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Introducing the Foreign Exchange Reserve Demand – Inflation Buffer Hypothesis

Abstract: This paper examines the role of foreign exchange reserve demand in mitigating inflationary pressures resulting from money supply growth in reserve currency issuing states (RCISs). Despite recurrent substantial monetary expansions in RCISs in response to recessions such as the 2000 Post-Dot Com Bubble, the 2008 Great Recession, and the 2020 Covid-19 pandemic-induced recession, RCISs have not experienced commensurate inflation. Within the framework of the Quantity Theory of Money (QTM), factors such as economic slowdown and reduction in the velocity of money may contribute to dampening inflationary pressure that stems from money supply growth; however, GDP slowdowns have not explained the disproportionally low inflation in RCISs compared to their monetary expansions, and the impact of reduction in the velocity on lowering inflation remains unclear due to limited real-world data. In contrast, there is reliable data for foreign exchange reserve demand, characterized by currency exports in exchange for real economic resources of equivalent value. By analyzing the relationship between money supply growth, foreign exchange reserve demand, and inflation within the framework of QTM, this paper introduces the foreign exchange reserve demand-inflation buffer hypothesis. The theoretical and empirical investigation sheds light on the role of foreign exchange reserve demand in moderating inflationary pressures in RCISs.

Keywords: Monetary Policy, Inflation, Reserve Currency, Central Banking.

JEL Classification: E31, E51, F31.

1. Introduction

Reserve currency-issuing states (RCISs) have significantly expanded their money supply since 2008 without a proportionate increase in inflation. This notable surge in money supply has been particularly evident following the 2008 global financial crisis, which sparked the Great Recession, and more recently, since 2020 amid the economic downturn induced by the Covid-19 pandemic. Several factors may contribute to this phenomenon, including a reduction in the velocity of money due to the slowdown in economic activity. However, it is important to note that real-world data on money velocity is non-existent. Therefore, its exclusive role in curbing inflation resulting from excessive money supply growth cannot be definitively established. The available data on money velocity is primarily a residual derived from the Quantity Theory of Money. Nevertheless, there is evidence to suggest that foreign exchange reserve demand, for which reliable data exists, may play a significant role in mitigating inflation stemming from the excessive expansion of the money supply. Meeting the demand for reserve currencies from entities outside RCISs effectively amounts to exporting currency. This process entails withdrawing a portion of the local money supply from circulation in exchange for tangible economic resources. According to the Quantity Theory of Money (QTM) represented by the balance MV=PY, where M is the money supply, V is the velocity of money, P is the price level, and Y is the economic output, this action of currency export withdraws portions of the money supply in exchange of economic resources. This transaction exerts downward pressure on price levels and, consequently, on the inflation rate. This mechanism underscores the significance of foreign exchange reserve transactions between RCISs and the rest of the world. This paper introduces *the foreign exchange reserve demand-inflation buffer hypothesis*. Specifically, the study undertakes a theoretical and empirical exploration of the role played by foreign exchange reserve demand from abroad in alleviating inflationary pressures resulting from the expansion of money supply within RCISs.

The rest of the paper follows a structured outline. Section 2 involves a literature survey that offers a thorough review of the relevant academic works to establish a solid foundation for subsequent analyses. Moving on to Section 3, the Foreign Exchange Reserve Demand Inflation Buffer Hypothesis is presented, outlining its theoretical framework and relevance in the broader economic context. Section 4 provides the empirical examination of the hypothesis, detailing empirical methods and findings. The paper concludes in Section 5, where the contribution of the paper is summarized by reiterating key insights from the hypothesis presentation, and empirical examination.

2. Literature Survey

The analysis of the economic benefits of reserve currency to its issuing state has been regularly visited in the literature. Wang and Pauly (2013), Eichengreen (2011), and Cohen (2012) acknowledged that the US Dollar's world reserve status has been a strength for the United States economy in what is framed as exorbitant privilege, which has given the US Dollar stability of value, provided the US financial markets with liquidity, lowered the external transaction costs, and granted the United States a capacity of international seigniorage. Cohen (1971) discussed the considerable gains obtained through international seigniorage that accrues to the country that is a monopolist in the production of an international currency. Ivanova (2010) stated that the position of the U. S. dollar as key international currency has conferred upon the US monetary authority the privilege of international seigniorage, whose advantages include not only seigniorage income and the benefits derived from the large-scale recycling of American debt, but also the ability to profit from exchange rate manipulation of the dollar, which has given further stimulus to the productivity of the US economy. McCauly (2015) stated that the US benefits substantially from the reserve status of the US Dollar as it may borrow in its own currency, and its banks can enjoy a substantial advantage through offshore US Dollar operations. Caramichael, Gopinath & Liao (2022) documented several empirical facts that show how the US economy enjoyed an exorbitant privilege because of the US Dollar reserve status through the premium the US government and corporate bonds have enjoyed in the international markets thanks to the reserve status.

Papaioannou and Portes (2008) expressed a similar position but on the Euro. They claimed the status of the Euro as an international reserve currency has yielded the euro area's monetary authority international seigniorage, which has had a positive effect on terms of trade in the euro area and a mitigating effect on the Euro's exchange rate volatility. Canzoneri, Cumby, Diba & Lopez-Salido (2013) argued that the exorbitant privilege accruing to the reserve currency issuing state comes from three sources: Bond seigniorage, asymmetric responses to exogenous monetary shocks, and macroeconomic hegemony in monetary and fiscal policy, which made these policy instruments more effective. Rogoff and Tashiro (2015) showed that Japan has enjoyed an exorbitant privilege thanks to the reserve status of the Japanese Yen. Pietro, Pagano & Pisani (2014) argued that the increased global demand for Euros would boost aggregate demand in the euro area by lowering interest rates.

