Journal of
*Risk and Financial Management*

*Article*

# Constructing Divisia Monetary Aggregates for Singapore

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**Abstract:** Since Barnett derived the user cost price of money, the economic theory of monetary services aggregation has been developed and extended into a field of its own with solid foundations in microeconomic theory. Divisia monetary aggregates have repeatedly been shown to be strictly preferable to their simple sum counterparts, which have no competent foundations in microeconomic aggregation or index number theory. However, most central banks in the world, including that of Singapore, the Monetary Authority of Singapore (MAS), still report their monetary aggregates as simple summations. Recent macroeconomic research about Singapore tends to focus on exchange rates as a monetary policy target but ignores the aggregate quantity of money. Is that because quantities of money are irrelevant to economic activity? To examine the role of monetary quantities as potential monetary instruments, indicators, or targets and their relevance to predicting real economic activity in Singapore, this paper applies the user cost of money formula and the recently developed credit-card-augmented Divisia monetary aggregates formula to construct monetary services indexes for Singapore. We produce those state-of-the-art monetary services indexes from Jan 1991 to Mar 2021. We see that Divisia measures behave differently from simple sum measures in the period before the year 2000, while interest rates were high. Credit-card-augmented Divisia monetary services move closely with the conventional Divisia monetary aggregates, since the volume of credit card transactions in Singapore is relatively small compared with other monetary service assets. In future work, we plan to use our data to explore central bank policy in Singapore and to propose improvements in that policy. By making our data available to the public, we encourage others to do the same.

**Keywords:** Divisia index; Divisia monetary aggregates; credit-card-augmented Divisia; open-economy macroeconomics; monetary policy analysis; Singapore

**JEL Classification:** E32; E40; E41; E47; E50; E51; E52; E58



**Citation:** Barnett, William A., and Van H. Nguyen. 2021. Constructing Divisia Monetary Aggregates for Singapore. *Journal of Risk and Financial Management* 14: 370. https://doi.org/10.3390/jrfm14080370

Academic Editor: Thanasis Stengos

Received: 21 June 2021
Accepted: 4 August 2021
Published: 12 August 2021



## 1. Introduction

Since Irving Fisher (1922) published his classic book, *The Making of Index Numbers*, statistical indexes have been extensively applied in economic measurement. For instance, to measure real GDP, no one would today add apples and automobiles, since one apple is not a perfect substitute for one automobile. For the same reason, we cannot impute the same weight to percentage changes in the price of automobiles as to the percentage changes in the price of apples when measuring inflation. Although widely used in economic measurement since the appearance of Fisher's book, statistical index theory has not been applied in financial and monetary aggregation until recent decades.

Up until the 1980s, economists throughout the world measured different levels of monetary aggregation, such as M0/MB (monetary base), M1 (narrow money), M2 (broad money), and M3 and M4 (financial liquidity), by simply adding up the quantities of component assets. Simple summation assigns the same weights to different monetary assets and thereby implicitly assumes that all monetary assets are perfect substitutes. In modern economies, in which monetary assets possess different levels of liquidity and yield different interest rates, simple sum measures are misleading and can damage inferences about economic behavior and the economy. Crystal and MacDonald (1994) coined the now well-known term "Barnett critique" to designate the resulting distortions of economic inferences.

To properly aggregate components in monetary service aggregation, we need both their quantities and prices. However, how to measure monetary service prices was not known to economists until the 1980s. Monetary asset services are not analogous to perishable consumer good services, such as apples, but to capital goods or durable goods, such as houses or automobiles. Hence, we need to measure their service prices in terms of their user cost prices.

