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SCHOOL OF ACCOUNTING, ECONOMICS & ACCOUNTING

INVESTIGATING SOUTH AFRICA'S EXPOSURE TO POTENTIAL CURRENCY CRISES

NTOKOZO T. HADEBE

216075449

SUPERVISORS: DR. SIMISO MSOMI & DR. MALIBONGWE NYATI

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DECLARATION

I, **Ntokozo Hadebe**, declare that:

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(ii) This thesis has not been submitted for any degree or examination at any other university.
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Mr. Ntokozo T Hadebe, 216075449

Date: 14 January 2025

DEDICATION

This thesis is dedicated to my late grandmother who always encouraged me to do my master's degree as it would open opportunities for me. Her support throughout my academic life has carried me through till day.

I would also love to dedicate it to my parents and two brothers, whose unwavering support and love has been a great source of strength and inspiration throughout my academic journey. Your encouragement, sacrifices and support has allowed me to pursue my passion for research, for that, I remain forever grateful.

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ABSTRACT

This study investigates South Africa's potential exposure to currency crises, aiming to identify effective economic indicators for anticipating such crises. Using annual data from 1994 to 2020, a probit model analysis and the Market Turbulence Index (MTI) are employed to facilitate this investigation.

The results suggest that none of the 10 variables identified in empirical literature have predictive power in the South African context. The insignificant findings can be attributed to data frequency restrictions, as annual data was used instead of daily, weekly, or monthly data due to limited public access to monthly statistics.

The study concludes that the modelling approach employed may not be helpful for policymakers and central banks in predicting currency crises in South Africa. However, the use of higher frequency data and additional variables, such as political instability, may improve the significance and predictability of currency crises.

Despite the insignificant results, the study highlights the potential adoption of the MTI in identifying crisis thresholds. With higher frequency data and more influential variables, this study can contribute significantly to the literature, particularly in a country like South Africa with a volatile economic climate.

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Chapter 1: Introduction

1.1 Background

According to Kaur (2015), a financial crisis is situation where the economic system experiences a structural breakdown which could possibly attribute to a currency crisis, a payment crisis, a banking crisis, or even a debt crisis.

Over the past decades, several developing and developed countries experienced financial crises of different magnitudes, depending on the structural and institutional conditions of each of those countries (Bordo and Schwartz, 1996). A number of these crises such as the American, France and Britain currency crises of 1933, 1923 and 1931, respectively occurred prior to the failure of the Bretton Woods system in 1973 (Fontaine, 2005). Nevertheless, there are several countries that experienced deep currency crises post the collapse of the Bretton Woods system.[1]

According Glick and Hutchison (2013), a currency crisis occurs when a nation's currency depreciates sharply and rapidly, typically followed by an abrupt reduction in that nation's foreign reserves and capital flows. A domestic economic downturn or the propensity of institutions, businesses, and individuals to shift their financial and monetary assets from domestic to foreign currencies can both be indicators of a currency crisis. By converting from domestic to foreign currency, the institutions can avoid a currency fall that could be caused by macroeconomic disparities. Under such circumstances, monetary authorities are compelled to give up the fixed exchange rate in favour of a free-floating one as they are unable to defend it. Due to such a movement, the currency crisis becomes more contagious. This means that not only does it affect the domestic economy but other economies too.

One would expect that only nations with fixed exchange rate regimes would have currency crises. Though theoretically they should be more resilient to currency crises, nations with flexible exchange rates can also encounter them (Boonman et al., 2012). To prevent the accumulation of pressures that could result in severe currency overvaluation and subsequent substantial, discrete currency declines, as might occur under fixed exchange rate regimes, these countries would initially be expected to undergo ongoing market adjustments. Pegged and intermediate exchange rate regimes are also linked to increased vulnerability to currency crises,

[1] These included Argentina in 2002, Egypt in 2002, Turkey in 2000, Brazil in 1999, Russia in 1998, East Asia in 1997 and Mexico in 1994 FRANKEL, J. A. & SARAVELOS, G. 2010. Are leading indicators of financial crises useful for assessing country vulnerability? Evidence from the 2008-09 global crisis. National bureau of economic research, ibid., ibid.

especially in emerging and developing nations with more open capital accounts (Ghosh et al., 2015). Currency crises, however, can occur in nations with a floating exchange rate regime for several reasons. These explanations may be related to the fact that nations that declare their currencies to be floating are typically wary of letting them do so; this phenomenon is referred to as "fear of floating behaviour" (Reinhart and Rogoff, 2012)

The fear of floating behaviour is due to the possible losses and the cost of recovering and restructuring suffered by the economy of a country. As a result, during a currency crisis there is the need for an early warning system. The Early Warning Indicators (EWI, henceforth) is a method that is used to detect currency crises prior to their occurrences, so that they can be avoided or better yet, their impact mitigated. Essentially, EWIs are quantitative models that rely on available statistical information and mechanisms from past events to be able to predict extreme occasions (Zhao et al., 2014).

EWI models are very useful to policymakers as they present them with essential tools to identify the domestic economy's vulnerabilities and weaknesses so that preventative measures can be adopted to reduce or even possibly eliminate the risk of a currency crisis. These EWI models are not only desirable for policymakers but also are of importance to companies from the perspective of exchange rate risks. In such a case, these companies can alleviate risk by reducing their exposure or even taking hedge funds in alternative markets. Kaur (2015) observed that currency crises stressed capital flight, further speculations and rumours drove the value of the currency to depreciate even further resulting in a self-fulfilling crisis. With all this mentioned, early discovery of the problematic macroeconomic variables accompanied with preventative actions by the authorities can maintain the confidence of investors and consequently avoid a currency crisis altogether.

The idea of EWI was developed amid a crisis and with each crisis, there were other macroeconomic causes that arose which at times consequently led to further crises. Considering a study by Bussiere and Fratzscher (2006) which concluded that high levels of short-term debt were one of the factors contributing to a crisis, whereas when looking at the same for other crises, the variable was not significant. Further, there are several other important variables to look at to understand crisis, these include contagion and lending boom. Within the context of short-term debt, one can consider the 1998 Brazil currency crisis where the short term to reserves ratio had substantially increased, however, the level of short-term debt and exchange rate overvaluation were not at a disturbing level (Evangelist and Sathe, 2006). Such findings signalled that each crisis is unique and that some revisions were important in the model.

The EWIs for financial crises, however, have also come under fire throughout the years. According to Frankel and Saravelos (2010), one of the reasons for this is that these indicators are only helpful in identifying previous crises, not the ones that are happening right now. One of the reasons for this is because the forecasters frequently do not have timely access to the data, they need to create the EWIs. Additionally, these variables' selection criteria frequently benefit from hindsight.

The empirical literature on currency crises has demonstrated that several macroeconomic variables exhibit unexpected behaviour prior to the start of a crisis. This suggests that the deterioration of financial and real sector variables, both internally and externally, puts pressure on the foreign exchange market, ultimately leading to a currency crisis. One of the International Monetary Fund's (IMF) top focuses has been the development of EWI models. These methods were designed for emerging market economies as well as developed nations (Kaur, 2015). A few researchers have looked into this field and offered useful models, such as (Kaminsky et al., 1998).

South Africa like many other emerging economies is faced with many turbulences in its foreign exchange markets. These turbulences are seen in the high volatility of the South African Rand, its domestic currency. Because of the scale of their economies, most emerging markets have high levels of exchange rate volatility. The economies being small consequently leads to a relatively small market for their currencies. As a result of such conditions, it is found that the impact on exchange rates is much greater in small economies than it is for larger economies (Knedlik, 2006). Other explanations for a heightened deviations in currency markets include a generally higher risk of investments as well as political instability. Therefore, the higher levels of turbulences in the South African exchange rate are expected and are comprehensible as they merely reflect the structure of the economy (Khomo and Aziakpono, 2020).

A currency crisis is likely to occur when the degree of volatility reaches an unmanageable level. The result is a sharp decline in the value of the home currency. The South African Reserve Bank (SARB) frequently intervenes during depreciation episodes, primarily by raising interest rates and using foreign reserves to buy the local currency. There will be both macro and microeconomic distortions if the initiatives fail. The financial industry is adversely impacted on the microeconomic level, but so are imports and every other economic sector that depends on finance (Knedlik, 2006). Furthermore, from a macroeconomic perspective, the currency crisis may result in instability in the level of domestic prices, which would then lead to poor rates of economic growth. Due to the high cost of intervention, many central banks worldwide,

including the South African Reserve Bank, choose to accept the crises as inevitable rather than act in the foreign exchange markets.

Scholars have examined and classified various South African historical occurrences as currency crises. Bhundia and Ricci (2005) identified currency crises in 1998 that took place from the end of April to the end of August. Additionally, they recognized issues that occurred from the end of September until the end of December 2001. However, by Aron and Muellbauer (2000)assert that in February 1996, they recognized the first South African currency crisis. In addition, they noted currency problems in April 1998, November 1997, and October 1996. It is important to note that the 2001 "event" was not regarded by Aron and Muellbauer (2000) as a currency crisis.

In most cases, when an economy is faced with exchange rate pressure for example, high capital inflows, the authorities are often expected to intervene to stabilize the economy and while those authorities are formulating remedies there are several things that the countries suffer from. These include high inflation, output losses, low exports, financial costs, high debt, high budget deficits and low foreign reserves (Claessens and Kose, 2013). Further suffering can be seen on the levels of welfare which can be quite serious, especially when one considers the rates of poverty. South Africa for example is subjected to challenges like a slowdown of GDP growth declining from 1.9% in 2022 to just 0.7% in 2023 (Adelzadeh, 2024). This decline has been attributed to several factors, including high inflation, large currency account deficit and decelerated economic growth. These challenges have grown and further increased the country's vulnerability to a currency crisis. It is therefore paramount to examine which indicators we can consider and can detect a crisis before its occurrence.

Because of the previously mentioned currency crisis times and their effects on the SARB and the general populace of the country, this study is focused on finding currency crisis indicators in South Africa. These crises may have been prevented or at least lessened with a greater understanding of how crises arise and how to lessen their effects. To achieve the above aim, an

EWI model for South Africa is developed. Where variables that directly crisis, namely, foreign reserves,[2] balance budget,[3] exports,[4] Real exchange rate and Real interest rate are selected.
To the best of the researcher's knowledge, no research work exists with this framework and methodology making this research a needed method for the identification of the warning indicators of a currency crisis in South Africa. This gap is puzzling because a currency crisis has an impact on economies at both the micro and macro levels.
link to a currency.

1.2 Statement of the Research Problem

When an economy faces pressure on its national currency or exchange rate, such as from large capital inflows, the authorities typically step in and stabilize the economy. However, while these authorities are coming up with solutions, the countries suffer from several issues. According to Claessens and Kose (2013), the issues suffered include high rates of inflation, output losses, low exports, financial expenses, high debt, large budget deficits, and low foreign reserves. Additional suffering is seen in the welfare levels, which can be extremely severe, particularly considering the prevalence of poverty in South Africa, for instance, (Knedlik, 2006).

