THE RELATIONSHIP BETWEEN FOREIGN EXCHANGE RESERVES, PULA EXCHANGE RATE AND INFLATION IN BOTSWANA

BY: BOFELO OLORATO ISRAEL (ISRBOF001)

SUPERVISED BY: AKIOS MAJONI

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Plagiarism Declaration

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Student number	ISRBOF001
Student name	Bofelo Olorato Israel
Signature of Student	Signed by Candidate
Date:	22/02/2022

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Abstract

This study examines the relationship between foreign exchange reserve, Pula exchange rate and inflation in Botswana over the period 1995-2020. The period covered contains recent data on level of foreign exchange reserves through global events like Covid-19 pandemic in which significant drawdowns in foreign reserves were experienced and not covered in prior studies. Secondary time series data was sourced from Bank of Botswana financial statistics bulletin and a linear regression was run for two models using R studio statistical software. Unit root and correlation tests were run on the data to ensure the variables were stationery and error terms correlation was eliminated in the time series. Regression equation showed that the relationship between foreign exchange reserves and inflation was negative. Similarly, the second regression revealed that the correlation between foreign exchange reserves and foreign exchange rates was negative. Empirical results further revealed that foreign exchange reserves have no statistically significant impact on inflation and exchange rates in Botswana.

The statistically insignificant relationship results between the variables implies that foreign exchange reserves have not significantly influenced exchange rate and inflation which may be due to sterilization by the central bank, therefore, other factors may be responsible for changes in exchange rate and inflation locally. This may indicate that the monetary policy framework which requires foreign exchange reserves have served the country well as it maintained a stable exchange rate and did not stir inflation. However, monetary authorities should note that the current framework may not be sustainable given the tremendous pressure that foreign reserved faced in recent years and a move to a floating exchange regime should be considered as a long-term policy goal. The negative correlation of foreign reserves with inflation and exchange rate further suggest to the monetary authorities that Botswana's economy may be influenced by endogenous monetary policies rather than external variables. The relationship between exchange rates and foreign reserves is consistent with elasticity approach and economic theory of modern mercantilism which predict a negative relationship between the two variables. This may provide monetary authorities and policy makers with a framework that explains the link of Botswana's foreign reserves and exchange rates.

Table of Contents

List of Tables

List of Figures

Section 1: Introduction

1.1 Background of the study

Bank of Botswana defines foreign exchange reserves as assets under the custody of the central bank held in foreign currencies. Surpluses on the balance of payments, as well as growth in the value of existing foreign currency investments, are the main sources of reserves. Botswana must keep sufficient foreign exchange reserves in order to meet ongoing demand for foreign currency to pay for imports of goods and services, as well as other international payment commitments, such as debt servicing payments (Bank of Botswana Annual Report, 2008). Reserves play a critical role of improving currency intervention efficiency, aiding in management of sovereign financial crises as well as enhancing a state's ability to control national macroeconomics. Countries keep reserves to enable monetary authorities to intervene in markets in order to manage their exchange rates and control inflation. In the case of Botswana, faced with vulnerability to trade shocks, climate change and prolonged draughts foreign exchange reserves have been a factor in the past in absorbing the impact of shocks as the main financial buffer (Bank of Botswana Monetary Policy Report, 2020). In addition, adequate reserves are essential to support a managed exchange rate, such as the crawling peg of which is the basis for Botswana's exchange rate policy.

According to data from Bank of Botswana (BoB) the amount of foreign exchange reserves held by the central bank has declined significantly from a peak of 39 months of import cover in 2001 to a record low of 12 months of import cover as at July 2020 (Bank of Botswana Annual Report, 2020). The decrease in these buffers is a major cause of concern and may diminish the sovereign's ability to endure and manage future shocks. Declining foreign reserves could ultimately affect the capability to have a pegged exchange rate for the Pula (Motlaleng, 2009) .This will bear an impact on the sustainability of the underlying peg and the valuation of the Pula.

Globally the exchange rate is regarded as a fundamental tool to preserve stability in international payments underlying financial liberalization and economic growth. To maintain international competitiveness of domestic industries and macroeconomic stability exchange rate system ought to compliment monetary policy to ensure that inflation is managed effectively. The decline in

foreign reserves reflects the state of foreign trade activities as well as national capital flows. It is also the outcome of exchange rate interventions employed by monetary policy authorities.

According to Hoshikwa (2012) foreign reserves and currency rates have a long-term relationship. A study by Chaudhry et al. (2011) established that an increase in foreign exchange reserves led to a lower rate of inflation in Pakistan. This dissertation explores the relationship between Botswana's foreign exchange reserves, exchange rate and inflation to find out whether this link is similar or different to that which exists in other countries.

1.2 Problem statement

Several studies have been carried out to investigate the relationship between foreign exchange reserves, exchange rates and inflation. Research have shown that there is a link between foreign currency reserves and the exchange rate. However, contradicting results were reported as some studies concluded that a positive relationship existed (Abdullateef and Waheed, 2010; Jin, 2000; Elhiraika and Ndikumano, 2007) while others deduced that a negative link was present (Havarangisi, 2020; Hoshikawa, 2012; Emmanuel, 2013). Most authors (see Emmanuel, 2013) discovered that no significant relationship existed between foreign exchange reserves and inflation. Furthermore, the sample period of most previously conducted studies is prior global events like the Covid-19 pandemic and it is against this background that this study aims to explore the relationship between foreign exchange reserves, Pula exchange rate and inflation in Botswana using most recent data. Countries like Botswana tapped on their foreign reserves to fight or mitigate economic impacts of covid-19 pandemic so latest data used will contain information on the level of foreign exchange reserves under current economic circumstances. Botswana forms a suitable case study because it is a developing country which uses a multiple currency crawling peg exchange rate system and needs foreign exchange reserves to trade. A number of countries that were covered by prior studies mostly used a single currency fixed exchange rate regime (see Havarangsi, 2020; Emmanuel, 2013; Yu and Lili, 2011) while others had adopted a free-floating system (see Kayham, 2014; Hoshikawa, 2012).

1.3 Research questions

Using Botswana as a case study this research aims to empirically answer the following questions:

i) What is the relationship between foreign reserves and Pula – US Dollar exchange rate?

ii) What is the relationship between foreign reserves and inflation in Botswana?

1.4 Rationale of the study

Rationale of this study is to examine the nature of the relationship between foreign exchange reserves, exchange rate and inflation in Botswana's scenario of declining foreign reserves to understand how this may influence domestic economy and monetary policy. Furthermore, the research employs data from most recent sample period which will provide other researchers with most recent information available on the subject and discoveries made on the relationship while incorporating data that reflect current global economic events like the covid-19 pandemic. The findings will extend existing literature by providing empirical results on the relationship between variables in the context of a developing African country which is Botswana in this case. Botswana's economy is modest and open, with a strong reliance on mineral exports. Unlike many developing countries (which commonly encounter balance of payments crises), Botswana's policymakers have had little need to use the exchange rate solely for balance of payments purposes due to the country's historic outstanding foreign exchange reserves levels. To my knowledge no similar study has been carried out in Botswana before. Researchers and policy makers will find this study useful as it will have information on the link between variables of interest in a developing economy of Botswana.

