4. CURRENCY-EQUIVALENT VS. DIVISIA MONETARY AGGREGATES: THEORETICAL EVALUATION AND EMPIRICAL EVIDENCE FROM THE UNITED STATES AND CHINA[1]

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Abstract

The paper derives and compares the theoretical models of currency-equivalent and Divisia monetary aggregates in a new way. We show that currency-equivalent monetary aggregates are superior to Divisia monetary aggregates. Moreover, we compare the stability of demand functions of different monetary aggregates in the United States and China, through Pesaran (1998, 2001)'s methods of "bounds testing for level relationships" and "ARDL approach to cointegration". We show that in both countries the demand functions of currency-equivalent monetary aggregates are more stable than those of Divisia and simple-sum monetary aggregates. Moreover, currency-equivalent monetary aggregates are more controllable than Divisia and simple-sum monetary aggregates in both countries.

Keywords: Currency-equivalent; Divisia; monetary aggregates

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I. Introduction

Nowadays China's primary monetary policy is quantitative monetary policy whose intermediate target is simple-sum M_2 because interest rate liberalization hasn't come true in China. However, the correlation between simple-sum M_2 and macroeconomic variables such as GDP, interest rate and CPI is becoming increasingly smaller. It's hard for China's monetary authority to find out a new ideal intermediate target. Although the United States has carried out pricing monetary policy whose intermediate target is the federal funds rate because of interest rate liberalization, it is hard for the Federal Reserve to stimulate economy when the rate is falling to near zero. Therefore quantitative monetary policy such as QE has obtained its status again. In a word, quantitative monetary policy is important in great nations such as the United States and China. And it has practical significance to look for a better monetary aggregate to replace the less effective simple-sum monetary aggregate.

At present, the money supply (referred to in this paper as monetary aggregates), as announced by the central banks of countries throughout the world, are just the simple sum of different monetary assets[4]. However, there are differences in the liquidity of different monetary assets[5], meaning they cannot be exact substitutes for each other. The simple sum of monetary aggregates only considers the effect of the total amount of money, without considering the effects of monetary liquidity structures. The theoretical defect of simple-sum monetary aggregates is an important contributing factor to its ineffectiveness as a monetary policy intermediate target. Friedman and Schwartz (1970) were the first to become aware of the problem, and suggested giving weight in the interval of [0, 1] to assets with different liquidity in order to conduct a weighted summation. Obviously, cash is the most liquid asset, so the weight is set to be 1; non-monetary assets do not have liquidity in the sense of money, and so the weight is set to be 0; the weights of other kinds of deposits will be located in the interval of (0, 1), whereas with no clear explanations or rules for their specific values. Therefore, how to transform liquidity of monetary assets from qualitative analysis into quantitative analysis is the key for correcting the simple aggregation methods. Based on the liquidity premium theory in the term structure of interest rates, we can intuitively recognize that the liquidity of monetary assets is inversely proportional to their yield rates. If we can find the functional relation between liquidity and the yield rates for monetary assets, we can also find the solution to the problem of how to quantify the liquidity of monetary assets. After a long-term exploration based purely on this idea, and using consumer behavior theory (utility theory), some studies devised Divisia and currency-equivalent monetary aggregates, which both have microeconomic foundations, in order to successively

[4] From central banks' point of view, all kinds of money are classed as deposit liabilities; but as far as households and enterprises are concerned, money can be described as assets. By using the utility function analysis, this study treats the liquidity services that money provides primarily from the point of view of households and enterprises. In this way, the complete text will consider money as assets in a uniform way.

[5] Obviously, cash is the most liquid asset, followed by current deposits, and then time deposits, where the longer the maturity of the time deposit is, the weaker its liquidity.

correct simple-sum monetary aggregates. Barnett (1980) assumed that monetary assets have a weak separability from other consumer goods, and that total liquidity is homogeneous of degree 1 in a variety of monetary assets; from this he then deduced the Divisia monetary aggregates. Based on the hypothesis of Divisia monetary aggregates, Rotemberg, Driscoll and Poterba (1995) supposed that in terms of total liquidity, cash is additively separable from other monetary assets, and thus derived the currency-equivalent monetary aggregates.

Academics have conducted a number of empirical comparisons between Divisia and simple-sum monetary aggregates. Barnett, Offenbacher and Spindt (1981, 1984) used three methods of Granger causality, information content, and stability of the money demand function to conduct empirical comparisons of the two; Serletis and Robb (1986) used the same methods to analyze data from Canada; Belongia and Chalfant (1989) conducted analysis of correlation and controllability; Belongia and Chrystal (1991) analyzed data from the UK based on the correlation and stability of the money demand function; Hueng (1998) used the theory of cointegration to analyze data from Canada; Acharya and Kamaiah (2001) used the stability of the money demand function, information content, and J test to analyze data from India; Schunk (2001) conducted correlation analysis based on the VAR model. All results showed that Divisia monetary aggregates are better than simple-sum monetary aggregates.

Yet the birth of the currency-equivalent monetary aggregates did not raise the attention of any academic circles. Due to an overall lack of research into currency equivalent monetary aggregates, evaluations comparing them to Divisia monetary aggregates have no consistent conclusions. Based on the correlation test devised by Rotemberg et al. (1995), and the J test, information content, and stability of the currency demand function by Acharya and Kamaiah (1998), they empirically concluded that currency-equivalent monetary aggregates are better than simple-sum monetary aggregates. Serletis and Uritskaya (2007) argued that the long-term demand functions of simple-sum and Divisia monetary aggregates are more stable, and that the short-term demand function of currency-equivalent monetary aggregates are more stable. Lebi and Handa (2007) argued that currency-equivalent monetary aggregates are better than simple-sum and Divisia monetary aggregates.

Through a literature review, we found that in the study of the rationality and validity of which kind of monetary aggregates is more suitable as monetary policy intermediate targets, academics tend to focus more on Divisia monetary aggregates, while little attention is given to currency-equivalent monetary aggregates. Existing empirical studies show that Divisia and currency-equivalent monetary aggregates are more effective than simple-sum monetary aggregates (the main judgment standard being the stability of the money demand function). However, few researchers have explored the advantages and disadvantages of Divisia and currency-equivalent monetary aggregates, and only a few articles obtained no consistent conclusion. In addition, most researches focused on empirical tests, with a lack of theoretical analysis.

