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Macroeconomic Indicators as Determinants of the U.S. Dollar as a Primary Reserve Currency

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MACROECONOMIC INDICATORS AS DETERMINANTS OF THE U.S. DOLLAR AS A PRIMARY RESERVE CURRENCY

by

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ABSTRACT

Several currencies have arisen as credible competitors for the dollar's primary reserve currency position in central banks around the globe, and many wonder how long the dollar can maintain its position. Reserve currency usage is dependent relative to the size of the home economy, openness to trade, and prosperous and stable growth, including an inertial bias. This paper utilizes econometric methods to examine the significance of macroeconomic indicators of the U.S. dollar's reserve currency status. The dataset is gathered from the IMF's COFER database using a time period from 2000 to 2013 in order to capture the most relevant reserve levels post-euro adoption. The estimated coefficient values indicate a significant inertial bias. This result implies that we can expect the dollar to hold the primary reserve currency position for the near future.

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1. INTRODUCTION

The Great Recession of 2008 brought about many concerns in regards to the future of our evolving global economy. Roles of key economic players in the international monetary system like the United States have been under tremendous scrutiny and media coverage. Long-standing confidence in the U.S. dollar as a reserve currency has been doubted as international policymakers seek security and stability in the aftermath of widespread economic crisis. Doubts arise even from within the United States; former Federal Reserve Chairman Alan Greenspan has gone on record to say, "[It is] absolutely conceivable that the euro will replace the dollar as reserve currency, or will be traded as an equally important reserve currency (Reuters 2007)." The immense size of the quantitative easing program by the Federal Reserve raises many concerns about possible inflation, debasing of the dollar, and resulting capital losses of foreign-exchange reserves. Considering the size of the largely Chinese financed U.S. trade deficit, speculators worry about the dollar's dominant position over rising currency contenders like the renminbi (Mauldin 2013). The continuance of the U.S. dollar's dominant reserve share is questionable when considering the international roles of other widely used currencies like the euro, renminbi, pound sterling, franc, or yen.

One must wonder about the reason for all this talk about the dollar's status as reserve currency. From a general overview, COFER (Currency Composition of Official Foreign Exchange Reserves) estimates of the allocated reserve claims in dollars were about 72% in Q2 1999. Yet, as of Q4 2013 the allocated reserve claims in dollars are down to less than 62%; meaning there was a 10% drop in the use of the dollar as a reserve currency by central banks

worldwide. The large drop is what has many economists, policy makers, and citizens alike concerned about the implications of the trending decline of the dollar and why? Some of these implications include reduced shock insulation, constrained fiscal policy, and a reduction in global influence (Goldberg 2011). Before I can answer why, I should ask what are the determinants of demand for international reserves in the first place? By discovering what these determinants are, we can obtain a better idea of what could be causing this situation to occur and where it is likely headed. In order to proceed further however, several terms and concepts shall be defined when dealing with reserve currencies.

1.1. Currency Roles

Economic principles concur that a currency has three primary roles: being a store of value, unit of account, and medium of exchange (Mankiw 2013). These roles become very clear in the domestic scope of the definition. A dollar kept today is a store of value that is retained for consumption tomorrow and further on. Prices seen across the store shelves are denominated in dollar units, and when a transaction is completed the dollar is used to exchange its stored value for a product or service. However, it is also important to mention that a currency itself usually has little to no intrinsic value as fiat money; fiat money instead derives its value from a trust that the issuing government or central bank has the ability to pay back its financial obligation. It is through mutual trust of its backing that enables a currency to take on its primary roles (Lascaux 2012).

Currency roles expand in an international scope to become "primary currency in official foreign exchange reserves; a transaction currency in foreign exchange and international capital markets; and an invoicing and settlement currency in international trade (Goldberg 2011)."

While all these currency roles are important for the dollar, one of the most visible and often estimated roles is that of the dollar as a primary currency in official foreign exchange reserves.

1.2. Official Foreign Exchange Reserves

Official foreign exchange reserves are a broad figure, the sum of "foreign banknotes, bank deposits, treasury bills, short- and long-term government securities, and other claims usable in the event of balance of payments needs" according to IMF statistical definition (2013). Official foreign exchange reserves are composed of specific denominated claims including U.S dollars, Japanese yen, and so on (See Table 1). About half of all U.S. currency was held abroad in end 2011 (Judson 2012), and a portion of currency ends up as central bank reserves.

Table 1: IMF COFER Report (2013-2014)

World	**2013**				**2014**	
(In millions of U.S. dollars)	I	II	III	IV	I	II
Total Holdings	11,089,871	11,131,969	11,442,197	11,685,791	11,859,244	12,001,163
Allocated reserves	6,083,317	6,076,458	6,190,092	6,224,671	6,327,393	6,314,175
Claims in U.S. dollars	3,763,002	3,758,855	3,803,375	3,792,551	3,817,909	3,830,349
Claims in pounds sterling	235,512	232,002	242,905	248,992	242,357	244,996
Claims in Japanese yen	236,159	233,389	235,226	239,712	246,879	254,663
Claims in Swiss francs	15,830	15,648	16,287	16,741	16,677	17,081
Claims in Canadian dollars	96,031	108,992	113,752	116,039	119,441	127,309
Claims in Australian dollars	101,077	102,460	103,975	113,221	117,377	120,096
Claims in euros	1,432,685	1,449,645	1,493,474	1,522,124	1,582,094	1,527,400
Claims in other currencies	203,021	175,467	181,098	175,292	184,658	192,282
Unallocated reserves	5,006,554	5,055,512	5,252,105	5,461,120	5,531,852	5,686,988

Source: IMF Statistics Department COFER database and International Financial Statistics

The Currency Composition of Official Foreign Exchange Reserves (COFER) database of the International Monetary Fund presents an estimate of official foreign exchange reserves. Allocated reserves are voluntarily reported to the IMF by 138 member countries, and aggregate

all items listed in the definition of official foreign exchange reserves. Unallocated reserves simply consist of the difference between the total foreign exchange reserves and the total allocated reserves reported in COFER.