1.5 Scope of Study

Data used in this study covers a period from 1995 to 2020. A time series secondary data on foreign exchange reserves, exchange rates and inflation were collected to carry out the study. The period covered is of interest because Botswana went through some structural reforms including abolishment of foreign exchange controls or restrictions, and adoption of a crawling band exchange rate arrangement. This brought some essential changes in the economy, dealings of foreign exchange and inflation objective.

1.6 Structure of the Study

The study has five sections as arranged below,

Section 1 encompasses introduction background of the Study, research questions of the study, rationale of study and scope of study.

Section 2 incorporates theoretical foundations and review of literature including empirical studies.

Section 3 covers data and methodology

Section 4 integrates data presentation and results analysis

Section 5 concludes the study

Section 2: Literature Review

This section provides a discussion of the relevant background that explores the relationship between foreign exchange reserves, inflation and foreign exchange rates. The review begins by explaining three theoretical frameworks linking foreign exchange reserves with exchange rates followed by empirical findings from previous studies. It then proceeds to discuss theoretical principles and empirical findings relating foreign exchange reserves and inflation. A conclusion of literature review ties this section at the end.

2.1 Foreign exchange reserves and exchange rates

Foreign exchange reserves are all foreign assets under the monetary authority's control that can be utilized at any time to pay the balance of payments, maintain monetary policy stability by intervening in foreign exchange markets, and for other purposes (Tambunan, 2001). One of the principles that link foreign exchange reserves and exchange rate is the economic theory of modern mercantilism. According to Lee and Yoon (2020), a country can keep international reserves as a part of a planned development strategy, i.e., an outward-oriented growth strategy, which supports growth by keeping a real exchange rate undervalued in order to keep a country's export competitiveness. In this strategy foreign exchange reserves are used to boost exports, create better jobs, and absorb excess labor in traditional industries like agriculture. The low valuation of the

local exchange rate supported by foreign exchange reserves will drive growth through improved exports competitiveness. The framework forecast a negative relationship where foreign reserves will be used to keep an exchange rate lower hence undervalued thus boosting exports which will lead to more foreign reserves accumulation.

The second theory explored is elasticity approach which relates foreign exchange reserves and exchange rates through balance of payments or a country's imports and exports policy actions. According to the elasticity approach, if the balance of payments is in equilibrium, devaluation of the currency will reduce the price of exports which is expected to stimulate demand of those elastic exports thus leading to foreign exchange reserves accumulation (Nzotta, 2004). This theory predicts a negative relationship where a decrease in exchange rate through devaluation results in accumulation or increase of foreign exchange reserves.

Lastly the monetary theoretical approach recognizes that there are different exchange rate regimes and a country can choose to adopt either a floating exchange rate or a fixed exchange rate regime. As stated by Caramazza and Aziz (1998), under a fixed exchange rate system, the domestic currency is pegged to one or a basket of currencies and the exchange rate is managed or regulated by a country's monetary authority. In a floating exchange rate regime, the market forces of demand and supply are predominant determinants of the currency's exchange rate relative to other currencies. The theory postulates that a change in demand and supply forces for currency lead to a fluctuation of the exchange rate in the foreign exchange market (Goschen, 2010). The supply of foreign exchange will increase as foreign exchange reserves accumulate. This will lead to a local currency appreciation due to an upward shift in supply curve while demand curve remains constant. However, if the monetary authority does not want the currency to appreciate, it will sell local currency and purchase foreign exchange. This will result in an increase of both demand and supply of foreign exchange while the exchange rate remains stable (Goschen, 2010). Excessive selling of local currency, on the other hand, would result in local inflation. When the costs of inflation surpass the benefits of maintaining an exchange rate, the monetary authority would stop intervening in the market. The exchange rate would therefore rise, leading to an increase in the value of the local currency. As a result, the massive increase of foreign exchange reserves will inevitably lead to a strengthening of the local currency. The theory therefore envisages a positive

association where accumulation of foreign exchange reserves leads to an increase in exchange rate or currency appreciation.

A central bank that opts for a fixed exchange rate regime may find itself in a situation where market forces of supply and demand causes currency's value to fluctuate hence to keep its fixed exchange rate, the central bank would have to utilize reserves (Goschen, 2010). In this scenario of presumed fixed exchange rates, foreign reserves ought to be sufficient to support foreign exchange rates. Fixed pegs were commonly utilized as a kind of monetary policy, as tying the home currency to the currency of a lower-inflation country should usually ensure price convergence. In a free-floating regime, the central bank does not engage in dynamics of exchange rate determination hence the exchange rate is set by market forces of demand and supply. Theoretically, reserves are not required in this circumstance and other monetary policy instruments like interest rates are employed in the context of inflation targeting policy or regime.

As discussed above, there is an intimate relationship between exchange rate, foreign reserves and monetary policy because adopting a fixed exchange system necessitates the deployment of foreign exchange operations to maintain a fixed exchange rate. Foreign exchange operations can be sterilized (their effect on the money supply is offset by other financial transactions) or unsterilized (their influence on the money supply is not negated by other financial transactions). Non-sterilization will result in an increase or decrease in the amount of local money in circulation, affecting inflation and monetary policy directly. For example, to keep the same exchange rate if demand increases, the central bank can issue more domestic currency and acquire foreign currency thus increasing the total amount of foreign reserves. Because the domestic money supply is expanding (money is being 'printed') if there is any kind of sterilization performed, this may result in domestic inflation as the currency depreciates.

2.1.1 Empirical studies on how foreign exchange reserves influence exchange rates

Studies carried out on foreign exchange reserves dates as far back as the 1960s. This field of research has been covered by a number of researchers who contributed to the foundation of studies on exchange reserves, amongst them Heller (1966) and Hamada and Ueda (1977). Following Bretton Woods system collapse, Frenkel (1983) established that exchange rate regime reformed to a floating exchange thus leading to a decline in the level of foreign exchange reserves.

Empirical studies on the relationship between foreign exchange reserves and exchange rates has yielded contradictory results. A negative relationship between foreign reserves and exchange rates was established by Havarangsi (2020), Hoshikawa (2012), Yu and Lili (2011) and Emmanuel (2013). Two of these studies (see Havarangsi, 2020; Yu and Lili, 2011) were conducted in China to find out the connection between China's foreign reserves and exchange rate. Havarangsi (2020) focused on the period from 2000 to 2018 and the data sets were evaluated by application of multiple linear regression analysis on SPSS 24.0 software to find out the causal relationship. On the other had Yu and Lili (2011) carried out their study following the 1994 exchange rate regime reform. The study was based on monthly data from 1994 to 2011 and analysis tests of ADF, Johansen and Granger causality were performed to draw conclusions. The study found out that foreign exchange reserves and foreign exchange rate have a long-term equilibrium relationship. Hoshikawa (2012) also carried out an investigation following Japanese exchange rate regime shift. The study looked at the long-term relationship between the yen/dollar exchange rate and international reserves. Results revealed a long-term negative relationship after applying ADF test, co-integration test, and dummy variables as analytical tools. The research by Emmanuel (2013) was conducted in Nigeria to find out effect of accumulation of external reserves on foreign exchange rates and inflation. Results from Minitab 14 for Windows which was used to run linear regression for the two models revealed that foreign exchange reserves had a negative relationship with exchange rate.