The Federal Reserve used to release Divisia and currency-equivalent monetary aggregates data simultaneously on its website, but since 2006, it no longer publishes the currency-equivalent monetary aggregates, only the Divisia monetary aggregates. It is thus clear that Divisia monetary aggregates are now considered an effective complement to simple-sum monetary aggregates by the Federal Reserve. However, why does the status of currency-equivalent monetary aggregates seem uncertain? Are currency-equivalent monetary aggregates really less valid as an intermediate target than Divisia monetary aggregates? What is the real reason? This study is going to solve these questions.

The second part of this paper conducts an analysis and comparison into the theoretical models of currency-equivalent and Divisia monetary aggregates, and concludes that the former is superior to the latter. The third part conducts an empirical test into the inference of the second part, including two aspects of "the stability of the money demand function" and "controllability", where all empirical results support the conclusions. The fourth part outlines conclusions and policy recommendations. The academic contribution of this paper is to demonstrate that currency-equivalent monetary aggregates are more effective than Divisia monetary aggregates from the two aspects of theory and practice for the first time. This fills the lack of academic research into currency-equivalent monetary aggregates to some extent, and enriches the theory of monetary policy intermediate target.

II. Theoretical Comparison of each monetary aggregate

Micro basis of currency-equivalent and Divisia monetary aggregates both use the money-in-the-utility function (MIU, proposed by Sidrauski (1967)) as their measurement method. This function assumes that money produces utility directly, and the real balance is introduced into the Walrasian general equilibrium analysis framework. The reason why monetary analysis is covered by the utility function is as follows: assuming there are various types of goods in an economy, a single economic entity can only produce and consume a small part of them. When two economic entities meet, they often do not need the other's products. Therefore, if you want the trading business to be successful, a double coincidence of demands is needed. In this case, the realizing cost of trading will be very high. And through the use of money, the realization of both parties becomes a single coincidence of demand, thus greatly reducing the transaction difficulty and the transaction costs to the economic entity, and increasing the economic entity's utility. The following is a specific theoretical comparison of each monetary measurement method.

Assuming the utility function of a representative consumer in period t is as follows:

$$U_t = U\left(C_t, m_{0,t}, m_{1,t}, ..., m_{n-1,t}\right) \quad (1)$$

Where C_t is consumption in period t, $m_{i,t}$ is the stock of monetary assets (real value) in period t.

Hypothesis 1: the amount of consumption has nothing to do with the monetary assets holding structure. Equation (1) can be written as:

$$U_t = U\left(C_t, f_t(m_{0,t}, m_{1,t}, ..., m_{n-1,t})\right) \quad (2)$$

Order $L_t = f_t(m_{0,t}, m_{1,t}, ..., m_{n-1,t})$ [6], L_t is the expression of the weighted monetary aggregates based on the theory of consumption, also known as the aggregation of liquidity services[7].

Hypothesis 2: L_t is the linear function of $m_{i,t}$. L_t can be written as:

$$L_t = \sum_{i=0}^{n-1} f_{i,t} m_{i,t} \tag{3}$$

Where $f_{i,t}$ is the liquidity size of monetary asset i in period t. L_t is the weighted monetary aggregates weighted according to the size of liquidity in period t.
The expected lifetime utility of consumers in period t is as follows:

$$V = E_t \sum_{j=0}^{\infty} \beta^j U(C_{t+j}, L_{t+j}) \tag{4}$$

Where E is the expectation operator. $0 < \beta < 1$ is the subjective discount rate, i.e. the time preferences of consumers; the smaller the value of β, the more consumers tend towards immediate consumption rather than long-term consumption. For the sake of simplicity, assume that the resource allocation of consumers only has three forms: consumption, monetary assets, and benchmark assets. Benchmark assets are risk-free investments with liquidity much more inferior to monetary assets, which have no liquidity service function for monetary assets, and they are only a way of storing value. Assume $r_{i,t}$ is the yield rate of monetary assets i in period t, $r_{b,t}$ is the yield rate of benchmark assets in period t, and P_t is the price level in period t. Clearly, the yield rate of cash is $r_{0,t} = 0$. Because monetary assets and benchmark assets are the real values, the unit conversion ratio among consumption, monetary assets and benchmark assets is 1:1. The condition for maximizing expected lifetime utility in Equation (4) is that the

[6] *Rotemberg, Driscoll & Potebra (1995), order $L_t = f(m_{0,t}, m_{1,t}, ..., m_{n-1,t}, \alpha_t)$, and reflect the change of liquidity of non-cash monetary assets over time with the time-varying parameter α_t, while this paper sets no more parameters, reflecting this change directly by $f_{i,t}$ in Equation(3), which can avoid obscure mathematical assumptions and derivation process by the original author.*

[7] *The statistical caliber of liquidity services aggregates and weighted monetary aggregates is consistent. If the liquidity size of monetary assets within (0, 1] interval can be quantified, consider liquidity as weighted weights, ∑liquidity × monetary assets = weighted monetary aggregates; take liquidity as the research object, ∑liquidity × monetary assets = liquidity services aggregates. As liquidity can be regarded as "service" into the utility theory to be analyzed, this paper takes liquidity services aggregates as the main object of study, to obtain the weighted monetary aggregates.*

marginal utility of consumption, the marginal utility of monetary assets and the marginal utility of benchmark assets are all equal.

The marginal utility of consumption is equal to the marginal utility of monetary assets as follows:

$$U_C(C_t, L_t) = U_L(C_t, L_t) f_{i,t} + (1 + r_{i,t}) E_t \frac{P_t \beta U_C(C_{t+1}, L_{t+1})}{P_{t+1}} \quad (5)$$

Where U_C , U_L is the marginal utility of consumption and liquidity demand respectively.

Through Equation (5), we know that the marginal utility of monetary assets comes from two aspects: one is the utility directly produced by possessing monetary assets (the first item on the right of the equation), and the other is the utility indirectly produced by monetary assets changing into consumption in the next period (the second item on the right of the equation).

The marginal utility of consumption is equal to the marginal utility of benchmark assets as follows:

$$U_C(C_t, L_t) = (1 + r_{b,t}) E_t \frac{P_t \beta U_C(C_{t+1}, L_{t+1})}{P_{t+1}} \quad 6)$$

Where U_C , U_L is the marginal utility of consumption and liquidity demand respectively.

Through Equation (6), we can see that the marginal utility of benchmark assets only comes from the utility indirectly produced by benchmark assets changing into consumption in the next period.

Taking Equation (5) and Equation (6) as simultaneous equations, we can obtain

$$U_L(C_t, L_t) f_{i,t} = \frac{r_{b,t} - r_{i,t}}{1 + r_{b,t}} U_C(C_t, L_t) \quad (7)$$

Where $\frac{r_{b,t} - r_{i,t}}{1 + r_{b,t}}$ is the user cost[8] of monetary assets. Through Equation (7), we can see that holding 1 unit of monetary assets i instead of 1 unit of benchmark assets, is equivalent to using $\frac{r_{b,t} - r_{i,t}}{1 + r_{b,t}}$ unit consumption price to purchase $f_{i,t}$ units of liquidity demand, which has no effect on lifetime utility.