Therefore, due to South Africa's dynamic economic landscape, the need for an effective Early Warning Indicator (EWI) model has become increasingly critical, particularly in the wake of recent economic crises. Existing models often fail to adequately account for the nuances of economic cycles, leading to suboptimal predictions and preparedness strategies. This research aims to develop a robust EWI model specifically tailored to the South African economy, with a focus on testing leading methodologies, including the probit model, while rigorously addressing the post-crisis bias inherent in traditional approaches.

The challenge lies in recognizing and analysing the distinct characteristics of normal periods, calm periods, and post-crisis recovery phases. Each phase presents unique economic

[2] Economic theory states that foreign reserves serve as a buffer against events that can have a detrimental impact on the value of the currency.

[3] In accordance with economic theory, there is a budget deficit when government spending exceeds receipts.

[4] Exports can be described as transportable items created within the limits of one country, which are traded with another one. These products' sales bring in foreign exchange profits for the nation where they are produced, which promotes robust economic expansion.

indicators and risk profiles that must be considered independently to enhance the model's predictive accuracy. By systematically evaluating the performance of various methodologies during these distinct phases, this research seeks to identify the most effective strategies and variables for early warning signals, thus providing valuable insights for policymakers and stakeholders in mitigating economic downturns and fostering resilience in the South African economy.

This study will also address the limitations of existing EWI frameworks by incorporating a comprehensive analysis of economic data and contextualizing findings within the specificities of South Africa's socio-economic environment. The goal is to contribute to the field of economic forecasting and crisis management by delivering a model that not only predicts potential economic instability but also accounts for the complexities of varying economic conditions.

1.3 Aim of the Research

This paper's objectives are to investigate the possibility of a currency crisis in South Africa and evaluate some of the most advanced approaches for creating an EWI-probit model while taking post-crisis bias into account. The bias suggests that the post-crisis (recovery phase), tranquil times, and normal periods should all be considered separately.

1.4 Objective of the Research

The objectives of the study are as follows.

- To investigate the potential of a currency crisis in South Africa.
- To ascertain the trajectory of the key currency crisis indicators in South Africa.
- To assess the predictive power of the probit model in forecasting currency crisis vulnerability in South Africa
- To determine the management strategies for SARB and policy makers that may be implemented well in advance of a currency crisis.

1.5 Main Research Questions

The study's overarching goal is to increase knowledge of the warning indicators of a South African currency crisis to prevent one from occurring. The study specifically seeks to respond to the following query:

What are the indicators of a currency crisis in South Africa?

1.6 Specific Research Question

- What are the indicators that may signal an impending currency crisis in South Africa?
- What is the trajectory of the currency crisis indicators in South Africa?
- How effective is the probit model in identifying the key crisis indicators in the context of South Africa?
- What are the management strategies for SARB and policy makers that may be implemented well in advance of a currency crisis?

1.7 Significance of the study

This thesis will benefit government authorities, policymakers and businessowners amongst many others. It will achieve this by directing these stakeholders on which indicators or variables they must closely monitor to detect a possible crisis prior to their occurrence. Further it will help the SARB to save on all the corrective measures they had to undertake in situations where the economy was under attack of a currency crisis. That will particularly speak to risk management. Finally, it will serve as a source of reference for indicators for a currency crisis in South Africa.

1.8 Contribution of the study

The thesis will contribute quite significantly to the existing literature on currency crises in various ways. Firstly, it will provide new insights into the determinants of currency crisis vulnerability in the South African context. In this, the study will highlight the importance of external debt and fiscal policy. Secondly, the study will employ the probit model approach as its econometric approach which has not been the case for other South African scholars who have investigated currency crises. This makes the study different in its approach. The study’s findings have significant policy implications, suggesting that policymakers prioritize debt management, fiscal discipline to reduce the risk of currency crises. Moreover, the study’s

results can inform the development of early warning systems for currency crises, allowing fiscal institutions and policymakers to take pre-emptive measures to mitigate potential risks.

1.9 Scope of the study

The remainder of this thesis is structured as follows: it first examines prior models on EWS for currency crises and pertinent literature, after which the theoretical and empirical strands will be examined. The variables expected signs and model specification of the study will be discussed in the third portion of this thesis, with a focus on the Probit model using the Market Turbulence Index (MTI). The study's estimations and results from the model based on the most important variables for elucidating currency crises in the South African economy will be covered in the fourth section. Lastly, a conclusion and recommendations will be provided by the thesis of the paper.

Chapter 2: Literature Review

Emerging markets have frequently had currency crises, which have resulted in severe financial and economic instability. The destructive effects of currency crises are exemplified by the global financial crisis in 2008, the Argentine crisis in 2001, and the Asian financial crisis in 1997. Offering a thorough summary of the theoretical and empirical research on the phenomenon of currency crises is the goal of this chapter. This literatures focus will particularly be on the determinants of currency crisis vulnerability and development of early warning indicator systems.

On the theoretical side, we are encountered firstly by the genesis of crises which has been used when modelling currency crisis. It is categorized into three generation models: the first, second and third generation models.

Krugman (1979) and Flood and Garber (1984) proposed the first-generation models, commonly referred to as the exogenous generation models. Salant and Henderson (1978) work served as the foundation for both of their studies. The Bretton Woods system collapsed in 1973 as a result of unsustainable fiscal policies, which prompted the proposal of these models (Brüggemann and Linne, 2002). These models have played a very vital role in explaining currency crisis in Economics. The models predict that in a situation where the government must finance its expenditures, if it resorts to printing out more money to do that while also maintaining its fixed exchange regime; then this may lead to speculative attacks on exchange rate (Krugman, 1979).This is especially if the central bank has a shortage of foreign reserves. As earlier mentioned, this would mean that the government must abandon that fixed exchange because its method of financing its expenditure conflicts with its chosen exchange rate regime. This point of view highlighted that exchange rate regimes had a significantly large effect on policy in a broader level, which further highlighted that the regime would be maintained if it remains in sync with the fiscal and monetary policy objectives of that country,(Khomo and Aziakpono, 2020).

In the first-generation models, speculative attacks start before reserves are completely depleted (Krugman, 1979). This is because during the time when the exchange rate system transitions from a fixed to a flexible one, speculators are unable to profit. Only those speculators who were dealing in the local currency before the exchange rate regime collapsed had a chance to make any significant gains. If all speculators had access to complete information, they would be proactive and purchased great amounts of foreign exchange before the system collapsed,

hastening the fall. According to these models, speculative attacks only cause the exchange rate system to collapse, which is a sign of how the exchange rate regime contributes to currency crises in economies (Berg et al., 2004).

Alternative explanations for the currency crisis are offered by second generation models, which are based on the research of Obstfeld (1984) , Krugman (1996) and Flood and Marion (1999).The purpose of this currency crisis model was to guarantee that the government will maximize an explicit objective (El-Shazly, 2011). Even when currency rate policies and economic realities are in harmony, speculative attacks can still happen because these models are self-fulfilling. Speculators then attempt to determine if the government can defend its currency rate policy goals in such a scenario. Furthermore, in these models, speculative attacks take place in the expectation that the monetary policy would abandon its fixed exchange rate if it thought the current economic policies may have the opposite effect on the other macroeconomic variables (Obstfeld, 1996).

There are several reasons for this action, but the most obvious is that maintaining the current exchange rate system is more expensive than switching. For instance, the potential benefits of protecting it would be greatly outweighed by the public debt and inflation, ensuring credibility, favourable trading conditions, and an increase in foreign direct investment. In second-generation models, it is feasible to achieve several equilibria. While self-fulfilling crises lead to changes in economic policies, they are typically in equilibrium when there are no speculative attacks. This is regardless of government intervention with its efforts to sterilise the impacts of a decline in money supply caused by losses in reserves, triggered by slow money supply growth throughout the attack period. Speculators are pushed into other money markets because of the sterilizing. The second-generation models differ from the first in that they generate a currency crisis rather than predict one.

In general, both first- and second-generation models are likely to be present in currency crises. This leads to the establishment of what may be considered the third-generation model of currency crises. The contagion models are another name for the third-generation models. In this paradigm, a currency crisis that affects one economy influences other economies, which is why the word "contagion" is used. These models were developed following the Asian crisis of 1997, and Aghion et al. (2000) ,Krugman (2001), Chang and Velasco (2001) all went into detail about them. Since it is believed that a crisis is not just a currency crisis but also a mix of a currency and banking crisis, the banking system is included in this model. This phenomenon is famously known as the ‘twin crises’ (Goldstein, 2005). In these models, economies experience a great number of crises in their banks and financial institutions, where the most

imperative element initiating the crisis is large withdrawals because of the prevailing financial panic.

The simultaneous banking and currency crisis are caused by a great number of foreign investors withdrawing their money at the same time. The worsening of financial institutions and bank's balance sheet because of non-asymmetric information, raises in leverage and uncertain debts enlarged the speculative bubble and when the bubble finally exploded, the crisis erupted. As may be observed, the models of currency crises differ significantly. However, more empirical evidence needs to be investigated. According to Bucevska (2015), the fourth-generation model of currency crises is an additional generation model that is presently being created. According to this generation model, the primary causes of currency crises are institutional factors.

The empirical literature on currency crises has recognized multiple key determinants of currency crisis vulnerability. These include financial, economic and political factors.

When looking at financial factors, we consider high level of short-term debt, a low level of foreign exchange reserves, and an unstable banking system, have also been considered as key determinants of currency crisis vulnerability (Goldfajn and Valdés, 1998).

High levels of foreign debt are one of those financial determinants which could lead to a potential currency crisis, particularly short-term debt Reinhart (2009). Calvo (1998) had also found similar findings in his study where the reason for such findings alluded to factors like debt servicing difficulties, particularly in the short term and could lead to loss of confidence in the currency. His findings also suggested potential reduced creditworthiness due to high foreign debt, making it difficult to access international capital markets, further increasing the currency's vulnerability.

Financial liberalization is another determinant that could potentially lead to a currency crisis, especially if rapid. This is especially if that liberalization is not accompanied by enough supervisory and regulatory frameworks (Kaminsky et al., 1998). Some of the reasons mentioned by the scholars is that financial liberalization could potentially lead to risk-taking behaviour by banks other various other financial institutions, which could lead to a potential banking and currency crisis. However, it is worth noting that Tornell et al. (2004) argued that financial liberalization can potentially lead to improved economic growth which could protect the economy from any crisis. This was due to reasons like improved financial intermediation, which could improve the efficiency of the financial system and consequently reducing its vulnerability to any crisis.

Further, a fragile or unstable banking system can also increase the possibility of a currency crisis, especially if it is exposed to significant amounts of foreign debt (Calvo, 1998). This was

a build up from Obstfeld (1994) study where he emphasized that a banking crisis could lead to a currency crises by simply reducing confidence in the banking system and potentially leading to capital flight. On the contrary, Diamond and Dybvig (1983) argued that a fragile banking system does not necessarily lead to a currency crisis especially if sufficient regulatory measures are put well in place.