Contrarily other studies (see Abdullateef and Waheed 2010; Jin 2000; Elhiraika and Ndikumana, 2007) concluded that a positive relationship exist between foreign exchange reserves and exchange rates. All of these studies used liner regression to establish the effect of accumulated foreign exchange reserves rates on exchange rates. The study by Abdullateef and Waheed (2010) incorporated data from 1986 to 2006 investigate the effects of keeping external reserves on the exchange rate in Nigeria. Elhiraika and Ndikumana (2007) examined sources, motives, and impacts of reserves accumulation on the exchange rate in 21 African countries using data from 1979 to 2005. The study concluded that in both the short and long run, changes in international reserves have a significant impact on the nominal exchange rate. They found that an increase in reserves leads the nominal exchange rate to appreciate instantly, and the appreciation was permanent if the increase in reserves is permanent. Jin (2000) used data covering a period range

between 1981 and 1999 to establish the effect of China's foreign exchange reserves on exchange rates.

In other studies, a central bank's activity of transacting in foreign exchange market using foreign reserves was believed by Friedman (1986) to result in keeping the exchange rate stable. According to Griton and Roper (1977), the exchange rates volatility and exchange reserves variations are brought about by domestic currencies' excess supply (or demand) in the foreign market. An investigation on the long-run determinants of currency rates in Taiwan and the United States were carried out by Chiu (2008). The study discovered that foreign exchange reserves have a direct influence on the exchange rate i.e., foreign reserves aid in the long-term stabilization of the exchange rate. Aizenman, Chinn and Ito (2010) through their study in developing countries demonstrated that if a country's foreign reserves are more than a threshold level, greater exchange rate volatility can be minimized.

Some studies (see Ramana Raju and Gokhale, 2013; Kasman and Ayan, 2008) concluded that no relationship exist between foreign exchange reserves and exchange rate. Ramana-Raju and Gokhale (2013) explored a causal association between exchange rates and foreign exchange reserves in the India using a time series data set between 1980 and 2010. They found that India had amassed massive foreign exchange reserves while simultaneously facing a significant depreciation in its currency against the U.S dollar. This pattern motivated them to do research to see if there was any link between the two trending developments. In their data analysis, they used unit root test, Johansson co-integration test, and VAR. Similarly in Turkey, Kasman and Ayan (2008) applied unit root and co-integration tests. They further utilized the Granger causality test to examine the causation, and the outcomes revealed that unidirectional Granger causality exists between foreign exchange reserves and the real exchange rate in both the long and short run.

2.1.2 Empirical studies on how exchange rates affect foreign exchange reserves

There are few papers on the impact of exchange rates on exchange reserves, however numerous studies on the impact of foreign exchange reserves on foreign exchange rates have been carried out.

Studies conducted by Yasir et al. (2012), Narayan and Smyth (2006), Marjanovic and Markovic (2019) and Kayhan (2014) tested for causality between foreign exchange rates and foreign reserves. Empirical evidence from all of the above studies produced results that derived a positive relationship executed from foreign exchange rates to exchange reserves. Yasir et al. (2012) applied augmented Dicky–Fuller (ADF) and VEC approach on annual data sets from 1980 to 2010 to empirically evaluate the short run relationship between foreign exchange reserves and nominal exchange rates in Pakistan. Similarly, Kayhan (2014) tested for causality and integration using data from 2003 to 2014 to explore the asymmetric link between the nominal-real exchange rate and the Central Bank of Turkey's foreign exchange reserves. Findings showed that there is no relationship from foreign exchange reserves to nominal and real exchange rates in Turkey, but that there is a causal positive relationship executed from nominal and real exchange rates to foreign exchange reserves. On the other hand, Narayan and Smyth (2006) conducted research in China to examine the dynamic link between real exchange rate, real interest rates and foreign exchange reserves in the long and short-run. They conducted unit root tests and the bounds testing method to cointegration on monthly data from 1980 to 2002. They discovered that the real exchange rate displayed a positive and significant impact on foreign exchange reserves in the long run, but that there is no monotonic relationship between the real exchange rate and foreign exchange reserves in the short run.

The asymmetric link between the nominal-real exchange rate and the Central Bank of Turkey's foreign exchange reserves from 2003 to 2014 was investigated by Kayhan (2014). Nonlinear cointegration, causality, and frequency domain causality tests were performed on the data consisting of foreign reserves, nominal effective exchange rates and real effective exchange rates in the study. The findings revealed substantial evidence of nonlinear cointegration between the real exchange rate and the foreign exchange reserves held by the Central Bank. Both nonlinear cointegration tests and frequency domain causality analyses were applied. The results of the nonlinear Granger causality test indicated that nominal and real exchange rates have a correlation with foreign currency reserves.

Lastly Marjanovic and Markovic (2019) investigated the causality between exchange rate and foreign exchange reserves in Serbia. Using monthly data from September 2006 to April 2019 the research determined the link between the exchange rate (nominal and real) and foreign currency

reserves. Unit root and cointegration tests that account for existence of possible structural breaks were applied. The findings of the causality test showed that real exchange rate and foreign exchange reserves have a short-term positive causality, i.e., the real exchange rate Granger-causes foreign exchange reserves.

2.2 Foreign exchange reserves and Inflation

The theoretical relationship between foreign exchange reserves and inflation is explained by the quantity theory of money. Increases in foreign exchange reserves strengthen the monetary base, and the presence of a steady money multiplier directly increases the national money supply (Chaudhry, 2011). Subsequently, through supply changes, an increase in national money supply influences national inflation rates. Generally, an increase in monetary base by virtue of an increase in foreign reserves tends to raise the economy's aggregate demand and inflation.

Empirical studies regarding the relationship between foreign exchange reserves has yielded mixed results. Studies by Elhiraika and Ndikumana (2007), Abdullateef and Waheed (2010) and Emmanuel (2013) observed no significant relationship between the two variables. Two of these studies (see Abdullateef and Waheed, 2010; Emmanuel, 2013) were carried out in Nigeria during a period of foreign exchange reserves accumulation to find out the impact on inflation. Emmanuel (2013) used Minitab 14 for widows to run a linear regression on the data from 1986 to 2010. On the other hand, Abdullateef and Waheed (2010) incorporated data from 1986 to 2006 and used a combination of ordinary least squares (OLS) and vector error correction (VEC) techniques for analysis. A study by Elhiraika and Ndikumana (2007) focused 21 African countries. The data used covered the period from 1979 to 2005. The study applied cointegration, panel unit root tests techniques and estimated regression equations.