[8] *Compared to holding the benchmark assets with no liquidity whatsoever, this is the discounted value of interest for holding monetary assets. It can be interpreted as the extra pay due to buying the "liquidity services" of monetary assets.*

(I) Deduction of the currency-equivalent monetary aggregates

Hypothesis 3: $f_{0,t} = 1$[9]. The purpose of this hypothesis is to standardize liquidity demand with cash. Hypothesis 3 also means that liquidity of cash does not change over time. Substituting $f_{0,t} = 1$, $r_{0,t} = 0$ into Equation (7), we obtain:

$$U_L(C_t, L_t) = \frac{r_{b,t}}{1 + r_{b,t}} U_C(C_t, L_t) \quad 8)$$

Dividing Equation (7) by Equation (8), we obtain:

$$f_{i,t} = \frac{r_{b,t} - r_{i,t}}{r_{b,t}} \quad (9)$$

Equation (9) is the liquidity size of monetary assets i in period t; it is thus clear that the liquidity of monetary assets has a negative linear correlation with its yield rate. Through the establishment of a functional relationship between the liquidity of monetary assets and its yield rate, we solved the difficult problem of how to quantify the liquidity of monetary assets, and made the weight measurement of weighted monetary aggregates liquidity dependent to a certain extent.

Substituting Equation (9) into Equation (3), we obtain expressions for currency-equivalent monetary aggregates:

$$L_t = \sum_{i=0}^{n-1} \frac{r_{b,t} - r_{i,t}}{r_{b,t}} m_{i,t} \equiv CEM_t \quad (10)$$

Using Equation (10), we can see that currency-equivalent monetary aggregates depend on the three factors of stock, yield rate of monetary assets and yield rate of benchmark assets. The weight of monetary assets i has a negative linear correlation with its yield rate $r_{i,t}$; namely, the stronger the liquidity, the lower the yield rate and the greater the weight, which accords with economic common sense and logic.

(II) Deduction of Divisia monetary aggregates

Through a total differentiation of Equation (10), we obtain:

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[9] *Hypothesis 3 looks simple, but it is a very important contribution to our research, and makes a new life for the currency-equivalent method. Hypothesis 3 is a very weak assumption because the proposition "cash is the most liquid and most stable asset" is almost an axiom. But Rotemberg, Driscoll & Potebra (1995) made a simple problem complex, through the "additive detachable" assuming* $f(m_{0,t}, m_{1,t}, ..., m_{n-1,t}, \alpha_t) = h(m_{0,t}) + k(m_{1,t}, m_{2,t}, ..., \alpha_t)$, *combined with Equation (3), deducing* $f_{0,t}$ *is a constant, and then normalizing it to 1. Based on monetary economics common sense, this paper directly gave hypothesis 3, which is easier to understand compared to the original author's purely mathematical assumptions and derivation, equal to "relaxing" hypothesis 3 of the original author to a certain extent, thus improving the superiority of the currency-equivalent monetary aggregates in the measurement theory.*

$$dCEM_t = \sum_{i=0}^{n-1} \frac{r_{b,t} - r_{i,t}}{r_{b,t}} dm_{i,t} + \sum_{i=0}^{n-1} m_{i,t} d\left(\frac{r_{b,t} - r_{i,t}}{r_{b,t}}\right) \quad (11)$$

Dividing Equation (11) by Equation (10), we obtain

$$\frac{dCEM_t}{CEM_t} = \sum_{i=0}^{n-1} \frac{(r_{b,t} - r_{i,t})m_{i,t}}{\sum_{j=0}^{n-1}(r_{b,t} - r_{i,t})m_{j,t}} \frac{dm_{i,t}}{m_{i,t}} + \sum_{i=0}^{n-1} \frac{(r_{b,t} - r_{i,t})m_{i,t}}{\sum_{j=0}^{n-1}(r_{b,t} - r_{i,t})m_{j,t}} d\left(\frac{r_{b,t} - r_{i,t}}{r_{b,t}}\right) / \left(\frac{r_{b,t} - r_{i,t}}{r_{b,t}}\right) \quad (12)$$

Writing Equation (12) in logarithmic form, we obtain

$$d \ln CEM_t = \sum_{i=0}^{n-1} \frac{(r_{b,t} - r_{i,t})m_{i,t}}{\sum_{j=0}^{n-1}(r_{b,t} - r_{i,t})m_{j,t}} d \ln m_{i,t} + \sum_{i=0}^{n-1} \frac{(r_{b,t} - r_{i,t})m_{i,t}}{\sum_{j=0}^{n-1}(r_{b,t} - r_{i,t})m_{j,t}} d \ln\left(\frac{r_{b,t} - r_{i,t}}{r_{b,t}}\right) \quad (13)$$

Equation (13) is equivalent to Equation (10): it is the expression of the growth rate of currency-equivalent monetary aggregates, which is affected by two aspects: one is the change of monetary assets stock (the first item on the right of the equation), and the other is the change in liquidity of monetary assets (the second item on the right of the equation). However, the expression of the rate of change of Divisia monetary aggregates in a continuous situation as deduced by Barnett (1980) is:

$$d \ln DVM_t = \sum_{i=0}^{n-1} \frac{(r_{b,t} - r_{i,t})m_{i,t}}{\sum_{j=0}^{n-1}(r_{b,t} - r_{i,t})m_{j,t}} d \ln m_{i,t} \quad (14)$$

Contrast Equation (13) and Equation (14): it can be seen that there are significant theoretical defects within Divisia monetary aggregates as they are generally used by academics, as it misses the impact of monetary aggregates due to the variation in liquidity of monetary assets over time. To make Equation (13) and Equation (14) equal would be difficult (unless one were to assume that liquidity of non-cash monetary assets does not change over time at all, but this is obviously not consistent with reality), because with the development of financial markets and the progress of payment technology, liquidity of non-cash monetary assets (deposits) will continue to increase.

