB denotes potential break-date. ZA tests the null of a unit root, against stationarity with a break.

To the best of our knowledge, no study has considered the sustainability of South Africa's current account utilising unit root tests with a break. This is reasonable, considering the existing unit root studies by Chu et al. (2007) and Holmes et al. (2003) find the current account stationary– hence further testing is redundant and might similarly obfuscate results. However, these studies utilise panel methods, which can be sensitive to member selection or generalise results due to assessing joint nulls. Hence, our findings based on the short quarterly sample highlight the necessity for individual country studies, both for stronger certainty in findings and the ability to interrogate current account dynamics more closely.

The ADF, DFGLS, and KPSS unit root and stationarity tests fail to find stationarity in the current account to GDP ratio of South Africa between 1985Q3 and 2021Q4. Similarly, the ZA unit root test fails to find stationarity in the variable, despite accounting for structural breaks in the alternative. While these results and conclusions are derived from linear-based tests following literature, there is motivation to consider the evolution of a country's current account as a nonlinear process. Indeed, the current account can exhibit nonlinearities due to factors such as government policy interventions and institutional preferences, as well as market forces, including changes in risk assessments by agents (Christopoulos & León-Ledesma, 2010; Clarida et al., 2007).

For South Africa, a practical motivation for considering nonlinearity is validated by the failure to find linearity in quarterly data between 1985Q3 and 2021Q4, as presented in Table 6.2.1. This is further reinforced by the inability to find stationarity with the above-discussed results, contrary to the expected theory. Given that linear-based tests can fail to find stationarity in the presence of nonlinearities, nonlinear unit root tests are applied to South Africa's current account to check for nonlinear mean reversion.

We utilise the Kapetanios et al. (2003) (KSS) unit root test, as it considers a null of a linear unit root process against a globally stationary exponential smooth transition autoregressive (ESTAR) alternative. If indeed for the short quarterly sample CAGDP follows a unit root process, the test will fail to reject its null and find the current account to have a unit root. This finding would be consistent with the ADF, DFGLS and ZA failing to reject the null of a linear unit root, and that of the KPSS rejecting stationarity. Additionally, this would suggest insufficient evidence for a nonlinear ESTAR alternative. However, if the process follows a nonlinear ESTAR stationary process, the test will favour the alternative hypothesis of a stationary ESTAR model. This latter finding would imply that the failure to reject the null by the ADF and DFGLS tests is because they fail to consider size nonlinearities. Similarly, it would imply the failure to reject the null by the ZA test is because of nonlinearities and not the presence of breaks. In this way, the KSS can discriminate between unit root and nonlinear stationary processes, where nonlinear stationary processes might be misclassified as unit roots by the ADF, KPSS, DFGLS, and ZA unit root tests. Additionally, we utilise the Sollis (2009) unit AESTAR unit root test, to account for both size and sign nonlinearities; the conclusions of which will have similar implications as the KSS noted above.

Following Cuestas (2013) and Christopoulos and León-Ledesma (2010), we demean CAGDP and present the KSS and Sollis unit root tests of the demeaned variable in Table 6.2.4. The data is demeaned as the primary objective is to check if CAGDP is converging to a stable equilibrium level (Cuestas, 2013). The null of a unit root is rejected at the 10 per cent significance level in favour of the nonlinear ESTAR and AESTAR alternatives. This finding suggests that current account to GDP ratio of South Africa is a nonlinear but stationary process; hence failure to find stationarity in the current account by the ADF, DFGLS, KPSS and ZA tests was due to their inability to discriminate between nonlinear and unit root processes. Specifically, size and sign nonlinearities are present in the current account to GDP ratio of South Africa, and failure to find stationarity through conventional tests is due to the misspecifications of the linear unit root tests that ignore these nonlinearities. The presence of size nonlinearities suggests the speed of adjustment depends on how large deviations from equilibrium are, whereas sign nonlinearities imply the speed of adjustment is also dependent on the sign of shocks to the current account.

Stationarity results suggest the current account of South Africa is sustainable. Over the longer terms based on the annual sample (1946-2021) and the full quarterly sample (1960Q1 – 2021Q4), the current account presents with linear mean reversion. Interestingly, the short quarterly sample does not. Indeed, we fail to find stationarity through linear unit root tests on the 1983Q3-2021Q4 sample. However, we overturn this result once we consider the presence of nonlinearities in the development of the current account. Hence, while nonlinear, the current account is indeed stationary and thus sustainable in the short quarterly sample.

Empirical literature has shown the conflict in current account sustainability results, specifically how results depend on the approach used. This prompts us to consider the cointegration approach for completeness. Hence, we proceed by checking for cointegration between components of South Africa's current account variables. The presence of cointegration would uphold our stationarity results, and reaffirm the sustainability of South Africa's current account deficits.

Table 6.2.4: KSS and Sollis unit root test on Current account to GDP ratio

	Test Stat	
Variable	KSS	Sollis
CAGDP	-2.713***	3.741***

Note: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. Critical values of the tests are presented in Kapetanios et al. (2003) and Sollis (2009). The KSS and Sollis test nulls of a unit root against stationary ESTAR and AESTAR alternatives, respectively.

6.3 Cointegration Approach

An alternative evaluation of current account sustainability is through the cointegration approach, which evaluates the long-run relationship between components of the current account. Cointegration between current account variables would imply that an economy can meet its long-run intertemporal budget constraint, and just as with the stationarity approach, a current account that is intertemporally solvent would be considered sustainable over the assessed time period.

The baseline model in this study considers the cointegration of exports and imports. This can be specified as model 1: $EX_t = \alpha + \beta IM_t$, following Husted (1992). For robustness of results, additional models are considered. These include model 2: $IM_t = \alpha + \beta EX_t$, following Arize (2002) and Herzer and Nowak-Lehmann (2006) utilising the same aforementioned variables.

Additionally, we consider the long run relationship between savings and investments in model 3: $I_t = \alpha + \beta S_t$, following Sinha (2002).

Cointegration evaluations are preceded by testing for unit roots in the current account components discussed above. The mean and covariance of nonstationary data vary over time; thus, the use of such data may lead to spurious results if an appropriate method of analysis is not followed. Thus, unit root tests are a necessary starting point prior to analysis of macroeconomic data for a determination of the appropriate cointegration procedures to follow. Indeed, different cointegration tests have different conditions for their usage, where a binding restriction for most cointegration tests is that variables are not integrated of the second order or higher (Shrestha & Bhatta, 2018). The Engle-Granger, Maki, and Johansen cointegration tests require all variables to be nonstationary I(1) variables, otherwise the tests are inappropriate. In contrast to these tests, the ARDL and NARDL approaches may be applied where variables are all I(1), or a mix of I(0) and I(1) variables.

If all variables are stationary in levels i.e. I(0), a cointegration test in line with the restrictions of the tests above is not necessary – instead, an ordinary least squares (OLS) or vector autoregressive (VAR) becomes appropriate (Shrestha & Bhatta, 2018). However, to keep up with the empirical strategy adopted in literature in assessing current account sustainability, this study does not pursue analysis for variables found to be stationary in levels. If both the export and import variables are stationary in levels, or if at least one of the variables is stationary of an order higher than the first, no further analysis will be conducted as this eliminates the possibility of a long run relationship and implies the current account is not sustainable. Hence, it is necessary to understand the data-generating processes of current account components before attempting to model their long-run dynamics.

First, the standard ADF, PP and KPSS unit root tests are utilised to determine the orders of integration of the current account components. The ADF and PP test a null of a unit root against the alternative of stationarity. In contrast, the KPSS tests a null of stationarity against a unit root alternative. Hence, results from these tests are consistent if the ADF and PP reject the null of a unit root, while the KPSS fails to reject the null of stationarity, or where the ADF and PP fail to reject their nulls while the KPSS rejects its null. All variables are tested in levels then at first difference to determine the level at which stationarity is achieved. Thus, for variables where the null of a unit root is not rejected in the ADF and PP tests or the null of stationarity is rejected in the KPSS test at level, variables are tested once more at first difference. To ensure robustness, unit root test equations are constructed to consider the constant, and the constant and trend, and results of all cointegration models are presented on Table 6.3.1.

For annual data, the ADF and PP tests suggest all variables have a unit root at level regardless of test specification, and unanimously suggest all variables are stationary at first difference as presented on Table 6.3.1. Results from the KPSS test are mixed, and depend on the test specification. The null of stationarity in the test is not rejected for exports regardless of test specification. However, for the rest of the variables, the null of stationarity is only rejected when a trend component is considered in the test equation. Lastly, most annual data variables can be considered to be at most I(1), given the rejection of the null at first difference by the ADF and PP, and given the failure to reject the null of stationarity at first difference by the KPSS. A notable exception to this is the KPSS test on import variables at first difference, where the null of stationarity at first difference is rejected, implying the variable might be I(2) or higher.