Contrarily some studies have established a negative relationship between foreign exchange reserves and inflation (Parmita and Budhi, 2020; Chaudhry, 2011). Chaudhry (2011) looked at effect of at the effect of Pakistan’s foreign exchange reserves on inflation using annual time series information from 1960 to 2007. The study employed ARDL model as well as OLS estimation. On the other hand, research conducted by Parmita and Budhi (2020) was carried out in Indonesia to investigate the connection between exchange rate, inflation, foreign investments and Indonesia’s foreign exchange reserves. The research used secondary data time series spanning from 1995 to

2018. The study employed path analysis as an analysis technique. The findings revealed that if inflation falls, Indonesia's foreign exchange reserves will rise due to domestic goods being more competitive, hence increasing exports.

In other studies Heller (1976) results contradicted the negative relationship after employing the least squares regression technique to examine international reserves and global inflation using data between 1958 and 1974. The study reported that global reserves influenced worldwide inflation positively when multiple currencies were connected by fixed exchange rates. This was due to the direct relationship between different national money supplies and national inflation rates. Heller (1976) concluded that global reserves had a major impact on global money supply and that there was a similar positive relationship between foreign exchange reserves and national inflation rate. Similarly, according to Steiner and Qian (2017), foreign exchange reserves accumulation may be inflationary hence a positive relationship since it increases the monetary base if it is not sterilized. However, Khan (1979) contends that these associations could be the result of reverse causation, in which reserves react to inflation. According to Kruskovic and Maricic (2015) foreign exchange reserves are not inflationary if the rate of accumulation does not surpass the rate of economic growth. The authors also concluded that a higher inflation can be bad for developing and emerging countries, prompting monetary authorities to keep more reserves.

2.3 Conclusion of literature review

According to recent research, academics reported contradicting results on the link between foreign currency reserves and foreign exchange rate as some concluded that there is a positive relationship while other results revealed a negative relationship. However, no significant relationship was discovered between foreign reserves and inflation by most researchers in the literature review. Furthermore, many scholars carried out their studies during a period when a country of interest was accumulating foreign exchange reserves as evident on studies carried out by Yu and Lili (2011), Elhiraika and Ndikumana (2007) and Emmanuel (2013) amongst others hence the desire to find out the impact on economic variables like exchange rate and inflation in an inverse case of Botswana. Another finding from the literature research is that there aren't many studies that focused on Africa, Botswana in particular. Therefore, this study is unique in that it analyzes and investigates the dynamic impact of foreign exchange reserves using a comprehensive analytical

tool focusing on a developing African economy that has accumulated impressive levels of reserves from diamonds sales in the past. The research also investigates the relationship between variables in a different scenario of declining reserves and employs the most recent data to reflect the current underlying economic conditions in Botswana.

Section 3: Data and Methodology

This section discusses the research strategy utilized to answer the research questions provided in Section 1, as well as the variables and data used in the study. The methodology is also discussed with related analysis.

3.1 Data

This study analyzes the relationship between foreign exchange reserves, foreign exchange rates and inflation rate in Botswana using the annual time series statistics from 1995 to 2020.The years covered are of interest since Botswana underwent fundamental reforms during this time period, including the elimination of foreign exchange controls or limitations and the implementation of a crawling band exchange rate regime. All of the data was sourced from Central Bank of Botswana Financial Statistics bulletin in particular, different issues of Botswana Financial Statistics and the Bank of Botswana Annual Report.

3.1.1 Variables

3.1.1.1 Dependent variable

The key variables are classified into dependent variable which is foreign exchange reserves whereas independent variables consist of foreign exchange rates and inflation respectively. Natural logarithms of the variables are utilized in the empirical analysis, based on existing research to ensure that they can be immediately interpreted as proportional differences approximates. As a result, this lowers the skewness and kurtosis of the variable's distribution hence the regression's normal distribution assumption is strengthened. Furthermore, such could increase the model's goodness-of-fit through better R Square and lower standard error.

Foreign exchange reserves are distinct assets that are under the custody of national monetary authorities for balance of payments and can be changed into other foreign currencies when

required. According to (Balance of Payments and International Investment Position Manual, 2009) International Monetary Fund (IMF) foreign exchange reserves are foreign assets that are readily available and administered by monetary authorities for the purpose of directly financing payments imbalances, indirectly managing the magnitude of such imbalances by intervening in exchange markets to influence the currency exchange rate, and/or for other objectives. In their most pure form, foreign exchange reserves are made up of cash, deposits in foreign currencies as well as securities. Sovereigns however, have taken a decision to add other assets like International Monetary Fund Reserve Positions and Special Drawing Rights (SDRs) as part of their foreign reserves of which this study adopt as a wider definition of reserves like it was applied in the study by Emmanuel (2013). Similarly in Botswana foreign exchange reserves are measured as money market and fixed income assets that include cash, fixed deposits and securities in foreign currencies held by the central bank. The level of foreign reserves is reported on a regular basis in both domestic and foreign currency terms (USD and SDR) in the bank's annual and monthly financial statement reports. In prior studies foreign exchange reserves were accounted as assets under the custody of a reserve bank which included cash, deposits and bonds reported on reserve bank's financial report. Foreign reserves values were expressed in both respective local currencies and foreign currency which was mostly the U.S Dollar. Although reserves are made up of different currencies, the U.S dollar mostly constituent the significant portion of the international reserves. In this study foreign exchange reserves are measured in millions of Pulas.

3.1.1.2 Independent variables

An indicator of inflation used is headline Consumer Price Index (CPI) which was also adopted in previous studies by Elhiraika and Ndikumana (2007) and Emmanuel (2013). It is measured as a weighted average of prices of a basket of goods and services in Botswana. Foreign exchange reserves form a part of money supply hence may lead to a reduction in inflation when level of foreign reserves drops.

The exchange rate between US Dollar and Pula is also employed in the analysis. Since Botswana is a small open economy, the nominal effective exchange rate (NEER) is incorporated to reflect the external environment as used in past studies of Marjanovic and Markovic (2019) as well as Kayhan (2014). The nominal effective exchange rate of Botswana currency is determined by a

weighted average of five distinct currencies being the South African Rand, the United States Dollar, the United Kingdom Pound, the Japanese Yen, and the Euro. Foreign exchange rates are published daily in the central bank of Botswana's website and captured in the bank's monthly financial statistics report.