Because continuous statistics cannot be gathered for data in practice, something which is usually published monthly, quarterly and yearly, we need to obtain a discrete expression for Equation (14). In practice, for the discrete case, the measurement Equation for approximately expressing the change rate of Divisia monetary aggregates, as devised by Barnett (1980), with a Tornquist index during the period t, is as follows:

$$\ln DVM_t - \ln DVM_{t-1} = \sum_{i=0}^{n-1} S_{i,t}^{*} (\ln m_{i,t} - \ln m_{i,t-1}) \quad (15)$$

Where:

$$S_{i,t}^{*} = \frac{S_{i,t} + S_{i,t-1}}{2}, \quad S_{i,t} = \frac{(r_{b,t} - r_{i,t})m_{i,t}}{\sum_{j=0}^{n-1}(r_{b,t} - r_{i,t})m_{j,t}}.$$

Equation (15) is an approximation of Equation (14), and there must be measurement errors present. The measurement errors are positively correlated with the time intervals of the statistics gathered, i.e. the order of magnitude of the measurement errors is: weekly frequency < monthly frequency < quarterly frequency < yearly frequency.

In conclusion, both the currency-equivalent and Divisia monetary aggregates are monetary aggregates weighted according to size of liquidity of monetary assets, but the currency-equivalent monetary aggregates allow liquidity of monetary assets to change over time, meaning there are no theoretical errors. Divisia monetary aggregates, on the other hand, do not allow liquidity of monetary assets to change over time, meaning there are theoretical errors present. Not only that, the currency-equivalent monetary aggregates give accurate absolute values of weighted monetary aggregates, again meaning there are no measurement errors, while Divisia monetary aggregates are approximate growth rates of weighted monetary aggregates, which also leads to measurement errors. In view of the theoretical advantages of currency-equivalent monetary aggregates, this paper made the following deduction: the currency-equivalent monetary aggregates method is more suitable for current monetary policy intermediate target than the Divisia monetary aggregates. Empirical tests will now be used for validation of them in the third part of this research.

III. Empirical tests and comparisons

In the division of money levels as carried out by the monetary authorities of various countries, M_2 has the international consensus as a monetary policy intermediate target. Therefore, this paper explores the effectiveness of different monetary aggregates in the United States and China under the M_2 level. In order to distinguish various kinds of monetary aggregates in the United States and China, we order the currency-equivalent, Divisia and simple-sum monetary aggregates in the United States to be CEM_2^{US}, DVM_2^{US}, and SSM_2^{US} respectively, and the currency-equivalent, Divisia and simple-sum monetary aggregates in China to be CEM_2^{CN}, DVM_2^{CN}, and SSM_2^{CN} respectively. In this section, we will conduct empirical comparison on the stability of money demand functions in the United States and China under different monetary aggregates measurement methods, in order to determine the effectiveness of the different monetary aggregates as monetary policy intermediate targets. Money demand functions examine the correlation between money and macroeconomic variables such as output, interest rates, prices, etc. from the point of view of demand. In this paper, the judgment on stability is divided into two steps: the first step is the cointegration relationship existence test; this is determining whether there is a long-term stable cointegration relationship between different monetary aggregates and output, interest rates, and prices. If there is, the second step test is required; if not, there is no need for the second test, and it can be directly determined that the monetary aggregates does not have a stable demand function. The second step is based on the premise of the cointegration relationship existing, in order to conduct an estimate of the cointegration coefficient and error correction terms, and judge the reliability of the coefficient in terms of demographic and economic rationality. The monetary aggregates which satisfy both these step tests have a stable money demand function, and can hence be an effective intermediate target for monetary policy. In addition, in order to make the research conclusions of this paper more convincing, we added a controllability test for different monetary aggregates.

(I) Choice of money demand function

The independent variables of money demand functions are divided into two categories: scale variables and opportunity cost variables (income as a function of GDP). Scale variables measuring the income effect are expressed through real GDP figures in this paper, while opportunity cost variables measuring the substitution effect are expressed using market interest and inflation rates. There are many specific forms of money demand functions, but the previous related research rarely considered the lag effect of the impact of income variables and opportunity cost variables on money demand, and this neglect will bring about the systemic error present in money demand function estimates. Therefore, this paper uses the Auto Regressive Distributed Lag (ARDL) model to depict the money demand function, which has the advantage of simultaneous and steady estimation of long-term and short-term monetary demand relationships. To focus the research, we did not choose a complicated money demand function, but adopted the concrete form of money demand function as follows:

$$\ln(M_t) = a + \sum_{i=1}^{p_1} b_i \ln(M_{t-i}) + \sum_{i=0}^{p_2} c_i \ln(GDP_{t-i}) + \sum_{i=0}^{p_3} d_i \pi_{t-i} + \sum_{i=0}^{p_4} e_i MR_{t-i} + \varepsilon_t \qquad (16)$$

M_t represents monetary aggregates, M_{t-i} represents order 1 to p_1 lag of monetary aggregates, GDP_{t-i} represents order 0 to p_2 lag of GDP, π_{t-i} represents order 0 to p_3 lag of inflation rate, and MR_{t-i} represents order 0 to p_4 lag of the market rate.

(II) Data selection and processing

Empirical data is selected from different time periods for the United States and China, namely 1959-2005 for the United States, and 2004-2013 for China. There are two main reasons for this: firstly, the United States no longer published indicators, or indeed any relevant information on currency-equivalent monetary aggregates, after 2006, and the related data can therefore not be obtained in full. Secondly, relatively speaking, the degree of interest rate marketization during these two inconsistent periods of time, as well as the standpoint and attitude of the Central Banks towards using money supply as intermediate targets in both the United States and China, are in fact relatively similar. Therefore, this kind of inter-temporal comparison can still place the objects being analyzed in a relatively homogeneous economic environment, thus enabling more comparable conclusions

1. Data selection and processing in the United States

The data period involving the money demand function in the United States is the quarterly data from 1959 to 2005[10]. Dividing nominal GDP by the real GDP (2009=100),

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[10] Anderson et al. were in charge of the specific development of the Federal Reserve's Monetary Services Index (MSI) Project, for which the related detailed data gained support from the FED. However, because they only considered the currency-equivalent monetary aggregates as a

we can get the fixed-base price index with 2009 as the base period. The chain relative ratio of the fixed-base price index is taken as the inflation rate. Dividing nominal monetary aggregates CEM_2^{US}, DVM_2^{US}, SSM_2^{US} and nominal base money by the fixed-base price index, we can obtain the real monetary aggregates CEM_2^{US}, DVM_2^{US}, SSM_2^{US} and the real base money with 2009 as the base period. We chose the "Federal funds effective rate" as the market interest rate; the above data was obtained from the official website of the Federal Reserve St Louis Regional Fed (https://research.stlouisfed.org), while the nominal base money, nominal monetary aggregates, and nominal GDP are seasonally adjusted data. The plot of CEM_2^{US}, DVM_2^{US} and SSM_2^{US} time series is at the end of the paper named Figure 1.