The concept of user cost pricing of durable services was first introduced by Jorgenson (1963). He introduced user cost theory applicable to durable and capital goods for which perfect rental markets do not exist. When perfect rental markets exist for a good, the user cost price equals the market rental price. When a perfect rental market does not exist for a durable, the theoretically computed user cost price is sometimes called the "equivalent rental price" or shadow rental price. The theory of monetary aggregation was originated by Barnett in the 1980s, following his derivation of the user cost price of monetary services in Barnett (1978, 1980). Using the resulting user cost pricing, Barnett (1980, 1987) applied existing index number and aggregation theory to construct the Divisia index for monetary service aggregation. The famous Divisia index, originated by Francois Divisia (1925), measures the growth rate of a quantity (or price) aggregate as the weighted average of the growth rates of the quantities (or prices) of the component goods over which the index aggregates. The weights are the component expenditure shares.

Since the economic theory of monetary aggregation became available, the theory has been developed and extended substantially. Barnett et al. (1997) extended the theory to risk, based upon the consumption capital assets pricing model (CCAPM). That result extended Barnett's perfect certainty theory to the case of risk, when consumers of monetary services are risk-averse and interest rates are not known at the beginning of the period. Barnett (2007) extended the theory to multilateral monetary aggregation over different countries. More recently, Barnett et al. (2016) and Barnett and Su (2016, 2017, 2018) have taken credit card transactions into account and produced the theoretical framework for the new credit-card-augmented Divisia monetary aggregates. Other extensions have included measurement of the economic capital stock of money, based on the expected discounted flow of monetary services, and extension of the risk adjustment to the case of intertemporal non-separability.

Hundreds of empirical papers from throughout the world have compared Divisia monetary aggregates with their simple sum counterparts. Key articles, books, and works on the topic can be found at the online library of Center for Financial Stability (CFS). Since simple sum monetary aggregation is theoretically inadmissible, having no competent theoretical foundations, it should be no surprise that in almost all cases, the Divisia monetary index has proven to be strictly preferable to its simple sum counterpart, relative to all available empirical tests (see, for example, Barnett et al. (1984), Barnett (2011), Belongia and Ireland (2014), and Ellington (2018)). Belongia and Ireland (2015) are critical of the omission of monetary quantities in recent mainstream macroeconomic models. These omissions are largely a result of empirical findings in such papers as Bernanke and Blinder (1988), who argue that the demand for money function has become unstable; but all such findings use simple sum monetary aggregates. Recent DSGE models often include an interest rate feedback rule as a basis for monetary policy, while totally ignoring monetary services in the economy. The most common interest rate rule in the literature is the Taylor rule, based on Taylor (1993). Replacing the traditional simple sum measure of money supply by Divisia measures, Belongia (1996), Barnett and Chauvet (2010), Barnett et al. (2013), and Liu et al. (2020), among many other researchers, have shown that money still shares a strong relationship with aggregate economic activity, and the demand for money function still exhibits stability. This simple solution has been found to be true in hundreds of publications throughout the world, since Divisia monetary aggregates became available.

Faced with all this theoretical and empirical evidence, central banks such as the Federal Reserve (FED) in the US, the Bank of England (BOE) in the UK, the European Central Bank (ECB), the Bank of Japan (BoJ), the National Bank of Poland, and the Bank of Israel, among others, have, at various times and in diverse ways, produced and maintained Divisia indexes for monetary aggregation. Some central banks choose to make it available to the public on an official basis, such as the BOE. Others choose to make those aggregates available only for internal use. However, the availability of the simple sum aggregates has continued. For good reasons, those incompetent simple sum aggregates are declining in usage by central banks and by the economics profession.

Many other central banks in the world, including the Monetary Authority of Singapore (MAS), continue to report their money supplies solely as simple sum measures. Singapore is a very small economy, the size of a medium city, with a population of about 5.8 million people, yet it has produced a remarkable success story as a major financial center in Southeast Asia. This success may be related to its unique and interesting monetary policy system, which has been centered on the management of the exchange rate since 1981. This approach is different from the conventional monetary policy targeting of interest rates or monetary aggregates. Nevertheless, the economy has not received much attention from academic scholars. Recent DSGE macroeconomic models often ignore aggregate quantities of money as possible instruments or targets of monetary policy. In the case of a small open economy such as Singapore's, exchange rates are often targeted to achieve goals for inflation and output gap (see, e.g., McCallum (2007)). Chow et al. (2013) discuss the monetary regime choice in Singapore and compare its exchange rate rule with the Taylor rule but ignore money quantities.