Sandbeck (2003) highlighted that reserve currencies issuing states (RCISs) benefit from seigniorage on an international scale as these countries can pay for some of

their imports or foreign assets purchases with the international seigniorage gains accruing from the expansion of international reserves held in their currencies. Osman (2023a) discussed how fiat reserve currencies yield imperial rents to their issuing states and by using the QTM he provided a method to estimate the cumulative quantity of this rent using the tenets of the QTM and he estimated that in the period 1971-2021, the cumulative rent for the US Dollar, the Euro, the British Pound Sterling, and the Japanese Yen amounted to ~11.1 trillion USD. A paper released by the European Central Bank (2019) confirmed the existence of an exorbitant privilege that benefits all reserve currencies issuing states by lowering government borrowing costs and estimated that the term premiums on government bonds are reduced by 0.93 for the U.S, 0.13 for Japan, 0.74 for the U.K, and 1.38 for the euro area. The benefits enjoyed by the RCISs are the ability to borrow in their currencies, which entails lower borrowing costs, the existence of a high level of immunity against the balance of payment shocks, maintaining low interest rates which is a stimulus to economic activity, and giving a competitive edge which the financial institutions, firms, and consumers of RCISs hold over their counterparts in non-reserve currency issuing states (NRCISs) in international and domestic markets.

While the literature emphasized the exorbitant privilege of reserve currency as the ability to achieve international seigniorage, and the low borrowing costs associated with the massive capital inflows to RCISs due to the reserve status of their currencies, the literature has not adequately investigated the role of reserve currency status in mitigating inflationary pressures that result from excess money supply growth. Particularly, the literature has bypassed analyzing the fact that foreign exchange reserve demand, through its effect on the local money supply and income, may provide an inflation buffer against excess money supply growth in RCISs.

As Table 1 shows, the amounts of the allocated worldwide official holdings of foreign exchange reserves are colossal. The amount of the official foreign exchange reserves held worldwide at the end of the fourth quarter of 2022 is equivalent to ~12.93 Trillion USD, which is equivalent to ~14% of world GDP of the same year. Around 60% of the allocated official foreign exchange reserves are held in US Dollars alone and it represents ~30% of the US' annual GDP, followed by the Euro with ~20% of total world foreign exchange reserve holdings, and it represents ~18% of the Euro Area's annual GDP. Other significant reserve currencies (with more than 200 billion USD held worldwide) include the Japanese Yen, the British Pound Sterling, the Chinese Renminbi, the Canadian Dollar, and the Australian Dollar.

Table 1: World- Official Foreign Exchange Reserves Holding by Currency (USD, Trillion)

Currency / Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total Official Forex Holdings	10.949	11.695	11.604	10.932	10.725	11.457	11.436	11.826	12.706	**12.937**
Allocated Total	6.085	6.223	6.800	7.413	8.418	10.013	10.726	11.072	11.865	12.051
USD	3.742	3.813	4.431	4.874	5.502	6.281	6.625	6.726	6.991	7.087
Euro	1.465	1.507	1.443	1.419	1.611	2.019	2.218	2.279	2.526	2.487
Yen	0.249	0.238	0.241	0.278	0.333	0.490	0.557	0.650	0.715	0.672
Pounds Sterling	0.246	0.248	0.252	0.350	0.366	0.455	0.475	0.514	0.561	0.576
Australian Dollar	0.089	0.113	0.108	0.131	0.142	0.180	0.174	0.188	0.217	0.218
Canadian Dollars	0.087	0.114	0.119	0.132	0.163	0.203	0.197	0.206	0.247	0.287
Swiss Franc	0.013	0.017	0.016	0.020	0.014	0.018	0.015	0.017	0.021	0.025
Other currencies	0.195	0.173	0.189	0.209	0.196	0.243	0.263	0.278	0.315	0.363
Total Official Gold Holdings										**0.871**

Source: IMF Macroeconomic & Financial Data, World Gold Council. Data is reported at the end of the respective year

Demanding a reserve currency entails providing real economic value in exchange for this reserve currency, whose production costs are negligible. The QTM suggests that there is a strong link between money supply growth and inflation. According to the QTM, holding everything else constant, an increase in the money supply induces an increase in the price level. Cagan (1956) established the high correlation between inflation and money supply growth during the episodes of hyperinflation in Germany, Greece, Hungary, and Poland. Lucas (1980) showed that annual inflation is closely correlated with annual money supply growth in Germany, the United States, Japan, the United Kingdom, and Brazil. Moroney (2002) concluded that cross-section inflation rates in 81 countries for the period 1980-1993 are explained almost entirely by the average money supply growth rates. Duck (1993) undertook an empirical analysis with data from dozens of countries to conclude the validity of the strong relationship between money supply growth and inflation.

The QTM may be expressed as follows:

$$M * V = P * Y$$

where M stands for the Money Supply, V for the Velocity of Money, P for the Price Level, and Y for Real GDP.

Taking logs and differentiating with respect to time, the equation resolves to:

Growth Rate of Money Supply Growth + Growth Rate of Velocity of Money = Growth Rate of the Price Level (Inflation) + Growth Rate of Output.