3.2 Statistical tests

3.2.1 Unit root

In a regression model, most time series data is non-stationary. The result of regression analysis without the use of a stationary test is a spurious regression. When non-stationary data is used, spurious regression can result in seemingly substantial connections between unrelated variables (Gklezakou, 2010). As a result, many researchers check if time series are stationary before performing regression analysis. Kasman and Ayhan (2008), for example, utilized it to evaluate Turkey's foreign exchange reserves and exchange rates; Narayan (2006) used unit root test to avert structural breaks; and the study on exchange rate shift by Hoshikwa (2012). The Augmented Dickey– Fuller test (ADF) is now commonly used to determine if a time series is stationary (Yu, 2011). The ADF test is based on the Dickey-Fuller (DF) test, which was created by (Dickey, 1979). The basic purpose of the DF test is to see if there is a unit root in an autoregressive model. This autoregressive model is non-stationary if the unit root is present. The normal autoregressive model is given below, based on Dickey and Fullers' theory (Green, 2007).

$$Yt = \lambda Yt{-}1 + \epsilon t \qquad (1)$$

According to the model, λ symbolize the coefficient, ϵt is the error term ($\epsilon t \sim N[0, \sigma 2]$ and $\mathrm{Cov}[\epsilon t , \epsilon s] = 0 \ \forall \ t \neq s$). If λ = 1, the autoregressive model has a unit root, indicating that it is non-stationary. The autoregressive model is stationary if |λ| < 1. This model was also expressed as shown below in order to make calculations easier,

$$\Delta Yt = (\lambda - 1)\, Yt{-}1 + \epsilon t = \delta Yt{-}1 + \epsilon t \qquad (2)$$

In the equation above Δ represent first difference operator and $\delta = \lambda - 1$. As a result, if δ=0, it indicates that the autoregressive model has a unit root and is non-stationary. We only need to test hypothesis H_0: $\delta = 0$ and H_1: $\delta < 0$ in other words.

The DF test uses a first-order autoregressive model, however, in reality the time series would come from a higher-order autoregressive model. As a result, the ADF test, an enhanced variant of the DF test, was created. The ADF test has the same testing technique as the DF test, however it is larger and more sophisticated. The standard ADF model provided by Green (2007) is as follows,

$$\Delta yt = \alpha + \beta t + \gamma y_{t-1} + \delta 1 \Delta y_{t-1} + \cdots \delta_{p-1} \Delta y_{t-p+1} + \varepsilon t \qquad (3)$$

ADF allows for higher order autoregressive processes because it accommodates lags of the order p. The model hypothesis that H_0: $\lambda = 0$ and H_1: $\lambda < 0$. If H_0 is rejected, the variables are said to be stationary. In fact, there is a simple way to do the ADF test. There are statistical packages like R software and EViews which can be used to compute the ADF statistic value of a variable. Then compare this value to the critical value; if the ADF statistic value is less than the critical value, we can say the variable is stationary; if the ADF statistic value is greater than the critical value, we can say the variable is non-stationary. In general, first order differences of variables are taken when the variables are non-stationary or variables can be detrended hence simply eliminating the time series' trend component. After that, the ADF test is repeated to check if the variables are stationary after the first order difference. Finally, a regression analysis can be computed when the data is found to be stationary. In this study all-time series data used was checked for stationarity.

3.2.2 Serial Correlation Test

Since time series data will be employed, the error terms are checked for serial correlation, as the presence of serial correlation may cause the results to be misinterpreted (Gujarati, 2003). Serial correlation is a phenomenon that explains the correlation of error terms in a time series model (Gujarati, 2003). The Lagrange Multiplier Test (LM) and the Durbin-Watson test have been claimed to be the most often utilized tests for serial correlation (Mokoti, 2009). The LM test is favored over the Durbin-Watson test when testing for serial correlation in a model containing lagged variables because the Durbin-Watson test ignores the relationship between the regressors and the lagged disturbances (Mokoti, 2009).

3.3 Multiple Linear Regression analysis methodology

The regression analysis was found to be a valuable quantitative tool for determining the relationship between the dependent and independent variables (Warner, 2013). It emerged not only as a useful instrument for outlining interdependency but it also came in handy to define it in numerical values (Mayers, 2013). An alternative quantitative technique, the correlational research design, was not appropriate. It ignored the changes between independent and dependent variables so it would only be relevant to analyze the interdependence between variables in general (Mayers, 2013). In a correlational design, the researcher would assume a two-sided similarity between specific variables to simplify things. As a result, regression analysis was the quantitative instrument of choice.

To determine the relationship of foreign exchange reserves on exchange rate and inflation the following two econometric models were developed,

$$FER = \alpha_0 + \alpha_1 FER_{t-1} + \alpha_3 EXR + M_i \quad (4)$$

$$FER = \beta_0 + \beta_1 FER_{t-1} + \beta_3 CPI + e_i \quad (5)$$

Here FER denotes foreign exchange reserves at a particular period of time, FER_{t-1} signifies level of foreign exchange at the previous year or at a period t minus one. EXR symbolize exchange rate while CPI represent inflation measured by consumer price index. Regression coefficients for model 4 are given by $\alpha_0 + \alpha_1 + \alpha_3$ while $\beta_0 + \beta_1 + \beta_3$ represent regression coefficients for model 5, applying a normal distribution at a mean of zero with a standard deviation of one. M and e are error terms for normal distribution with mean = 0 and standard deviation = S; I is the ith observation since data is time serial. R studio software is used to run a linear regression for the models with variables in their natural logarithm form.

Section 4: Research findings, analysis and discussion

The outcomes of the data analysis from econometric models defined in the methodology are provided and discussed in this section. The section begins with analysis of descriptive statistics. Followed by a review of the unit root results before moving on to serial correlation tests and results discussion.

4.1 Descriptive Statistics

A summary of the descriptive statistics for foreign exchange reserves, inflation and exchange rates are provided in Table 1 below.

Table 1: Descriptive Statistics

Statistic	N	Mean	St. Dev.	Min	Pctl (25)	Median	Pctl (75)	Max
FX	26	48.9	21.5	13.3	29.1	52.1	67.1	84.9
CPI	26	6.981	2.863	2.00	4.775	7.30	8.575	12.60
EX	26	0.165	0.067	0.089	0.108	0.153	0.209	0.354

Note: FX = Foreign exchange reserves, CPI = Inflation, EX = Foreign exchange rate

A look at the descriptive data reveals that foreign exchange reserves had an average of about 48.9 billion Pula which is not far off the median of 52.1 billion. For the entire period the minimum level of reserves was about 13.3 billion Pula with the highest ever recorded reserves standing at around 84.9 billion Pula. The standard deviation of 21.5 which is considerably moderate indicate that the sample exhibit some variation in the volume of foreign reserves recorded across the years.

Regarding inflation, the sample exhibited an average of 6.98 percent, with a minimum and maximum values of 2 percent and 12.6 percent respectively. A standard deviation of about 2.9 shows that there was some variation in inflation from the data observed during the sample period.

Descriptive statistics of foreign exchange rates displays a minimum and maximum values of 1BWP / USD0.089 and 1BWP / USD0.354 respectively with a mean of 1BWP / USD0.165. lower standard deviation of 0.067 illustrate that fluctuations in the exchange rate was quite low and stable during the period. This is not surprising given that Botswana uses a crawling peg exchange rate system which aims to maintain a stable exchange rate with minimal fluctuations or variations.

4.2 Diagnostics

4.2.1. Confirming the time trend with regression

A preliminary graphical study of the time series data that would be used in the model revealed that all of the variables have a noticeable trend. All of the variables were regressed against time, and the presence of a time trend in all of the variables was determined through an examination of the Adjusted R-squared. The adjusted R squared for foreign exchange reserves, inflation, and exchange rates regressions against time were very high at 0.86, 0.33, and 0.79, respectively. These findings revealed that there is a time trend, necessitating the detrending of the variables. It's worth noting, though, that detrending only removes a time trend, not non-stationarity. The findings can be found in the appendix A.