It has been discovered that economic factors including inflation, a sizable current account deficit, and slow economic growth raise the likelihood of a currency crisis (Kaminsky et al., 1998). It has been suggested that significant and ongoing current account deficits may raise the risk of a currency crisis (Reinhart and Rogoff, 2012). One explanation for this would be a decline in investor trust in the currency, which might lead to a speculative attack and, ultimately, a currency crisis.

Currency crisis vulnerability may also be created by fiscal deficits, that is particularly if they are financed foreign borrowing (Obstfeld, 1984). In the late 1990s, Calvo (1998) examined the relationship between foreign borrowing, fiscal deficits and currency crises. In the study, he argued that fiscal deficits financed through foreign borrowing can heighten the likelihood of a country to experience a currency crisis. This finding is like one earlier discussed by (Obstfeld, 1984). The overall theme is to highlight the importance of fiscal discipline and debt sustainability to ensure currency crises prevention, particularly in emerging markets.

Extremely high rates of inflation tend to reduce a nation's export competitiveness. A currency crisis is hence more likely to occur in that nation (Krugman, 1979). Similar results were observed by Reinhart and Rogoff (2012), who emphasized that high rates of inflation may cause the value of the nation's currency to depreciate, hence increasing the burden of its foreign debt. Nevertheless, some research has shown that there isn't always a clear correlation between high inflation and currency crises. According to an Taylor (2002) analysis, the New Zealand dollar did not lose value in spite of high rates of inflation in the late 1980s and early 1990s. The author ascribed this to several things, notably the New Zealand government's fiscal restraint, which served to lower the likelihood of a currency crisis. Additionally, New Zealand boasted a robust institutional framework that comprised a defined monetary policy framework and an independent central bank.

The Political and Institutional determinants of currency crises include political instability. Reinhart and Rogoff (2012) argued that political instability could increase an economy’s likelihood of experiencing a currency, especially because it could lead to loss of confidence in the government’s capacity to manage the economy. Pepinsky (2009) also shared similar findings. Other authors who have also explored the relationship between political instability

and investment like Satyanath (2007) have found that political instability indeed could lead to an increased possibility for a currency crisis. On the more opposite side, Block and Vaaler (2004), found that political instability did not necessarily heighten the potential for a currency crisis in an economy. The author alluded to factors like economic performance and institution quality are more important.

Considering this, institutional weakness is another factor that may contribute to the likelihood of a currency crisis. Weak institutions that lack transparency and accountability may do so (Obstfeld, 1984). According to similar research by researchers like Acemoglu et al. (2003), there may be a higher chance of a currency crisis in an economy with weak institutions when evaluating the relationship between institutional weakness and economic volatility. There are few studies with opposing findings. Research conducted by Bordo et al. (2001), Caprio and Klingebiel (2002) and Demirgüç-Kunt and Detragiache (2005) all concluded that there is no substantial correlation between institutional weakness and banking and, by extension, currency crises.

Further, a wide range of methodological techniques have been used in the empirical literature on currency crises, including case studies, econometric modelling, and machine learning algorithms. Kaminsky and Reinhart (1999) Signals extraction methodology is one of the methodological advances. Using this approach, the researchers attempted to pinpoint some of the key elements that determine a currency. By employing this method, they were able to identify similar elements that cause currency crises in different nations. Additionally, the researchers were able to create a composite index of the key factors that contribute to currency crises, which included the actual exchange rate, the current account balance, and the ratio of wide money to reserves. Using the threshold analysis, the scholars were able to identify the critical values which are lead indicators that signal to an imminent currency crisis.

According to Berg and Pattillo (1999) econometric models, like the probit and logit models have been extensively used to analyse the causes of currency crisis. Bordo et al. (2001) employed the probit and logic model to estimate the potential for a currency crisis as a function of several economic variables. This approach is mostly used to model the probability of a binary outcome. Their findings suggested that currency crises have become very common and severe over the past century. Their study further found that the possibility of a currency crisis heightens when the economy is experiencing declines in foreign exchange reserves, rapidly expanding domestic credit and large current account deficits. Bordo et al. (2001) also employed the logit model which is very similar to the probit. The only difference is the probit model uses a different functional form to model the probability of the binary output. Many more studies

have employed the probit model because of its versatility, like Caprio and Klingebiel (2002) and Demirgüç-Kunt and Detragiache (2005) also employed this model in their analysis and found the results highlighted the importance of banking sector and institutional reform to reduce any potential banking or currency crises.

Rodrik (1998), used an instrument variable to detect the casual relationship between institutional weakness and currency crises. Using this approach the scholar was able to control endogeneity of institutional weakness. Rodrik (1998) further conducted case studies for all those currencies that experienced crises in the 1990s, these included Indonesia, Thailand and Mexico. His findings suggested that institutional weakness, more especially in the financial sector could increase the possibility of a currency crisis. The study also found that the relationship between currency crises and institutional weakness is a non-linear one. This means that any small changes in institutional weakness could have significantly large effects on the possibility of a currency crisis. Another study that employed the instrumental variable approach was by Acemoglu et al. (2003) which they used to identify the casual relationship between economic volatility and institutional weakness. Like the previous scholar, this approach also allowed for endogeneity of institutional weakness to be controlled. They further conducted a panel data analysis consisting of a large sample of countries. This model enabled them to control country-specific factors that determine the common determinants that impact on economic volatility across different economies, particularly those with weak financial systems. They further found a conditional relationship between economic volatility and institutional weakness.

In the case of South Africa, there has been numerous scholars that have explored the relationship between debt sustainability, trade balances and currency crises. Some of the foundational scholars include Aron and Muellbauer (2002) who analysed the impact of trade liberalization on South Africa's trade balance and currency volatility, particularly focusing the importance of trade balance management in avoiding currency crises. The relationship between South Africa's currency crises, foreign debt and trade balance was examined by Fedderke and Liu (2002) and in their findings they highlighted the importance of debt sustainability, like the earlier scholars cited. Research by Moolman et al. (2006) discusses the economic volatility in South Africa and the importance of context-specific indicators, such as exchange rates and commodity prices. Moreover, the distinct socio-economic factors affecting South Africa, such as unemployment and inequality, necessitate tailored early warning system models that reflect local realities. In a more recent study, Ncube and Ndou (2013) assessed the magnitude of

capital flows on the South African Rand's volatility. Their findings emphasized the importance of capital flow management, debt sustainability in preventing a currency crisis from occurring in South Africa.

Even though the existing literature on currency crises has made some substantial contributions to us understanding this phenomenon, there are numerous gaps that exist and need addressing. One of the major limitations include the reliance on econometric models that assume normality and linearity, when the relationships between the variables are usually complex and non-linear. Another limitation worth noting is the failure to account for the role of financial factors, like financial contagion and asset price bubbles, in currency crises. This study aims to address those gaps and limitations by employing a non-linear approach and exploring the role of financial factors in currency crises.

The existing literature highlights the critical need for a nuanced approach to currency crisis and Early Warning Indicator development in South Africa, particularly through the lens of probit modelling while considering post-crisis bias. By systematically analysing economic cycles and integrating robust methodologies, this research aims to contribute to the growing body of knowledge on effective crisis prediction and economic stability. This literature review underscores the importance of tailored models that not only predict crises but also offer insights into the specific challenges faced by emerging economies.

Chapter 3: Methodology

3.1. Variable Definition and Data Sources

As previously said, the aim of this research is to develop an early warning currency crisis indicator model, which involves investigating the performance of traditional indicators in the context of the 1996 and 2006 currency crisis in South Africa. Thus, an analysis of the selected indicators' behaviour is conducted using the graphical displays. The study's main indicators include net foreign reserves, the real effective exchange rate, the ratio of M2/reserves, domestic credit extension, and dollar-denominated imports and exports. Theoretically and empirically, as demonstrated in the preceding chapters, there is a fall in reserves in the months preceding the crisis period due to factors such as excessive domestic credit expansion, real exchange rate appreciation, an increase in the ratio of M2/reserves, and a decline in imports and exports.

The study employs a mixed-frequency approach, utilizing both quarterly and annual data. The quarterly data, spanning 1990-2020, are used to analyse the Market Turbulence Index (MTI). In contrast, the annual data, covering 1990-2020, are employed for the probit model. The use of different data frequencies is necessitated by the availability of the data. High frequency data was unavailable for some of the key variables due to the period required. However, for the MTI model which is meant to look at the fluctuation of the exchange rate over time was able to be measured using quarterly data. This model is discussed in detail later in this chapter. The main model, which is the probit model uses annual data. Despite these differences, the results are consistent and provide a comprehensive understanding of the complex relationships between exchange rate and currency crisis in South Africa.

A few considerations were made when determining the sample size. First, sanctions were abolished in 1990 following President Mandela's release; as a result, South Africa was allowed to rejoin the global financial system and was granted access to grants and loans. Second, the apartheid government was replaced by a democratic government in 1994. It is well recognized that these two elements have impeded economic development, leading to subpar performance of macroeconomic variables both inside and outside the economy. Without a doubt, South Africa had significant capital inflows and a boom in investment following the announcement of the country's transition to democracy and the easing of sanctions, in addition to the financial market's liberalization and the removal of currency restrictions. This change in the economy

had both advantages and disadvantages. Due to the significant inflows, the Rand's value initially increased before sharply declining in February 1996, signalling the start of the crisis.

The variables that need to be considered when investigating potential exposure to currency crises along with their expected signs are clearly given in both chapters 1 and 2 above. For example, when looking at the first-generation models, it is known that they are concerned with inconsistencies between exchange rate regime (ERR) and the macroeconomic policies in place in that economy. Therefore, the variables chosen in this study from the first generation of models include foreign reserves. Economic theory states that foreign reserves serve as a buffer against events that could have a negative impact on the exchange rate of the currency. Kaminsky and Reinhart (1996) asserted that an increase in foreign reserves would not only increase foreign debt but would also cause a shift in illiquid debt to liquid debt. So, in the context of this study the expected sign for this variable would negative (Kindman, 2010).

The budget balance is another variable from the first-generation models. The total difference between government revenues and expenditures is the simplest way to define the government's budget balance. According to economic theory, there is a budget deficit when government spending surpasses revenue. This is because a large budget deficit can lead to a depreciation of exchange rate, making imports more expensive and potentially fuelling inflation. Therefore, when researching currency crises, it is crucial to consider the relationship between the budget balance and the exchange rate. According to Sevim et al. (2014), this explanatory variable should have a negative sign.

When looking at the second-generation models, one may remember that their focus is on the policy makers' decisions on whether to maintain or abandon their current exchange rate regime. In doing so, external shocks play a fundamental role, thus, the indicators considered include exports. Any movable products made inside the borders of one country and traded with another nation are considered exports. The nation that produces these goods makes foreign exchange profits from their sale, which in turn promotes strong economic growth. According Megersa and Cassimon (2015), exports are expected to have a predicted negative sign as an indicator of currency crises. This is because an increase in exports is likely to lead to an increase in foreign exchange earnings and reduce the pressure on the exchange rate. The negative sign is on this indicator suggests that as exports increase, the probability of a currency crisis decreases.