Therefore,

Inflation Rate = Growth Rate of Money Supply + Growth Rate of Velocity of Money – Growth Rate of Real GDP,

which implies that the money supply growth rate plus the growth rate of the velocity of money less real GDP growth rate estimate the inflation rate. RCISs have increased their money supply substantially in the last decades, especially with the monetary expansion that followed the 2008 global financial crisis that led to the Great Recession, the 2010/2011 European debt crisis, and since the second quarter of 2020 in response to the economic recession induced by the Covid-19 pandemic. Despite RCISs' relatively sluggish economic growth since the 2007/2008 crisis, their inflation rates remained low, between 0% - 2%, as shown in Figure 2. This observation violates the predictions of QTM.

Table 2 reports the gap between the average annual inflation rates predicted by the QTM through the difference between broad money growth rate and real GDP growth rate, and the actual annual inflation rates for the period 1996-2021[1].

Table 2[2]: QTM Predicted Vs Annual Inflation 1996-2021

	Predicted Average Inflation	Actual Average Inflation	Gap
USA	4.48%	2.31%	2.17%
Euro Area	4.20%	1.97%	2.13%
UK	6.53%	2.08%	4.45%
Japan	9.05%	0.17%	8.88%

Regardless of the accuracy of the predicted/actual inflation gaps' quantities reported that may be due to the imperfection of the QTM or to variations in GDP size, country-specific broad money definitions, or variations in the velocities of money across RCISs, the gap is positive and persistent. Arias and Wen (2014a) claimed that an economy falls into a liquidity trap, where investors hoard the increased money supply instead of spending it because of the opportunity cost

[1] There is no real-world data on velocity to incorporate it in the analysis. Data that exists on velocity in the official statistics and used in literature is a mere residual of Nominal GDP/Broad Money. Therefore, velocity is normalized to 1 in this analysis, and its rate of change is 0. Later in the paper, the variability of velocity is incorporated in the argument.

[2] Data was obtained from World Development Indicators.

of holding cash in times of uncertainty, and that slows down the velocity of money and mitigates the effect of the excess money supply growth on inflation. Nonetheless, these were theoretical speculations without empirical backing. In a similar argument, Arias and Wen (2014b) argued that the lower than predicted inflation in the U.S in the period 2008-2013 has to do with the drastic slowdown in the velocity of money in that period. However, the method used followed a methodological fallacy. Their argument used the data on velocity as a residual using QTM (V=PQ/M), instead of reporting exogenous data on velocity and then inserting the data into the QTM equation to find out whether it compensates for the gap. They used QTM equation of M.V = P.Q, then they replaced velocity with the residual of PQ/M, so in mathematical terms, their argument goes as follows: M.(P.Q/M) = P.Q, where the tautology is obvious. They essentially asserted that "it must have been velocity" rather than using data on velocity to truly check whether its slowdown is the reason behind lower than expected inflation. Mendizbal (2006) and Benk, Gillman & Kejak (2008) committed the same fallacy when they used data on velocity obtained through a residual estimate and made conclusions on determinants of velocity variations. The former claimed that the correlation between the velocity of money and the inflation rate appears to be low because of the diverse transaction technologies available in different economies, while the latter claimed that money supply and credit shocks explain velocity variations. As a matter of fact, there is no real-world data on the velocity of money, and the data that exists in official statistics are mere estimates as a residual using the other elements of QTM. Therefore, using these data on velocity in empirical analysis suffers from evident endogeneity.

It is reasonable to expect that declining velocity in times of economic slowdown has a mitigating effect on inflation. However, within the tenets of the Quantity Theory of Money, the substantial leakage of the money supply to meet the foreign exchange reserve demand abroad in exchange for real economic resources flown into a given RCIS' economy must also take part in mitigating inflation, as this leaked quantity of money left the circulation of the economy, and additional economic resources were introduced to the economy in exchange[3]. Therefore, there is less currency in circulation and more income, and that mitigates inflation according to the tenets of the QTM. That suggests that there exists an inflation buffer that mitigates the effect of money supply growth on inflation in RCISs through the global reserve currency regime.

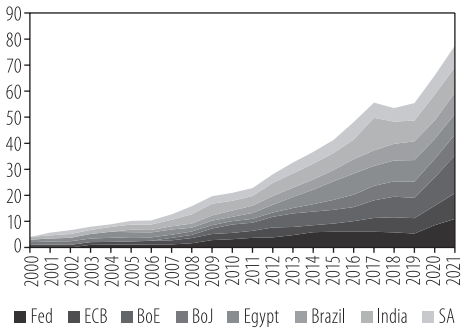
[3] Most of the foreign exchange reserve exports go back to their issuing states in the form on investments. Therefore, these FOREX invested amounts are converted to capital and do not remain as mere currency. This is explained later in the paper.

Güler (2021), Trabelsi (2022), and Krušković (2022), along with other scholars, have explored the role of macroprudential policies and central bank interventions in stabilizing price levels during periods of financial turmoil. These studies emphasize how such measures can mitigate inflationary pressures and restore stability in times of economic stress. However, one critical limitation in their analyses is the lack of differentiation between the inflation dynamics in RCISs and NRCIs. They do not address the broader implications of state's status as a reserve currency issuer on its inflationary processes and overall monetary conditions. The unique role of RCISs in the global financial system, particularly in terms of their ability to issue a currency that is held as a global reserve, introduces distinct factors that could influence inflation in ways that differ from those in NRCIs. This loophole in the literature highlights the need for a more nuanced understanding of how reserve currency status may shape inflation dynamics and the broader monetary policy environment in these countries.