Results based on quarterly data are even less unanimous on the order of integration of all variables across the three tests. The ADF and PP reject the null of a unit root in imports at levels and find the variable to be I(0) in the full quarterly sample (1960Q1 – 2021Q4). In contrast, the KPSS rejects the null of stationarity at levels and suggests the variable is I(1) instead. In addition, while the ADF suggests exports are I(1), the PP suggests the variable is I(0), while the KPSS results depend on the test specification. A similar contradictory finding of the tests presents itself in the savings variable, where the ADF and KPSS suggest the variable is I(1) while the PP finds it I(0). Unanimity on this data set is only possible with the investment variable, where the ADF and PP reject the null of a unit root at first difference while the KPSS fails to reject stationarity, suggesting the variable is I(1). A similar lack of consensus presents itself with the short quarterly data, where different tests suggest different orders of integration.

Overall, the results of the unit root tests in Table 6.3.1 are concerning due to the lack of consensus on the order of integration of the variables. This is because of the reasons provided before; the use of cointegration tests critically depend on the assumptions made on the order of integration of the variables under assessment. An incorrect assumption might lead to using an inappropriate cointegration test, leading to misleading results. To resolve this, the study proceeds by considering the more powerful Zivot-Andrews (ZA) unit root test. The ZA unit root test considers the possibility of endogenous breaks in the alternative hypothesis, i.e. that the series might alternatively be a stationary variable with breaks. Thus, there might be structural changes in our data inducing these inconsistent results. This is motivated by the low testing power of these tests in the presence of structural breaks, where these tests might mistake the variables' breaks for unit root processes. For example, it might be that the finding of an I(2) or higher order of integration on annual imports through the KPSS is due to a break in the series, and not necessarily a unit root process. Accounting for such breaks with a test like the ZA might reveal that the true data generating process of the variable is stationary around a break in the series. Indeed, it is worthwhile to consider additional results from more powerful unit root tests rather than confirmatory analysis of the ADF and PP unit root tests with a similarly weak powered KPSS test (Maddala & Kim, 1998).

Results from the ZA test for all data sets and variables are presented in Table 6.3.2. The ZA unit root finds all annual data and short quarterly data variables to be stationary at first difference i.e., I(1). Except for finding imports to be I(0), the ZA suggests all short quarterly sample variables to be I(1). Furthermore, all of the test results are consistent and unanimous regardless of test equation specification. Thus, the true order of integration of the variables in this study will be as determined by the Zivot-Andrews test for the reasons already provided.

Since the respective pairs of exports-imports and savings-investments for the annual data and short quarterly data are integrated of order one as determined by the ZA unit root test, there might exist a linear combination of these pairs that is stationary, i.e., in each case, the two variables might share the same stochastic trend when evaluated through the Engle-Granger, Johansen, Maki, ARDL or NARDL cointegration tests. The same applies for the full sample quarterly data savings-investment pair. However, the export-import pairs of the full quarterly sample are of mixed orders of integration and can only be assessed through the ARDL and NARDL.

If stationary linear combinations of these pairs exist, there would exist long-run relationships between the variables. As a result, short-term divergences between the variables would be temporary, as exports-imports or savings-investments converge in the long run to ensure intertemporal solvency and, thus, current account sustainability. In light of these unit root results, we proceed with testing for long run relations next.

6.3.1 Engle-Granger Cointegration Test

Cointegration is first evaluated through the Engle and Granger (1987) residual-based cointegration test, which requires all variables to be stationary at first difference. The Engle-Granger test entails applying the ADF unit root test on the residuals of the regression between current account components. Rejecting the null of a unit root implies the residuals are stationary, which provides evidence for cointegration hence intertemporal solvency and current account sustainability. A cointegration result would imply that deviations between the variables of interest are temporary. Conversely, failure to reject the null of a unit root

Table 6.3.1: Unit root and stationarity tests on Current Account Components

Level						
	ADF		PP		KPSS	
	C	C+T	C	C+T	C	C+T
Annual (1946-2021)						
EX	-2.75	-2.93	-2.89	-3.1	0.27	0.11
IM	-2.9	-2.89	-2.9	-2.86	0.19	0.19**
I	-1.13	-1.55	-1.85	-2.38	0.31	0.17**
S	-2.21	-2.53	-2.17	-2.41	0.32	0.24*
Quarterly (1960Q1-2021Q4)						
EX	-2.78	-3.34	-4.68*	-5.43*	0.53*	0.14
IM	-3.04**	-3.62**	-3.35**	-3.99**	0.72**	0.24**
I	-1.47	-2.46	-1.53	-2.32	0.86*	0.20**
S	-1.58	-2.68	-4.22*	-6.99*	1.35*	0.23*
Quarterly (1985Q3-2021Q4)						
EX	-2.01	-3.49**	-2.26	-3.52**	0.83*	0.14
IM	1.84	-3.39**	-2.17	-3.76**	1.03*	0.15**
I	-2.42	-2.48	-2.67	-2.67	0.23	0.18**
S	-2.72	-1.92	-4.78*	-6.87*	0.97*	0.27*
First Difference						
	ADF		PP		KPSS	
	C	C+T	C	C+T	C	C+T
Annual (1946-2021)						
EX	-7.83*	-7.78*	-7.79*	-7.73*	-	-
IM	-8.82*	-7.48*	-11.44*	-15.16*	-	0.3*
I	-7.45*	-7.49*	-5.95*	-5.99*	-	0.07
S	-9.43*	-9.66*	-9.43*	-9.71*	-	0.13
Quarterly (1960Q1-2021Q4)						
EX	-26.85*	-26.85*	-	-	0.08	-
IM	-	-	-	-	0.04	0.03
I	-5.00*	-5.07*	-18.32*	-18.45*	0.14	0.07
S	-17.73*	-17.70*	-	-	0.03	0.03
Quarterly (1985Q3-2021Q4)						
EX	-16.12*	-	-16.26*	-	0.12	-
IM	-5.45*	-	-17.08*	-	0.06	0.06
I	-4.47*	-4.44*	-12.44*	-12.40*	-	0.11
S	-15.13*	-15.39*	-	-	0.20	0.04

Notes: **, * represent significance at 5% and 1% levels, respectively. C represents test equation that includes a constant term only, while C+T includes a constant and trend. ADF and PP test a null of a unit root against a stationary alternative, while the KPSS tests a null of stationarity against a unit root alternative.

Table 6.3.2: Zivot-Andrews unit root tests on Current Account components

	Level		First Difference		Outcome
Annual (1946-2021)					
EX	-4.14 (2006)	-4.64 (1989)	-8.01* (1981)	-8.04* (1981)	I(1)
IM	-3.67 (2000)	-3.31 (1985)	-8.15* (2009)	-8.19* (1995)	I(1)
I	-2.82 (1986)	-3.33 (1984)	-8.11* (1978)	-8.12* (1978)	I(1)
S	-3.88 (1990)	-4.53 (1981)	-10.96* (1981)	-11.16* (1981)	I(1)
Quarterly (1960Q1-2021Q4)					
EX	-4.49 (1988Q4)	-4.61 (1988Q4)	-8.25* (1980Q2)	-8.44* (1980Q2)	I(1)
IM	-5.10** (1982Q2)	-5.09** (1982Q2)	-	-	I(0)
I	-3.34 1985Q2)	-3.71 (1984Q1)	-5.58* (1976Q1)	-5.67* (1976Q1)	I(1)
S	-4.03 (1990Q1)	-4.04 (1981Q1)	-18.44* (1980Q4)	-18.44* (1980Q4)	I(1)
Quarterly (1985Q3Q1-2021Q4)					
EX	-3.75 (2006Q2)	-4.19 (1993Q1)	-6.48* (2009Q1)	-6.53* (2009Q1)	I(1)
IM	-4.34 (2016Q2)	-4.78 (2006Q1)	-6.49* (2008Q4)	-6.34* (2008Q4)	I(1)
I	-4.29 (2005Q3)	-4.02 (2005Q3)	-5.57* (2009Q1)	-5.44** (2009Q1)	I(1)
S	-3.39 (1992Q2)	-3.34 (1992Q2)	-15.57* (2012Q1)	-15.83* (2012Q1)	I(1)

Notes: **, * represent significance at 5% and 1% levels, respectively. The figure in brackets denotes the break date suggested by the test. C represents test equation that includes a constant term only, while C+T include a constant and trend. The last column presents the final order of integration for the respective variables.

implies failure to find a stationary linear combination between the variables. This lack of cointegration implies that deviations between current account components would be permanent, such that intertemporal insolvency persists and the current account remains on an unsustainable path.

Since the ADF test is applied on the regression residuals and not an observable time series, i.e., the unit root test is applied to residuals of an estimated relationship, ADF test critical values do not apply and are invalid. In this study, the test statistic derived from the ADF test is compared against MacKinnon (1996)'s simulated critical values and corresponding probability values. Table 6.3.3 presents the cointegration results of all models and time frames whose variables meet the Engle-Granger test requirements.