1.3. Reserve Currency

Now, in regards to a specific currency denomination of official foreign exchange reserve claims, we arrive at answering what reserve currencies are and their purpose. A reserve currency is, "foreign currency held by central banks and other major financial institutions as a means to pay off international debt obligations, or to influence their domestic exchange rate (Investopedia)." The global financial system is sustained by the use of reserve currency that is liquid and easily convertible in order to settle debt obligations or influence the exchange rates. Central banks and financial institutions favor the use of a reserve currency from a country or economic union that exhibits factors including: a large economy, significant openness to international trade, creditworthiness, stable and sound political and economic institutions (Goldberg 2011). There are many currencies that display none, one, or all of these factors, and reserve managers generally develop preferences based on how a currency measures up accordingly.

It is important to analyze the history and context of major reserve currency changes that exemplify the theory behind reserve currency usage. As Goldberg (2011) explains, "international currency usage is a market driven decision." Market preferences toward a reserve currency exhibiting ideal factors can explain why the dollar has not always held the dominant reserve currency position. For example, foreign exchange reserves of 1899 held by central banks worldwide were dominated by the British pound sterling even until as late as 1940. However, the

reserve currency role of the pound sterling and U.S. dollar became reversed after World War II's impact on the global financial status (Aliber 1964). The United Kingdom and much of the modern world had encountered tremendous amounts of debt in order to finance the wars; therefore, these currencies began to lack trust of creditworthiness, stability, and soundness. Meanwhile, the United States became a huge international player after the success of the allies in defeating Nazi Germany. The United States exemplified great strength in regards to the size of its economy, creditworthiness, and stability during post–World War II economic expansion (Goldberg 2011). Despite the cancellation of the direct convertibility of the dollar to gold in 1971, many central banks continued to hold dollar reserves. Economic growth coupled with the newfound international financer status of the United States quickly caused the dollar's ascendance as the primary reserve currency (Chinn, Frankel 2008).

However, in the 1990's economists began to really take notice of what seemed to be a decline of the importance of the dollar over the past twenty years. A widely circulated article in *The Economist* pointed out a waning of the dollar in response to the Deutsche mark (Chinn, Frankel 2008). With the adoption of the euro in 1999 and the expansion of Asian markets, speculation about the dollar reserve currency status came into more discussion. Although real GDP climbed up to above 5% in Q2 2000 for the United States, the current account deficit widened to about 4.25% in Q1 2002. Yet, Euro Area and East Asian countries were showing comparable or even greater growth at the same time. For example, Korea saw 8.8% real GDP growth from 1999 to 2000 and Euro Area real exports approached 10% growth rates (WEO 2002). At this time, the world saw other major currencies exhibiting those ideal factors that motivated a reserve manager's preference for a certain reserve currency. As a result, the last

decade or so has seen substantial change in the realm of official foreign exchange reserves as exhibited in Table 2.

Table 2: Reserve Data (2002-2011)

All Countries	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Total Holdings	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Allocated Reserves	75%	73%	71%	66%	63%	61%	57%	56%	56%	55%
Claims in $	*67%*	*65%*	*66%*	*67%*	*65%*	*64%*	*64%*	*62%*	*62%*	*62%*
Unallocated	25%	27%	29%	34%	37%	39%	43%	44%	44%	45%
Advanced										
Share of Total	60%	58%	55%	48%	43%	36%	34%	34%	33%	33%
Allocated Reserves	89%	88%	88%	88%	88%	89%	88%	87%	88%	89%
Claims in $	66%	67%	67%	69%	68%	66%	67%	65%	65%	66%
Unallocated	11%	12%	12%	12%	12%	11%	12%	13%	12%	11%
Emerging & Developing										
Share of Total	40%	42%	45%	52%	57%	64%	66%	66%	67%	67%
Allocated Reserves	54%	53%	49%	46%	44%	46%	41%	40%	40%	39%
Claims in $	67%	62%	62%	62%	61%	62%	60%	59%	58%	58%
Unallocated	46%	47%	51%	54%	56%	54%	59%	60%	60%	61%

Source: International Monetary Fund, Currency Composition of Official Foreign Exchange Reserves (COFER) data.

Overall, a nominal value of total holdings for all countries increased 324% from 2002 to 2011. Emerging and developing countries drove the growth of total holdings at a substantial rate of 606% versus 136% of advanced countries from 2002 to 2011. Advanced countries used to account for the larger share of official foreign exchange reserves, but now emerging and developing countries have reversed that role. While allocated reserves held a majority share, unallocated reserves have almost closed the gap in 2011. In fact, unallocated reserves as a share of total have almost doubled from 2002 to 2011. The identities of holding countries and the

composition of these unallocated reserves are unknown; however, it can be inferred from the absence from the list of reporting countries that China accounts for a large portion due their crawling peg. Interestingly enough, allocated reserve claims in dollars have been relatively stable for an "Advanced Countries" aggregate despite concern about the dollar losing its prominence as a reserve currency. However, the data does show a minor trending decline in dollar claims for "All Countries" over the last decade, more so in the developing and emerging countries.

1.4. Implications

A changing role of the dollar from a primary reserve currency to a lesser reserve currency has many implications for the United States. Although these implications are not the focus of this paper, they provide us motivation to discover the determinants of reserve currency allocation. For example, a primary benefit of being a reserve currency allows for reduced transaction costs in the foreign exchange markets. "According to a 2008 survey about the average daily global turnover in traditional foreign exchange markets, 89% of trading involved the dollar on one side of the transaction or the other (Frankel 2008)." Because the dollar is so often traded, the cost of exchanging dollars for other currencies is far less than exchanging less often traded currencies. There are many other implications for a decline in dollar prominence as summarized in Table 3, of which the literature on reserve status loss concurs.