Another variable is terms of trade (TOT), which is best described as the ratio of the export price index to the import price index. It is important to remember that a nation has favourable terms of trade when its export prices rise faster than its import prices. Currency exchange rates are influenced by terms of commerce; for instance, a nation with strong demand for its goods exports more than it imports, which raises the demand for its currency. Currency crisis terms of trade were incorporated by Nil et al. (2010), and they had the anticipated negative sign.

Real Exchange Rate (RER) is another variable and can best be defined as the current price consumers and businesses will pay to buy a foreign product using home currencies. The deviations of this variable are important to be observed when checking for a possible currency crisis because an increase in these deviations increases the amount of money one needs to buy in a foreign country Frost and Saiki (2014). For this explanatory variable, a negative sign is expected.

The Real Interest Rate (RIR), which is the interest rate that an investor, saver, or lender receives after accounting for inflation, is another explanatory factor. The amount of savings and fixed investment in the economy determines it. Economic theory states that if fixed investment declines or saving rises, the real interest rate will fall, ceteris paribus. On the other hand, a rise occurs when savings fall or when fixed investments rise. When looking for early warning signs of currency crises, this variable is crucial. Eliasson and Kreuter (2001) and in Cuaresma and Slacík (2008) both found this variable to have the predicted positive sign.

The value of foreign products and services that households, businesses, government agencies, and other organizations in a nation purchase over a certain period is the final explanatory variable from the second-generation models. According to economic theory, import spending is a withdrawal or a leakage out of the circular flow of income. This explanatory variable is very important for this study as the real exchange rate affects real import prices. As a result, according to Feridun (2004), one may expect a positive sign for imports when observing for a potential currency crisis.

As we go on to the third-generation models, it should be noted that the focus is on the banking system's role, namely its vulnerabilities and flaws that increase the likelihood of a currency crisis. The Current Account (CA), which records all a nation's transactions for goods and services as well as investment income and transfers between other nations, is one of the indicators used from these models. Payments leaving the economy are referred to as debits and

payment coming into an economy are referred to as credits. The current account balance should be zero in accordance with economic theory, which is regrettably not achievable. Thus, the account will determine if an economy is experiencing a surplus or a deficit. An economy that is a net creditor to the rest of the world is represented by a surplus, while an economy that is a net debtor to the rest of the world is represented by a deficit. Due to the necessity of assessing the state of the economy to detect a potential currency crisis, this variable is crucial to the study. According to Emin and Aytaç (2016)., this variable should have a negative sign.

Another explanatory variable is interest rate spread. And according to the World Bank can be defined as the interest rate charged by banks on loans known as the 'lending rate' to private sector customers minus the interest rate paid by commercial and like banks also known as a 'deposit rate'. This explanatory variable is very important when looking at factors that could possibly lead to a currency crisis in an economy. Especially because a narrow interest rate spread means low transaction costs, which in turn reduces the cost of funds for investment which is crucial to economic growth. As a result, the expected sign for this variable is positive as found in (Zhao et al., 2014).

The US interest rate will be the final variable covered in this study. Since the US is one of South Africa's largest trading partners, changes in US interest rates have an impact on most economies. As a result, this variable is crucial for this research since it is still necessary to understand interest rates because a decline could raise the likelihood of a currency crisis. According to Yepez et al. (2010), the variable's predicted sign is positive.

3.2. Model Specification

The limited dependent variable takes a value of zero during non-crisis or tranquil periods, and it has a value of one during crisis periods and the variously defined "window" periods that precede a crisis. Typically, the probit models look like this:

$$\mathrm{Pb}(y = x) = F(xb) \tag{3.1}$$

Starting with the signals approach, Berg and Pattillo (1999) devised a strategy. Although Berg and Pattillo only utilized one threshold, the authors use the signals produced by each individual indicator as independent variables. In terms of the predictability of currency crises, their panel data analysis and method performance test demonstrate that the probit approach is superior to the signals approach. Throughout their work, they alter the methodology and employ percentiles of the independent variables' distribution in addition to varying the independent variables' slopes below the crisis thresholds, leaps at the threshold, and slopes over the

thresholds. The Berg & Pattillo technique is part of the Developing Country Studies Division model used by the International Monetary Fund. In this work, we treat each individual indicator signal as an independent variable, reproducing the methods of Berg and Pattillo. However, by using a 12 and 18-month crisis timeframe and adding second thresholds, we expand the coverage.

Using the data itself rather than the calculated signals is another method of handling the independent variables, as demonstrated by Frankel and Rose (1996). Preventing information loss due to data transformation is one possible advantage of using the original data. Therefore, we also forecast the 2006 South African currency crisis using the Frankel and Rose technique. A challenge with both the probit and signals approaches is that, now, one is unable to predict whether an Exchange Market Pressure (EMP) index-defined crisis will occur. The previous times that fell inside the crisis timeframe apply the same rules. As a result, the only data we can use to calibrate our forecasting model is prior to the window period. Thus, for the out-of-sample projections of the crisis in June 2006, we can only calibrate the model using data up to November 2004 (in the 18-month crisis window instance). The dependence on a specific crisis definition and a crisis timeframe is removed with Markov-switching models.

The dependent variable, crisis, is a dummy variable that will have a value of 1 in the event of a currency crisis and 0 otherwise. The following is one way to convey it:

$$Crisis = \begin{cases} 1; if\ MTI_t > \mu_{MTI} + \sigma_{MTI}, \\ 0, otherwise \end{cases} \tag{3.2}$$

Where, μ_{MTI} is the mean value and σ_{MTI} is the standard deviation. The specification of the model may be presented as follows:

$$Crisis_t = \beta_0 + \beta_1 Budget\ Deficit_t + \beta_2 CA\ Balance_{t-1} + \beta_3 Exports_{t-1} + \beta_4 Imports_{t-1} + \beta_5 Interest\ rate\ spread_t + \beta_6 RER\ Deviations_t + \beta_7 RIR_t + \beta_8 Terms\ of\ Trade_t + \beta_9 Total\ Reserves_t + \beta_{10} US\ Interest\ rate_{t-1} + u_{t.} \tag{3.3}$$

The equation above shows all the relevant key indicators that need to be taken into consideration when assessing a currency crisis. The dependent variable as earlier explained is Crisis. The rest of the explanatory variables have been defined within the model specification and include budget balance, current account balance (CA), exports levels, import levels,

interest rate spread, real exchange rate deviations (RER), real interest rates (RIR), terms of trade and total reserves. The intercept term is denoted by β_0 and an error term by $u_{t.}$

Capturing Currency Crisis.

There is no one definition of a currency crisis, even though this study used the one proposed by Frankel and Rose (1996). However, many economists concur that a currency crisis occurs when a successful speculative attack on the currency results in its decline. Policymakers could, however, respond to this by raising interest rates.

A key question that then arises to be solved in the analysis of currency crisis is how to detect a speculative attack in the foreign exchange rate, and to establish when this attacked can be declared as a crisis. A few of these questions include: is currency crisis only limited to an exchange rate depreciation/devaluation? By how much must the movement be in the index for it to be declared a currency crisis? lastly, in high inflation periods, how large must a depreciation be for it to be considered a crisis?

Eichengreen et al. (1996) proposed the Exchange Market Pressure Index (EMPI), one of the most well-known indices ever used to detect currency crises. This is a weighted measure of speculative attack that includes factors including shifts in international reserves, interest rates, and currency rates. The inverse of each component's variability is used to weight them.

An analysis by Moreno and Trehan (2000) suggested that the assumption of this approach is that a one standard deviation change in interest rate signifies a currency crisis as one standard deviation change in international reserves or exchange rate. Several researchers have followed this methodological approach, some making a few adjustments. For example, Kaminsky and Reinhart (1999) formulated an alike index, however, they did not include interest rate in their index. Their reason was unavailability of data, especially for interest rate which was not consistently available for their full sample.

Frankel and Rose (1996) used the EMPI approach to construct an indicator of changes in the nominal exchange rate. Their study excluded variables such as international reserves because it was believed that its data contained a lot of noise; it also excluded interest rates because only a few countries in the sample had short-term loans which were market-determined. Further, since a successful speculative attack leads to a currency depreciation/devaluation (especially in most emerging countries) then, only changes in the nominal exchange rate are required to identify currency crises.

The second part that needed attention was by how much the movement in the given index must be for it to be considered as a crisis. Several researchers have suggested different criteria, for example, Frankel and Rose (1996) suggested an absolute cut off point. Other researchers simply determine crisis by relying on moments of distribution (standard and mean). Others consider moments of distribution of the index to determine crisis (see Kaminsky and Reinhart (1999) and Eichengreen et al. (1994)), while others such as Moreno and Trehan (2000) preferred moments of the component of the index.

When considering episodes of high inflation, the rate of depreciation is subsequently high. To avoid considering each of these depreciations as individual crisis, it is important to calculate separate standard deviations for those episodes. This is important to do because as highlighted by Kaminsky and Reinhart (1999), that when a standard deviation for a full sample is computed, several crises may be detected during inflationary periods, while a few others that may remain undetected outside of the inflationary episodes.

A few pointers can be drawn from the discussion above. Some of these are the fact that there is no perfect measure of currency crises, each measure has its own advantages, disadvantages, and other elements of arbitrariness. This thesis chooses an index like that of Eichengreen et al. (1994) and Kaminsky and Reinhart (1999), because of its interest to captures all speculative attacks, whether successful or not. This index is named the Market Turbulence Index (MTI) which was proposed by (Cerro and Meloni, 2004).

3.3 Market Turbulence Index (MTI)

This index is based on the idea that when interest rates rise, international reserves fall, and the exchange rate depreciates (rises), market pressure increases. Prior to an exchange rate depreciation, interest rates would increase, and international reserves will decrease in a system with a floating exchange rate regime as the crisis intensifies.

In this index, the reserve variable is recognized as an instrument for exchange rate market relief for the central bank, and this is shown by the negative sign. This index also accounts for interest rate being a possible contributor to market turbulences, where an increase in market pressure is shown by increases in interest rates. This index is as follows:

$$MTI_t = \frac{\Delta ex_t}{\sigma \Delta ex_t} - \frac{\Delta res_t}{\sigma \Delta res_t} + \frac{\Delta int_t}{\sigma int_t}, \qquad 3.4$$

Here the percentage changes are denoted by Δex_t for nominal exchange rate, Δres_t for foreign reserves and, Δint for interest rates. Further, the standard deviations of the very same variables are presented as $\sigma \Delta ex_t$, $\sigma \Delta res_t$ and σint, respectively. From the index above, whenever MTI_t

exceeds the pre-determined threshold, a currency crisis episode would occur. This threshold includes the index's mean μ and standard deviation σ. Therefore, it can be shown as follows:

$$Crisis_t = 1 \; if \; MTI_t > (\mu_{MTI} + \sigma_{MTI}) \qquad 3.5$$

One thing worth noting is that the standard deviation seems to vary with the authors preferences and the data employed. For instance, Kamin et al. (2007) evaluated different standard deviations using the exchange market pressure (EMP) index, which is a very similar to our market turbulence index (MTI). Based on author's data, it was concluded that all episodes would be covered by 1.75 stand deviations.