Chart for each variable is provided prior to the logarithm conversion process. We can determine whether each variable has a trend before conducting empirical analysis; the results are as follows:

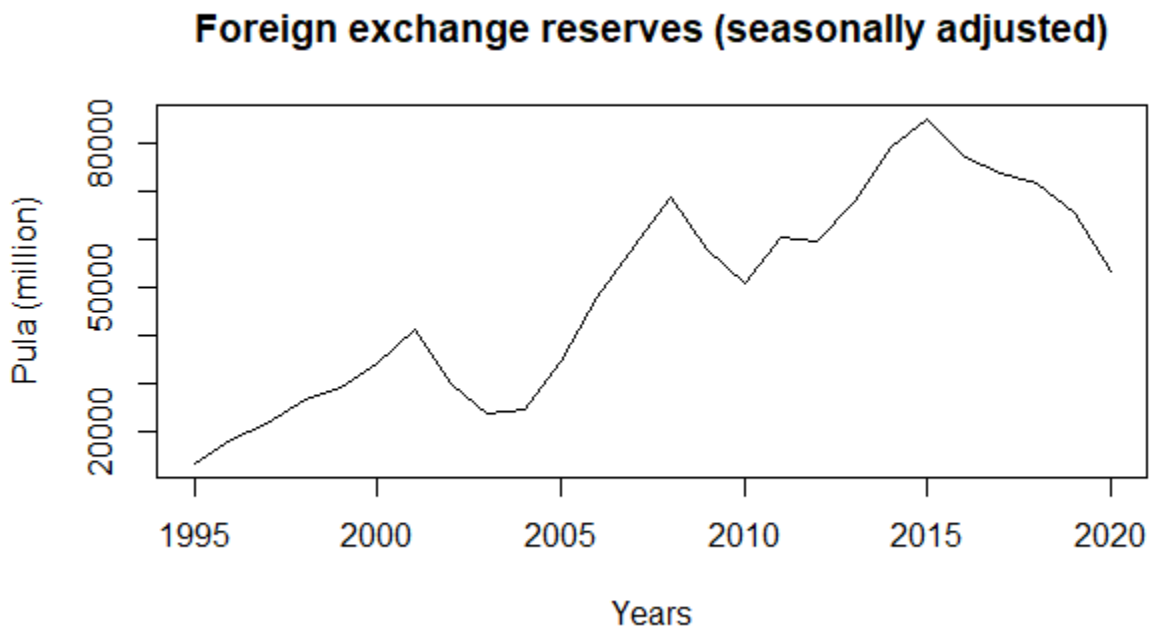

Figure 1: Foreign exchange reserves

Figure 1 above illustrates that the foreign exchange reserves are non-stationary at levels and has a distinct upward time trend, indicating the need for some data transformation.

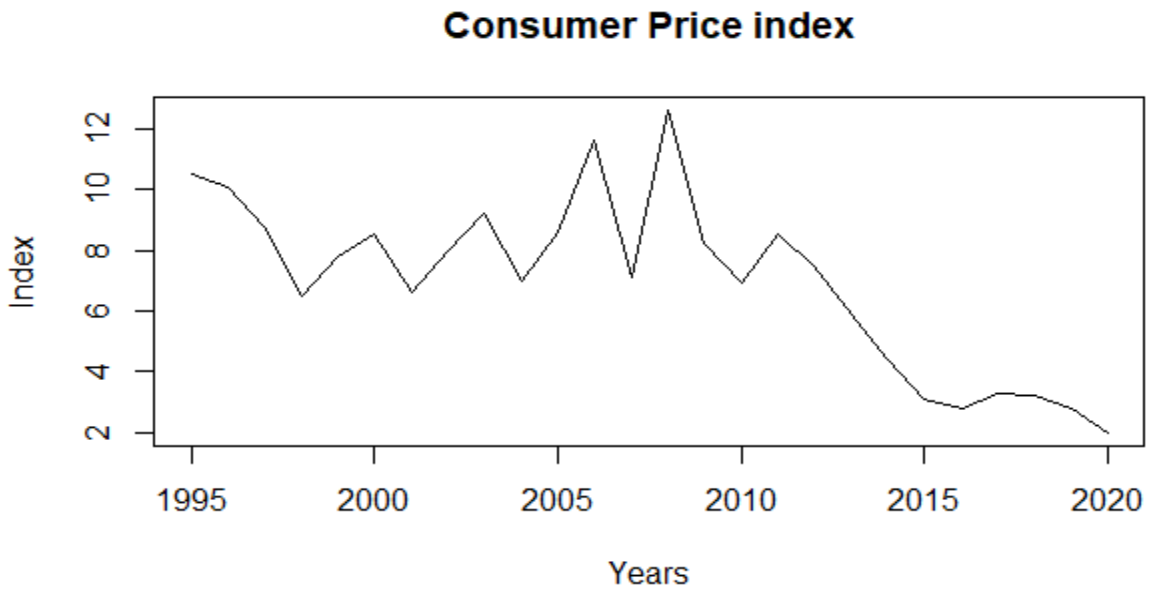

Figure 2: Consumer Price Index

Figure 2 above shows that consumer price index is non-stationary at various levels, indicating a downward time trend and the need for detrending.

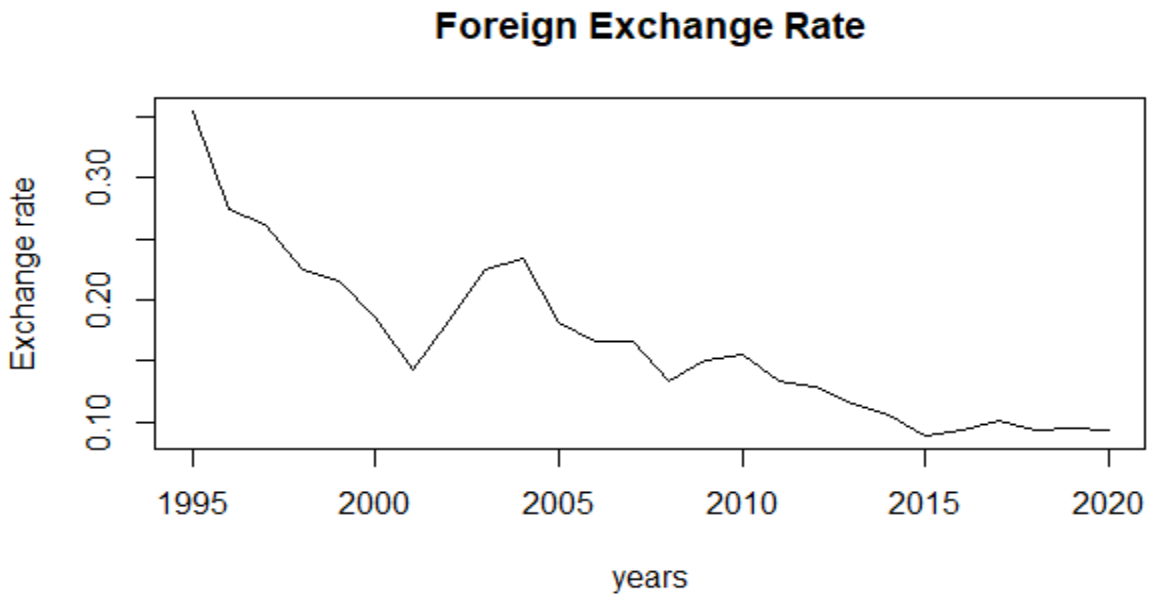

Figure 3: Foreign exchange rate

Figure 3 above clearly demonstrates that exchange rate is non-stationary at levels, showing that there is a downward time trend hence detrending is required.