Table 3: Summary of Reserve Status Implications for U.S

IMPLICATION	EFFECT	NOTE
Seignorage	Reduced	Small impact
Funding Costs	Increased	Reduced demand increases transaction costs
Dollar Value	Depreciation	Due to lower demand as well
Shock Insulation	Decreased	Change in invoice pricing and import prices may spillover into monetary policy
Fiscal Policy	Constrained	Crowding out of domestic expenditure
Global Influence	Reduced	Flight to quality role is affected

Source: (Table 3) Goldberg, Linda. "The International Role of the Dollar: Does it Matter if this Changes?" Federal Reserve Bank of New York, Staff Reports: 522, 2011

As previously mentioned, COFER statistics indicate a minor decline within the total allocated reserve claims in dollars for all countries. The decline of the dollar as a primary reserve currency could potentially follow some serious implications for the U.S. economy and international policy.

1.5. Determinants of Reserve Currency

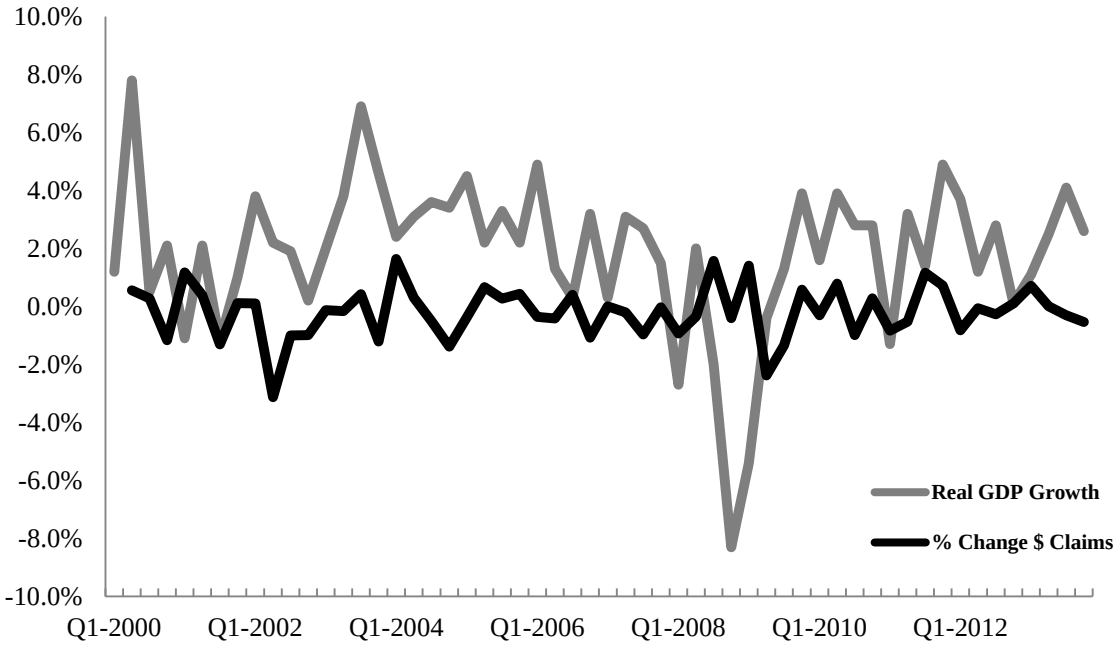
"As the sterling fell in the past, so too can the dollar lose its dominant position in the future. Its reserve currency status is attributed to the vibrant US economy, liquidity of financial markets, and stability in US monetary policy (Lee 2014)." Lee summarizes why central banks choose the dollar as the primary reserve currency in the above quote. Yet more formally, Chinn and Frankel (2008) explicitly listed the four determinants of a currency's suitability as the primary reserve currency: (1) output and trade, (2) financial markets, (3) confidence, and (4)

network externalities. Output and trade are measured as a country's GDP share of world GDP. This first determinant is most easily understood; the country with the largest economy and trade will be changing hands with more countries than a country with a smaller trading economy, and thus will acquire a natural placing in official reserves. "A country's financial market must be open, unrestricted, deep, and developed for its currency to attain international currency status (Lee, 2014)." As a proxy to measure openness and depth of the second determinant, foreign exchange turnover in the respective country's financial centers is often used. A primary reserve currency must be stable in order to ensure confidence for holders; therefore inflation and exchange rate volatility are used to measure the third determinant of stability. Finally, network externalities are understood to be the fourth determinant and defined as the continued use of a currency based on the principle that others are using it as well. The inertial bias to use a popular currency achieves economies of scale and scope for the primary currency, however it is not enough to maintain the primary position (Chinn, Frankel 2008).

1.6. Motivation

Chinn and Frankel have provided some good proxies for reserve currency determinants that have shown significance through empirical testing. However, an initial look at real GDP growth with changes in the percent of dollars claimed as allocated reserves showed an interesting relationship and possibility as another reserve currency determinant. Figure 1 plots a relationship in which real GDP growth and changes in the percent of dollars claimed seem to follow each other with differing magnitudes; in addition, dollar claims seem to follow a lagged relationship to real GDP growth.

Figure 1: Real GDP Growth vs. % Change of Claimed Dollar Share



An initial look at this relationship provided motivation to proceed with further research to determine if real GDP growth and other macroeconomic indicators could be significant in determining the percentage of dollars claimed as allocated reserves. The literature on international reserves tends to follow the Chinn and Frankel (2008) model, and little has been done to test the explanatory power of macroeconomic indicators as measures of growth, stability, and creditworthiness. If these macroeconomic indicators as dollar determinants prove to be significant, then we may have another viable way to predict the dollar's future status as a primary reserve currency.