For the export and import variables, a cointegration evaluation is considered for the annual and short quarterly (1985Q3-2021Q4) samples only, as all variables in these data sets were I(1), unlike variables in the Quarterly(1960Q1-2021Q4). Engle-Granger results presented in Table 6.3.3 suggest evidence of cointegration at the 10 per cent level of significance in model 1 using annual data. This finding is corroborated by the robust check of model 2, where imports are set as the dependent variable. This suggests that there exists a long run-relationship and co-movement between exports and imports between 1946 and 2021 in South Africa, suggesting further that the economy's current account balance over the time period was sustainable due to meeting intertemporal solvency. In contrast, model 1 and 2 utilising short quarterly data between 1985Q3 and 2021Q4 fails to reject the null of cointegration over the period, suggesting South Africa's current account to be on an unsustainable path.

While annual Engle-Granger results on exports and imports corroborate the existence of a cointegrating relationship found by Searle and Touna-Mama (2010)'s quarterly data analysis of South Africa, they contrast with our findings based on quarterly data. Two possible reasons might account for this. Firstly, annual data spans a longer period; hence the presence of cointegration in our annual data (in contrast to our quarterly data) might be due to having data that spans longer, especially since cointegration might be best modelled as a long-term relationship as posited by Hakkio and Rush (1991a). Secondly, Searle and Touna-Mama (2010) utilise exogenous breaks to improve their quarterly data analysis. This is done to accommodate changes in the variables' long-run relationship. We revisit the possibility of breaks inducing the lack of cointegration results in our quarterly sample when considering the Maki cointegration test, as it can endogenously accommodate breaks in cointegrating relationships. In the presence of breaks, the Maki cointegration test is preferred to utilising exogenously determined breaks to prevent inducing biases in the result.

An additional robust check considers the cointegration between investments and savings, where as in the export and imports analysis, cointegration similarly implies intertemporal solvency and current account sustainability. Our Engle-Granger findings indicate the presence of a long-run relationship between investments and savings based on annual data. However, quarterly data finds no long-run relationship between the two variables. Similarly, this might be due to the quarterly data spanning a relatively less time frame than annual data since cointegration tends to hold better in the long-run, as previously established.

While the Engle-Granger is easy to implement, one of its notable critiques pertains to the

Table 6.3.3: Engle-Granger cointegration tests

Model 1: Exports on Imports		
EX = f(IM)		
	t-stat	P-Value
Annual (1946 - 2021)	-3.28	0.07***
Quarterly (1960Q1 - 2021Q4)	-	-
Quarterly (1985Q3- 2021Q4)	-2.80	0.17

Model 2: Imports on Exports		
IM = f(EX)		
	t-stat	P-Value
Annual (1946 - 2021)	-3.40	0.052***
Quarterly (1960Q1 - 2021Q4)	-	-
Quarterly (1985Q3- 2021Q4)	-2.57	0.25

Model 3: Savings and Investments		
I = f(S)		
	t-stat	P-Value
Annual (1946 - 2021)	-4.38	0.00***
Quarterly (1960Q1 - 2021Q4)	-2.96	0.12
Quarterly (1985Q3- 2021Q4)	-2.08	0.49

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. The null hypothesis is that the series are not cointegrated (i.e., presence of unit root on the regression residuals). The full quarterly sample of exports and imports is excluded because both variables are not I(1), hence cannot be cointegrated according to the Engle-Granger test. For all models, we consider models with a constant only. Results are not reported here for brevity, but results remain unchanged when considering a constant and trend specification.

normalisation of the regression equation, whose residuals are tested to establish cointegration. This implies cointegration results may depend on how the regression equation is specified (Pfaff, 2008), for instance, testing residuals of regressing exports on imports may yield different results to residuals generated when regressing imports on exports. The differences might disappear with a large enough data set. However, in practice, results might differ. This drawback of the Engle-Granger in current account sustainability literature through the analysis of exports and imports is highlighted by Arize (2002), who specifies the cointegrating relation as $IM_t = \alpha + \beta EX_t$ in contrast to Husted (1992)'s specification of $EX_t = \alpha + \beta IM_t$. Our Engle-Granger analysis on these variables considers both of these specifications for robust results given the two specifications suggested by empirical literature, i.e., in our model 1 and model 2, and finds that model specification does not impact the cointegration result in the samples utilised as they are consistent. Regardless of which variable is specified as the regressor or regressand, the presence of cointegration or lack thereof remains unchanged between exports and imports in the samples we evaluate, hence our results are robust. We proceed by considering the Johansen cointegration test next, which considers all variables as endogenous (thus the presence of cointegration is indifferent to model specification).

6.3.2 Johansen Cointegration Test

While the Johansen cointegration tests' benefits become more apparent in a multivariate analysis due to its ability to identify multiple cointegrating relationships, the Johansen still offers superior properties to the Engle-Granger in a bivariate setup. Furthermore, due to its formulation, the method does not require the selection of a regressand, unlike the Engle-Granger. Our Johansen cointegration analysis considers model 1 and model 3, but excludes model 2. Model 2 is excluded as the cointegration results are similar to those of model 1 due to the Johansen cointegration test result being invariable to model specification i.e., whether exports or imports are set as the dependent variable does not change the outcome of whether cointegration is found. This study follows Arize (2002)'s use of the Pantula principle detailed in Harris and Sollis (2003) to decide on the rank order and deterministic components of its Johansen cointegration test specification. The Pantula principle entails testing Johansen cointegration specifications from the most restrictive with regards to deterministic assumptions, to the least restrictive, and selecting the specifications where the null of no cointegration is no longer rejected based on the trace statistic. For comparison reasons, we provide max-eigen statistics of the models selected by the Pantula principle, and results from both tests are presented in Table 6.3.4.

The Johansen test finds evidence of cointegration between 1946 and 2021 based on both the trace statistics and maximum eigenvalue statistics of model 1 presented in Table 6.3.4. Both tests reject the null of no cointegrating equation at the 5 per cent significance level, then fail to reject the presence of at most one cointegrating relationship. This suggests current accounts are on a sustainable path over the period. In contrast, short quarterly data is unable to find evidence of a cointegrating relationship as the null of no cointegration is not rejected at the 5 percent level of significance. Our quarterly data finding contrasts with that of Arize (2002), who similarly uses the Pantula principle and finds that South Africa does not violate its IBC between 1973Q2 and 1997Q4. Other than differing sampling periods, the differing results might be due to the differing definitions of the import variable, where Arize (2002) does not adjust the import variable for current account incomes and current transfers.

Model 3 results based on investments and savings in all samples depend on which statistic is relied upon as the trace statistic and max-eigen statistic suggest different conclusions based on the samples. The trace statistic fails to reject the null of no cointegration in all of the sampled periods. Similarly, both statistics fail to find cointegration in the short quarterly sample. However, in contrast to the trace statistic, the max-eigen statistic finds evidence of cointegration at the 5 per cent level of significance in the full quarterly and annual samples. According to Cheung and Lai (1993), the trace statistic proves to be more robust than the max-eigen statistic when the residuals present with excess kurtosis. Based on our analysis, we find excess kurtosis in the residuals as presented on Table 9.1.1 in the appendix. Hence, for model 3, we conclude based on the trace statistic and find that there is no cointegration in any of our sampled periods. Notably, the short quarterly sample of model 1 does not present with kurtosis, but the result is immaterial to the conclusion noted above, since both the trace and max-eigen statistics unanimously find no cointegration between the export and import variables in the sample.

Table 6.3.4: Johansen cointegration tests

Model 1: Exports and Imports				
EX = f(IM)	Trace Statistic		Max-Eigen Statistic	
	r = 0	r ≤ 1	r = 0	r ≤ 1
Annual (1946 - 2021)	25.94**	7.12	18.82**	7.12
Quarterly (1960Q1 - 2021Q4)	-	-	-	-
Quarterly (1985Q3- 2021Q4)	9.64	3.81	5.84	3.81

Model 3: Investments and Savings				
I = f(S)	Trace Statistic		Max-Eigen Statistic	
	r = 0	r ≤ 1	r = 0	r ≤ 1
Annual (1946 - 2021)	17.51	1.48	16.02**	1.48
Quarterly (1960Q1 - 2021Q4)	18.45	0.76	17.69**	0.76
Quarterly (1985Q3- 2021Q4)	14.48	5.25	9.23	5.25

Note: ** denotes rejection of the hypothesis at the 5% level. r denotes the number of cointegrating relations, where the null checks if there is 0 or at most 1 cointegrating relationship respectively. The full quarterly sample of exports and imports is excluded because both variables are not I(1). As decided by the Pantula principle, model 3 long quarterly sample relies on the specification that data has linear trends but the cointegrating equations only have intercepts. For the rest of the samples, data has no trend but cointegrating equations have intercepts.

The failure to find cointegration through the Johansen cointegration test might be due to the presence of breaks in the cointegrating relationship. Failing to correct for breaks can induce a no cointegration result, when there is in fact cointegration between the variables. The inability of the Johansen test to endogenously consider breaks is a notable drawback of the method. This drawback similarly plagues the Engle-Granger test. In light of this, we consider the Maki cointegration test next, due to its ability to endogenously consider breaks in the cointegrating relationship.