2. Selection and processing of data for China

The data period used for the money demand function in China is the quarterly data from 2004 to 2013, using the median of the 7 days annualized yield at the end of the season of all monetary funds listed on "www.hexun.com" as the market interest rate. Because China has not reported quarterly CPIs, the specific algorithm for quarterly CPI and the inflation rate is as follows: taking January 2004 as the base period, the fixed base CPI of the later months is calculated, then the arithmetic averaging is taken as the quarterly fixed base CPI, and the chain relative ratio of the quarterly fixed base CPI is taken as the quarterly inflation rate. The CPI and GDP data are taken from the statistics database from CEInet. Real GDP and real monetary aggregates are obtained after adjusting nominal GDP, and nominal monetary aggregates through X-11 season divided by the quarterly fixed base CPI. Monetary aggregates CEM_2^{CN}, DVM_2^{CN}, SSM_2^{CN} data are taken from the calculated results in our working paper *Correction and Newborn* of *China's M2* (refer to the website of Financial Development and Policy Research Center of Wuhan University, http://fdprc.whu.edu.cn/). The plot of CEM_2^{CN}, DVM_2^{CN} and SSM_2^{CN} time series is at the end of the paper named Figure 2.

Before generating the cointegration relationship (long-term relationship) and the error correction term (short-term) of money demand in the United States and China using Equation (16) (with the ARDL cointegration estimation method), bounds testing for the level relationships should be used to confirm the existence of the cointegration relationship of money demand in the United States and China.

(III) The unit root test

Before the cointegration test, a unit root test is required. In this paper, we use ADF to conduct unit root tests for variables involved in Equation (16), with the United States having a maximum lag order of 14; the largest lag order of the Chinese data set is taken as 9, and the number of lag order is automatically selected based on the rule of SIC information. Test results are shown in Table 1.This shows that, under a significance

supplement to the Divisia monetary aggregates, and even considered them to be dispensable, academics did not pay much attention to their study. As a result, almost no effect was achieved, and the related data were not published again after 2006. But copying out the currency-equivalent monetary aggregates after 2006, according to the standard process of the Federal Reserve, is extremely difficult in terms of operability, so this paper only studied the data before 2006. There are nonetheless enough available in terms of time series and the sample size needed for empirical tests.

level of 5%, in addition to the fact that π^{CN} and $MR^{US}$are the I (0) series, other variables are I (1) unit root series.

Table 1

Unit root test

	Level		First order differential value	
Variable	Test form	P value	Test form	P value
MR^{CN}	c,0,0	0.1672	0,0,0	0.0000
π^{CN}	c,0,4	0.0053		
$LNSSM_2^{CN}$	c,t,1	0.5433	c,0,0	0.0011
$LNCEM_2^{CN}$	c,t,2	0.0860	c,0,0	0.0013
$LNDVM_2^{CN}$	c,t,2	0.3751	c,0,0	0.0003
$LNGDP^{CN}$	c,t,0	0.8834	c,0,0	0.0000
MR^{US}	c,0,5	0.0381		
π^{US}	c,0,1	0.1018	0,0,1	0.0000
$LNSSM_2^{US}$	c,t,1	0.3409	c,0,0	0.0000
$LNCEM_2^{US}$	c,t,0	0.0940	c,0,0	0.0000
$LNDVM_2^{US}$	c,t,1	0.6875	c,0,0	0.0000
$LNGDP^{US}$	c,t,2	0.1095	c,0,0	0.0000

Note: Test forms (c, t, p) represent intercept term, time trend and number of lag order respectively.

(IV) Existence test for the cointegration relationship

The commonly used cointegration test methods are the E-G two-step method and Johansen cointegration test, but both of them require that all variables are unit root process (i.e., I (1)). However, π^{CN} and MR^{US} are smooth sequences (i.e., I (0)), so the cointegration test for money demand cannot adopt the above two methods. This paper adopts bounds testing as proposed by Pesaran et al. (2001), the results of which are effective whether variables are I (1) or I (0). The test equation is as follows:

$$\Delta\ln(M_t) = a + \sum_{i=1}^{p} b_i \Delta\ln(M_{t-i}) + \sum_{i=0}^{p} c_i \Delta\ln(GDP_{t-i}) + \sum_{i=0}^{p} d_i \Delta\pi_{t-i} + \sum_{i=0}^{p} e_i \Delta MR_{t-i} + f\ln(M_{t-1})$$
$$+ g\ln(GDP_{t-1}) + h\pi_{t-1} + iMR_{t-1} + \varepsilon_t \tag{17}$$

The test is divided into the F test and the t test. The null hypothesis of the F test is f=g=h=i=0, and the null hypothesis of the t test is f=0. Most academics believe that once the F-statistic is significant, it can be concluded that a cointegration relationship exists. In addition, if the t-statistic is significant, the conclusion can be strengthened further; if the t-statistic is not significant, Pesaran et al. (2001) argued that the cointegration relationship is a degenerate level relationship. This paper considers the F test as the first criterion and the t test as the second criterion. If the F test is not passed, it suggests that there is no cointegration relationship; if the F test is passed, it shows that there is a cointegration relationship. Furthermore, a cointegration relationship which passes both F test and t test is stronger and more stable relative to a cointegration relationship which only passes the F test and fails to pass the t test.

The test basis of the model is that there is no autocorrelation in ε_t, so the lag order p should be sufficiently large, but in order to reduce excessive parameterization, the lag order p also needs to be kept reasonably small. The appropriate choice of p needs to take into consideration whether the residual has both autocorrelation and excessive parameterization simultaneously. This paper will give priority to the lag order p with larger AIC and SBC, under the condition that the residual does not exhibit autocorrelation.

1. Existence test for the cointegration relationship in the United States

The cointegration test results of money demand, output, as well as market interest rates for the United States are shown in Table 2. It should be noted that, in each regression equation given in (17), the present and lagged values of the rate of inflation π^{US} are both insignificant. In order to assess the cointegration relationship more accurately, this paper has eliminated the effect of inflation rates on the opportunity cost variation of the US money demand function, and has considered only the effect of market interest rates. In other words, (16) and (17) have both eliminated the inflation rate variable π^{US}. Table 2 shows that the F-statistic of the American monetary aggregates SSM_2^{US} and DVM_2^{US} are not significant, indicating that SSM_2^{US} and DVM_2^{US} do not have a long-term and stable cointegration relationship with output and market interest rates, while the F-statistic and t-statistic of monetary aggregates CEM_2^{US} are significant under a significance level of 5%, indicating that CEM_2^{US} has a strengthened cointegration relationship with output and market interest rates.