2. LITERATURE REVIEW

Under the Bretton Woods system, the rule of thumb for optimal reserve holdings was generally three to four months of import coverage (Aizenman, Genberg 2012). Heller (1966) first thought of international reserves as a buffer stock, in order to manage pegs or floating exchange systems; reserve managers used a cost-benefit analysis when managing the optimal level of reserves. For a large portion of time after Heller, the majority of researchers supported this buffer stock theory until key economists began to take note of the variation of reserves between countries of differing regimes (Flood, Marion 2002) and the anomalous expansion of reserves in Asia (Edison 2000).

Furthermore, Edwards (2004) simultaneously investigated the idea of sudden stops, capital reversals, and the threat they posed even to developed economies. The East Asian Financial Crises were motivational examples for economists to further consider optimal reserve levels to prevent further crisis. Out of fear and protection came the "Guidotti-Greenspan rule of thumb—that countries should hold liquid reserves equal to their foreign liabilities coming due within a year (Aizenman, Genberg 2012)." Jeanne and Rancière (2011) provided a utility estimation approach to determine the optimal level of reserves; a reserve-to-GDP ratio of 10% was deemed as the long run average and therefore the optimal level of reserves.

Another different and more recent approach to optimal reserve policy was the view that the choice was mercantilist based: reserves accumulation was the result of export promotion, which created more plentiful jobs in traditional sectors (Dooley, Folkerts-Landau, and Garber, 2003). What's more intellectually interesting was the thought that countries accumulated

reserves in order to "keep up with the Joneses," otherwise the country with lesser reserves would be susceptible to speculative flows (Aizenman, Genberg 2012). This idea came after Cheung and Qian (2009) proposed an interdependence of the demand for international reserves among East Asian countries.

Now, we go back to the 1990's when some economists looked at the dollar's declining reserve currency status and proposed replacement by the Deutsche Mark (Kindleberger 1995) or possibly by the yen (Hale 1995). Time went on, but the 2000's still saw continued dollar dominance. However, the debate about which currency would be the next contender for the dollar did not stop. By a combination of optimal reserve theory and contending reserve currency speculation, Chinn and Frankel sought "empirically to ascertain the determinants of international reserve currency shares in the past, in order to ascertain the conditions and timing under which the euro might possibly surpass the dollar in the future (2008)." The general model found significance of determinants being (1) output and trade, (2) financial markets, (3) confidence, and (4) network externalities. Ever since, economists have tweaked the general model to predict the rise of other currencies like Jong-Wha Lee (2014) applies to the renminbi.

Macroeconomic indicators have not been tested as reserve currency determinants over the course of international reserve studies, so I this study provides a first look at the relationship between macro indicators and reserve currency. However, the closest literature that I could find was the use of indicators as signals for currency crises. In the Budsayaplakorn, Dibooglu, and Mathur (2010) paper, real GDP growth was the third most useful indicator to predict a currency crisis; in addition, these authors also found that the domestic credit to GDP ratio was significant. Currency crises are similar to reserve currency usage, in the sense that indicators of government

policies and the macroeconomic environment play a role in deciding which currencies are most fit for use or should be fled from.

2.1. Reserves Data

Deciding which data source to use as a measure of official reserves is a complex decision. The International Monetary Fund's International Financial Statistics (IFS) aggregates world reserves using the instruments mentioned in COFER in addition to gold, special drawing rights, and IMF reserve positions. IFS captures the totality of world reserves, but specific information on dollar claims is estimated in smaller and more specific data sets that are incomplete across the board. Wooldridge (2006) divides the three sources of detailed reserve data as national sources, surveys, and counterparty data; the COFER database captures the most data at approximately 67.0% of total identified holdings. Table 4 is a summary from Philip's findings on reserve data sources.

Table 4: Summary of Wooldridge's Findings

	World total	National data	Survey data		Counterparty data	
	IMF IFS	**SDDS**	**IMF COFER**	**IMF SEFER**	**US TIC**	**BIS LIB**
Identified holdings (USD bn)	4,347	2,832	2,911	2,145	1,938	1,079
– as % of total	100	65.2	67	57.2	49.1	24.8
Countries included	184	65	114	?	184	184
Industrial	24	24	24	23	24	24
Developing	160	41	90	45	160	160
China	Yes	No	No	No	Yes	No
Taiwan, China	Yes	No	No	No	Yes	Yes
By instrument	No	Yes	No	Yes	Yes	Yes
By currency	No	No	Yes	No	Yes	Yes
Frequency	Monthly	Monthly	Quarterly	Annually	Annually	Quarterly
Disclosure lag	1 week	1 Month	3 months	1 year	1 year	4 Months

Source: (Table 1) Wooldridge, Phillip. "The changing composition of official reserves." BIS Quarterly Review, September 2006

Data on official foreign exchange reserves has not always been the easiest information to obtain. Most countries disseminate data on reserves, of which are generally aggregate figures. However, certain key economic players like China and Taiwan do not report their claims included in COFER, which can amount up to 20% of world reserves for China alone (Wooldridge 2006). It is important to note the incompleteness of datasets without China and Taiwan, especially considering that emerging and developing economies account for 67% of total reserves in the 2014 COFER estimates.

As the world has changed and economies evolved, there have also been breaks in the COFER datasets. The first break occurred after 1979 with the creation of the European Monetary Cooperation Fund. The second break occurred in 1995 under a methodology change and a more

limited use of estimations. Finally, the third break occurred in 1999 with the creation of the use of the euro as currency for the euro area and European Monetary Union (Truman, Wong 2006). Significant changes of U.S. dollar shares from one annualized period to the next were seen throughout these breaks in COFER data. Therefore, this study will use COFER data beginning in 2000 in order to avoid using the significant break in the dataset from the inclusion of the euro in 1999.