Empirical work using Divisia monetary aggregates in Singapore is limited, with the only related work in the literature being Habibullah (1999). The focus of that paper was not primarily the case of Singapore, but rather the monetary policies in many Asian countries, including Indonesia, Malaysia, Singapore, Philippines, South Korea, Taiwan, and Thailand among others. The data used in that research were mostly before the Asian financial crisis and did not use credit-card-augmented Divisia monetary aggregates, which were not yet known at that time.

Our paper constructs Divisia monetary aggregates for Singapore based on monthly data from Jan 1991 to Mar 2021. We find that the major contributions to the growth rates of Divisia monetary service flows come from demand deposits, fixed deposits, and savings (and other) deposits in commercial banks. Fixed deposits and savings deposits in finance companies provide moderate contributions, while the weights of other components such as negotiable CDs, repurchase agreements, and Treasury bills are negligible.

Although credit card transactions are augmented into our monetary aggregates, their weights are small. Therefore, we find their contributions at this time to the growth rate of Divisia monetary services in Singapore to be minor, although this could change in the future as money market institutional innovations continue. Another finding is that during the period before 2000, when interest rates were high and more volatile, Divisia monetary aggregates behaved significantly differently from the simple sum measures, while during the period after 2000, when interest rates on monetary assets have become close to each other at very low levels, Divisia monetary aggregates have behaved almost identically to the simple sum measures.

Providing the constructed data to the public, we would encourage others to do the same. We plan to use Divisia data to examine monetary policy in Singapore. Our planned first direction will be to examine the cyclical correlations and Granger causality relations between different measures of money and real economic variables. We also plan to build a New Keynesian model for a small open economy to be used to examine the potential role of money aggregates as a policy target in Singapore, in comparison with the central bank's current policy rule, targeting a trade-weighted exchange rate index.

## 2. Methodology

### 2.1. Conventional Divisia Monetary Aggregates

Barnett (1978, 1980) derived the user cost of monetary asset services from an intertemporal consumer utility maximization problem. Let U be the representative consumer's current intertemporal $T$-period utility function

$$U = U(u(\mathbf{m}_t), \mathbf{m}_{t+1}, \ldots, \mathbf{m}_{t+T}; \mathbf{x_t}, \ldots, \mathbf{x_{t+T}}; A_{t+T})$$

for each period's consumption of goods $\mathbf{x}_s$ having prices $\mathbf{p}_s$, monetary assets $\mathbf{m}_s$, and bond holdings $A_{t+T}$ for $s = t, t+1, \ldots, T$. In theory, the "bond" is called the benchmark asset, which formally is a pure capital investment held solely for its investment rate of return, and thereby providing no other services. The intertemporal utility function is assumed to be weakly separable in the current period consumption of monetary services, $\mathbf{m}_t$. The representative consumer maximizes utility subject to the constraint

$$\mathbf{p_s}'\mathbf{x_s} = w_s L_s + \sum_{i=1}^{n} [(1 + r_{i,s-1}) p^*_{s-1} m_{i,s-1} - p^*_s m_{i,s}] + [(1 + R_{s-1}) p^*_{s-1} A_{s-1} - p^*_s A_s]$$

for $s = t, t+1, \ldots, T$, where $p_s{}^*$ is the true cost of living index, $w_s$ is the wage rate, $L_s$ is the per capital labor supply, $r_{i,s}$ is the rate of return on monetary asset $m_{i,s}$, and $R_s$ is the yield on the benchmark asset $A_s$.