3. The Foreign Exchange Reserve Demand - Inflation Buffer Hypothesis

3.1. Observation and Hypothesis

Figure 1: Central Bank Total Assets in the Period 2000-2021

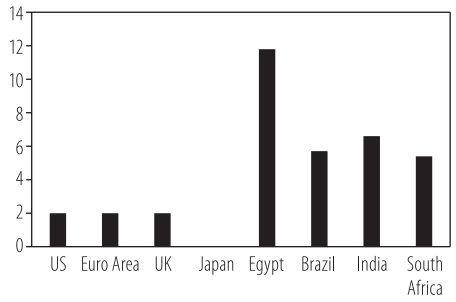


Source: Central Banks' Official Data

Notes: Data is normalized to 1 at the initial input

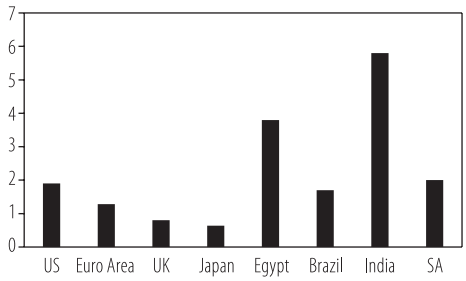
This section presents the Foreign Exchange Reserve Demand - Inflation Buffer Hypothesis to explain the inflation gap observed between countries with reserve currency status (RCISs) and those without reserve currency status (NRCISs). Despite similar money supply growth rates and slower economic growth in RCISs, a persistent gap in inflation rates exists between the two groups. One possible explanation is the foreign exchange reserve demand on RCIS currencies from abroad, which may mitigate inflation as a result of the significant amounts of money supply leaving the circulation of RCISs to meet global foreign exchange demand in exchange for real economic resources.

Figure 2: Average Annual Inflation Rate in the Period 2000-2021, %



Source: Central Banks' Official Data

Figure 3: Average annual GDP growth rates in the period 2000-2021, %



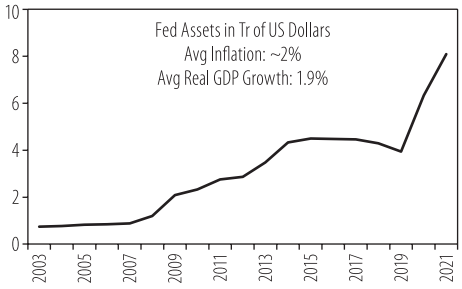
Source: World Development Indicators, World Bank Data

Figure 1 shows that the trajectory of central bank total assets, which is used as a proxy for money supply growth, have been comparable to their counterparts of a sample of NRCISs, and have been noticeably larger in RCICs than in NRCISs since 2007. Meanwhile, the inflation rates in RCISs in the period 2000-2021 have been substantially lower than inflation rates in NRCISs, as presented in Figure 2, despite the less average annual GDP growth rates of RCIS's compared to their GDP growth rates of NRCISs as shown in Figure 3.

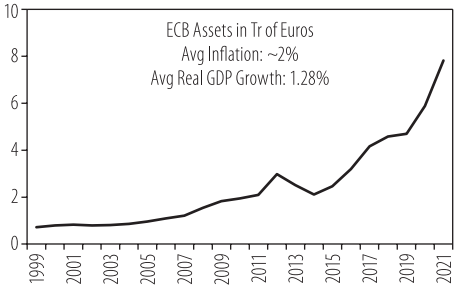
In cross-sectional analyses, data of central bank total assets growth is utilized as a proxy of money supply growth as it is more reliable than broad money data due to the significant variability in the latter's definitions across countries and also across time for each country as shown by Lim & Subramanian (2003) and O'Brien (2006). When the monetary authorities decide to engage in monetary stimuli, one of the most common practices is that the central bank purchases assets, primarily government bonds to inject new currency into circulation and stimulate economic activity in Open Market Operations (OPO) which, if it occurs in protracted period of time, has become known as Quantitative Easing (QE). Therefore, central bank total assets' growth is a key factor and indicator of money supply growth and its use is proper for the analysis. Reynard (2023) and Webster (2023) argued that there is a strong link between central bank total asset growth and increased inflation. Furthermore, the central banks around the world have been reducing their total assets since mid-2022 as a counter measure to curb inflation. For instance, the Federal Reserve Bank of the United States (2022) has embarked on "monetary tightening" to curb inflation and it decreased its total assets from its peak of ~9 Trillion USD in Q1 2022 to 8.1 Trillion USD in

Q3 2023, which further showcases the influence of changes of central bank total assets on inflation.

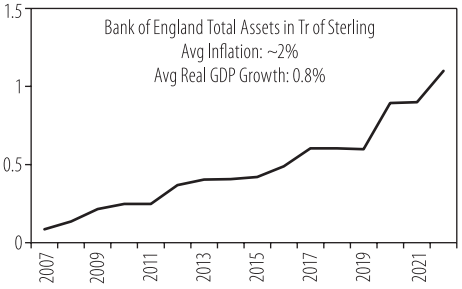
Figure 4: QTM Variables for the four major RCISs