4.2.2. Unit root test

The unit root is checked on all of the variables in the model. A non-stationary time series might lead to misleading regression, according to Gujarati (2003). Non-related variables will appear to be moving together as a result of the time trend, making them appear to be related. As a result, employing stationery data will yield more consistent results. To test for stationarity, the Augmented Dickey- Fuller (ADF) test will be utilized.

The ADF test results are shown in the table below for all variables before and after data transformations. Considering the trend behavior, Wang et al. (2005) propose that variables indicating a trend should be tested for stationarity. However, because our variables have been detrended prior to the ADF test, there is no need to account for trend behavior. The power of the stationery test is influenced by trend behavior, causing stationery variables to appear non-stationary.

Table 2: ADF test results

Variable	ADF statistics	P-value	Decision
	Variables at levels		
FER	-2.1458	0.5168	Non-Stationery
EXR	-4.2731	0.01373	Non-Stationery
CPI	-0.98535	0.9227	Non-Stationery
	Variables in first difference		
Log(D(FER))	-4.9533	0.01	Stationery
D(Log(EXR))	-4.6615	0.01	Stationery
Log(D(CPI))	-2.0123	0.00	Stationery

Source: Own computations

The first section of the table 2 present results of the ADF test of the variables examined at levels. It shows the ADF statistic as well as the t-statistic obtained from R-studio. The p-values are high, hence the null hypothesis that "variable has unit root" is not rejected. The findings show that all variables are non-stationary at different levels, indicating a need for data transformations. All the variables are first differenced before obtaining the log of each except for the NEER. The initial

step in the NEER is logging, which is followed by differencing. This is because the time series will have negative values at initial difference, resulting in missing values when logged.

The next step is to re-test the variables after taking their first difference. The results of the ADF test after the first difference and the logging of the variables of interest are shown in the second half of table 2. For all of the variables, the p-values are significant at a 5 percent level of significance, where a lag of four is employed, for all the variables. The null hypothesis is rejected, and we conclude that at first difference, all of the variables are stationary. The use of these transformed variables in our models will ensure that the number of false correlations are minimized.

4.3. Serial Correlation test

Models employed in this study were tested for serial correlation. This was to ensure that the error terms of the time series model were not correlated, hence no misinterpretation of results. Lagrange Multiplier test (LM) was used to test both models for serial correlation and results are contained in appendix A. In both models p-values were not statistically significant implying failure to reject the Null hypothesis of 'no serial correlation' thus no correlation was detected on the error terms. The outcome was not surprising given that the foreign exchange reserve was first differenced.

4.4. Results

4.4.1 Relationship between Foreign Exchange Reserves and Exchange Rate

Table 3: Model 1 results

	Dependentvariable:
	log_fx_diff
log_fx_diff_1	0.333
	(0.257)
diff_log_ex	-0.08
	(0.230)
Constant	0.036
	(0.042)
Observations	21
R2	0.151
Adjusted R2	0.057
Residual Std. Error	0.173 (df = 18)
F Statistic	1.606 (df = 2; 18)
Note:	*p<0.1; **p<0.05; ***p<0.01

The model's specification results are shown in the table above. The regression equation reveals that foreign exchange reserves and exchange rate in Botswana have a negative relationship, however, results shows that the relationship is not statistically significant. This contradicts the monetary theorical approach that predict a positive relationship between the two variables supported by empirical results from studies carried out by Abdullateef and Waheed (2010), Jin (2000) and Elhiraika and Ndikumana (2007). A reason for lack of significance maybe alluded to sterilization where money supply from foreign reserves is offset by other financial transaction performed by the central bank to maintain a fixed exchange rate (Goschen, 2010). The negative relationship nonetheless is consistent with elasticity approach and economic theory of modern mercantilism which is supported by findings of investigations carried out by Havarangsi (2020), Hoshikawa (2012), Yu and Lili (2011) and Emmanuel (2013). The adjusted R squared value is roughly 5.7 percent, implying that only 5.7 percent of the data fits the regression model.

4.4.2 Relationship between Foreign Exchange Reserves and Inflation

Table 4: Model 2 results

	Dependent variable:
	log_fx_diff
log_fx_diff_1	0.388*
	(0.217)
diff_log_cpi	-0.061
	(0.138)
Constant	0.028
	(0.041)
Observations	21
R2	0.151
Adjusted R2	0.061
Residual Std. Error	0.173 (df = 18)
F Statistic	1.651 (df = 2; 18)
Note:	*p<0.1; **p<0.05; ***p<0.01

Results of the regression above shows that inflation rate is negatively related to foreign exchange reserves. These findings accord with studies by Parmita and Budhi (2020) and Chaudhry (2011) who established that foreign exchange reserves have a negative connection with inflation. Furthermore, empirical evidence has shown that the relationship is not statistically significant. This indicate that foreign reserves do not significantly impact aggregate inflation in Botswana. The outcome is in agreement with Elhiraika and Ndikumana (2007), Abdullateef and Waheed (2010) and Emmanuel (2013) whose studies found out that foreign exchange reserves had no statistically

significant impact on inflation. However, this discovery is inconsistent with quantity theory of money which predict a positive link where an increase in foreign exchange reserves strengthen the national monetary base (money supply) hence exerting a rise in inflation. The coefficient of determination (adjusted R squared) yielded a result of 6.1 percent. The low adjusted R-squared indicates that the independent variables do not explain much of the variation in foreign exchange reserves, only about 6.1 percent. At a 10 percent level of significance, the foreign exchange reserves lag is statistically significant, whereas the percentage change in inflation is not statistically significant.

Section 5 Conclusion and Recommendations

Inspired by decreasing foreign reserves this study analyzed the interaction between foreign exchange reserves, inflation and foreign exchange rates in Botswana covering a sample period from 1995 to 2020 using a linear regression model. The purpose of this research was to find out the relationship of foreign exchange reserves with Pula – US Dollar exchange rate and inflation in Botswana respectively. The results of the linear regression showed that foreign exchange reserves have a statistically weak effect on both foreign exchange rate and inflation. Empirical evidence further revealed that foreign exchange reserves have a negative relationship with foreign exchange rates and inflation respectively.