Let $\mathbf{m}^*_t = (m^*_{1,t}, m^*_{2,t}, \ldots, m^*_{n,t})'$ be the solution for period $t$'s monetary assets in the intertemporal decision. Barnett (1978, 1980) showed that $\mathbf{m}^*{}_t$ is also the solution to the current period conditional decision of maximizing $u(\mathbf{m}_t)$ subject to

$$\boldsymbol{\pi}_\mathbf{t}'\mathbf{m_t} = y_t,$$

where $y_t$ is expenditure allocated to the portfolio of $n$ monetary assets

$$\mathbf{m}_t = (m_{1,t}, m_{2,t}, \ldots m_{n,t})'$$

during the intertemporal decision and

$$\boldsymbol{\pi}_t = (\pi_{1,t}, \pi_{2,t}, \ldots, \pi_{n,t})'$$

is the vector of user costs of monetary asset services. To assure the existence of a current period monetary services aggregate, the category utility function, $u$, is assumed to be monotonically increasing, strictly concave, and blockwise weakly separable within intertemporal tastes.

Barnett (1978, 1980) proved that the resulting nominal user cost price of each monetary asset is

$$\pi_{i,t} = \frac{p^*_t (R_t - r_{i,t})}{1 + R_t}, \tag{1}$$

where the true cost of living index is used to deflate nominal quantities to real quantities, $R_t$ is the expected one-period holding yield on the benchmark asset, and $r_{i,t}$ is the current-period rate of return on the $i$-th monetary asset. As emphasized in Barnett (1978, 2011), the user cost price of a monetary asset is not its interest rate but its opportunity cost, consisting of the interest rate forgone by consuming the services of the asset. For example, if the asset is currency, having an interest rate of zero, the forgone interest rate is the benchmark rate itself.

The corresponding real user cost price is

$$\frac{\pi_{i,t}}{p^*_t} = \frac{R_t - r_{i,t}}{1 + R_t}. \tag{2}$$

With availability of the user cost prices of monetary assets, both their quantities and their prices are well-defined. The economic theory of aggregation over monetary assets becomes available. Barnett (1987) proved that the exact monetary quantity aggregate, $M_t = M(\mathbf{m_t})$, can be tracked without error in continuous time by the Divisia index, defining the growth rate of aggregate monetary services to be

$$\frac{d\log M_t}{dt} = \sum_{i=1}^{n} s_{i,t}\frac{d\log m^*_{i,t}}{dt}, \tag{3}$$

where

$$s_{i,t} = \frac{\pi_{i,t}m^*_{i,t}}{y_t} = \frac{\pi_{i,t}m^*_{i,t}}{\sum_{j=1}^{n}\pi_{j,t}m^*_{j,t}}. \tag{4}$$

The weight $s_{i,t}$ of monetary asset $i$ is its share in the total expenditure on the portfolio. Since economic data are in discrete time, an approximation is needed. The Tornqvist–Theil approximation (often called the Tornqvist index or just the Divisia index in discrete time) is a second order approximation to the continuous Divisia index,

$$\log M_t - \log M_{t-1} = \sum_{i=1}^{n} \bar{s}_{i,t}(\log m^*_{i,t} - \log m^*_{i,t-1}), \tag{5}$$

where the discrete time share weights are approximated by

$$\bar{s}_{i,t} = \frac{1}{2}(s_{i,t} + s_{i,t-1}). \tag{6}$$

In short, the growth rate of a Divisia monetary quantity index is the share weighted average of the growth rates of its components. Barnett (1987) showed that the discrete time Divisia index is accurate to within three decimal places for monthly or weekly data. As a result, the remainder term in the Tornqvist approximation is less than the roundoff error in the available component data. Equation (4) can equivalently be written as

$$\frac{M_t}{M_{t-1}} = \prod_{i=1}^{n}\left(\frac{m^*_{i,t}}{m^*_{i,t-1}}\right)^{\bar{s}_{i,t}}. \tag{7}$$

The growth rate of the dual Divisia user cost price aggregate, $\Pi_t = \Pi(\boldsymbol{\pi}_t)$, in continuous time, is derived in a similar manner to be

$$\frac{d\log \Pi_t}{dt} = \sum_{i=1}^{n} s_{i,t}\frac{d\log \pi_{i,t}}{dt}, \tag{8}$$

with the corresponding Tornqvist discrete time approximation being

$$\log \Pi_t - \log \Pi_{t-1} = \sum_{i=1}^{n} \bar{s}_{i,t}(\log \pi_{i,t} - \log \pi_{i,t-1}) \tag{9}$$