3. METHODOLOGY

This paper seeks to find an alternative empirical framework of currency determinants for estimating the U.S. dollar share of official reserve claims using ordinary least squares regression. The empirical research takes place in two stages; first, establishing a baseline regression of real U.S. GDP growth on the percent of allocated reserve claims in dollars and examining the results. Second, by adding additional variables to the baseline regression to determine their significance in estimating the percent of allocated reserve claims in dollars. The final model utilized is displayed below in Equation (1). Using the OLS framework, I will obtain estimates of the currency share determinants. Then I will examine the significance of determinant coefficients by conducting individual hypothesis tests at the 95% confidence level. I will follow with lag tests of the independent variables of up to four quarters to determine the significance in a similar fashion. The significant determinants will be useful to infer a positive or negative association with level of currency share.

$$Y_t = ß_0 + ß_1 Y_{t-1} + ß_2 RGPG\_US_t + ß_3 ERVOL_t + ß_4 UE_t + ß_5 CA_t + ß_6 DEBT_t + ß_7 BUDGET_t + U_t \quad (1)$$

3.1. Data and Variables

I will use COFER data on official allocated reserve dollar claims as the dependent variable as opposed to estimates from other data sources. The dependent variable will be expressed as a proportion, the share of allocated reserves denominated in U.S. dollars. Although reporting from China, Taiwan, and other international players are missing from COFER, so are they missing from all other relevant data sources (Wooldridge 2006). The advantage of COFER

over the other datasets include timeliness and, most importantly, the most identified holdings overall. Furthermore, the time period from COFER will be post-euro adoption. 1999 marked a third major break in the data due to reclassification by the IMF within COFER (Truman, Wong 2006). Therefore, I will be using quarterly time periods from 2000 to 2013 in order to obtain estimators for more modern times without the 1999 structural break.

The independent variables will be sourced from the Federal Reserve Economic Data (FRED) database and International Monetary Fund's International Financial Statistics (IFS). "FRED contains more than 217,000 regional, national, and international economic data series, with data coming in from 67 reporting agencies around the world," making it one of the most comprehensive databases and a standard for U.S. economic data (Stierholz 2014). FRED is used to source quarterly data on the macroeconomic indicators of real GDP growth (RGDPG_US), exchange rate volatility (ERVOL), unemployment rate (UE), current account to GDP ratio (CA), public debt to GDP ratio (DEBT), and budget surplus/deficit to GDP ratio (BUDGET), all in real terms. The GDP growth rates of other various economic regions will be gathered from the IMF's IFS, in order to preliminarily test their significance on estimating the dollar's currency share of allocated reserve claims. These economic areas will include growth of the World (RGDPG_W), Advanced Economies (RGDPG_ADV), Euro Area (RGDPG_EU), Emerging and Developing Asia (RGDPG_EDA), and the Middle East and North Africa (RGDPG_MENA).

I will use STATA for the econometric analysis, using the *regress* command to conduct OLS regressions and the post estimation *robust* command for robust standard errors. The post estimation *test* command will used to conduct tests of joint significance as well.

3.2. Establishing a Baseline Regression

The initial hypothesis of U.S. real GDP growth having an effect on the dollar currency share of allocated reserves would be modeled by the Equation (2). In which Equation (2), Y_t is the dependent variable (CLAIMS) for time period *t*, and $ß_1$ is the estimated coefficient for the U.S. real GDP growth rate (RGDPG_US. However, this simplistic model has three critical issues that must be addressed for OLS to be the best linear unbiased estimator.

$$Y_t = ß_0 + ß_1 RGPG\_US_t + U_t \quad (2)$$

First, the error term U_t must be mean independent across the observations, otherwise we have a problem of autocorrelation and the estimators will be unbiased but inefficient. When an initial Durbin-Watson test for autocorrelation is conducted, the Durbin Watson test statistic of near 0, at 0.07, determines that there is strong positive autocorrelation. Second, is the issue of heteroscedasticity that will also generate an unbiased estimator but bias the standard error. The Breusch-Pagan test and White test are used to test for heteroscedasticity in this model. However the Breusch-Pagan test is for linear forms of heteroscedasticity, so I used the White test in addition to combat the instance of nonlinearity. The *hettest* and *whitetst* commands to conduct the tests are both based on the null hypothesis that the variance is constant. Therefore, when the probability is large as in this case, we fail to reject the null hypothesis of constant variance. Third, is the possible issue of a nonlinear relationship, in which the link test and Ramsey RESET test used to test the specification. From the results of the link test, the test of *_hatsq* coefficient is not significant; meaning, the link test has failed to reject the assumption that the model is specified correctly. The Ramsey RESET test provided an insignificant p-value of 0.77, indicating

that the model is adequate according to the test diagnostic. Given these results, it appears that the OLS model is a suitable specification to proceed forward.

Now, after testing Equation (2) I have concluded that the model suffers from autocorrelation. To remedy this problem, a lagged dependent variable is added to the original regression in Equation (2). The lagged dependent variable acts as an essential dynamic of reserve currency usage, which is theorized as inertial bias by Chinn and Frankel (2008). The reserve currency share is influenced by the continued use of it, and therefore likely captured in the single quarter lagged dependent variable (L.CLAIMS). Not including the lagged dependent variable in a model with such strong positive autocorrelation would have some serious problems. So, the inclusion of a lagged dependent variable becomes necessary although it likely means OLS is biased but consistent. The Durbin-Watson test is not applicable for models using a lagged dependent variable. Therefore the Durbin alternative test is used, and it indicates no autocorrelation. Similar to the Durbin alternative but used for high orders of autocorrelation, the Breusch–Godfrey test indicates no autocorrelation when tested even up to 12 periods of lags. While it is possible that there is some autocorrelation overlooked and undetected, the remaining autocorrelation has been reduced to a minimal amount with the inclusion of the lagged dependent variable.

In regards to heteroscedasticity, the Breusch-Pagan test rejects the null hypothesis of constant variance at the 5% significance level. At the 10% significance level, however, I cannot reject the null hypothesis and assume constant variance. The White test gives a contradictory result of moderate probability, and so I fail to reject the null hypothesis of constant variance. This raises minor concern about the ability to meet the assumption of homoscedasticity. So,

robust standard errors are used moving forward, which do not assume homoscedasticity. With robust standard errors, the estimator coefficients are exactly the same as OLS. The changes stemming from the use of robust standard errors, however, are reflected in the adjusted t-tests and standard errors.