The insignificant relationship results between the variables implies that foreign exchange reserves have not significantly influenced exchange rate and inflation which may be due to sterilization by the central bank, therefore, other factors may be responsible for changes in exchange rate and inflation locally. This may suggest that the monetary policy framework which requires foreign exchange reserves have served the country well as it helped to maintain a stable exchange rate and did not exacerbate inflation. Foreign reserves are vital and critical for central banks that want to archive low and stable inflation with a moderately strong exchange rate. However, foreign reserves have come under tremendous pressure in recent years in Botswana hence monetary authorities should note that the current framework may not be sustainable if the trend continues and should consider a move to a freely floating exchange rate system as a long-term policy goal. The negative correlation of foreign reserves with inflation and exchange rate further suggest to the monetary authorities that Botswana's economy may be influenced by endogenous monetary policies rather

than external variables. This means that there may be other factors which have a positive association with Botswana's exchange rate and inflation domestically because foreign reserves are proved to be inversely related to the two variables.

The relationship between exchange rates and foreign reserves is consistent with both elasticity approach and economic theory of modern mercantilism which predict a negative relationship between the two variables. This may provide monetary authorities and policy makers with a framework that explains the link of Botswana's foreign reserves and exchange rates. This is because foreign exchange reserves are used as an instrument of both monetary policy and balance of payments by monetary authorities. Lastly, knowledge of this relationship maybe useful to investors, consumers and business owners. For the reason that exchange rates provide a basis for pricing any commodity so these stakeholders may use this knowledge as a tool to make informed economic decisions on how level of foreign reserves affect exchange rates which is ultimately a price of imported and exported goods and services.

5.3 Recommendations for areas of further research

This study only analyzed the relationship between foreign exchange reserve, inflation and exchange rate over the period of 1995-2020. Upcoming research could therefore advance this study as follows:

Utilizing reserve adequacy measures as a dependent variable to examine how reserves can be managed to maximize macroeconomic stability benefits.

Incorporate more variables and increase the investigation period to include pre- 1995 and post-2020 samples to determine the historic impacts of Botswana's shifting financial economic policy regimes.

Examine factors used to assess macroeconomic stability to observe if they are determinants of foreign exchange reserve decline in Botswana, and if they can lead to excessive decline rather than reserve adequacy management.

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APPENDIX A: Serial Correlation results

```
# Let's test for serial correlation

model1_sc <- lm(model1$residuals ~ dplyr::lag(model1$residuals,1))

stargazer(model1_sc, type = "text")

model1_sc_summary <- summary(model1_sc)

#if its not significant then there is no serial correlation

model2 <- lm(log_fx_diff ~ log_fx_diff_1 + log_cpi_diff, data = data_sample)

stargazer(model2, type = "text", median = T, title = "Table 9:  Model2", out = "DL(2) Model.html")

# Let's test for serial correlation

model2_sc <- lm(model2$residuals ~ dplyr::lag(model2$residuals,1))

stargazer(model2_sc, type = "text")

model2_sc_summary <- summary(model2_sc)

#if its not significant then there is so serial correlation
```

```
data:  cpi_sample$log_cpi_diff

Dickey-Fuller = -1.9768, Lag order = 4, p-value = 0.5812

alternative hypothesis: stationary
```

```
> #creation of lags

> data_sample$log_fx_diff_1 <- dplyr::lag(data_sample$log_fx_diff,1)

> data_sample$log_fx_diff_2 <- dplyr::lag(data_sample$log_fx_diff,2)
```

> data_sample <- data_sample[-2,]

> data_sample <- data_sample[-1,]

> data_sample$diff_log_ex_1 <- dplyr::lag(ex_sample$diff_log_ex,1)

> data_sample$diff_log_ex_2 <- dplyr::lag(ex_sample$diff_log_ex,2)

> data_sample$diff_log_ex <- (ex_sample$diff_log_ex)

> cpi_sample <- cpi_sample[-1,]

> data_sample$log_cpi_diff_1 <- dplyr::lag(cpi_sample$log_cpi_diff,1)

> data_sample$log_cpi_diff_2 <- dplyr::lag(cpi_sample$log_cpi_diff,2)

> data_sample$log_cpi_diff <- (cpi_sample$log_cpi_diff)

> #Models

> model1 <- lm(log_fx_diff ~ log_fx_diff_1 + diff_log_ex, data = data_sample)

> stargazer(model1, type = "text", median = T, title = "Table 8: Model1", out = "DL(1) Model.html")

Table 8: Model1

==

Dependent variable:

---

log_fx_diff

--

log_fx_diff_1 0.333

(0.257)

diff_log_ex -0.080

(0.230)

Constant 0.036

(0.042)

Observations 21

R2 0.151

Adjusted R2 0.057

Residual Std. Error 0.173 (df = 18)

F Statistic 1.606 (df = 2; 18)

==========

Note: *p<0.1; **p<0.05; ***p<0.01

```
> model1_sc <- lm(model1$residuals ~ dplyr::lag(model1$residuals,1))
> stargazer(model1_sc, type = "text")
```

==========

Dependent variable:

---

residuals

---

residuals, 1) 0.102

(0.231)

Constant -0.007

(0.038)

Observations 20

R2 0.011

Adjusted R2 -0.044

Residual Std. Error 0.169 (df = 18)

F Statistic 0.196 (df = 1; 18)

==========

Note: *p<0.1; **p<0.05; ***p<0.01

> model1_sc <- lm(model1$residuals ~ dplyr::lag(model1$residuals,1))

> stargazer(model1_sc, type = "text")

==========

Dependent variable:

---

residuals

---

residuals, 1) 0.102

(0.231)

Constant -0.007

(0.038)

Observations 20

R2 0.011

Adjusted R2 -0.044

Residual Std. Error 0.169 (df = 18)

F Statistic 0.196 (df = 1; 18)

==========

Note: *p<0.1; **p<0.05; ***p<0.01

> model1_sc_summary <- summary(model1_sc)

> model2 <- lm(log_fx_diff ~ log_fx_diff_1 + log_cpi_diff, data = data_sample)

> stargazer(model2, type = "text", median = T, title = "Table 9: Model2", out = "DL(2) Model.html")

Table 9: Model2

==========

Dependent variable:

---

log_fx_diff

---

log_fx_diff_1 0.388*

(0.217)

log_cpi_diff -0.061

(0.138)

Constant 0.028

(0.041)

Observations 21

R2 0.155

Adjusted R2 0.061

Residual Std. Error 0.173 (df = 18)

F Statistic 1.651 (df = 2; 18)

==========

Note: *p<0.1; **p<0.05; ***p<0.01

> model2_sc <- lm(model2$residuals ~ dplyr::lag(model2$residuals,1))

> stargazer(model2_sc, type = "text")

==

Dependent variable:

----

residuals

--

residuals, 1) 0.153

(0.231)

Constant -0.005

(0.038)

--

Observations 20

R2 0.024

Adjusted R2 -0.031

Residual Std. Error 0.169 (df = 18)

F Statistic 0.438 (df = 1; 18)

==

Note: *p<0.1; **p<0.05; ***p<0.01

> model2_sc_summary <- summary(model2_sc)

> #if its not significant then there is so serial correlation

> #if its not significant then there is so serial correlation