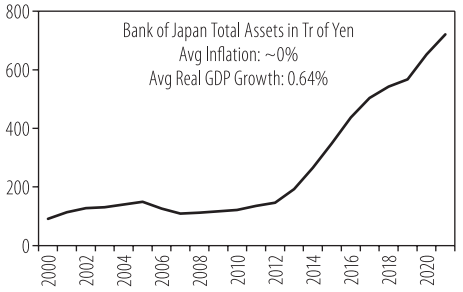
Source: Federal Reserve Economic Data



Source: European Central Bank

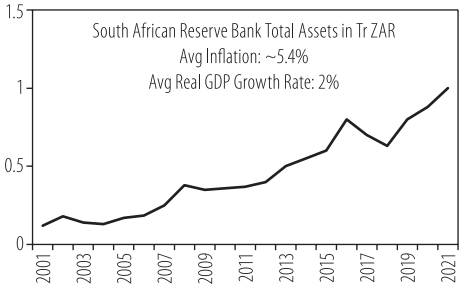


Source: Bank of England

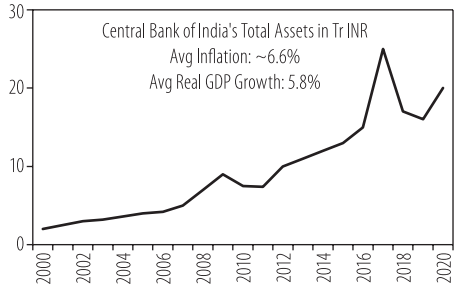


Source: Bank of Japan

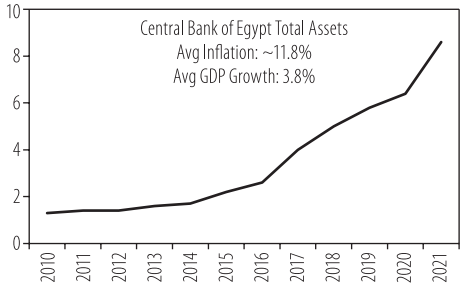
Figure 5: QTM Variables for a sample of NRCISs from Asia, Africa, and Latin America



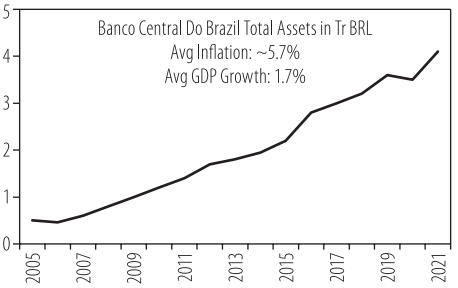
Source: The South African Reserve Bank



Source: Central Bank of India



Source: Central Bank of Egypt



Source: Banco Central Do Brazil

Figures 4 and 5 show the disparity in the inflationary outcome that results from increases in money supply growth illustrated by data of central bank total assets growth. Figure 4 shows the vast increases of nearly 9 fold for the US and the euro area, more than ten-fold for the UK, and more than seven-fold times in Japan in their central bank total assets since 2007. The increases in central bank total assets, which have been driven almost entirely by increases in money supply to stimulate the economy since the 2007-2009 Great Recession, happened through fiscal stimulus packages and a protracted regime of monetary expansion, which is a monetary policy known as *Quantitative Easing*. However, and in spite of the relatively slow average economic growth for the period, there have not been increases in the price levels that are proportional to the increases in money supply as predicted by the QTM. For the period 2000- 2021, inflation rates averaged ~2% for the US, the euro area, and the UK, and ~0 for Japan. For the similar tenure, Figures 2 and 5 show disproportionally higher inflation rates for a sample of NRCISs, despite having comparable growth rates in the money supply with often higher GDP growth rates. For example, both the US and Brazil had a

nine/ten-fold increase in central bank total assets in the period 2005-2021, they both had similar economic growth rates. However, the average annual inflation rate in Brazil was ~2.7% higher than that of the US. In India[4], central bank total assets increased nearly? five-fold in the period 2007-2021, the same period when the UK central bank total assets increased by more than ten- fold. However, and despite India's GDP growth rates having been substantially higher than that of the UK, India's average annual inflation rate has been 4.6% higher than that of the UK. In South Africa, between 2007 and 2021, the central bank total assets increased four-fold, less than that of the UK for the same period, but the annual inflation rate for South Africa was 4% higher on average than that of the UK, even though both economies grew at a similar rate for the same period. Similar findings occur if we look at the Egypt's central bank total assets that increased five-fold in the period 2010-2021, which is similar to the increases in total banks assets in RCISs in that period, while Egypt's average annual inflation was 11.8%, notwithstanding its higher real GDP growth than that of all RCISs in that tenure. Overall, and despite the existence of other factors of friction standing between money growth and inflation that may differ from one country to another, the average trajectory of inflation in RCISs is *distinctly* lower than that of NRCISs, despite both parties' comparable money supply growth in the last few decades.

The discrepancy shown in data in Figures 2-5 in inflation as an outcome of money supply growth in excess of economic growth between RCISs and NRCISs indicates the existence of mechanisms that counteract the effect of money supply growth on inflation in RCISs. One of these mechanisms could be explained by the presence of an inflation buffer provision that alleviates the effect of money supply growth on inflation, which, within the tenets of QTM, is activated by the contemporary world reserve currency regime. A foreign exchange currency sale entails that a quantity of money leaves the national circulation[5] of a given RCIS to meet foreign exchange reserve demand abroad in exchange for real economic resources that were added to the income of the RCIS. This extra income manifests as a reduction in inflation in RCISs. Figure 6 illustrates geometrically the foreign exchange reserve demand hypothesis using the general framework of the QTM. Quantity of money is represented by the horizontal axis. The value of money (inverse of the price level) is represented by the vertical axis with exogenous money supply S decided by the monetary authority and downward sloping money demand curve D. The framework suggests that an increase in the money