An alternative way to derive the dual user cost price aggregate is from Fisher's factor reversal test, in accordance with which

$$\Pi_t = \frac{\boldsymbol{\pi}'_t\mathbf{m}^*_t}{M_t} = \frac{\sum_{i=1}^{n}\pi_{i,t}m^*_{i,t}}{M_t}. \tag{10}$$

so that

$$\Pi_t M_t = \boldsymbol{\pi}'_t\mathbf{m}^*_t = \sum_{i=1}^{n}\pi_{i,t}m^*_{i,t}.$$

For a rigorous discussion, Barnett (1980) showed that in continuous time, the two methods of computing the dual user cost aggregate produce identical results. In discrete time, the two methods produce slightly different results, with the difference being less than the roundoff error in the component data and thereby negligible.

### 2.2. Credit-Card-Augmented Divisia Monetary Aggregates

In recent years, credit card payments have become increasingly common in modern economies worldwide. By accounting conventions, liabilities cannot be added to assets. Since credit card balances are liabilities, they cannot be added to monetary assets. Hence credit cards cannot be included in simple sum monetary aggregates. However, in economic theory, aggregation over services is possible, regardless of whether the services are produced from assets or liabilities. The deferred payment services of credit card transactions can be augmented into the Divisia monetary service aggregates.

The theoretical framework is provided in Barnett et al. (2016) and Barnett and Su (2016, 2017, 2018). Accordingly, the user cost price of a credit card's services is

$$\pi^c_{j,t} = \frac{p^*_t(e_{j,t} - R_t)}{1 + R_t}, \tag{11}$$

where $e_{j,t}$ is the interest rate charged by credit card type $j$, with $j = 1, \ldots k$, during time $t$. The consumer's optimal choice of the volume of purchases of goods and services during period $t$ with credit card type $j$ is $c^*_{j,t}$. The consumer's utility maximizing solution for the transaction services of the $k$ credit card types is

$$\mathbf{c}^*_{i,t} = (c^*_{1,t}, c^*_{2,t}, \ldots, c^*_{k,t})'.$$

The growth-rate weight of monetary asset $i$'s services is

$$w_{i,t} = \frac{\pi_{i,t} m^*_{i,t}}{\boldsymbol{\pi}'_t \mathbf{m}^*_t + (\boldsymbol{\pi}^c_t)' \mathbf{c}^*_t}, \tag{12}$$

while the growth-rate weight of credit card $j$'s services is

$$w^c_{j,t} = \frac{\pi_{j,t} c^*_{j,t}}{\boldsymbol{\pi}'_t \mathbf{m}^*_t + (\boldsymbol{\pi}^c_t)' \mathbf{c}^*_t}. \tag{13}$$

The credit-card-services-augmented Divisia monetary aggregate becomes

$$\frac{d \log M_t}{dt} = \sum_{i=1}^{n} w_{i,t} \frac{d \log m^*_{i,t}}{dt} + \sum_{j=1}^{k} w^c_{j,t} \frac{d \log c^*_{j,t}}{dt} \tag{14}$$

The Tornqvist discrete time approximation is analogous to that for the conventional Divisia index.

### 2.3. User Cost and Interest Rate Aggregation

Divisia user cost price aggregates can be computed in a manner similar to the Divisia monetary quantity aggregates, using Equation (9) with the weights computed by Equations (4) and (6). However, in this paper, given that we already constructed the Divisia quantity index, $M_t$, the corresponding user cost price aggregate is derived from Fisher's factor reversed test as in Equation (10). Credit-card-augmented user cost price aggregates are also computed accordingly.

For interest rate aggregation, this paper follows Barnett et al. (2013) using accounting principles. Accordingly, the aggregated interest rate on a portfolio is the rate of return on the portfolio,

$$r_t = \frac{\sum_{i=1}^{n} r_{i,t} m_{i,t}}{\sum_{i=1}^{n} m_{i,t}}. \quad (15)$$

## 3. Data and Construction

To construct Divisia monetary aggregates for monetary services, we needed data on both quantities and interest rates of each monetary asset. This section describes the data we used and the construction results.