Because the MTI characterizes each standard deviation (SD) bound in a way that is related to the intensity of the crisis, this study prefers it over the EMPI. For example, according to MTI model as employed by this study; a non-crisis period is defined as one in which the MTI is less than 0.5 SD. Furthermore, an incident is deemed to be a mild crisis or turbulence if the MTI falls between 0.5 and 2 SD. A light crisis is defined as two to three SD, whereas a severe crisis is defined as three or more SD. The Table below depicts the above-mentioned criterions:

Table 1: Criteria to sort Crises

Data		
Criteria		**Classification**
Index	***No. of Signals***	
MTI < 0.5 σ_{MTI}		Non-Crises
0.5 σ_{MTI} < MTI < 2 σ_{MTI}	1 quarter	Minor Turbulence
2 σ_{MTI} < MTI < 3 σ_{MTI}	1 quarter	Mild Turbulence
MTI > 3 σ_{MTI}	1 quarter	Severe Turbulence

Source: Author's Computation

3.4 Testing for Stationarity

Many econometric methodologies are under the assumption that there is stationarity in time series, when in fact at times there could be non-stationarity. This often leads to inaccurate statistical tests, misleading and erroneous results, and inferences. Therefore, testing for stationarity is very crucial. We employ a two prominent unit root tests, testing at series of level to test for stationarity, these include: firstly, the Augmented Dickey Fuller (ADF) test and the Phillips-Perron test

Said and Dickey (1984) augmented the basic autoregressive unit root test model, this test is known as the augmented Dickey-Fuller (ADF) test. It is an extended version of the Dickey-

fuller test aimed at handling more complex time series data. This model tests the null hypothesis of whether a unit-root exists or not in time series sample. Depending on which version of the test is used, the alternative hypothesis tends to be different. However, under normal circumstances the hypothesis is stationarity or trend-stationarity. Said and Dickey (1984) state that the ADF statistic utilized in this test is a negative number. The magnitude of the negative number is very important, therefore a strongly negative number meant that a stronger rejection of the hypothesis that there was unit root at any level of confidence. To optimally undertake this test, the dependent variable needs to be lagged (k_{t-1}). The test is based on the following regression:

$$k_t = \beta_1 + \beta_2 k_t + \mu_t \quad 3.6$$

Where k_t represents the time series, t is time subscript, and μ_t is a white noise error term. Now accounting for time-period imbalances:

$$\Delta k_t = \tau k_{t-1} + \beta_1 \Delta k_{t-1} + \beta_2 \Delta k_{t-2} + \beta_3 \Delta k_{t-3} + \cdots + \beta_n \Delta k_{t-n} + \mu_t \quad 3.7$$

Until autocorrelation is eliminated from the model, a lagged variable will be added continuously. According to one of the assumptions of Ordinary Least Squares (OLS), the error term (μ_t) ought to be independent. This implies that μ_t must be normally distributed and free of structural breakdowns, and that heteroscedasticity should not exist. In terms of the testing process, the ADF test only checks for stationarity by following the Dickey Fuller test Zhao et al. (2014). The null hypothesis, $H_0: \tau = 0$, indicates that the series is non-stationary and that the ADF test contains a unit root.

In this case, if the series is non-stationary then the variables will suffer from unit root. The variables are however non-stationary in the alternative hypothesis $H_1: \tau < 1$ because this suggests that the unit root is non-existent.

In the analysis of time series, Phillips (1988) developed a number of unit root tests that have since gained popularity. The primary distinction between the recently discussed ADF test and the Phillips-Perron unit root test is how each handles heteroscedasticity and serial correlation errors. This unit root test is a good way to test models with drift and trend components. Like the ADF, non-stationarity is linked to the null hypothesis, while the opposite is true for the alternative hypothesis. The regression for the PP test is as follows:

$$\Delta k_t = \alpha + \tau y_{t-1} + \mu_t \quad 3.8$$

In the above equation, μ_t may possibly be heteroscedastic and stationary even before taking the first difference into account. The Phillips-Perron test is employed to detect possible serial correlation that may be found in the error test of the test statistics denoted by $t_{\tilde{\zeta}=0}$ and $T_{\check{\zeta}}$. The improved statistics are given by:

$$V_t = \left(\frac{\sigma^2}{\tilde{\zeta}^2}\right)^{\frac{1}{2}} \cdot t_{\tilde{\lambda}=0} - \frac{1}{2}\left(\frac{\tilde{\zeta}^2-\sigma^2}{\tilde{\zeta}^2}\right) \cdot \left(\frac{T.\ S\,E(\tilde{\lambda})}{\sigma^2}\right)$$

3.9

$$V_\lambda = T_{\tilde{\lambda}} - \frac{1}{2}\left(\frac{T^2.SE(\tilde{\lambda})}{\sigma^2}\right)(\tilde{\zeta}^2 - \sigma^2) \qquad 3.10$$

The terms $\tilde{\zeta}^2$ and σ^2 represent the variance parameters and are consistent in estimation.

$$\sigma^2 = \lim_{T\to\infty} T^{-1} \sum_{t=1}^{T} E[u_t^2] \qquad 3.11$$

$$\tilde{\zeta}^2 = \lim_{T=\infty} \sum_{t=1}^{T} E\,[T^{-1}\, S_T^2] \qquad 3.12$$

In a way that $S_T = \sum_{t=1}^{T} u_t . u_{\tilde{t}}$, which denotes the least square residual sample variance appears to be a consistent estimate of σ^2 and u_t which is the long-run variance estimate depicted as $u_{\tilde{t}}$ is consistent with $\tilde{\zeta}^2$. Furthermore, the null hypothesis is in a manner that $\zeta = 0$. Just like the ADF t-statistic, the PP test's statistics V_t and V_{ζ}have identical asymptotic distributions, also a normalized bias statistic. A positive attribute of the Phillips Perron test is that optimally tests for robustness of correlation that could be found in μ_t our error term.

roots.

3.6 Econometric Approach

The most applicable method for financial crisis analysis in accordance with literature is the probit model. This model will be adopted in this thesis and will combine several variables from the three generation models as found in the literature.

The probit analysis model, called by Bliss (1934) and Maddala (1983) is a model under the assumption that there lies an underlying variable y_i^* represented by the following regression:

$$y_i^* = \sum_{k=1}^{K} \beta' x_i + u_i \qquad 3.13$$

In this model, y_i^* is unobserved or a latent variable, ranging from $-\infty$ to ∞. Further, u_i is symmetrically distributed with a mean of 0 together with a cumulative distribution function (CDF) defined as $F(u)$. From there, a dummy variable y is observable is generated and is defined by:

$$y = 1\ if\ y_i^* > 0$$
$$y = 0\ otherwise \qquad 3.14$$

In this construction, $\beta' x_i$ is not $E(y_i \,|x_i)$ like it would be in a linear probability model; it is $E(y_i^* | x_i)$.

From combining (3.13) and (3.14) we get:

$$\begin{aligned} Prob(y = 1) &= Prob(\textstyle\sum_{k=1}^{K} \beta' x_i + u > 0) \\ &= Prob(y_i = 1) = Prob(u_i > -\textstyle\sum_{k=1}^{K} \beta' x_i) \\ &= 1 - F(-\textstyle\sum_{k=1}^{K} \beta' x_i) \end{aligned} \qquad 3.15$$

where F is the error term u's cumulative distribution function. The observed values of y in this case simply turn into a binomial process, with probabilities represented by 3.15 Ordinary least squares (OLS) cannot be used to estimate the model when the dependent variable is binary, and the latent variable is unobserved. The alternative is maximum likelihood estimation, which necessitates assumptions regarding the distribution of the error terms (Long, 1997). This is the likelihood function:

$$L = \textstyle\prod_{y_i=0} F u_i \,(-\beta' x_i) \prod_{y_i=1} [1 - F\,(-\beta' x_i)] \qquad 3.16$$

The assumptions made about u_i in 3.14 will be what the functional form for F in 3.16 will depend on. The rationale for using this modelling approach is that it implies the presence of a discrete time series because the dependant variable is a dummy variable that can only take values of 1 or 0. For instance, it is expected that the dependent variable in an OLS model will have a continuous time series since the OLS assumptions would be broken otherwise. In particular, the assumption of error normality, which causes the regression errors to become heteroscedastic and not fit the data well. Assessing the impact of a set of variables on the likelihood of currency crises is the main goal of this study. Furthermore, an index that serves as the basis for the dependent variable must be constructed; this requires a procedure that takes this type of dependent variable into consideration. This is effectively accomplished via the probit model.

The definition of a currency crisis episode in each technique is the primary distinction between the signals and the probit method. According to this thesis, Ötker and Pazarbaşioğlu (1996) and Frankel and Rose (1996) were the first to use the probit model. As was previously indicated, the study by Frankel and Rose (1996) defined a currency crisis episode as a 25% decline in the value of the currency. This definition gained a lot of recognition by researchers and since then, a lot have referenced this definition to construct their dependent variable (see Leblang and Satyanath (2008) and Boonman et al. (2019)). However, for the topic at hand,

Berg and Pattillo (1999) considered this definition a possible drawback of the probit model because of the possibility of several crisis episodes not being detected by it.

On the other hand, the signals approach's definition of currency crisis episodes is based on an index that accounts for changes in both reserves and the exchange rate, making it easier to capture more crisis episodes. Nonetheless, it is worth noting that the probit model can be modified to also account for reserves and the exchange rate (just like the signals approach).

According to Adams and Metwally (2019), the probit method outperformed the signals approach in terms of accuracy and reliability for predicting currency crisis occurrences. This is yet another compelling argument in favour of using the probit analysis method. According to Kaminsky et al. (1998), the signals method's rationale is to examine how variations in the behaviour of individual indicators would increase the probability of a currency crisis episode within 24 months. Therefore, we need to use monthly data for the signals approach to produce meaningful results that could be used for forecasting purposes. This thus, means that the signals approach does not allow the use of variables that are routinely provided, for example annual data and which includes data like the budget deficit (which we need for this study). Additionally, data that is available on a monthly, quarterly, or annual basis may be used by the probit. Based on the arguments mentioned previously, this thesis concluded that the probit method is the most appropriate approach for this study.