Finally, the issue of stationarity must be addressed in addition to the OLS assumptions. The time series spans over a period of thirteen years, so it is possible that the relationship between reserve shares and GDP growth is a non-stationary process. The Dickey-Fuller test is performed to test the null hypothesis that the variables contain a unit root, against the alternative that the process is stationary. In each test, the results indicate a rejection of the null hypothesis at all common significance levels and deem a stationary process. A final baseline model is shown in Equation (3) after tackling the issues with the model in Equation (2). Examples of the baseline regressions with and without robust error adjustments are displayed in Table 5.

$$Y_t = ß_0 + ß_1 RGPG\_US_t + U_t \quad (2)$$

$$Y_t = ß_0 + ß_1 Y_{t-1} + ß_2 RGPG\_US_t + U_t \quad (3)$$

4. RESULTS

4.1. Baseline Regression

The first stage of empirical research sought to establish a baseline regression, which we determined Equation (2) to be representative of our baseline when used in combination with robust standard errors. The results of this baseline regression are shown in Table 5 in the previous section under Column (2).

Table 5: Baseline Regression, Robust Standard Error Comparison

Explanatory Variables	Coefficients w/o Robust SE	Robust SE
	(1)	(2)
RGDPG_US	-0.003	-0.003
	(0.047)	(0.049)
L.CLAIMS	0.951***	0.951***
	(0.035)	(0.040)
Constant	0.030	0.030
	(0.023)	(0.026)
N	55	55
R^2	93.5%	93.5%

(Standard errors in parentheses)
* Significant at 10% ** Significant at 5% *** Significant at 1%

The coefficient of real U.S. GDP growth on the claims of dollar reserves is -0.003; meaning, given a single unit increase in the real U.S. GDP growth rate, we can expect the level of claims to decrease by 0.3% on average. This implies a negative relationship of real GDP growth on the level of dollar claims; however, significance testing up to the 10% significance level has determined that the real GDP growth variable coefficient is not statistically significant

from zero. It appears that the real GDP growth rate has no explanatory power. Furthermore, the results from this regression also indicate that the single period lagged dependent variable of claims is statistically significant, even at the 1% significance level. The coefficient on the lagged dependent variable is 0.951. This means that there is 95% persistence level of claims based on the previous period. The model also shows a particularly high R^2, which indicates that about 93.5% of the variation in reserve claims can be explained by the model.

Recall that in our motivational graph we saw what appeared to be a lagged relationship between real U.S. GDP growth and the level of dollar reserves. Therefore, after establishing the baseline I decided to test out the effects of lagging on the real GDP growth rate. The lagged dependent variables act as instruments to test causality of GDP growth on the level of claims. I lagged the GDP growth rate up to four periods to see if this would make the estimator statistically significant or improve the explanatory power of the model. The results of these individual tests all showed that the GDP growth was consistently statistically insignificant throughout, as displayed in Table 6. A test of joint significance of the lagged growth variables generated a probability of 0.2898, indicating that not even one of the growth variables was statistically different from zero. Despite lagging the growth variable, only the lagged dependent variable seems to be consistently significant on estimating the level of reserves.

Table 6: Real U.S. GDP Growth Lag Tests[1]

Explanatory Variables	Coefficients				
	Baseline	Lagged (1)	Lagged (2)	Lagged (3)	Lagged (4)
RGDPG_US	-0.003				
	(0.049)				
L.RGDPG_US		-0.006			
		(0.069)			
L2. RGDPG_US			0.063		
			(0.065)		
L3. RGDPG_US				0.081	
				(0.051)	
L4. RGDPG_US					0.033
					(0.043)
L.CLAIMS	0.951***	0.951***	0.938***	0.923***	0.932***
	(0.040)	(0.040)	(0.043)	(0.043)	(0.049)
Constant	0.030	0.030	0.037	0.046	0.042
	(0.026)	(0.026)	(0.028)	(0.028)	(0.031)
N	55	55	54	53	52
R^2	93.5%	93.5%	93.4%	93.1%	92.2%

(Standard errors in parentheses)
* Significant at 10% ** Significant at 5% *** Significant at 1%

Dependent variable lags were tested up to four periods, and the results are displayed in Table 7. Compared to the baseline regression, longer lags of the dependent continued to remain statistically significant. I was surprised by the consistent statistical significance of the lagged

[1] A regression on CLAIMS using all lagged U.S. growth rates and a lagged dependent results in a combined coefficient of 0.065 for all growth variables; joint significance testing showed no difference from zero. L.CLAIMS is statistically significant, and the model has an R^2 of 93.08%.

dependent variables. Based upon the results of testing the dependent and independent lags, I conclude that the baseline regression of a contemporaneous GDP growth variable and a single period lagged dependent variable is the most explanatory model thus far. I proceeded by using the model in Equation (3) for the addition of other possible explanatory variables.

Table 7: Dependent Variable Lag Tests

Explanatory Variables	Coefficients			
	Baseline	Lagged (2)	Lagged (3)	Lagged (4)
RGDPG_US	-0.003	-0.039	-0.043	-0.046
	(0.049)	(0.052)	(0.078)	(0.069)
L.CLAIMS	0.951***			
	(0.040)			
L2.CLAIMS		0.898***		
		(0.053)		
L3.CLAIMS			0.845***	
			(0.063)	
L4.CLAIMS				0.800***
				(0.074)
Constant	0.030	0.063	0.0964*	0.124*
	(0.026)	(0.034)	(0.040)	(0.047)
N	55	54	53	52
R^2	93.5%	88.2%	84.0%	79.6%

(Standard errors in parentheses)
* Significant at 10% ** Significant at 5% *** Significant at 1%

4.2. Modified Baseline Regressions

4.2.1. Global Growth Rates

Using real U.S. GDP growth added no significant explanatory power to the model, but there are other economic areas that could explain the changes in the dependent variable. I mentioned earlier that claims were starting to shift more in proportion to unallocated reserves; Woon, Sharma, and Strömqvist (2007) note a large accumulation of these reserves by emerging and developing economics. I used some growth rate variables like that of the World (RGDPG_W), Advanced Economies (RGDPG_ADV), Euro Area (RGDPG_EU), Emerging and Developing Asia (RGDPG_EDA), and the Middle East and North Africa (RGDPG_MENA) in order to get a broad range of explanatory variables. However the results once again generated insignificant values, and the only consistently significant variable was the lagged dependent. Even the constant was statistically insignificant. The results of the individual regressions are displayed in Table 8. A test of joint significance on all of the growth rates generated a probability of 0.3847, meaning the variables are jointly not statistically significant from zero.