Table 2

Bounds testing for level relationships (the United States)

Monetary aggregates	Optimal lagging order p	F statistic	t statistic
SSM_2^{US}	4	3.71	-2.95
CEM_2^{US}	1	5.63**	-4.03**
DVM_2^{US}	4	1.26	-1.44

Note: 5% of the F-statistic threshold range of the two independent variables provided by Pesaran et al. (2001) is (3.79,4.85); this is significant if higher than the upper limit, and not significant if below the lower limit, and is uncertain in the middle. The deduction of the t-statistic is similar: 10% of the t-statistic threshold range is (-2.57,-3.21), 5% of the t-statistic threshold range is (-2.86,-3.53), and 1% of the t-statistic threshold range is (-3.43,-4.1). ** means significant at a 5% level.

2. Existence test for the cointegration relationship in China

The cointegration test results of money demand and output, the rate of inflation and market interest rates for China are shown in Table 3. Table 3 shows that the F statistic of three monetary aggregates under a 1% significance level are all significant, indicating that all three have a cointegration relationship with output, rate of inflation and market interest rates. But the t statistic of CEM_2^{CN} is significant under a 1% significance level, and t statistics of SSM_2^{CN}, DVM_2^{CN} are not significant, indicating that: the cointegration relationship of CEM_2^{CN} is strengthened, while the cointegration relationships of SSM_2^{CN} and DVM_2^{CN} are degraded; in other words, the cointegration relationship of CEM_2^{CN} is steadier.

Table 3

Bounds testing for level relationships (China)

Monetary aggregates	Optimal lagging order p	F statistic	t statistic
SSM_2^{CN}	1	14.61***	-2.49
CEM_2^{CN}	4	7.18***	-4.47***
DVM_2^{CN}	1	12.1***	-2.34

Note: 1% of the F statistic threshold range for the three independent variables provided by Pesaran et al. (2001) is (4.29,5.61); it is significant if higher than the upper limit, not significant if below the lower limit, and uncertain in the middle. The deduction of the t statistic is similar: 10% of the t statistic threshold range is (-2.57, -3.46),5% of the t statistic threshold range is (-2.86,-3.78), 1% of the t statistic threshold range is (-3.43,-4.37). ***means significant at a 1% level.

3. Existence comparison of the cointegration relationship between the money demands of the United States and China

Table 2 and Table 3 show that the degree of significance of the F statistic of all three kinds of monetary aggregates in China is superior to that of the corresponding three kinds of monetary aggregates in the United States. This shows that in China, the correlation between monetary aggregates and macroeconomic variables under either measurement method is more stable than the same correlation in the United States. That is to say, using monetary aggregates as intermediate targets is more suitable for China than it is for the United States. This corresponds to the phenomenon that the monetary authorities of the two countries do in fact adopt widely different intermediate monetary targets. China gives priority to quantitative targets, while the United States gives priority to price type targets. However, national differences of effectiveness in intermediate targets are not the focus of research for this paper, so it is not favorable to continue an in-depth discussion on the topic here.

(V) Estimation of cointegration coefficient and error correction term

According to the existence test result for the cointegration relationship of respective monetary aggregate series and macroeconomic variables in the United States and China, we can be sure that for the American stability of money demand function, CEM_2^{US} is better than SSM_2^{US} and DVM_2^{US}. In the following estimation of cointegration coefficient and error correction term, we only report the results of CEM_2^{US} which have a cointegration relationship, and the results of SSM_2^{US} and DVM_2^{US} which do not have a cointegration relationship shall not be reported. However, the result we see is that China's CEM_2^{CN} is a strengthened cointegration relationship, whereas SSM_2^{CN} and DVM_2^{CN} are degenerate level relationships. According to most academics' point of view, both the strengthened and degenerate level relationship show the presence of a cointegration relationship; therefore, it does not seem very persuasive to judge the effectiveness by only relying on the cointegration relationship existence test. To this end, we have reported and compared the cointegration relationship and the results of estimation of error correction terms of three monetary aggregates.

On the premise that a cointegration relationship is confirmed, this paper adopts an autoregressive distributed lag, ARDL model proposed by Pesaran and Shin (1998), namely Equation (16), to estimate the cointegration coefficient and error correction term. ARDL cointegration estimation is suitable under the conditions of containing the I(1) and I(0) variables simultaneously, when containing the endogenous variable, or for small samples. Cointegration relationships and error correction terms are estimated by running the Microfit 4.1 software.

1. Results for the United States

The results of CEM_2^{US} are shown in Table 4. Table 4 shows that the income elasticity in the cointegration relationship of currency-equivalent monetary aggregates is 1.21, the interest rate semi-elasticity is -0.02, and the error correction term is-0.12; these figures are significant at a significance level of 10%. The plus or minus sign also meets economic theory, which shows that CEM_2^{US} have the right condition for being intermediary targets. SSM_2^{US} and DVM_2^{US} did not pass the bounds testing for level relationships, so there is no need to discuss.

Table 4

Cointegration relationship and error correction term (the United States)

	(p1, p2, p4)	C^{US}	$LNGDP^{US}$	MR^{US}	$ECM(-1)^{US}$
$LNCEM_2^{US}$	(1, 0, 2)	-2.91[0.001]	1.21[0.000]	-0.02[0.092]	-0.12[0.000]

Note: Inner [.] is the P value. C is a constant term. C, LNGDP and MR are the corresponding coefficients in the cointegration relationship. ECM (-1) is the error adjustment coefficient in the error correction model.

2. Results for China

China's three monetary aggregate results are shown in Table 5. Table 5 shows that both the degrees and significance of the coefficient in the cointegration relationship of CEM_2^{CN} are bigger than those of SSM_2^{CN} and DVM_2^{CN}, and that the symbols of the coefficients are consistent with the expected symbols; that is to say, a rise in the market interest rate and inflation rate will cause real money demand to decline, whereas a rise in real incomes will cause real money demand to rise; this shows that the long-term money demand function of CEM_2^{CN} is reliable. While the MR^{CN} coefficient of SSM_2^{CN}, DVM_2^{CN} is not significant and is positive, this does not conform to the explanation of monetary economic theory, indicating that the cointegration relationship (long-term money demand function) of $SSM2^{CN}$ and $DVM2^{CN}$ is not reliable. This is consistent with the conclusion that a cointegration relationship degradation degree of SSM_2^{CN}, DVM_2^{CN} is greater than that of CEM_2^{CN} in the bounds cointegration test; in an economic sense, this suggests that the long-term demand relationship of CEM_2^{CN} is more reliable. In addition, from the aspect of error correction terms, the error correction coefficient of CEM_2^{CN} is greater than that of SSM_2^{CN} and DVM_2^{CN}, illustrating that the short-term money demand function of CEM_2^{CN} can approach the long-term equilibrium state more quickly, and that the short-term money demand function is more stable. From the perspective of stability of the money demand function, CEM_2^{CN} is more suitable as an intermediate target for China's monetary policy than SSM_2^{CN} and DVM_2^{CN}.