Chapter 4: Empirical Estimation and Explanation of Results

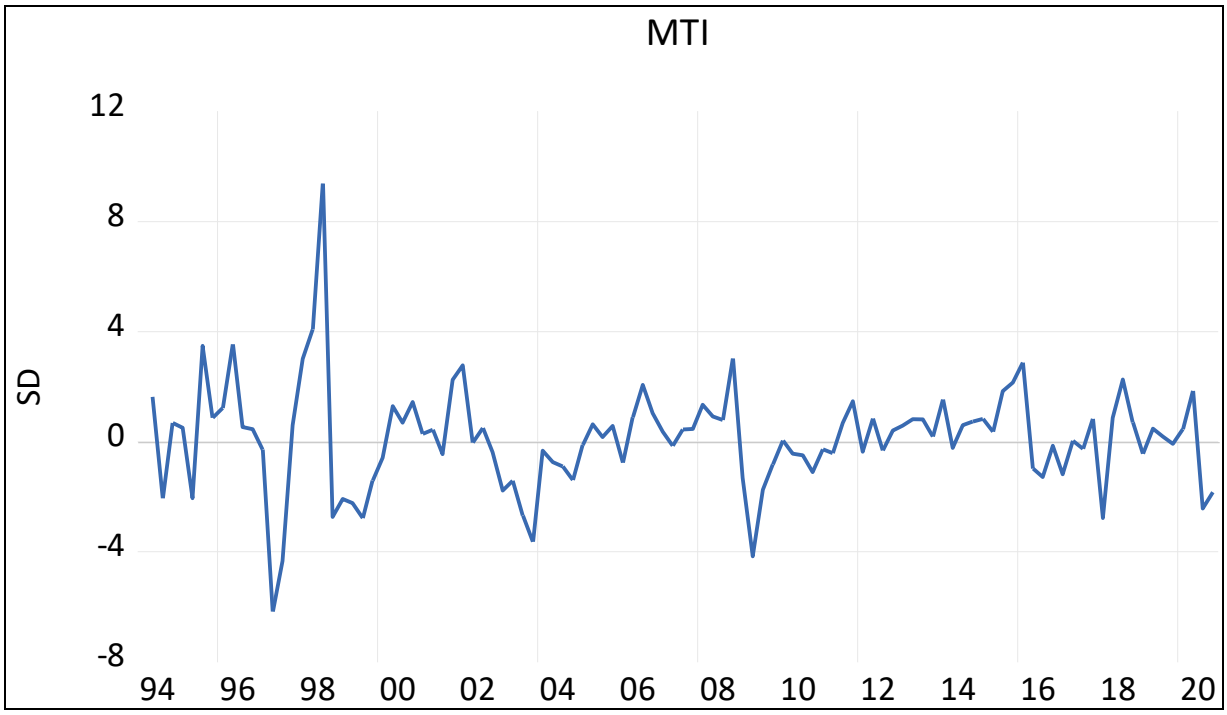
The preceding chapters provided an overview of the theoretical framework, literature review, and methodology employed to investigate South Africa's exposure to potential currency crises. This chapter presents the empirical findings of the study, which are based on the analysis of the indicators that should be considered when examining potential crises along with their expected signs as indicated by the different generation models in the literature. The indicators to be discussed include budget deficit, currency account (CA) balance, exports, imports, interest rate spread, real exchange rate (RER) deviations, foreign reserves, real interest rate (RIR), terms of trade (TOT) and United States Interest rate (USIR). The findings are organized in line with the key research questions and objectives outlined in chapter 1.

The chapter is structured as follows: Section 4.1 will discuss the findings of the Market Turbulence Index (MTI). Section 4.2 reports the results of the statistical tests, including the Augmented Dickey Fuller and Phillips-Perron tests. Additionally, the cointegration results will be discussed. Section 4.3 will provide an interpretation of the probit model results and highlight the key implications for South Africa's exposure to potential currency crises. Finally, section 4.4 concludes the chapter by summarizing the main findings and setting the stage for discussion of the policy recommendations in Chapter 5.

4.1 The Market Turbulence Index (MTI)

The MTI for South Africa for the duration of this study is shown in Figure 1. The data shows that during these 26 years, the index has had 32 turning moments in total, or more than three per three years on average (Figure 1).

Figure 1: South Africa's MTI from 1994 to 2020



Source: Author's Own Estimates

Table 2 is derived from figure 1 and illustrates how the MTI at threshold 1 (SD 3) encompasses the main crisis episodes that South Africa has seen since late 1995 to early 1996, including those that happened in 1998, 2001, 2006, 2008, and 2016. The different episodes are accompanied by explanations of events that occurred around that period.

Table 2: Currency crises episodes by MTI threshold level

Threshold	Episodes Captured	Classification
MTI < 0.5 σ_{MTI}	1995, 1996, 2001,2002,2005,2007,2010,2012,2013,2015,2017,2019,2020	Non - crisis
0.5 σ_{MTI} < MTI < 2 σ_{MTI}	1994, 1995, 1996, 1997, 2005,2006,2008,2011,2012,2013,2014,2015,2017,2018,2020	Minor Turbulence
2 σ_{MTI} < MTI < 3 σ_{MTI}	2001,2006,2015,2016,2018	Mild Turbulence
MTI > 3 σ_{MTI}	1995,1996,1998,2008	Severe Turbulence

Source: Author's Own Estimates

When considering the 1995 to early 1996 currency crisis, during this period, South Africa's economy was undergoing significant transformation after the country's democratic transition in 1994 (Aron and Muellbauer, 2002). The years preceding the actual crisis periods may be discussed for better understanding of how they were experienced to start with. This is because as shown in figure one, the highest turbulence was witnessed that period. During this transformation, South Africa's international reserves experienced significant fluctuations. According to the Kaminsky and Reinhart (1996) report, the country's net reserves in US dollars increased substantially between 1990 and 1991, reaching $2.9 billion by the end of 1991.

However, this upward trend was short-lived. Beginning in the third quarter of 1992, net reserves started to decline, and by the end of 1993, they had dropped by $3.1 billion, reaching a mere $1.0 billion. This sharp decrease was largely attributed to significant net outflows of capital unrelated to reserves, which outpaced the current account surplus. The situation worsened in the first half of 1994, with net gold and other reserves decreasing further. Short-term withdrawals totalled around $3 billion in the second half of 1993 and $1.1 billion in the first half of 1994. These outflows were likely driven by persistently negative leads and lags in foreign payments and receipts, as well as the strength of the US dollar and downward pressure on the rand.

The country's political instability and social unrest during this period also contributed to the significant withdrawals. However, by the third quarter of 1995, the situation began to reverse, with a net inflow of almost $1.6 billion. This shift was likely driven by renewed confidence in the country's transition to a new political order. Despite this brief respite, the net reserves continued to fluctuate, decreasing by $1.1 billion in April 1995 before increasing by $1.6 billion in May. By the end of December 1995, net reserves had reached $4.3 billion, only to decline slightly to $4.2 billion in January 1996. These fluctuations set the stage for the currency crisis that would unfold in 1996.

The 1998 crisis like the first crisis periods, falls under severe turbulence classification in our MTI results. This is because during this period, the Asian financial crisis had occurred, which had a spill-over effect on South Africa, leading to a sharp depreciation of the Rand (Aron and Muellbauer, 2002). This, combined with a decline in commodity prices, exacerbated the country's economic challenges. Further, this led to a decline in investor confidence and put pressure on our exchange rate.

The last year considered to have had a severe crisis is 2008. The whole world was encountered by a global economic depression which had significant impacts on many economies including South Africa. Some of the effects to the economy included rapid declines in the demand for exports, consequently deteriorating the trade balance. In turn, the value of the Rand depreciated by about 25 percent against the US dollar between 2008 and 2009 (Aron and Muellbauer, 2009). This depreciation had major implications such as increasing the price of imports, reduced customer spending and ultimately higher inflation. The effects of this continued to cascade throughout the economy, leading to increased unemployment and a decline in economic growth. Investor confidence also reduced during this period, with foreign investors becoming more risk-averse and withdrawing funds from the country.

Some of the other crisis episodes identified were classified as mild, meaning they were greater than two but less than 3 standard deviations. 2001 is a perfect example of such a period, where South Africa experienced significant depreciation of the rand which led to higher inflation and interest rates (Fedderke and Liu, 2002). In 2006, South Africa was faced with a surge in capital inflows, which led to an appreciation of the rand (IMF, 2006). However, this also created concerns about the economy's vulnerability to external shocks.

In 2015, South Africa was faced with a combination of internal and external challenges, including a decline in commodity prices, a drought, and the impact of the European sovereign debt crisis (reference) these challenges went onto the first quarter of 2016. Lastly the 2018 crisis was not officially found to be a crisis by other scholars, however, in our study it was

classified as a year where a minor crisis occurred. Upon reading, it is found that the country experienced a technical recession, and the rand depreciated significantly due to internal and external factors, including the impact of the US-China trade war.

In conclusion, the currency crisis periods discussed above were characterized by significant economic disruptions, which included depreciation of the rand, recessions, and declines in investor confidence. The outcome of the MTI is in line with the literature on South African currency crisis periods, because there is existing proof of such events. It is also clear from the literature that net reserves are a good indicator to consider when gauging for a possible currency crisis in an economy.

4.2 Stationarity Test Results

As discussed in the prior chapter, it is paramount to determine the order of integrations of the variables. This is to help one identify whether the variables exhibit stationarity or non-stationarity. The ADF and PP test results are presented in table 3. The test statistic values, and the p-values denote whether the null hypothesis (non-stationary) of a unit root can be rejected or not.

Table 3: Unit Root Tests (ADF AND PP Test)

Variable	Augmented Dickey Fuller Test Statistic	Unit root test p-value	Phillips – Perron Adjusted Test Statistic	Unit root test p value
Budget Deficit	-3.113693	0.0395**	-1.951079	0.3497
Current Account Balance	-2.059696	0.2614	-1.328513	0.6000
Exports	-3.705252	0.0104**	-3.565718	0.0143**
Imports	-3.301081	0.0257**	-3.301081	0.0257**
Interest Rate Spread (IRS)	-0.430837	0.8885	-0.465204	0.8819
RER Deviations	-1.9288626	0.3146	-1.863093	0.3432
Foreign Reserves	-1.184929	0.6636	-0.630908	0.8464
RIR	-2.066737	0.2587	-1.970606	0.2969
TOT	0.940628	0.9944	0.690707	0.9894
US Interest Rate	-2.152378	0.2275	-1.843510	0.3520

Notes: Constant and Linear trend were included in the test equations. *, ** Significant at 1 and 5 percent levels, respectively

Source*: author's own estimates*

The ADF and PP test statistics and p-values for the explanatory variables in the probit model are shown in table 3. When assessing the stationarity of the variables, primarily focusing on the corresponding levels of significance, it is evident that some of them are stationary at level form. This is because the p-values of these variables are below 0.05, thus making them significant at 5 percent level of significant (**, on the table). The stationary variables at level form include the budget deficit, exports and imports. This means that the statistical properties of these variables are constant overtime and that any shocks or disturbances would only be temporary, without any permanent impact.