Table 8: Global Growth Rate Regressions

Explanatory Variables	Baseline	World	Advanced	Euro Area	Asia	Middle East & North Africa
RGDPG_US	-0.003	-0.032	-0.048	0.013	0.001	-0.004
	(0.049)	(0.053)	(0.058)	(0.051)	(0.048)	(0.050)
L.CLAIMS	0.951***	0.952***	0.938***	0.959***	0.948***	0.952***
	(0.040)	(0.040)	(0.043)	(0.044)	(0.038)	(0.041)
RGDPG_W		0.095				
		(0.117)				
RGDPG_ADV			0.115			
			(0.111)			
RGDPG_EU				-0.122		
				(0.247)		
RGDPG_EDA					-0.028	
					(0.056)	
RGDPG_MENA						-0.018
						(0.026)
N	55	55	55	55	55	55
R^2	93.5%	93.6%	93.7%	93.5%	93.5%	93.5%

(Standard errors in parentheses)
* Significant at 10% ** Significant at 5% *** Significant at 1%

4.2.2. Stability and Growth Indicators

The next round of trials included several indicator variables, tested both individually and together to determine their significance on predicting the level of reserve shares. These quarterly macroeconomic indicators include exchange rate volatility (ERVOL), unemployment rate (UE), the dollar per barrel price of crude oil (OIL), current account to GDP ratio (CA), public debt to

GDP ratio (DEBT), and the budget surplus/deficit to GDP ratio (BUDGET). Each of these indicators was tested for lags up to four periods to determine significance. Additionally lagged periods always resulted in a lower adjusted R^2 value for the model. The constant consistently came up insignificant while the lagged dependent was always significant for all other variables and their respective lags.

Once each variable was tested for lags, I regressed all of the indicators on CLAIMS. Now that the model includes additional indicators, the explanatory power of the model has increased slightly. An R^2 comparison across the models tells us that the baseline regression had among the highest explanatory power; the all-inclusive expanded model had the most explanatory power. When the debt to GDP ratio and unemployment rate variable were added to the baseline regression, the R^2 value actually increased. For the first three and last indicator models, the inclusion of other variables deemed not significant either does not add or takes away from the explanatory power of the model. A test of joint significance determined that these indicator variables jointly did not differ from zero. The tabulation of results is displayed in Table 9.

Table 9: Indicator Regressions

Explanatory Variables	Baseline	Σ	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
RGDPG_US	-0.003	0.005	-0.004	-0.012	-0.005	-0.002	-0.005	-0.006
	(0.049)	(0.054)	(0.050)	(0.052)	(0.051)	(0.050)	(0.051)	(0.049)
L.CLAIMS	0.951***	0.745***	0.952***	0.939***	0.942***	0.901***	0.900***	0.910***
	(0.040)	(0.120)	(0.039)	(0.045)	(0.048)	(0.074)	(0.063)	(0.076)
ERVOL		0.000	0.000					
		(0.002)	(0.002)					
BUDGET		0.062		0.062				
		(0.118)		(0.118)				
CA		-0.065			-0.065			
		(0.109)			(0.109)			
DEBT		-0.013				-0.013		
		(0.012)				(0.012)		
UE		-0.135					-0.135	
		(0.108)					(0.108)	
OIL		0.000						0.000
		(0.000)						(0.000)
N	55	55	55	55	55	55	55	55
R^2	93.5%	94.1%	93.5%	93.5%	93.5%	93.6%	93.7%	93.5%

(Standard errors in parentheses)
* Significant at 10% ** Significant at 5% *** Significant at 1%

4.2.3. Final Regression

The final OLS regression included every variable, and the results were somewhat surprising. Only until this final regression, the coefficient on the lagged dependent dropped to 0.710 from the usual 0.951 persistence level. In addition, the coefficients of the constant term

and debt-GDP ratio (DEBT) were significant at the 5% level. The debt coefficient is negative, and implies a 7.5% decrease in the expected level of dollar reserves given a 1% increase in the public debt to GDP ratio. The negative coefficient is expected and coincides with the literature that reserve currency managers prefer currencies from growing and table economies. A growing debt worries many that the federal government will have trouble repaying its debts, and therefore is a signal for the market to switch to a more perceivably stable currency (Budsayaplakorn, Dibooglu, and Mathur 2010).

Furthermore, the Middle East and North Africa growth rates were statistically significant at the 10% significance level. The negative 0.082 coefficient for the Middle East and North African growth rate actually brings the level of dollar reserves down by 8.2% on average for every 1% increase of the growth rate. Besides China, Middle Eastern countries like Saudi Arabia are expected to account for large shares of unallocated reserves. When countries in this region grow economically, they are most likely to accumulate unreported reserves, which account for unallocated reserves. Therefore the negative coefficient is an accurate estimator of the relationship, because an increase in the MENA region's growth rate will take away from the share of dollars as allocated reserves. The entire tabulation of the regression results is listed below in Table 10.