Table 5

Cointegration relationship and error correction term (China)

	$LNSSM_2^{CN}$	$LNCEM_2^{CN}$	$LNDVM_2^{CN}$
（p1，p2，p3，p4）	(1,1,0,3)	(2,1,4,4)	(1,0,0,3)
C^{CN}	-0.615 [0.168]	-1.68[0.001]	-0.961[0.019]
$LNGDP^{CN}$	1.24 [0.000]	1.34[0.000]	1.24[0.000]
MR^{CN}	0.006 [0.553]	-0.07[0.001]	0.005[0.645]
π^{CN}	-0.15 [0.000]	-0.27[0.000]	-0.13[0.000]
$ECM(-1)^{CN}$	-0.22 [0.001]	-0.27[0.000]	-0.25[0.001]

Note: Inner [.] are P values. C is a constant term. C, LNGDP, MR, π are the corresponding coefficients of the cointegration relationship. ECM (-1) is the error adjustment coefficient in the error correction model.

3. Results comparison between the United States and China

Table 4 and Table 5 show that for both the United States and China, the cointegration coefficient and the size and degree of significance of the error correction term of the currency-equivalent monetary aggregates are optimal compared to those of the two other monetary aggregates used domestically. Furthermore, the effectiveness of the currency-equivalent monetary aggregates in China is obviously greater than in the United States: monetary income elasticity is 1.34 in China, which is larger than the 1.21 for the United States; semi-elasticity of interest rates in China is -0.07, while the absolute value is greater than -0.02 in the United States; the error correction term is -0.27 in China, while the absolute value is greater than -0.12 in the United States.

We can see from the above that, in both the United States and China, the correlation between the currency-equivalent monetary aggregates with macroeconomic variables are closer than the Divisia monetary aggregates and simple-sum monetary aggregates, and that this conclusion is more significant in China.

(VI) Controllability test

The stability of the money demand function can be used to inspect the effectiveness of monetary aggregates under different measurement methods from the perspective of demand; the controllability test is used to inspect the Central Bank's ability to control different monetary aggregates from the perspective of supply. Monetary policy is transmitted from the operating targets to intermediate targets, and finally transmitted and adjusted to final targets. Therefore, to study the controllability of medium targets, we should first examine whether they have stable correlativity with the operating targets. This paper uses the classic expression of monetary theory for reference, and considers that the base money is the most suitable to be used as an operating target. In this paper, we use the unit root test for the money multiplier of the corresponding monetary aggregates to determine the stability of its correlativity with the base money. The money multiplier is equal to the SSM_2, CEM_2 and DVM_2 divided by the base money, which are SSMM, CEMM, and DVMM respectively. Our analytic logic is that in the monetary aggregates measured by the three different methods, that method whose money multiplier is the most stable will also exhibit the strongest controllability of monetary aggregates.

China's base money is the "reserve money" found in the balance sheet of monetary authorities, and the data is taken from the official website of the People's Bank of China (http://www.pbc.gov.cn/). For the United States, the base money is derived from the official website of the Federal Reserve Bank of St. Louis (https://research.stlouisfed.org). The monetary aggregate data of the three kinds of measurement methods in the two countries was listed in the preceding part of the text, so there is no need to list them again here.

1. Results for the United States

Table 6 shows that under a significance level of 5%, $CEMM^{US}$ is stable, while $SSMM^{US}$, $DVMM^{US}$ are not stable; this shows that by regulating the base money in order to control the money supply, it will be more stable and accurate to adopt CEM_2 in order to reflect the extent to which the FED controls M_2.

Table 6

Money multiplier unit root test (the United States)

Money multiplier	Test form	P value
$SSMM^{US}$	c,0,3	0.5652
$CEMM^{US}$	c,t,0	0.0494
$DVMM^{US}$	c,t,3	0.4148

Note: The test form (c, t, p) represents intercept term, time trend and number of lag order respectively.

2. Results for China

Table 7 shows that under a 1% significance level, $CEMM^{CN}$, $SSMM^{CN}$ are stable, $DVMM^{CN}$ is not stable, and $CEMM^{CN}$ is somewhat more stable (unit root P value is smaller) than $SSMM^{CN}$. This shows that in the aspect of controlling the money supply through regulating the base money, it is more stable and accurate to use CEM_2^{CN} to reflect the extent to which the central bank controls M_2.

Table 7

Money multiplier unit root test (China)

Money multiplier	Test form	P value
$SSMM^{CN}$	c,t,4	0.0077
$CEMM^{CN}$	c,t,4	0.0063
$DVMM^{CN}$	c,t,0	0.2793

Note: The test form (c, t, p) represents intercept term, time trend and number of lag order respectively.

3. Results comparison between the United States and China

From Tables (6) and (7), we know that for both the United States and China, both the controllability and effect on currency-equivalent monetary aggregates by monetary authorities through the base money are superior to both Divisia and simple-sum monetary aggregates. We also find that, in terms of the monetary aggregates of each kind of measurement method, the monetary multiplier for China is more stable (the corresponding P value is smaller) than that of the United States. This shows that both the controllability and effect of controlling each kind of monetary aggregate by China's central bank are stronger than that held by the FED.

IV. Conclusions and recommendations

This paper conducted theoretical and empirical comparisons with a new method for monetary aggregates under different measurement methods, and obtained the following important conclusions:

1. Our research has found that currency-equivalent monetary aggregates allow liquidity of monetary assets to change over time, and that there are no theoretical errors to this approach. Divisia monetary aggregates, on the other hand, do not allow liquidity of monetary assets to change over time, meaning that there are theoretical errors in this approach. Furthermore, currency-equivalent monetary aggregates are accurate absolute values of weighted monetary aggregates, meaning there are no measurement errors. Since Divisia monetary aggregates are approximate growth rates of weighted monetary aggregates, they will lead to measurement errors. In other words, the method of currency-equivalent monetary aggregates is more accurate than Divisia monetary aggregates when measuring the aggregation of liquidity services, making it superior to Divisia monetary aggregates in terms of its theoretical model.