On the contrary, there are some non-stationary variables with p-values greater than 0.05. These variables include the current account balance, interest rate spread, RER deviations, foreign

reserves, real interest rate (RIR), terms of trade (TOT) and US interest rate. Therefore, this means that we fail to reject the null hypothesis of a unit root. This implies that these variables seem to be non-stationary, indicating that its variance, mean and autocorrelation structure changes over time. However, due to the nature of our study which does not focus on the long-run effect of the movement of the variables. Then the impact of these finding will not necessarily impact the study negatively.

4.3 Probit Model Results

The probit models are shown in table 4. The explanatory variable outcomes are then discussed in detail below where CRISIS (exchange rate) is the dependent variable. However, the results are insignificant, but the discussion is provided below. Before proceeding to the results of the model on the below table, it should be noted that the first lag for some indicators is taken: namely the current account, exports, imports and the US interest rates. The reason for this transformation is because the study wants to ensure that even delayed effects of these variables is well captured into the study. Also due to some the discussions in literature of how they may falsely signal one.

Table 4: Probit Model Results

Variable	Coefficient	p-value
Budget Deficit	-0.266914	0.3497
Current Account Balance	-0.065861	0.8662
Exports	0.109954	0.2922
Imports	0.003236	0.9663
Interest Rate Spread (IRS)	-0.481124	0.6412
RER Deviations	-0.20046	0.5711
Foreign Reserves	5.06	0.5776
RIR	0.207616	0.4481
TOT	-9.09	0.5578
USIR	-0.123357	0.6353

Source Author's own estimates

Budget Deficit

The findings indicate that as expected, the budget deficit indicator is negative because we generally expect the government's expenditure to be greater than its savings for an economy to have a currency crisis episode. The results from the Probit model indicate that this explanatory variable is insignificant at all levels. This means that the indicator is not a useful variable to consider when identifying factors that best predict a currency crisis in South Africa. There are several factors that contribute to such findings, such as changes in fiscal policies over time. These may include adjustments to government spending or taxation not being captured by the budget balance variable.

There are a few researchers who reported similar results to the ones found in this thesis. For example, Kaminsky et al. (1998) used the probit model and found that the budget balance variable was not to be a significant currency crises predictor. Their reasons for such a result included factors such as political instability and external shocks. Another study by Frankel and Rose (1996) found similar results and highlighted challenges in their model, in terms of it not being adequately specified possibly because of a variable omission. They also added that the sample size that they used was relatively small and could have affected the results. Some of these reasons could be attributed the results this thesis found.

Current Account Balance

The current account indicator has a negative sign, which is in accordance with the findings highlighted in the literature. This shows that the likelihood of a currency crisis rises as the current account balance declines at a notable rate. Meaning that the rate of savings would be increasing at a slower rate than the increase in expenses, consequently widening the deficit. However, it is important to note that this variable is also insignificant at all levels of significance. Therefore, this highlights that in South Africa, the current account balance is not an important variable one has to pay attention to when trying to predict a currency crisis. There are numerous factors that could have contributed to such results, such as trade balance fluctuations. These fluctuations could have masked the effects of the current account balance on the probability to predict a currency crisis. Moreover, the capital element of the capital account balance may have negatively influenced the results by having unaccounted adjustments which could potentially affect the current account calculation.

Eichengreen et al. (1994), used a logit model which and found that the current account balance was not a significant predictor of speculative attacks. The scholars highlighted possible non-linear relationships between the indicators and the probability of speculative attack. They also included possible data limitations in terms of the time periods chosen, and also the set of countries used in their study. Milesi-Ferreti and Razin (1996) have also highlighted that current account balance was an insignificant indicator of currency crisis. Potential reasons as to why this was the outcome according to the authors included limited sample size and a potentially incorrectly specified model, leading to omitted variable bias or the wrong functional form. Such reasons may also be attributable to this thesis. Especially considering that the expected coefficient sign was met.

Exports

A study by Kaminsky and Reinhart (1996) states that export trends tend to have frequent fluctuations, but tend to peak and then decline before a crisis period. They eventually begin to rise once more because of the local currency's depreciation**.** Figure 2 shows the South African export trend for the 1995-2020. Prior to an event that could be labelled a crisis, there was an upward movement rather than a downward movement. Following a four-year recession, exports gained pace, and by 1995, the value of merchandise exports had risen. In the fourth quarter of 1993, the value of merchandise exports increased from US $17.0 billion in the fourth quarter of 1992 to $19.0 billion. Seasonally adjusted and annualised, the value of net gold export rose from $6.1 billion in 1992 to $7. 3 billion. In the third quarter of 1993, the amount of gold shipped also climbed by 8%, whereas the quantity of other exported items fluctuated but showed a general upward trend.

In the first half of 1994, the 1993 economic rebound did not hold. During this time, the nation was going through a significant political upheaval. There was work stoppages and labour unrest; there was continuous violence in the run-up to elections; and there was political uncertainty regarding the outcome of political developments. These elements have a negative impact on manufactured products export volumes as well as domestic output.

Figure 2: South Africa's Exports from 1995 to 2020

Source: Author's Own Estimates

After declining to $17.0 billion in the second quarter, exports rebounded in the third quarter, reaching $18.5 billion and $21.6 billion in the fourth quarter of 1995. The rand's strength versus the dollar and an increase in the export price of goods were the primary causes of the high value

of exports. Since US dollars account for most of the nation's exports, the export industry benefited from the depreciation.

The upward shift of the curve from the second to the third quarter indicated a 20% increase in volume and a significant increase in the value of merchandise exports of roughly 4% during the first nine months of 1995. It was presented that export values increased until January 1996, when the possible crisis began, and then just started to fall. With the rand selling at R3,74 per dollar at the start of this period, it further declined to R4,70 by December 1996. A good indication should provide a signal ahead of time so that the policymaker can take preventative action, according to the signal's method. Figure 2 data indicates that, on average, exports provided a lead time of fifteen months, which is satisfactory. According to this research, exports do not appear to have indicated that a catastrophe was imminent. Export performance was still strong, increasing slightly until March 1996, when it began to decline to $22.0 billion before stabilizing in the third quarter of that year. According to the data and explanations, exports would not have been a strong leading indicator. This finding is confirmed in the results of this thesis, where the sign for the explanatory variable was positive despite the expected negative sign. Furthermore, exports were found to be insignificant at all levels. This implies that exports should not be considered when attempting to forecast a currency crisis in South Africa.

Imports

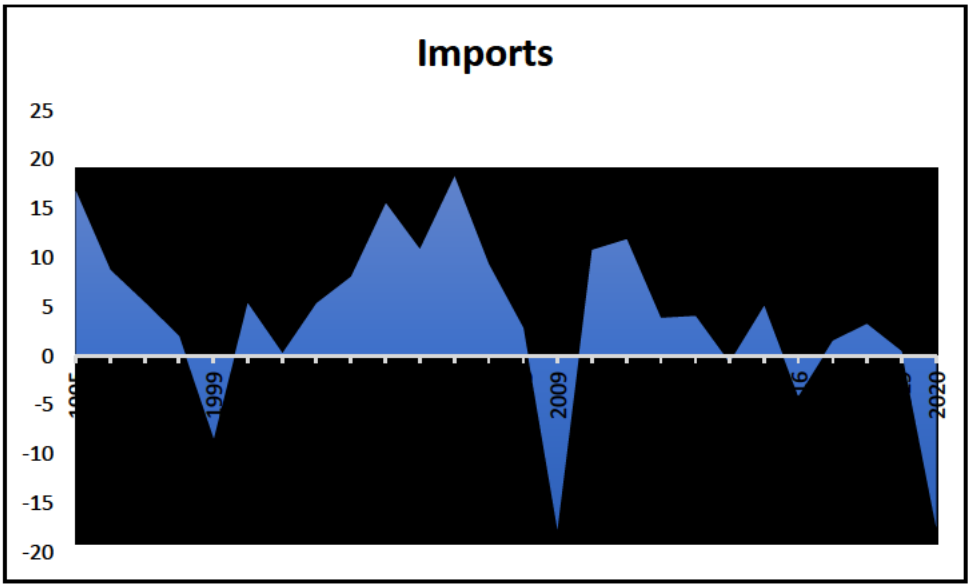
The results of the imports indicator show expected positive sign. However, is insignificant at all levels implying that while attempting to predict currency crises in South Africa, imports should not be considered. The empirical patterns from earlier work of Kaminsky and Reinhart (1996) demonstrate that imports typically show a declining trend prior to a crisis and begin to increase in intensity following a crisis. The authors stipulate that one possible explanation for this trend could be attributed to the slowdown in economic activity which, in most nations within the panel, tended to characterise the preceding crisis occurrences. The analysis found that throughout the post-crisis era, import growth even stayed below that of typical times. Prior to the crisis's episodes, there was a slowdown in economic activity as evidenced by a fall in output and a worsening in terms of trade.

Consequently, the authors concluded that these countries' import behaviour were puzzling and difficult to understand. Therefore, it was determined that imports could no longer be used as a reliable indicator. An evolution of the value and volume of imports from South Africa is displayed in Figure 3. It is evident that the pattern displayed is the opposite of what the authors mentioned. A consistent but modest rise in the net value and volume of imports was observed

during quiet times. The pre-crisis period began in the third quarter of 1994, when import value began to rise sharply. This trend continued until January 1996, when it slightly decreased to $28.06 billion by March of that same year.

As a result, import value increased from $19.28 billion in the fourth quarter of 1993 to $22.23 billion in the same period of 1994. The decrease in merchandised import values was caused by among others: A significant increase in the cost of imports. The number of imported items does not appear to have changed in response to the increase in import prices. In 1993, imports of goods increased by 4% overall, with a notable increase in the importation of machinery, electrical equipment, and transportation equipment. In the first quarter of 1994, both the volume and the value increased by 2% more. Unexpectedly, import volumes—which were predicted to fall—rose at a faster rate overall in 1994, ranging from 5% to 15.5%.

Figure 3: South Africa's Imports from 1995 to 2020



Source: Authors Own Estimates

Except for the US dollar and the Italian lira, the rand appreciated against all major currencies from the end of June 1995 and the end of August. The US dollar's strengthening versus the Japanese yen, German mark, and Netherlands guilder in the latter part of August 1995 was the cause of the rand's appreciation. This could have played a role in the rise in import volumes during that time.

As per the SARB (1994) annual Economic Report, there was a significant surge in import volume between 1993 and 1994, which was likely caused by several causes. These included

South Africa's high marginal propensity of imports, the positioning of obsolete and essential equipment and lastly, an increase in fixed assets and a build-up of stock.

The significant increase in inventory accumulation was partially caused by speculative purchases made in advance of the rand's anticipated further decline. As a result, even though depreciation is typically assumed to have a negative impact on the volume of commodities imported, South Africa's import quantities have been rising quickly, which has reduced the current account balance.

Therefore, the results indicated that imports did show the anticipated pattern before to the crisis. Thus, the signal was issued. Following this pattern would have led a policymaker to incorrectly predict a crisis soon. The performance of imports provided compelling evidence that the rand was overpriced, making imports less expensive and requiring a 19-month lead time. As a result, the current account balance was steadily declining. Conversely, exports did not indicate the impending catastrophe.