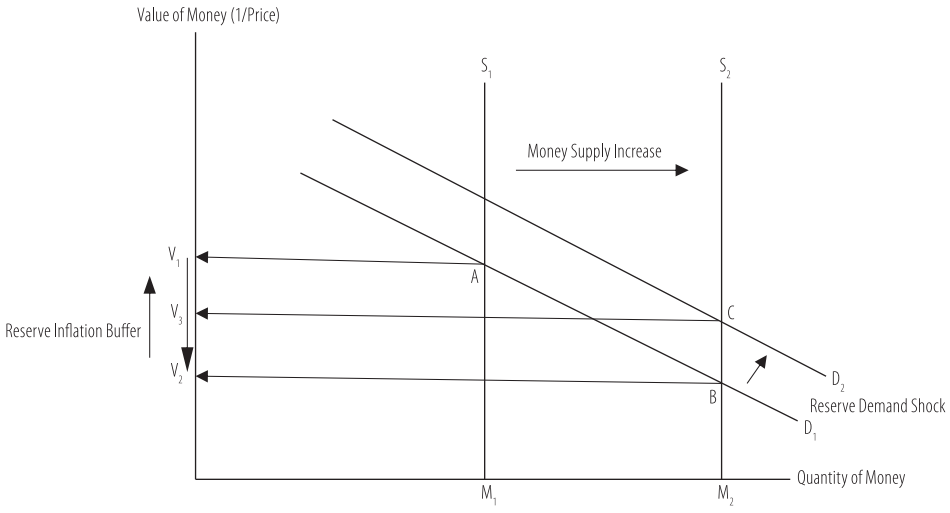
[4] Most of NRCISs have food and energy subsidies that mitigate inflation. Inflation rates without subsidies would probably be substantially higher, which would further make the gap between RCISs and NRCISs more pronounced.

[5] Refer to page 135 for clarification

supply (from S_1 to S_2) while holding everything else constant, would shift the equilibrium from A to point B to reflect a decrease in the value of money from V_1 to V_2 (or increase the price level). However, if a currency holds a foreign exchange reserve status, the money demand would experience an extra shock due to the foreign exchange reserve demand. Therefore, the money demand curve would shift from D_1 to D_2. The equilibrium for the foreign exchange reserve currency condition would be at point C, with value of money at V_3, vis-à-vis point B for the non-reserve currency condition with value of money V_2. The vertical distance between V_2 and V_3 represents the inflation buffer provided to a currency by the foreign exchange reserve demand on that currency.

It is worth noting that, as per the QTM, other factors such as output shocks or changes in the velocity of money can also affect inflationary outcomes to money supply shocks. However, foreign exchange reserve demand through its absorption of quantities of the money supply in exchange for economic output may also play a role in shaping inflationary outcomes.

Figure 6: Geometric Illustration of the Foreign Exchange Reserve Demand – Inflation Buffer Hypothesis Using the Framework of Quantity Theory of Money



3.2. Algebraic Modeling of the Foreign Exchange Reserve Demand – Inflation Buffer Hypothesis using Quantity Theory of Money

Assume time is discrete for illustrative purposes. Let M_1 be the initial money supply, P_1 be the initial price level, Y be the real output, and V be the velocity of money. To isolate the effect of reserve demand on inflation, assume that Y and V are constant. According to the Quantity Theory of Money, the following relationship holds:

$$M_1 * V = P_1 * Y \quad (1)$$

Therefore, the equilibrium price would be:

$$P_1 = M_1 * V/Y \quad (2)$$

Assume that the monetary authority decides to increase the money supply from M_1 to M_2. Therefore, the price level would increase, and the new equilibrium price P_2 would be:

$$P_2 = M_2 * V/Y \quad (3)$$

and the inflation rate would be

$$\Pi_1 = (P_2 - P_1) / P_1 \quad (4)$$

Assume that the currency becomes an international foreign exchange currency with foreign reserve demand of $R > 0$, $R < M$ from abroad. As reserve currency sale is effectively an export of currency, the money supply is reduced to $M_{2r} = (M_2 - R) < M_2$, and the reserve currency is exchanged for real economic resources with equivalent value of R, so the output Y increases to $Y_r = (Y + R) > Y$.

Let P_{2r} be the price level in the reserve currency condition. The equilibrium price P_{2r} would be:

$$P_{2r} = (M_{2r} * V) / Y_r \quad (5)$$

and the inflation rate Π_2 in the reserve currency condition would be:

$$\Pi_2 = (P_{2r} - P_1) / P_1 \quad (6)$$

Therefore, the price level in the reserve condition would always be less than in the non-reserve condition since:

$P_{2r} < P_2$, as $= (M_{2r} * V) / (Y_r) < M_2 * V/Y$, as $(M_2 - R) * V/(Y + R) < M_2 * V/Y$

and the inflation rate in the reserve currency condition would always be less than the inflation rate in the non-reserve currency condition since:

$\Pi_2 < \Pi_1$, as $(P_{2r} - P_1) / P_1 < (P_2 - P_1) / P_1$ since $P_{2r} < P_2$

The algebraic modelling of the Quantity Theory of Money with the incorporation of foreign exchange reserve demand shows that in the reserve currency condition, the price level (P_{2r}), and consequentially inflation (Π_{2r}), are affected not only by changes in the money supply, output shocks, and the velocity of money, but also by changes in the demand for the reserve currency through its effect on the money supply and income via transfers of real output from abroad. Therefore, if the demand for the reserve currency increases, it offsets the inflationary effects of a given increase in the money supply, thereby mitigating inflation.