2. Taking the stability of the money demand function, a figure which is commonly used by international academics as an important standard for judging the validity of different monetary aggregates as monetary policy intermediate targets, this study conducted empirical comparisons between currency-equivalent, Divisia and simple-sum monetary aggregates in the United States and China. In order to give the conclusions further credibility, this paper also added a controllability test.

The results of bounds testing for level relationships show that the currency-equivalent monetary aggregates of the United States exhibit a direct cointegration relationship with output and market interest rates, while simple-sum and Divisia monetary aggregates do not exhibit cointegration with output and market interest rates. The currency-equivalent monetary aggregates of China show an intensive cointegration relationship with economic variables such as output, rate of inflation and market interest rates, while simple-sum and Divisia monetary aggregates only exhibit a degenerate level relationship with such variables. By either measurement method, the calculated monetary aggregates in China are more effective than those in the United States.

Further ARDL cointegration estimation results show that the cointegration coefficient and error correction term for currency-equivalent monetary aggregates in the United States, where output and market interest rates are significantly under the 10% level, are in line with expectations. This suggests that the long-term and short-term money demand functions of currency-equivalent monetary aggregates are both more stable. The cointegration coefficient, and the size and degree of significance of the error correction term between the currency-equivalent monetary aggregates of China, exhibiting economic variables such as output, rate of inflation, market interest rates and others, are superior to those of simple-sum and Divisia monetary aggregates. Results are in line with expectations, and confirm that the long and short-term money demand functions of currency-equivalent monetary aggregates are more stable than those of simple-sum and Divisia monetary aggregates. As to the comparison between the United States and China, the method of currency-equivalent monetary aggregates is noticeably more suitable for China.

The controllability test results show that the currency-equivalent monetary aggregates of both the United States and China have better controllability than respective Divisia and simple-sum monetary aggregates, and that under each kind of measurement method, monetary aggregates in China have better controllability than those in the United States.

3. As to a comparison between the United States and China, whether in terms of the theoretical model or empirical performance, the currency-equivalent monetary aggregates method is obviously superior to Divisia monetary aggregates. The superiority of the currency-equivalent monetary aggregates has certain universality, but in terms of the United States and China, monetary aggregates are more suitable for China's intermediate targets. It is a pity that the emergence of the currency-equivalent monetary aggregates was not given enough attention by academics and economists, leading to current research mostly focusing on Divisia monetary aggregates with less effect - this has to be regarded as a real academic setback.

One of the research values of this paper is to make up for this defect. In addition, the superiority of the currency-equivalent monetary aggregates shown by our empirical test results has a significant policy value.

Figure 1

Quarterly Data of Different Monetary Aggregates in the United States

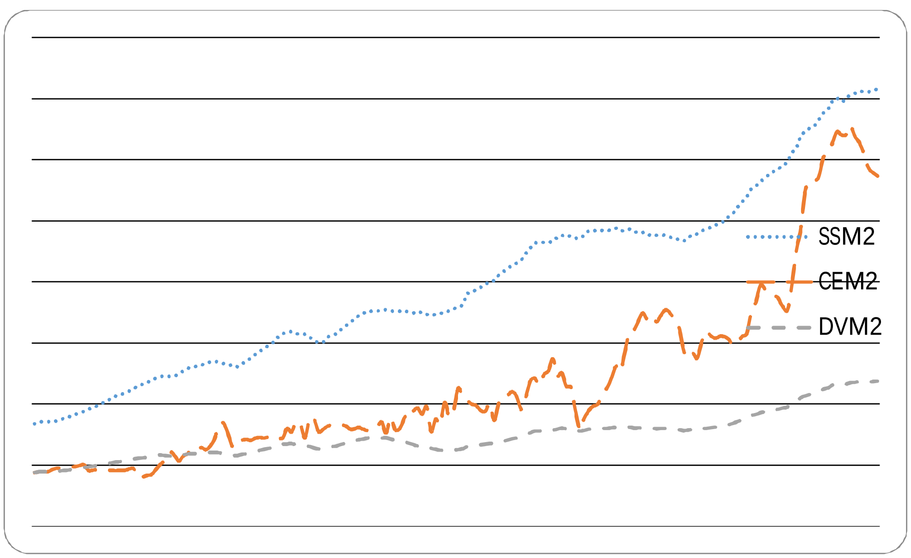
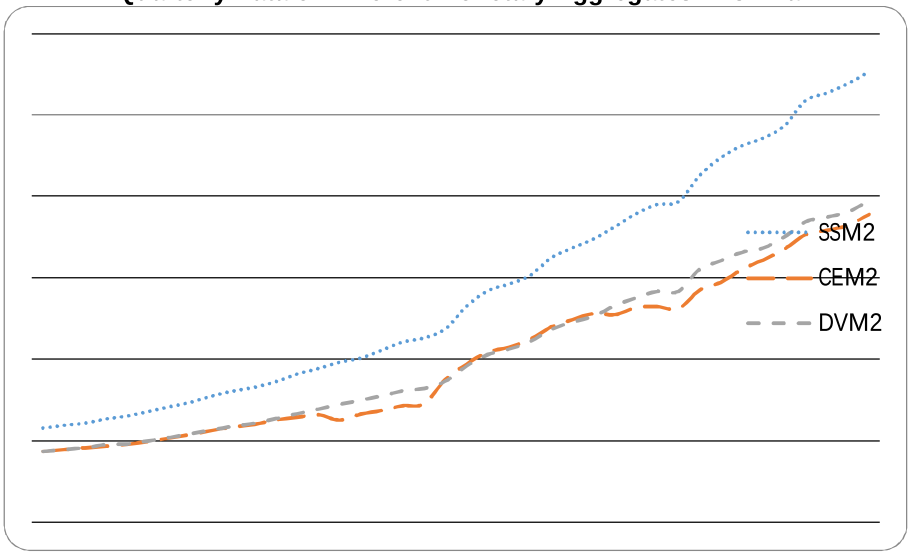


Figure 2

Quarterly Data of Different Monetary Aggregates in China



Our research conclusions attempt to convince central banks around the world, including the Federal Reserve, to attach importance to the theoretical basis and practical value of the currency-equivalent monetary aggregates as monetary policy intermediate targets, and to reevaluate the advantages and disadvantages of currency-equivalent monetary aggregates and Divisia monetary aggregates. We also hope they will consider currency-equivalent monetary aggregates as important supplementary reference indicators, or even alternative indicators, for intermediate targets of monetary policy related to simple-sum monetary aggregates, which will be conducive to improving the practicing effectiveness of monetary policy. The conclusion of this paper has more practical significance for the transition countries, of which China is an example, since these give priority to implementing quantitative monetary policy regulations.

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