6.3.3 Maki Cointegration Test

While the Engle-Granger test is popular due to its simplicity, and the Johansen is popular for its invariability to normalisation and ability to identify multiple cointegrating relationships, both these tests are poor at identifying cointegrating relationships in the presence of structural breaks. Indeed, it is more reasonable to believe that in the long term, shifts in the economic structure may change the long run relationship between variables (Baharumshah et al., 2003; Brissimis et al., 2012). The failure to consider breaks might explain why quarterly data persistently yields a no cointegration result in both sets of results contrary to our annual samples and *a priori* expectations.

Thus, to consider the possibility of breaks biasing the previous tests against finding a long-run relationship between exports and imports, we utilise the cointegration break test by Maki (2012) for samples the Engle-Granger and Johansen failed to establish cointegration for. The test offers several advantages over the Gregory and Hansen (1996). Firstly, the Gregory-Hansen test considers only one break. Thus, the test performs poorly if there is more than one break in the data. In contrast, the test by Maki (2012) allows for an unknown number of breaks, to a maximum of 5 (the Maki test is similar to the Gregory-Hansen test if the maximum number of breaks is set to 1). This closely matches reality, as it is unlikely that one knows the number of breaks beforehand. Hence, the Maki test reduces the chance of mis-specifying the number of breaks in the cointegrating relationship. Secondly, Maki (2012) finds their test to perform better than the Gregory-Hansen in the presence of persistent Markov switching shifts. Results from the Maki test are presented in Table 6.3.5, where the null hypothesis is of no cointegration. The alternative hypothesis is cointegration with j breaks, where j is at most five breaks.

The Maki cointegration test is unable to establish cointegration in the short quarterly sample of model 1. This is consistent with findings from our Engle-Granger and Johansen cointegration tests, implying there is no long run relationship between exports and imports over the sample spanning 1985Q3 to 2021Q4 regardless of whether breaks are considered or not. However, model 2 suggests otherwise for the same sample. Indeed, as presented in Table 6.3.5, we are able to find a long run relationship upon regressing imports on exports, hence evidence of current account sustainability. The relationship is established when considering test specifications with level shifts, and level shifts with a trend. The difference in results of model 1 (exports on imports) and model 2 (imports on exports) on the 1985Q3 – 2021Q4 sample highlights the sensitivity of the relationship between exports and imports to model specification. Additionally, the difference in our results for model 2 between the Engle-Granger and Johansen (no cointegration in both), versus our findings on the Maki (evidence of cointegration) highlight the importance of breaks in the export-import relationship in the sample.

The Maki cointegration test is unable to find a long run relationship between investments and savings over the short quarterly sample, consistent with the Johansen and Engle-Granger tests. However, evidence of a long run relationship can be found on the long quarterly sample and on annual data as presented on Table 6.3.5. The full quarterly sample is able to establish cointegration over a variety of Maki test specifications; the level shifts with trend model at a maximum of 3 and 4 breaks; the regime shifts model to a maximum of 2 breaks; and the trend and regime shifts model to a maximum of 4 and 5 breaks. For all these, significance is established at the 10 per cent level of significance. Lastly, annual data finds evidence of cointegration with 2 breaks on the regime shifts model at the 10 per cent level of significance. This finding is consistent with that of Stungwa and Mosikari (2023) for South Africa, although they utilise export and import variables. Overall, the difference in results between Engle-Granger and Johansen, versus Maki results for the investment and saving relationship highlights the relevance of breaks in the long run relationship.

The structural breaks in the Maki cointegration test coincide with several economic phenomena. The breakpoints in 1984 coincide with austerity measures which led to small surpluses being recorded in the South African current account. Breakpoints in 1994 and 1995, coincide with South Africa's transition to democratic independence and liberalisations of the capital account, respectively. These led to increases in capital flows to South Africa, resulting in small deficits post 1995. The breakpoint in 2003 coincide with deterioration in the trade balance driven by appreciations in the exchange rates, while breakpoints around 2008/2009 coincide with the global financial crisis. Having considered breaks and finding evidence of cointegration, we consider the long run estimates to check for the strength of the relationships.

Table 6.3.5: Maki cointegration test

Model 1: EX = f(IM) 1985Q3 - 2021Q4					
m	k ≤ 1	k ≤ 2	k ≤ 3	k ≤ 4	k ≤ 5
1	-3.57 (1993Q3)	-4.03 (1993Q3; 2015Q2)	-4.03 (1993Q3; 2012Q4; 2015Q2)	-4.2 (1993Q3; 1998Q4; 2012Q4; 2015Q2)	-4.43 (1993Q3; 1998Q4; 2002Q4; 2012Q4; 2015Q2)
2	-4.23 (1993Q3)	-4.23 (1989Q3; 1993Q3)	-4.78 (1989Q3; 1993Q3; 2008Q4)	-4.78 (1989Q3; 1993Q3; 2008Q4; 2015Q3)	-4.78 (1989Q3; 1993Q3; 1998Q4; 2008Q4; 2015Q2)
3	-3.87 (2010Q1)	-4.1 (1990Q1; 2010Q1)	-4.37 (1990Q1; 1998Q4; 2010Q1)	-4.84 (1990Q1; 1998Q4; 2003Q1; 2010Q1)	-5.71 (1990Q1; 1998Q4; 2003Q1; 2010Q1; 2015Q2)
4	-4.73 (2009Q2)	-4.73 (1995Q3; 2009Q2)	-4.73 (1995Q3; 2009Q2; 2015Q2)	-5.06 (1995Q3; 2002Q4; 2009Q2; 2015Q2)	-5.06 (1991Q3; 1995Q3; 2002Q4; 2009Q2; 2015Q2)

Model 2: IM = f(EX) 1985Q3 - 2021Q4					
m	k ≤ 1	k ≤ 2	k ≤ 3	k ≤ 4	k ≤ 5
1	-3.44 (2004Q1)	-3.44 (2004Q1; 2015Q2)	-4.98*** (1994Q4; 2004Q1; 2015Q2)	-5.38** (1994Q4; 2004Q1; 2010Q2; 2015Q2)	-5.38*** (1990Q2; 1994Q4; 2004Q1; 2010Q2; 2015Q2)
2	-5.59* (2015Q2)	-5.59** (2004Q1 ; 2015Q2)	-5.59** (1994Q4; 2004Q1; 2015Q2)	-5.59** (1994Q4; 2004Q1; 2008Q4; 2015Q2)	-5.59*** (1994Q4; 1998Q4; 2004Q1; 2008Q4; 2015Q2)
3	-3.22 (2004Q1)	-3.22 (1998Q2; 2004Q1)	-4.28 (1998Q2; 2004Q1; 2015Q2)	-4.28 (1994Q3; 1998Q2; 2004Q1; 2015Q2)	-4.28 (1994Q3; 1998Q2; 2004Q1; 2010Q2; 2015Q2)
4	-4.78 (2015Q2)	-4.94 (2004Q1; 2015Q2)	-4.94 (2004Q1; 2008Q3; 2015Q2)	-6.57 (1995Q1;2004Q1; 2008Q3; 2015Q2)	-6.57 (1990Q4; 1995Q1; 2004Q1; 2008Q3; 2015Q2)

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. Table presents test statistics, and numbers in brackets are structural break years determined endogenously by the test. m represents Maki model specification i.e., m = 1 is level shifts; m = 2 is level shifts with trend; m = 3 is regime shifts; m = 4 is trend and regime shifts. k is the maximum number of breaks allowed in the test.

Maki cointegration test

Model 3: I = f(S) 1960Q1 - 2021Q4					
m	k ≤ 1	k ≤ 2	k ≤ 3	k ≤ 4	k ≤ 5
1	-4.30 (1989Q4)	-4.30 (1975Q1; 1989Q4)	-4.62 (1975Q1; 1983Q4; 1989Q4)	-4.62 (1967Q1; 1975Q1; 1983Q4;1989Q4)	-4.62 (1967Q1; 1975Q1; 1983Q4; 1989Q4; 2007Q2)
2	-4.60 (1989Q4)	-4.60 (1971Q3; 1989Q4)	-5.21*** (1971Q3; 1989Q4; 2007Q2)	-5.35*** (1971Q3; 1979Q3; 1989Q4; 2007Q2)	-5.35 (1971Q3; 1979Q3; 1989Q4; 2007Q2; 2014Q4)
3	-4.15 (1984Q4)	-5.08*** (1975Q1; 1984Q4)	-5.08 (1967Q1; 1975Q1; 1984Q4)	-5.08 (1967Q1; 1975Q1; 1984Q4; 1992Q2)	-5.08 (1967Q1; 1975Q1; 1984Q4; 1992Q2; 2007Q2)
4	-4.42 (1984Q4)	-5.35 (1984Q4; 1994Q4)	-5.4 (1984Q4; 1994Q4; 2007Q2)	-6.95*** (1975Q1;1984Q4; 1994Q4; 2007Q2)	-7.13*** (1975Q1; 1984Q4; 1994Q4; 2007Q2; 2014Q4)