While[6] it holds true that the majority of reserve currency acquisitions swiftly re-enter the circulation of reserve currency-issuing states, it is imperative to delineate that this re-entry takes place in the form of capital investment, which falls within the purview of the 'investment' component in Gross Domestic Product (GDP) calculations. This capital infusion assumes various forms, encompassing investments in debt instruments such as treasury securities, acquisitions of equities in the private sector, ventures in Foreign Direct Investment (FDI), and in other investment asset classes. Consequently, the reintroduction of currency into the economies of reserve currency-issuing states engenders an expansion of both the monetary base (M) and economic output (Y) in direct proportion. Within the framework of the equilibrium equation denoted as P = M.V/Y, the price level (P) remains unchanged. Hence, the inflation buffer provided by foreign exchange reserve demand expected to remain intact.

4. Examining the Reserve Demand's Inflation Buffer Through Econometric Analysis

This segment provides an econometric analysis to determine whether the influence of reserve demand on inflation in RCISs is significant.

[6] Clarification for footnote 5.

The Econometric Model

$$\pi (it) = \beta o + \beta 1 ((Rd (i) * EMS (it-1)) + \beta 2 (EMS (it-1)) + \alpha (i) + \tau(i) + u (it)$$

The econometric model is a Difference in Difference (DiD) model with RCISs as the treatment group, and NRCISs as the control group, and the treatment is the foreign exchange reserve status of currency. π (it) is the annual inflation rate, Rd (i) is a dummy variable for the currency reserve status, EMS (it-1) is the lagged excess money supply growth represented by the difference between the annual growth of central bank total assets and annual growth of real GDP. The econometric model is based on the Quantity Theory of Money and it includes all its elements of: Inflation, monetary expansion, and output growth rate. Velocity is embedded in the variables since velocity is assumed to be (Output x Price)/Quantity of Money.

Data[7]:

The data used is panel data of 28 states[8] (8 RCISs and 20 NRCISs) for the period 2004-2021.

- The dependent Variable ((π it)) is the country annual inflation rate.
- The independent variable is an interaction (Rd(i) * EMS (it-1)) between a dummy variable with 2 for reserve currency issuing states and 1 otherwise and central bank total assets' annual growth rate minus real GDP growth rate. The variable is meant to capture the influence of currency reserve status on inflation through excess central bank asset growth. The reserve dummy variable was also regressed as an independent variable in a random effects model with controls to gauge the effect of reserve status on inflation apart from its interaction with excess central bank asset growth as shown in Table 3.
- For control, central bank total assets' annual growth rate minus real GDP growth rate, α (i) country fixed effects and τ(i) time fixed effects were included.
- (i) stands for country and (t) for time.

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[7] Osman (2023b)

[8] The selection of countries includes: the USA, the UK, the euro area, Japan, Australia, Canada, Switzerland, China, India, Indonesia, Egypt, Brazil, South Africa, Philippines, South Korea, Mexico, Morocco, Malaysia, Kazakhstan, Pakistan, Columbia, Vietnam, Tanzania, Nigeria, Chile, Guatemala, Panama, and Nicaragua. The selection was based on the availability of data and excludes economies under economic sanctions such as Iran, Russia and Turkey due to difficulties regarding the control for the disturbances caused by the sanctions.

- Data was obtained from World Development Indicators, and countries` central bank official data.
- Note: The variables that include central bank total asset growth rates and GDP growth rates were used with a time lag of one year because of the time lag between base money supply growth and inflation as suggested by Batini and Nelson (2001).
- Unit root tests were performed for the main dependent and independent variables. The results consistently rejected the null hypothesis of unit roots, indicating that all of these variables are stationary.[9]

Table 3: Inflation on Excess Money Supply Growth

	Dependent Variable: Inflation π (it)					
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS with Controls	OLS	OLS with Controls	Full Model (Random Effects)	Full Model (Fixed Effects)
Reserve Dummy (i)	-3.77***	- 3.94***				
	(0.34)	(0.34)				
Reserve Dummy (i) * Excess Money Supply Growth (it-1)			-.02**	-0.13***	-.055***	-0.046***
			(0.01)	(0.01)	(0.01)	(0.01)
Central Bank Asset Growth (it-1) – Real GDP Growth (it-1)		0.034***		0.25***	0.11***	0.10***
		(0.01)		(0.01)	(0.01)	(0.01)
Constant	5.51***	5.23***	4.49***	3.79***	4.11***	4.05***
	(0.18)	(0.19)	(0.17)	(0.18)	(0.43)	(0.13)
Between R^2	0.19	0.21	0.01	0.13	0.51	0.49
Hausman chi2(2)					32.48***	
Prob>chi2					0.01	
Observations	506	506	506	506	506	506
Number of States	28	28	28	28	28	28

standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Hausman Test was conducted with the null hypothesis that random effects model is appropriate and the results suggest a rejection of the null hypothesis

The results of the regression analysis illustrated in table 3 demonstrate a strong and consistent relationship between reserve currency status and inflation in RCISs. The significant result for the regression of the reserve dummy with controls in column 2 show that reserve currencies have experienced 3.46% lower annual inflation than non-reserve currencies. Results in columns 3 and 4 for OLS of

[9] Unit Root test results may be obtained upon request.

the interaction variable and OLS of the interaction variable with controls, and for column 5 with full model with random effects, and for column 6 of the full model with country fixed effects show that the coefficient of the interaction variable came out significant and negative consistently, which implies the reserve status of a currency dampens inflation in RCISs, specifically through its interaction with money supply growth.