Interest Rate Spread (IRS)

The interest rate spread variable for this study is negative even though the literature such as Adams and Metwally (2019), showed the expected sign to be positive. The indicator is also found to be insignificant at all levels. There are number of factors that could have led to such findings, for example, the South African Reserve Bank's monetary policy framework. Thus, making it an insignificant variable when predicting potential currency crisis. Financial market conditions such as risk appetite and liquidity could have also influenced the interest rate spread. The outcome of this study is the opposite to that of (Adams and Metwally, 2019), who found the interest spread to be one of the most important predictors of currency crisis in Egypt.

Our findings are however not unique to us. (Berg and Pattillo, 1999) employed a probit model and found that interest rate spread was insignificant predictor of currency crises. The authors cited several factors that could attribute to their findings, including possible non-linear relationships between the variables and the possibility of a crisis. The authors also highlighted potential data quality issues, such as missing observations as potentially affecting the results.

Another study with similar findings is that of Bussiere and Fratzscher (2006) who used a logit model and found that interest rate spread was insignificant of financial crises. Upon investigating these results, the authors found that variables like interest rate spread could potentially be endogenous, leading to spurious results. They also found that their data could have been limited for them to get a holistic representation of all the countries in their panel.

Real Exchange Rate (RER) Deviations

The expected sign for the RER deviations according to literature is a negative sign. This study is in line with that expectation, meaning that there is a higher likelihood of a currency crisis to occur in South Africa if the RER is overvalued. Moreover, like the prior discussed variables, RER is insignificant at all levels. Factors like productivity shocks could potentially influence the real exchange rate deviations in South Africa. The South African exchange rate regime could have also influenced these deviations and their probability to predict potential currency crises. Even though Adams and Metwally (2019) found that the RER deviations to be significant at 1 percent in potentially predicting a currency crisis in Egypt, some scholars such as (References) found similar results to that of this study.

In a study done by Obstfeld and Rogoff (1995), the authors claimed that real exchange rate deviations are not a reliable indicator currency crises. The authors noted that there was a possibility that their theoretical model did not capture all the relevant aspects that influence currency crises. They also highlighted possible data shortcomings where the data was limited to a specific time and could have hindered them from getting significant findings. Further, Williamson (1996) used data for Chile, Columbia, and Israel and the author's findings signalled that RER deviations were not an important or significant indicator for predicting currency crises. The author cited case study limitations, in that they were limited to a specific period and a specific set of countries. Such could have not fully represented the countries hindering the variable's predictive power. There were also data limitations which were cited to account for such results. Some of the reasons discussed may be attributable to the findings of this study, especially because the sign of the coefficient is in line with literature.

Foreign Reserves

The foreign reserves variable according to the findings of this study is not a viable currency crises indicator because it firstly has a positive sign instead of negative as stipulated by literature. Secondly, it has is insignificant at all levels. It is worth noting that the variable's coefficient has the largest weight compared to the others. Some possible causes to these results could be changes in the South African Reserve Bank's reserve management policies, which could potentially influence the foreign reserves level. Other factors like capital flow volatility or instability could have also been affected in the duration of the period assessed.

Flood et al. (2001) employed a probit model to find the most suitable currency crises predictor. Their findings suggested that foreign reserves were not a significant indicator of currency crises and should not be considered when trying to predict one. The authors alluded to possible

endogeneity being present in foreign reserves, consequently leading to biased results. They also noted, data quality issues as some of the challenges that could have affected the variables predictive power. Further, a study by Bussière and Mulder (1999) also found the foreign reserves variable to be insignificant in being a reliable indicator of external vulnerability. Similarly, the authors found the variable to potentially be endogenous, typically affecting the accuracy of the results. They also highlighted possible non-linear relationships between the variables, affecting foreign reserves predictive power.

Real Interest Rate (RIR)

The probit results indicate that the variable shows a positive sign as expected from literature. Typically, it would mean that, as the RIR increase so does the chance of potential exposure to currency crisis increase. The variable is however insignificant at all levels, thus making not worthing considering when trying to predict for a currency crisis in South Africa. In as much as some studies found this variable to be a significant currency crises indicator (see (Adams and Metwally, 2019)). Other authors like Kaminsky and Reinhart (1999) have found similar findings to that of this study that RIR is an insignificant predictor of currency crises. The authors highlighted that the reasons for such results could be attributed to some omitted variables such as external shocks that could have affected the results. They also alluded to a potential non-linear relationship between RIR and currency crises. These results were also found in Eichengreen et al. (1996) where it was reported that RIR were not significant when predicting banking crises. They mentioned data limitations especially on the period covered and type of data. The model specification was also a potential hindrance to significant results as variables may have been omitted.

Terms of Trade (TOT)

The results show a negative sign, which is in line with literature. This means that a decline in the TOT typically increases the likelihood of currency crises. Regardless of this indicator being in line with literature and having one of the highest coefficients in the set of results, the findings is insignificant at all levels in this study. This means that this variable is not an important currency crises predictor and should not be considered. There are a few factors that may lead to such results, including trade agreements and policies, but also commodity price shocks that could influence the South African TOT. A study by Edwards (2004) used a probit model to identify which indicators were important for current account reversals and found that TOT were insignificant. The authors cited that there were possible data quality issues that may have caused measurement errors and affected the results. Calvo et al. (2006) also conducted a study and found that TOT were an insignificant indicator for determining a financial crisis. The

authors stated that there may have been possible endogeneity as to why such results were found. The existence of a non-linear relationship between TOT and currency crises may have existed as well.

United States Interest Rate (USIR)

The USIR indicator is showing a negative sign whereas literature suggests that ideally, the sign should be positive. Moreover, the indicator is insignificant at all levels. There are few reasons as to why the USIR could have such results. This can be due to changes in the US Federal Reserve's monetary policy that may have influenced the interest rates. Further, one may find that global economic trends may affect the likelihood of the USIR to assist in predicting potential exposure to currency crises in South Africa.

These findings were also found by Adams and Metwally (2019) when they were looking at currency crises in Egypt and found that the USIR had a negative sign instead of positive. They attributed to their results potentially to the short-term capital inflows, which would increase the demand the Egyptian Pound because of the inherently high Egyptian interest rates compared to those of the US.

The overall findings of this study show that the Market Turbulence index (MTI) is effective because it was able to capture some of the crises there have been noted by other South African scholars, such as Aron and Muellbauer (2002) who found the 1996 and 1998 currency crises. Adams and Metwally (2019) also used to the MTI for Egypt using annual data and found five crises' periods with two being severe. Their study found the MTI to be an effective index to use when investigating currency crises. In the case of this study, the index was able to identify currency crises in the years 1995,1996,1998 and 2008. The crises in these years according to our definitions were severe.

When considering the unit root tests at level form, we found that some of the variables were stationary and significant 5 per cent level. The remaining variables were found to be non-stationary.

The main model, which is the probit model gave insignificant findings, which the thesis has addressed in detail together with some insights from the literature on such findings. There are also scholars which have been cited which have been contributed greatly the investigation of potential currency crises in economies.

Chapter 5: Conclusion and Discussion

The focus of this paper was to investigate South Africa's potential exposure to currency crises for the period 1994 to 2020. The study focused on the indicators that policymakers had to look out for to anticipate a currency crisis before it occurs in South Africa. The findings revealed that the US interest rate, terms of trade, real interest rate, foreign reserves, real exchange rate deviations, interest rate spread, imports, exports, budget balance and current account balance were insignificant for anticipating currency crises in South Africa. Basically, these findings indicate that these variables may not be reliable indicators of currency crises in South Africa, this finding is not entirely unexpected.

The literature suggests that the relationship between macroeconomic indicators and currency crises is complex and influenced by various factors, including economic conditions, political stability, and global events. The insignificant results may indicate that traditional macroeconomic indicators, when in isolation, may not be sufficient to predict currency crises in South Africa, This finding is consistent with previous studies that have highlighted the limitations of using macroeconomics.

There are several authors who found similar results when doing a similar study for different countries, it is important to explore why such results may be the case. There are numerous factors that can contribute to the study's results being insignificant. For starters, the data frequency and data quality. If the two are not sufficient, there is a possibility that the complexities of currency crises are not captured. This study employed annual data instead of daily or monthly daily due to data unavailability for some of the variables. This may have contributed to the study not being fully capable to capture those crises episodes over the period investigated.

Moreover, there is a possibility that the probit model may have not been the most suitable for this analysis. There is also a chance that the model was mis specified, causing the output to be insignificant. The selected explanatory variables may have not been the most relevant or comprehensive indicators of currency crises in the context of South Africa.

Another very important factor that could have led to these insignificant results is South Africa's distinctive economic conditions that may also be a challenge in trying to establish significant relationships between the explanatory variables and currency crises.

Numerous learnings have been picked up from this study to ensure that significant results are achieved in the future. Some of these including choosing alternative models to the one that was chosen for this study. These include models such as machine learning algorithms or Tobit models. More variables could also be incorporated into the study such as political instability, credit ratings or capital flows to help provide insightful data for the context of South Africa.

Another very important learning is to use higher frequency data, such as weekly, monthly or even quarterly data to help accurately capture the dynamics of currency crises in South Africa. The use of the MTI in this paper was quite effective because the study was able to capture some episodes that have also been found my other authors to have been currency crises in South Africa. This shows that there could be other factors that influence currency crises in South Africa that could be omitted.

The degree of arbitrariness and degree of subjectivity in the crisis threshold used in the paper were one of its biggest limitations. The absence of sound theoretical justification has been a dominant in the literature, where justification has been based on the inductivist paradigm. This has affected proper construction of these thresholds amongst scholars.

Another notable limitation the potential endogeneity issue arising from forward-looking behaviour. The model assumes that agents and policymakers make decisions based on current and past information, but in reality, they may adjust their decisions based on expectations about future currency movements. This limitation highlights the need for further research to address this issue and improve robustness of the model.

The insignificant results also have important implications for policymakers in South Africa. Firstly, they suggest that policymakers should not solely rely on traditional macroeconomic indicators to predict currency crises. Instead, they should consider a more comprehensive approach that incorporates other factors, such as financial market indicators, political risk factors, and global economic trends. Secondly, the results imply that policymakers should focus on maintaining a stable and diversified economy, rather than relying on specific macroeconomic indicators to predict currency crises. This can be achieved through policies that promote economic growth, reduce inflation, and maintain a stable financial system. Finally, the results highlight the need for policymakers to be vigilant and proactive in monitoring the economy and responding to potential risks. This can be achieved through regular monitoring of economic indicators, scenario planning, and contingency planning.

Future researchers are encouraged to consider all the additional variables suggested and construct a potential quantitative proxy for a variable like political instability because that indicator on its own could give better findings. It is also important for future researchers to construct more theoretically justified and objective thresholds for the indication of currency crises and have thorough robust checks to ensure that their findings will be according to their expectations.

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Appendixes