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A3 1 For All The Money In The World

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Abstract

In this paper, the mass of all cash (coins and banknotes) in circulation around the globe in 2021 is estimated to be $7.56 \pm 0.15 \times 10^9$ kg. Using figures from the US Federal Reserve and the US Mint, we calculated the mass of all cash in the USA. We then extrapolated this value, using a number of assumptions, to the globe's top 21 most predominant currencies to find an estimate for the mass of all cash in the world.

Introduction

The Bank of International Settlements (BIS) tracks the amount of physical currency (coins and banknotes, known as M0 in financial terms [1]) of the world's most important and most used currencies. Instead of laboriously searching through economic data for all 21 of these currencies' Central Banks, we decided to simplify this investigation by assuming all of these currencies share the same properties as the United States Dollar (USD). This is because the USD is the primary global currency, making up 27.0% of global M0 [2]. As a result, we assumed that:

- (1) All currencies have the same ratio of coins to banknotes as the USD
- (2) All currencies' coin and banknote denominations have the same mass as the USD

Methodology Overview

The US Federal Reserve does have a surprisingly definitive number for the total value of all USD coins and banknotes in circulation; in 2021 these figures were \$43,424,561,760 in fractional coins and \$2,148,023,822,440 in banknotes [3]. This means that 98.0% of USD cash is in the

form of banknotes, with only 2.0% in the form of coins!

We can estimate the total mass of USD coins in circulation (M_{coin}) and the total mass of USD banknotes in circulation (M_{note}); these two values can then be summed to find the total mass of all USD cash (M_{USD}). This can be extrapolated using assumption (1) to find the total mass of all cash on the planet (M_{TOT}).

Estimating the mass of USD coins

Despite the Federal Reserve having such a definitive value for all USD cash, it does not maintain a detailed inventory or estimate of how many coins there are of each denomination (1¢, 5¢, etc.) in circulation. As a result, we relied on coin production statistics from the US Mint to determine the number of each coin denomination in 2021 [4]. This is vital because the mass of different coin denominations varies [5], which could significantly impact our estimate. Therefore, we make a third assumption:

- (3) The percentage of each coin denomination minted in 2021 reflects the total percentage of that coin denomination in circulation

For example, 51.8% of coins minted in 2021 were 1¢ coins. Therefore, we assumed that 51.8% of coins in circulation were 1¢ coins. Using 2021 statistics from the US Mint and the total value of coins in circulation, we were able to determine the number of each coin denomination and then calculate their total mass, as seen in Table 1.

Coin	Coin prevalence [4]	Number of each coin	Coin mass (g) [5]	Total mass (kg)
1¢	51.8%	3.18×10^{11}	2.500	7.95×10^8
5¢	11.8%	0.73×10^{11}	5.000	3.65×10^8
10¢	20.9%	1.28×10^{11}	2.268	2.90×10^8
25¢	15.5%	0.95×10^{11}	5.670	5.39×10^8
Total	100%	6.14×10^{11}	NA	19.89×10^8

Table 1: Estimation of total mass of USD coins, where M_{coin} is shown to be 19.89×10^8 kg

Estimating the mass of USD banknotes

As the Federal Reserve knows the exact total value of each banknote denomination [3], this process is much easier. However, we simplified this process further by only focusing on banknotes values of \$100 or smaller. This is because larger banknotes, such as \$10,000 bills, do exist but their numbers (and combined value) are so low that they are completely negligible. As all USD banknotes weigh 1g [6], it is relatively easy to calculate their total mass, seen in Table 2.

Banknote	Combined worth [3]	Number of each banknote	Total mass (kg)
\$1	\$13,893,909,429	13,893,909,429	1.39×10^7
\$2	\$2,797,974,216	1,398,987,108	1.40×10^6
\$5	\$16,795,750,805	33,59,150,161	3.36×10^6
\$10	\$22,870,000,880	2,287,000,088	2.29×10^6
\$20	\$239,058,451,360	11,952,922,568	1.20×10^7
\$50	\$120,023,011,650	2,400,460,233	2.40×10^6
\$100	\$1,732,272,645,000	17,322,726,450	1.73×10^7
Total	\$2,148,023,259,840	52,615,156,037	5.27×10^7

Table 2: Estimation of total mass of USD banknotes in circulation, where M_{note} is shown to be 5.27×10^7 kg

Extrapolation of USD cash to global currencies

We can now calculate M_{USD} :

$$M_{USD} = M_{coin} + M_{note} = 2.04 \times 10^9 \text{ kg} \quad (1)$$

Employing assumptions (1) and (2), we can extrapolate the USD's 27.0% proportion of global M0 to that of the other top 20 currencies. This gives us a total mass for all cash on the planet to be:

$$M_{TOT} = \frac{M_{USD}}{27.0} \cdot 100 = 7.56 \times 10^9 \text{ kg} \quad (2)$$

Error analysis and Conclusion

Ultimately, determining errors for such a calculation where so many assumptions have been made seems difficult to quantify. However, one key error that can be determined is by looking at the difference between the BIS and Federal Reserve M0 values for the United States, which differ by 2.0%.

Considering this error, our estimate for the total mass of all cash on Earth in 2021 is $7.56 \pm 0.15 \times 10^9$ kg.

References

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