4.1. Robustness Check with Utilizing Time Fixed Effects

In order to ensure the robustness of the results, time fixed effects were utilized in both fixed effects and random effects models. Including time fixed effects is a common approach to control for unobserved time-varying factors that may affect the dependent variable. By doing so, the estimated coefficients are less likely to be biased due to the omitted variables problem. In addition, by including time fixed effects in both models, it allows for a direct comparison of the results from the fixed effects and random effects models, which can provide additional insights into the underlying dynamics of the data. Therefore, the inclusion of time fixed effects provides an important robustness check for the analysis.

Table 4: Robustness Check with Time Fixed Effects

	Dependent Variable: Inflation π (it)	
	(7)	(8)
	Random Effects + Time Fixed Effects	Fixed Effects + Time Fixed Effects
Reserve Dummy (i) * Excess Money Supply Growth (it-1)	-0.045***	-0.036***
	(0.13)	(0.12)
Central Bank Asset Growth (it-1) – Real GDP Growth (it-1)	0.095***	0.080***
	(0.01)	(0.01)
Constant	7.37***	7.18***
	(1.83)	(1.75)
Between R^2	0.26	0.18
Hausman chi2(2)	22.43	
Prob>chi2	0.38	
Observations	506	506
Number of States	28	28

standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Hausman Test was conducted with the null hypothesis that random effects model is appropriate and the results suggest non-rejection of the null hypothesis.

As table 4 shows, the inclusion of time fixed effects in columns 7 and 8 yields results that are consistent with the previous findings, which supports the robustness of the model. The estimates of the interaction variable in columns 5,6,7, and 8 show that with every 100% increase in central bank total assets, which is a key factor of money supply growth, in excess to real GDP growth, annual inflation is mitigated by 3.5-5.5% for reserve currencies. This supports the hypothesis that the strong and sustained global foreign exchange reserve demand, which serves as a channel absorbing substantial quantities of the money supply from the local economy of a given RCIS in exchange for real economic resources, mitigates inflationary pressure in RCISs.

4.2. Further Robustness Check by Using 2SLS Regression to Establish the Exogeneity of Currency Reserve Status to its Inflation Dynamics

The argument presented in this study follows that inflation is affected by reserve status of currency. However, one may think the opposite. Namely, that reserve status may be an outcome of low inflation in RCISs. Therefore, further econometric analysis using instrumental variables estimation in a Two Stage Least Squares Regression model was conducted to control for this potential simultaneous causality. The instrumental variables used for the main independent variable (the interaction variable) are 1) Annual GDP per capita, 2) Annual real interest rate, and 3) A dummy variable to represent political stability (ranged -2.5-2.5) with 1 for states with score above 0 and 0 for states with scores below 0. These instruments were selected based on their relevance to conditions in RCISs as being mostly of high-income status and politically stable. Real interest rates were used as their stability may influence decision in holding a specific reserve currency. Moreover, the instruments serve as proxies for developed and stable financial markets, which may influence the global status of currency as a foreign exchange reserve asset. Data for variables 1& 2 were obtained from World Development Indicators and data of variable 3 from World Wide Governance Indicators.

Table 5: Robustness with IV 2SLS Regression

	Dependent Variable: Inflation π (it)
	IV Estimate with Random Effects
Reserve Dummy (i) * Excess Money Supply Growth (it-1)	-0.52***
	(0.10)
Central Bank Asset Growth (it-1) – Real GDP Growth (it-1)	0.90***
	(0.18)
Constant	2.83***
	(0.43)
Between R^2	0.51
Hausman chi2(2)	0.10
Prob>chi2	0.95
Observations	491
Number of States	28

Note: Random effects were utilized instead of fixed effects. The selection of the random effects model is supported by the results of the Hausman test conducted in this analysis.

The total number of observations was diminished by a count of 15 observations, specifically from an initial count of 506 to a final count of 491. This reduction was primarily attributable to limitations in the availability of data after the inclusion of the designated instrumental variables.

Table 5 shows that the coefficient of the independent variable emerges as negative and statistically significant. This result is consistent with the patterns observed in both tables 3 and 4, reinforcing the robustness and reliability of the initial findings. Moreover, the instrumental variable estimation model employed in the analysis provides further assurance regarding the exogeneity of currency reserve status in relation to inflation dynamics or any other macroeconomic or institutional factors. Despite the additional complexity introduced by this approach, the regression results remain in harmony with the initial outcomes derived from the primary model. This alignment strengthens the confidence in the validity of the results and further emphasizes the relationship between currency reserve status and inflation across different analytical methods.

Conclusion

This paper contributes to the literature on reserve currency's exorbitant privilege by examining the role of reserve currency status in influencing inflationary outcomes in Reserve Currency Issuing States (RCISs). Within the framework of the Quantity Theory of Money (QTM), the study investigates how demand for foreign exchange reserves helps mitigate inflationary pressures resulting from mon-

ey supply growth. The findings reveal that, while factors such as economic slowdowns may explain the decoupling of money supply growth and inflation, foreign exchange reserve demand plays a crucial role in offsetting these inflationary pressures. The paper introduces the foreign exchange reserve demand-inflation buffer hypothesis, supported by empirical evidence. Specifically, meeting foreign exchange reserve demand from abroad withdraws money from circulation in exchange for real economic resources of equivalent value, thereby exerting downward pressure on the price level and moderate inflation.

These results offer a deeper understanding of the mechanisms driving inflation dynamics and emphasize the role of foreign exchange reserve demand in maintaining price stability in RCISs. Further research is needed to explore additional factors and dynamics that may influence the relationship between reserve currency demand and inflation in RCISs.

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