Table 10: Final Regression

Explanatory Variables	Baseline	Σ All
RGDPG_US	-0.003	0.013
	(0.049)	(0.069)
L.CLAIMS	0.951***	0.711***
	(0.040)	(0.133)
RGDPG_EU		-0.174
		(0.384)
RGDPG_UK		-0.178
		(0.314)
RGDPG_ADV		-0.301
		(0.450)
RGDPG_EDA		-0.386
		(0.250)
RGDPG_MENA		-0.068*
		(0.045)
RGDPG_W		0.753
		(0.599)
ERVOL		0.000
		(0.002)
BUDGET		-0.038
		(0.168)
CA		0.462
		(0.329)
DEBT		-0.075**
		(0.035)
UE		-0.090
		(0.174)
Constant	0.03	0.279**
	(0.026)	(0.125)
N	55	53
R^2	94%	95%

(Standard errors in parentheses)

* Significant at 10% ** Significant at 5% *** Significant at 1%

4.3. Logit Specification

The linear specification was used throughout this research for several reasons, including the simplicity of the model given an undergraduate understanding of econometrics. Also, a look at the values of the dependent variable shows us that the level of claims followed a relatively straight, downward trend that allowed the liner specification to be an appropriate estimate for our purposes. The OLS regression was the best linear unbiased estimator given the assumptions, which never provided an estimate of reserve claims that were outside the bounded possibilities of zero and one. However, given that the dependent variable is a ratio bounded between zero and one, it was possible to use the logit specification for my research purposes as well. Normally the logit specification is for binary outcomes representing a probability of acceptance or not, but could also be used to predict dependent variables as proportions like the level of dollar reserve claims. Therefore, I decided to use the baseline OLS regression in a logit model to test the significance of real U.S. GDP growth on predicting the level of reserve claims, including a lagged dependent variable. Although the logit specification was tested after OLS, it was important to develop a baseline logit regression as a way to scope out possibilities for further research. The result from the generalized linear model linked to the logit specification, using robust standard errors, is displayed in Table 11 below. The results indicate a similar finding to what we have seen before. Once again, the real U.S. GDP growth is statistically not significant from zero, but the lagged dependent variable and constant are statistically significant.

Table 11: Logit Specification

Explanatory Variables	Coefficients	
	OLS Baseline	Logit Baseline
	(1)	(2)
RGDPG_US	-0.003	-0.021
	(0.047)	(0.217)
L.CLAIMS	0.951***	4.273***
	(0.035)	(0.185)
Constant	0.030	-2.162***
	(0.023)	(0.119)
N	55	55
R^2	93.5%	

(Standard errors in parentheses)
* Significant at 10% ** Significant at 5% *** Significant at 1%

5. CONCLUSIONS

This paper sought to develop an empirical framework to model the estimated level of allocated reserve claims in dollars determined by macroeconomic indicators like real gross domestic product growth. Using the ordinary least squares regression model, I discovered that only a few of the macroeconomic indicators tested showed statistical significance. The real GDP growth rates of the Middle East and North Africa had some explanatory power according to the results. The debt-to-GDP of the U.S. also tested statistically significant in predicting the level of allocated reserve claims in dollars. However, the results for these variables were not robust in the sense that they consistently came up statistically significant. Although the indicator variables were not able to explain the U.S. dollar share of reserves, there is a possible use of indicators to estimate the level of reserve share for an alternative currency. Alternative currency shares may be more responsive to the changes of our indicators than the U.S. dollar.

Most importantly, the one variable that consistently showed statistical significance at the 1% significance level was that of the lagged dependent variable. Once the lagged level of reserve claims was included in the model, the generated R^2 value often meant that the model was able to account for 93% or more of the variation for the level of allocated reserve claims in dollars. The coefficient on the lagged dependent variable indicated very high persistence effects on the current level of reserves. Given the robustness of the statistical results, it is probably valid to conclude that the current level reserves in a given period are highly determined by the levels of the preceding period.

The literature on currency reserves theorizes that of an “inertial bias” of currency usage; reserve managers tend to use whatever currency is the status quo. The dollar, as a primary

reserve currency, has an inertial bias that I believe is captured empirically within the persistence of the lagged dependent variable. According to Chinn and Frankel's research (2008), "the implication is that small changes in the determinants will not produce corresponding changes in the reserve currency numbers, at least not in the short run." This may explain why the quarterly changes of indicators like real GDP came up statistically insignificant; a long run trend of unfavorable indicators is likely better at explaining the decline in the share of allocated reserve claims in dollars. Nonetheless, I believe my research has concluded with the findings of many other economists studying the use of the dollar as a primary reserve currency. At least for the near future, inertial bias will result in the continued use of the dollar as the primary reserve currency.

Subsequently, this leads me to discuss opportunities for further study on this matter. Foremost, I would additionally address the issue of stationarity and resulting bias, through the use of time dummy variables for each year and another for the Great Recession. These time dummies could help explain, for example, if the recession had a significant impact on the way these macro indicators were able to explain the level of dollar reserves. Second, I would like to replicate this study using the logit model as an alternative to ordinary least squares. The logit model would ensure an outcome of the dependent variable that is bounded between zero and one, while carrying most of the same assumptions as ordinary least squares. The results may very likely be the same or fairly close to the OLS regressions, but it is important to test out the model in the best specification possible and logit may very well be that specification. Third, as more data comes available I would like to test the indicators over a longer span of time utilizing longer lags as well; the short run fluctuations within these indicators may not have an immediate effect

on the level of currency reserves, but a longer time span and lag may show that the indicators do not have a significant effect until some time later.

Finally, I mentioned that unallocated reserves have grown to be an almost equally large share of total reserves. Given this information, I would like to test the ability of macroeconomic indicators to help explain the increasing share of unallocated reserves. Although we cannot know the exact proportion of dollars held as unallocated reserves, we can assume a very significant amount and likely more than the proportion held as allocate reserves. Therefore, these macroeconomic indicators might have much more explanatory power on predicting the proportion of unallocated reserves.

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