Model 3: I = f(S) 1985Q3 - 2021Q4					
m	k ≤ 1	k ≤ 2	k ≤ 3	k ≤ 4	k ≤ 5
1	-2.61 (1991Q2)	-2.61 (1991Q2; 2015Q2)	-3.87 (1991Q2; 2009Q4; 2015Q2)	-3.88 (1991Q2; 1998Q2; 2009Q4; 2015Q2)	-4.61 (1991Q2; 1998Q2; 2002Q2; 2009Q4; 2015Q2)
2	-4.3 (1992Q3)	-4.30 (1992Q3; 2008Q1)	-4.77 (1992Q3; 1998Q2; 2008Q1)	-4.77 (1992Q3; 1998Q2; 2002Q2; 2008Q1)	-4.77 (1992Q3; 1998Q2; 2002Q2; 2008Q1; 2015Q2)
3	-2.53 (1991Q2)	-2.87 (1991Q2; 2009Q3)	-3.55 (1991Q2; 2009Q3; 2015Q2)	-4.73 (1991Q2; 2005Q4; 2009Q3; 2015Q2)	-5.33 (1991Q2; 1997Q4; 2005Q4; 2009Q3; 2015Q2)
4	-4.53 (1994Q2)	-4.97 (1994Q2; 2008Q1)	-5.12 (1994Q2; 1998Q4; 2008Q1)	-5.39 (1994Q2; 1998Q4; 2008Q1; 2017Q4)	-5.51 (1994Q2; 1998Q4; 2008Q1; 2015Q2; 2017Q4)

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. Table presents test statistics, and numbers in brackets are structural break years determined endogenously by the test. m represents Maki model specification i.e., m = 1 is level shifts; m = 2 is level shifts with trend; m = 3 is regime shifts; m = 4 is trend and regime shifts. k is the maximum number of breaks allowed in the test.

Maki cointegration test

Model 1: I = f(S) 1946 - 2021					
m	k ≤ 1	k ≤ 2	k ≤ 3	k ≤ 4	k ≤ 5
1	-3.96 (1986)	-5.50* (1986; 1959)	-5.50** (1986; 1974; 1959)	-5.50** (1986; 1974; 1959; 2007)	-5.50** (1986; 1974; 1959; 1995; 2007)
2	-4.48 (1964)	-4.48 (1964; 2007)	-4.48 (1964; 1982; 2007)	-4.48 (1964; 1982; 1993; 2007)	-4.48 (1956; 1964; 1982; 1993; 2007)
3	-3.98 (1986)	-5.35*** (1974; 1986)	-5.35 (1960; 1974; 1986)	-5.35 (1960; 1974; 1986; 2003)	-5.35 (1960; 1974; 1986 2003; 2013)
4	-4.72 (1985)	-4.82 (1985; 2008)	-4.88 (1974; 1985; 2008)	-4.95 (1954; 1974; 1985; 2008)	-6.67 (1954; 1974; 1985; 1998; 2008)

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. Table presents test statistics, and numbers in brackets are structural break years determined endogenously by the test. m represents Maki model specification i.e., m = 1 is level shifts; m = 2 is level shifts with trend; m = 3 is regime shifts; m = 4 is trend and regime shifts. k is the maximum number of breaks allowed in the test.

6.3.4 Long Run Estimates

Thus far, we have only tested for cointegration to determine whether the IBC is met since meeting IBC implies current account sustainability. Indeed, cointegration remains the critical condition for establishing intertemporal solvency (Husted, 1992), hence the limited considerations of long run dynamics (i.e., the test on the coefficient to determine the strength of sustainability) by empirical studies (Arize, 2002). However, deriving long run estimates allows us to assess the strength of current account sustainability and understand the dynamics of the long run relationship better. As suggested by Quintos (1995), a coefficient of unity is synonymous with strong current account sustainability but a coefficient between 0 and 1 implies weak current account sustainability. While the Engle-Granger (OLS) and Johansen tests are able to provide these, we rely on the DOLS estimator by Stock and Watson (1993), as they are more asymptotically efficient and outperform estimates of the other estimators (Dees et al., 2007). An non exhaustive list of studies following this approach in current account literature i.e., studies that apply cointegration tests including the Engle-Granger, Johansen, and Gregory-Hansen, but adopt the DOLS for robust estimation of long run elasticities, include Baharumshah et al. (2003), Kao (1999), and Wu et al. (1996).

Table 6.3.6 reveals that all estimates are positive, and between 0 and 1, except for model 2 with annual data. These suggest imports have a positive impact on exports in model 1, exports positively impact imports in model 2, and savings have a positive impact on investment in model 3. However, a test for whether the coefficients are different from unity suggests that only Model 2 and Model 3 of the annual and full quarterly samples have unit coefficients synonymous with strong current account sustainability. Model 1 annual results suggest the current account is weakly sustainable, contrasting with model 2 annual results. This once more suggests the relevance of model specification in the export import relationship. Diagnostic checks for the DOLS models are presented in Table 9.2.1 of the appendix, and reveal that while all models have a high R-squared, all models have autocorrelation despite increasing lags. Additionally, the quarterly samples have heteroskedastic errors. To resolve these issues, we rely on the heteroskedasticity and autocorrelation (HAC) covariance estimator by Newey and West (1986), such that we are able to make reliable inferences.

Having only considered the cointegration between I(1) variables, we proceed by considering the ARDL and NARDL. These tests are also applicable to variables with mixed orders of integration, provided they are not I(2) and higher. Additionally, the tests perform better in small samples, unlike competing cointegration tests, for example, the Johansen cointegration.

6.3.5 Autoregressive Distributed Lag

Indeed, unit root tests conventionally precede cointegration analysis to determine whether variables are I(1). This is because only nonstationary variables can be cointegrated under the definition and procedure suggested by Engle and Granger (1987). This requirement is similarly a prerequisite for the Johansen cointegration test. However, the order of integration of variables is sometimes contentious as different unit root tests can suggest conflicting orders of integration. We see these differences in our evaluation of unit roots in current account components using conventional unit root tests presented in Table 6.3.1. This can prove cumbersome in cointegration analysis, considering that failure to identify the correct order of integration can impact whether or not a cointegration analysis is conducted. Moreover, incorrectly applying a cointegration analysis with the Engle-Granger and Johansen tests with stationary variables can provide unreliable results.

However, in contrast to the above cointegration tests, Pesaran et al. (2001) suggest the

Table 6.3.6: DOLS Long Run Estimates

		β	$H_0 : \beta = 1$	DOLS specification
Model 1: EX = f(IM)	Annual (1946 - 2021)	0.63	0.00*	Engle-Granger and Johansen
	Quarterly (1960Q1 -2021Q4)	-	-	-
	Quarterly (1985Q3 - 2021Q4)	-	-	-
Model 2: IM = f(EX)	Annual (1946 - 2021)	1.28	0.12	Engle-Granger and Johansen
	Quarterly (1960Q1 -2021Q4)	-	-	-
	Quarterly (1985Q3 - 2021Q4)	0.77	0.01*	Maki (level shifts with trend)
Model 3: I = f(S)	Annual (1946 - 2021)	0.49	0.049**	Maki (regime shifts)
	Quarterly (1960Q1 -2021Q4)	0.93	0.69	Maki (regime shifts)
	Quarterly (1985Q3 - 2021Q4)	-	-	-

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. A dash denoted " - ", implies the sample was omitted, either because of the absence of cointegration from the considered tests thus far, or because the variables were ineligible for cointegration analysis i.e., where both variables were not I(1). β presents the long run estimate, and $H_0 : \beta = 1$ presents the p-values of testing the strength of sustainability. Literature does not advice on which model is preferable across all Maki results, however, where possible we select the regime shifts specification to acknowledge the potential effect policy changes might have on the investment-saving relationship.

bounds test which is applicable to data with mixed I(0) and I(1) orders of integration, but similarly excludes variables of orders I(2) and higher. Given the advantage of being applicable to variables of mixed orders of integration, the ARDL offers more flexibility in contrast to the Engle-Granger, Johansen, and Maki cointegration tests. Hence, it might serve as a robust check in cointegration analysis, in case the long run properties of current account components are mis-specified in this paper's unit root testing stage, which would have implications for the sustainability result. Additionally, the ARDL model performs well in small samples. Hence, it might establish cointegration in our short quarterly samples easier – contrary to the cointegration tests we have used thus far.

The bounds test result assesses the presence of a long-run relationship, where an F-statistic that is greater than the upper critical value I(1) results in the rejection of the null of no long-run relationship, whereas an F-statistic that is lower than the lower bound I(0) critical value suggests the absence of a long run relationship and failure to reject the null of no cointegration (Pesaran et al., 2001). An F-statistic in between the bounds yields an inconclusive result. If cointegration exists, it is possible to derive short and long run estimates. Short run estimates are derived from the error correction model, where the error correction term explains the speed of reversion to the long run equilibrium. Error correction terms for cointegrated variables will be significant and be between -1 and 0. Table 6.3.7 presents bounds tests for all models, whereas Table 6.3.8 presents long and short run estimates of the evaluated models. Table 9.3.1 provides model diagnostics, finding all models free of serial correlation. Additionally, all models are free of heteroskedasticity, except for the full quarter samples of model 1 and 3. However we correct for this by using HAC estimators. Figure 5 in the appendix provides the ARDL stability tests, where cusum graphs find all models stable.

In model 1, exports and imports have a long run relationship across all data samples as shown in Table 6.3.7. The relationship is significant at the 1 percent level of significance based on annual data and full quarterly data (1960Q1 - 2021Q4). For the short quarterly sample (1985Q3 – 2021Q4), cointegration is only present at the 10 percent level of significance but inconclusive at the 5 percent level. Given the presence of cointegration in all samples, we proceed with long run and short run estimates. In the long run, imports have a positive and significant impact on exports at the 1 percent level of significance for all samples as shown in Table 6.3.8. However, the coefficient on the import variable is significantly different from 1 i.e., the coefficient is positive but less than 1. This implies that the current is sustainable, but in a weaker sense as suggested by Quintos (1995). Lastly, the error correction term is negative and significant at the 1 percent level for all samples. For annual data, the error correction term reveals that 40% of the discrepancies between the long run and short run are corrected within a year, while approximately 20% of the discrepancies are corrected within a quarter for both quarterly samples. For the short quarterly sample, a dummy has been included from 2020Q1 to 2021Q4 due to a break in the CUSUM graph. This break coincides with the COVID-19 pandemic, which impacted trade flows. Model diagnostics suggest annual and short quarterly (1985Q3 – 2021Q4) data is reliable for inference, as the models do not suffer from serial correlation or heteroskedasticity. However, for the full quarterly sample, the model suffers from serial correlation, but this is corrected for with HAC standard errors i.e., which adjusts standard errors for reliable inference.

Table 6.3.7: ARDL Bounds Testing

Model 1: Exports and Imports			
EX = f(IM)	Annual (1946-2021)	Quarterly (1960Q1 - 2021Q4)	Quarterly (1985Q3 - 2021Q4)
F statistic			
	10.1563	9.1457	5.4401
Critical Value	Lower & Upper Bound	Lower & Upper Bound	Lower & Upper Bound
1%	6.84 7.84	6.84 7.84	6.84 7.84
5%	4.94 5.73	4.94 5.73	4.94 5.73
10%	4.04 4.78	4.04 4.78	4.04 4.78
	cointegrated	**cointegrated**	**cointegrated**

Model 2: Imports and Exports			
IM = f(EX)	Annual (1946-2021)	Quarterly (1960Q1 - 2021Q4)	Quarterly (1985Q3 - 2021Q4)
F statistic			
	5.4302	6.3173	2.7174
Critical Value	Lower & Upper Bound	Lower & Upper Bound	Lower & Upper Bound
1%	6.84 7.84	6.84 7.84	6.84 7.84
5%	4.94 5.73	4.94 5.73	4.94 5.73
10%	4.04 4.78	4.04 4.78	4.04 4.78
	cointegrated	**cointegrated**	**not cointegrated**

Model 3: Investments and Savings			
I = f(S)	Annual (1946-2021)	Quarterly (1960Q1 - 2021Q4)	Quarterly (1985Q3 - 2021Q4)
F Statistic			
	7.3019	6.3292	2.9666
Critical Value	Lower & Upper Bound	Lower & Upper Bound	Lower & Upper Bound
1%	6.84 7.84	6.84 7.84	6.84 7.84
5%	4.94 5.73	4.94 5.73	4.94 5.73
10%	4.04 4.78	4.04 4.78	4.04 4.78
	cointegrated	**cointegrated**	**not cointegrated**

Notes: We rely on specifications with an unrestricted intercept and no trend.

The alternative specification of exports and imports is model 2, where imports are regressed on exports as a robust check. In this model, the bounds test fails to find cointegration in short quarterly data, as the F stat of 2.71 is below the lower bound of the 10 percent level of significance as shown in Table 6.3.7. In contrast, the bounds test finds a statistically significant long run relationship in the annual and full quarterly samples at the 10 percent and 5 percent levels of significance respectively. Hence, long and short run estimates can be evaluated for these models. Both these models suggest strong current account sustainability as the null that the coefficient on the export variable is 1 cannot be rejected. Additionally, the error correction terms are negative and statistically significant at the 1 percent level of significance. Both models lack serial correlation and have homoscedastic errors, hence can be relied upon for inference. An instantaneous dummy has been added to the last quarter of 2001 coinciding with the September 11 terrorist attacks that stifled trade flows in the quarter. The contrasting results from model 1 and 2 highlight the importance of robust checks, as we are able to find evidence of strong current account sustainability in model 2 as opposed to weak sustainability in model 1. This further highlights the importance of model specification is the export – import cointegration analysis for current account sustainability, as results are sensitive to which model is specified as the dependent variable.

Lastly, model 3 considers the long run relationship between investments and savings. Short quarterly data is unable to suggest current account sustainability, as the null of no cointegration is not rejected at the relatively weaker 10 percent level of significance. However, both annual and long quarterly data are able to find evidence of a long run relationship at the 5 percent level of significance. Of these two models, only quarterly data is able to suggest a strong long run relationship, with a coefficient insignificantly different from 1. Additionally, the error correction terms in both models are negative and statistically significant, with 23% and 13% corrections in deviations between long run and short run in annual and quarterly data respectively. While annual results remain reliable, passing all diagnostic tests, we rely on HAC errors for the long quarterly data.

6.3.6 Nonlinear Autoregressive Distributed Lag

The ARDL results presented thus far remain accurate, provided our regressors have a symmetric impact on our dependent variables i.e, the dependent variable responds in a similar fashion to negative and positive shocks of the regressor. However, this implicit assumption of linearity provides misleading results and inference in the presence of asymmetric relationships.

Shin et al. (2014) extends the ARDL and formulates a nonlinear ARDL (NARDL) method

Table 6.3.8: ARDL long and short run estimates

Model 1: Exports and Imports					
EX = f(IM)	Long Run Estimation (levels equation)			Short Run Estimation (ECM)	
	Variable	Coeff	H_0: $\beta = 1$	Variable	Coeff
Annual (1946 - 2021)	IM	0.63*	0.01*	ECT(-1)	-0.40*
Quarterly (1960Q1 - 2021Q4)	IM	0.64*	0.00*	ECT(-1)	-0.19*
Quarterly (1985Q3- 2021Q4)	IM	0.65*	0.00*	ECT(-1)	-0.20*

Model 2: Imports and Exports					
IM = f(EX)	Long Run Estimation (levels equation)			Short Run Estimation (ECM)	
	Variable	Coeff	H_0: $\beta = 1$	Variable	Coeff
Annual (1946 - 2021)	EX	0.74***	0.48	ECT(-1)	-0.26*
Quarterly (1960Q1 - 2021Q4)	EX	0.84*	0.50	ECT(-1)	-0.13*

Model 3: Investments and Savings					
I = f(S)	Long Run Estimation (levels equation)			Short Run Estimation (ECM)	
	Variable	Coeff	H_0: $\beta = 1$	Variable	Coeff
Annual (1946 - 2021)	S	0.60*	0.01*	ECT(-1)	-0.23*
Quarterly (1960Q1 - 2021Q4)	S	0.77*	0.12	ECT(-1)	-0.09*

Note: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. ECT represents the error correction term. $H_0 : \beta = 1$ presents the p-values for testing the null that the coefficient on the independent variable is equal to 1.

with the same requirements as the ARDL. The NARDL extension allows for the consideration of asymmetries in the long run relationship between variables. It is in recognition of the implicit assumption of symmetric linearity adopted in cointegration analysis, where methods assume the combination of nonstationary I(1) variables is linear (Puskas, 2020). This assumption of linearity is inherent in the ARDL's estimation of parameters as well as previously utilised cointegration tests, for example, the regression equation on which the Engle-Granger residuals are based assumes the impact of changes in the regressor on the dependent variable is linear. Where relationships are nonlinear, utilising linear tests would be misspecifying the relationship between the variables, and might lead to misleading results.

Shin et al. (2014) abstract from an F-bounds test, utilising the critical values provided in Pesaran et al. (2001). Results of this test are presented in Table 6.3.9. Results suggest none of model 3 samples have a long-run relationship. Except for model 1's short quarterly sample, the rest of the samples present with a long run relationship. To validate the use of the NARDL we must first test for asymmetries in the estimated models. Results of the asymmetry tests based on the wald test are presented in Table 6.3.10, and highlight that only model 2 short quarterly data can be estimated through the NARDL.

Table 6.3.9: NARDL Bounds test

Model 1: Exports and Imports			
EX = f(IM)	Annual (1946-2021)	Quarterly (1960Q1 - 2021Q4)	Quarterly (1985Q3 - 2021Q4)
F statistic			
	8.98	6.24	3.67
Critical Value	Lower & Upper Bound	Lower & Upper Bound	Lower & Upper Bound
1%	5.15 6.36	5.15 6.36	5.15 6.36
5%	3.79 4.85	3.79 4.85	3.79 4.85
10%	3.17 4.14	3.17 4.14	3.17 4.14
	cointegrated	**cointegrated**	**not cointegrated**

Model 2: Imports and Exports			
IM = f(EX)	Annual (1946-2021)	Quarterly (1960Q1 - 2021Q4)	Quarterly (1985Q3 - 2021Q4)
F statistic			
	5.74	5.86	4.77
Critical Value	Lower & Upper Bound	Lower & Upper Bound	Lower & Upper Bound
1%	5.15 6.36	5.15 6.36	5.15 6.36
5%	3.79 4.85	3.79 4.85	3.79 4.85
10%	3.17 4.14	3.17 4.14	3.17 4.14
	cointegrated	**cointegrated**	**cointegrated**

Model 3: Investments and Savings			
I = f(S)	Annual (1946-2021)	Quarterly (1960Q1 - 2021Q4)	Quarterly (1985Q3 - 2021Q4)
F Statistic			
	2.32	3.25	1.52
Critical Value	Lower & Upper Bound	Lower & Upper Bound	Lower & Upper Bound
1%	5.15 6.36	5.15 6.36	5.15 6.36
5%	3.79 4.85	3.79 4.85	3.79 4.85
10%	3.17 4.14	3.17 4.14	3.17 4.14
	not cointegrated	**not cointegrated**	**not cointegrated**

Table 6.3.10: Testing for Asymmetry

Exports and Imports	Short Run		Long Run	
EX=f(IM)	P-Value	Findings	P-Value	Findings
Annual 1946-2021	0.21	Symmetry	0.20	Symmetry
Quarterly 1960Q1 - 2021Q4	0.61	Symmetry	0.30	Symmetry
Exports and Imports	Short Run		Long Run	
IM=f(EX)	P-Value	Findings	P-Value	Findings
Annual 1946-2021	0.84	Symmetry	0.88	Symmetry
Quarterly 1960Q1 - 2021Q4	0.75	Symmetry	0.56	Symmetry
Quarterly 1985Q3 - 2021Q4	0.00	Asymmetry	0.21	Symmetry

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. Results test a null of symmetry.

6.4 Summary of Results

Results presented below indicate that current account sustainability tends to hold more in the long run as compared to the short run. These results indeed corroborate Hakkio and Rush (1991a) who suggests that concepts like cointegration are long run phenomena. However, our short run results for South Africa tend to contradict the results of Searle and Touna-Mama (2010) and Arize (2002) who finds cointegration in South Africa using short quarterly data sets. However, as noted before, these studies utilised exogenously determined breaks to improve their model fits. Hence, it is uncertain whether their results would still hold when subjected to our testing procedure. Nonetheless, our results are concerning, as they paint a gloomy picture about the South African economy, due to the implication that South Africa might be on an unsustainable trajectory. These results still hold when considered alongside long term sample results, as we generally do not find strong current account sustainability in our samples; implying the country might have a tendency to default on its obligations at some point in the near future. The general lack of a unity result (failure to find strong sustainability) coincides with South Africa's ballooning gross debt to GDP ratio, that has grown by 21 percentage points between 2004 and 2018, as well as the 22.8 percentage points increase in foreigner holdings of government debt over the same period. While these are necessary to meet the country's development efforts, the debt increases happened over a period when GDP growth rate reduced by 4.5 percentage points. Intuitively, this implies an economy gaining more debt, with minimal growth to support debt repayment – which can not be sustainable, hence speaks to an economy that might default on its debt.

Table 6.3.11: Summary of Results

Stationarity Approach			
	Annual (1946 - 2021)	Quarterly (1960Q1 -2021Q4)	Quarterly (1985Q3 - 2021Q4)
ADF	Sustainable	Sustainable	Not Sustainable
PP	Sustainable	Sustainable	Sustainable
KPSS	Inconclusive	Inconclusive	Not Sustainable
DFGLS	Sustainable	Sustainable	Not Sustainable
ZA	Sustainable	Sustainable	Not Sustainable
KSS (ESTAR)	-	-	Sustainable
Sollis (AESTAR)	-	-	Sustainable

Cointegration Approach								
		Engle-Granger	Johansen	Maki	DOLS: Unity result?	ARDL	ARDL: Unity result?	NARDL
Model 1 EX = f(IM)	Annual (1946 - 2021)	Sustainable	Sustainable	-	NO	Sustainable	NO	-
	Quarterly (1960Q1 -2021Q4)	-	-	-	-	Sustainable	NO	-
	Quarterly (1985Q3 - 2021Q4)	Not Sustainable	Not Sustainable	Not Sustainable	-	Sustainable	NO	-
Model 2 IM = f(EX)	Annual (1946 - 2021)	Sustainable	Sustainable	-	YES	Sustainable	YES	-
	Quarterly (1960Q1 -2021Q4)	-	-	-	-	Sustainable	YES	-
	Quarterly (1985Q3 - 2021Q4)	Not Sustainable	Not Sustainable	Sustainable	NO	Not Sustainable	-	Sustainable
Model 3 I = f(S)	Annual (1946 - 2021)	Sustainable	Not Sustainable	Sustainable	NO	Sustainable	NO	-
	Quarterly (1960Q1 -2021Q4)	Not Sustainable	Not Sustainable	Sustainable	YES	Sustainable	YES	-
	Quarterly (1985Q3 - 2021Q4)	Not Sustainable	Not Sustainable	Not Sustainable	-	Not Sustainable	-	-

7. Conclusion

Countries that run persistent current account deficits remain vulnerable and at risk of macroeconomic destabilisation. Such destabilisation include; exchange rate fluctuations, which can impact the competitiveness of domestic industries; capital flight, which reduces available foreign investment in the economy; and even the accumulation of excess foreign debt, where repayment of such can see government trimming on an economy's social welfare programs to the detriment of its citizens well-being. This underscores the need for proactive current account management, where an understanding of an economy's current account sustainability is crucial for policy adjustments - least economies find themselves undergoing painful macroeconomic adjustments. An understanding of current account dynamics and the sustainability of the current account is especially important for EMEs as they tend to rely on foreign markets for investments and financing of their current accounts. Hence, phenomena like capital flight or sudden stops in capital in light of unsustainable current account deficits can prove detrimental for the economy and its citizens. Additionally, EMEs tend to be vulnerable to external sector developments as they have limited means through which to insulate themselves from exogenous shocks, unlike their developed economies counterparts. This, coupled with the need for case studies that analyse current accounts of EMEs motivates this study to investigate the current account sustainability of South Africa.

We contribute to emerging market economies literature by considering a case study of South Africa; an emerging economy with a persistent current account deficit that is over reliant on portfolio inflows hence remains at risk of macroeconomic destabilisation due to unsustainable current account deficits. The baseline model assesses current account sustainability by testing for intertemporal solvency (hence current account sustainability) through the cointegration of exports and imports, and alternatively, by checking the stationarity of the current account to GDP ratio. As a robustness check, we also consider the cointegration of investments and savings, whose cointegration or lack thereof bears the same implications as those of the baseline variables. We exploit two datasets in the baseline models; an annual sample from 1946 to 2021, and a quarterly sample from 1960Q1 to 2021Q4. Lastly, given that cointegration and stationarity tend to hold in the long run, we also consider a shorter sample that runs from 1985Q3 to 2021Q4.

Generally, unit root tests are supportive of current account sustainability. The long quarterly

(1960Q1 – 2021Q4) and annual (1946–2021) current account to GDP ratios have linear mean reverting properties according to the ADF, PP, DFGLS and ZA unit root tests. However, except for the PP, the same set of tests find a unit root in the short quarterly sample. Hence, a short term view of the current account between 1985Q3 and 2021Q4 suggests that the current account is unsustainable. On considering nonlinearities through the KSS (ESTAR) and Sollis (AESTAR) tests, we reverse this stance, and find that the current account is indeed sustainable over the period, but it adjusts in a nonlinear way i.e., the current account has nonlinear mean reverting properties. This is significant as it highlights the importance of considering nonlinearities in macroeconomic relations, as opposed to implicitly assuming linear behaviours in macroeconomic modelling. The cointegration approach however tends to paint a gloomy picture about the state of the South African economy. To be precise, long samples are supportive of cointegration. However, results based on short samples suggest the economy is on an unsustainable path. The latter results is a cause for concern, as it is possible for long run trends to submerge periods of destabilising adjustments.

Future studies might consider exploring additional variables for example, political, technological, and climate change related factors, and their impacts on current account developments. Additionally, an extensive evaluation of the determinants of exports-imports, and savings-investments variables would provide a deeper understanding of the behaviour of the current account.

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9. Appendices

9.1 Johansen Cointegration Diagnostic Tests

Table 9.1.1: VAR residual normality tests

	Model 1: Annual (1946 - 2021)				Model 1: Quarterly (1985Q3- 2021Q4)			
Component	Skewness	Chi-sq	DF	P-Value	Skewness	Chi-sq	DF	P-Value
exports	-0.15	0.28	1	0.60	-0.12	0.35	1	0.55
imports	0.22	0.61	1	0.43	-0.34	2.79	1	0.09
Joint		0.89	2	0.64		3.14	2	0.21
Component	Kurtosis	Chi-sq	DF	P-Value	Kurtosis	Chi-sq	DF	P-Value
exports	4.28	5.00	1	0.03	3.65	2.45	1	0.12
imports	3.37	0.42	1	0.52	3.22	0.29	1	0.59
Joint		5.42	2	0.07		2.74	2	0.25
Component		Jarque-Bera	DF	P-Value		Jarque-Bera	DF	P-Value
exports		5.29	2	0.07		2.80	2	0.25
imports		1.04	2	0.60		3.09	2	0.21
Joint		6.32	4	0.18		5.89	4	0.21

	Model 3: Quarterly (1960Q1 - 2021Q4)				Model 3: Quarterly (1985Q3- 2021Q4)			
Component	Skewness	Chi-sq	DF	P-Value	Skewness	Chi-sq	DF	P-Value
Investment	0.31	3.81	1	0.05	-0.06	0.09	1	0.77
Savings	0.04	0.06	1	0.81	0.5	5.94	1	0.01
Joint		3.87	2	0.14		6.03	2	0.05
Component	Kurtosis	Chi-sq	DF	P-Value	Kurtosis	Chi-sq	DF	P-Value
Investment	4.48	22.11	1	0.00	2.94	0.02	1	0.90
Savings	4.55	23.63	1	0	5.03	24.31	1	0.00
Joint		45.74	2	0		24.33	2	0.00
Component		Jarque-Bera	DF	P-Value		Jarque-Bera	DF	P-Value
Investment		22.92	2	0.00		0.11	2	0.95
Savings		23.68	2	0		30.25	2	0.00
Joint		49.60	4	0		30.35		0.00

	Model 3: Annual (1946 - 2021)			
Component	Skewness	Chi-sq	DF	P-Value
Investment	0.81	8.07	1	0.00
Savings	-0.30	1.10	1	0.29
Joint		9.17	2	0.01
Component	Kurtosis	Chi-sq	DF	P-Value
Investment	4.94	11.66	1	0.00
Savings	4.42	6.19	1	0.01
Joint		17.86	2	0
Component		Jarque-Bera	DF	P-Value
Investment		19.73	2	0.00
Savings		7.29	2	0.03
Joint		27.03	4	0.18

9.2 Dynamic Ordinary Least Squares Estimator Diagnostic Tests

Table 9.2.1: DOLS diagnostics

DOLS	Sample	R^2	homoskedasticity
	Annual (1946 - 2021)	0.63	0.65
Model 1: EX=f(IM)	Quarterly (1960Q1 -2021Q4)	-	-
	Quarterly (1985Q3 - 2021Q4)	-	-
	Annual (1946 - 2021)	0.6	0.38
Model 2: IM=f(EX)	Quarterly (1960Q1 -2021Q4)	-	-
	Quarterly (1985Q3 - 2021Q4)	0.88	0.06
	Annual (1946 - 2021)	0.93	0.87
Model 3: I=f(S)	Quarterly (1960Q1 -2021Q4)	0.90	0.08
	Quarterly (1985Q3 - 2021Q4)	-	-

We also test for autocorrelation, but despite increasing lags, we are unable to resolve it. Therefore, while estimates from the DOLS remain consistent, they are not efficient. To resolve this, we rely on HAC(Newey-West) standard errors for reliable inferences.

9.3 Autoregressive Distributed Lag Diagnostic and Stability Tests

Table 9.3.1: ARDL model diagnostics

Exports and Imports			
EX=f(IM)	Test:	Homoskedasticity	Serial correlation
	null:	Homoskedasticity	No serial correlation
Annual 1946-2021		0.35	0.39
Quarterly 1960Q1 - 2021Q4		0.08***	0.47
Quarterly 1985Q3 - 2021Q4		0.10	0.27
Imports and Exports			
IM=f(EX)	Test:	Homoskedasticity	Serial correlation
	null:	Homoskedasticity	No serial correlation
Annual 1946-2021		0.47	0.15
Quarterly 1960Q1 - 2021Q4		0.11	0.56
Quarterly 1985Q3 - 2021Q4		0.37	0.23
Investments and Savings			
I=f(S)	Test:	Homoskedasticity	Serial correlation
	null:	Homoskedasticity	No serial correlation
Annual 1946-2021		0.65	0.50
Quarterly 1960Q1 - 2021Q4		0.04**	0.39
Quarterly 1985Q3 - 2021Q4		0.18	0.88

Notes: ***, **, * represent significance at 10%, 5% and 1% levels, respectively. The values represent the P-values of the respective tests. For heteroskedastic results, we rely on HAC(Newey-West) standard errors for reliable inference.

Figure 5: ARDL stability tests: *Model 1: Exports and Imports*

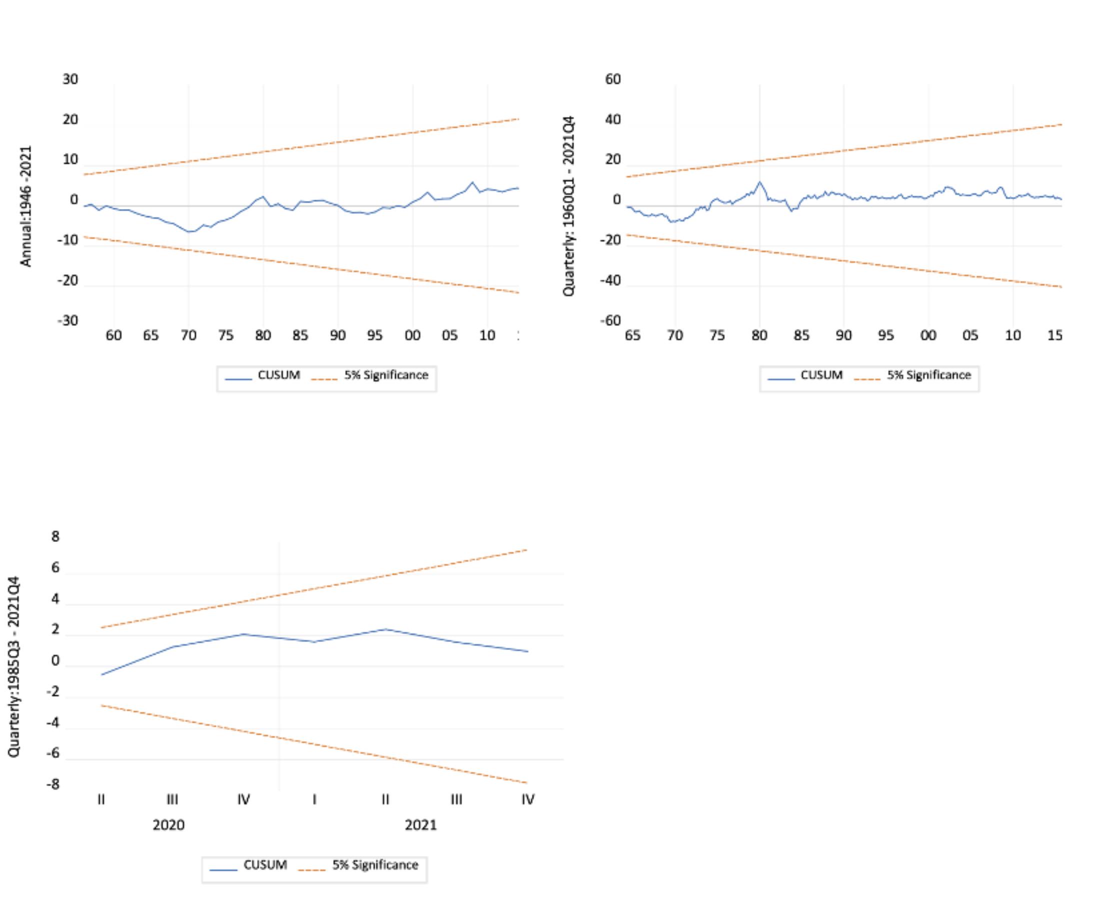

Figure 5: ARDL stability tests: *Model 2: Imports and Exports*

Figure 5: ARDL stability tests: *Model 3: Investments and Savings*

9.4 Nonlinear Autoregressive Distributed Lag Diagnostic and Stability Tests

Table 9.4.1: NARDL model diagnostics

Imports and Exports			
IM=f(EX)		Homoskedasticity	Serial correlation
	null:	Homoskedasticity	No serial correlation
Quarterly 1985Q3 - 2021Q4		0.84	0.73

Figure 6: NARDL stability tests