### *3.1. Data Description*

Table 1 provides a basic description for the data set. Data on levels and rates of return on monetary assets are monthly from Jan 1991 to Mar 2021, provided by the Monetary Authority of Singapore (MAS). The true cost of living index was measured by the consumer price index (CPI), which was from the Singapore department of statistics. For the United States, the Federal Reserve reports interest rates charged on credit card deposits averaged over all credit card users, including those who do not pay interest on their credit card balances, since they do not carry forward unpaid balances. That average interest rate is the one to use in modeling the decisions of the representative consumer, aggregated over all consumers (see Barnett and Su (2017)).

**Table 1.** Monetary Asset Components.

| m | Asset | Rate of Return |
|---|---|---|
| 1 | Currency | 0% |
| 2 | Demand Deposits | 0% |
| 3 | Fixed Deposits in Commerce Banks | 3-month CDs in banks |
| 4 | Negotiable CDs in Commerce Banks | 3-month Commercial Bills |
| 5 | Saving and Other Deposits in Commerce Banks | saving rate in banks |
| 6 | Fixed Deposits in Finance Companies | 3-month CDs in finance companies |
| 7 | Saving and Other Deposits in Finance Companies | saving rate in finance companies |
| 8 | Deposits in Post Office Saving Bank * | NA |
| 9 | Overnight and Term Repurchases | repos rate |
| 10 | Treasury Bills (all T-bills and SGSs) ** | 12-month T-bill yield |
| 11 | Credit Card Transaction Volumes *** | average credit card interest rate |

Data Source: Monetary Authority of Singapore (MAS). The monthly dataset covers the period from Jan 1991 to Mar 2021. Data on levels are in millions of Singapore dollars (SGD). * Post Office Saving Bank was acquired by the Development Bank of Singapore from Nov 1998. ** SGSs stands for Singapore Government Securities. *** In Singapore, those volumes are called "Total Credit Card Billings".

Unfortunately, the central bank in Singapore (MAS) does not report those interest rates. However, ValueChampion (https://www.valuechampion.sg/about, accessed on 11 August 2021) in Singapore does report that interest rate averaged over time. Experiments with the United States data show negligible differences in the credit-card-augmented monetary aggregates, if that interest rate is averaged over the sample period and then treated as a constant, rather than being used as the actual interest rate each month. As a result, with our Singapore data, we used the interest rate averaged over time, as reported at the surprisingly high level of 25% per year by ValueChampion. Perhaps that high interest rate may partially explain why the share of credit card deferred payment services in Singapore is relatively low.

The central bank of Singapore (MAS) categorizes the primary components of M1 as currency in circulation and demand deposits in banks. The MAS simple sum M2 includes M1 and the banking sector components, fixed deposits (CDs), savings (and other) deposits, and negotiable certificates of deposits (NCDs). Simple sum M3 incorporates the non-banking sector by including net deposits in finance companies. Post Office Saving Bank (POSB) deposits existed in Singapore before Nov 1998. Up to Oct 1998, POSB was included by MAS in its non-banking sector data and included in M3, but not in M2. However, from Nov 1998, with the acquisition of POSB by the Development Bank of Singapore (DBS), POSB's data have been incorporated as part of the banking system in M1 and thereby also in M2 and M3.

*Nesting components*: In this paper, we follow Barnett et al. (2013) in clustering and nesting components of monetary assets. Our clustering of components into different levels of aggregation prior to computing the Divisia aggregates is slightly different from that of the simple sum measures reported by the MAS. Table 2 summarizes the components in the MAS simple sum aggregates and our Divisia aggregates. Accordingly, our Divisia M1 (DM1) has the same components as its counterpart simple sum aggregate, M1. Our Divisia M2 (DM2) aggregate includes components in DM1 along with fixed deposits (CDs) and savings (and other) deposits, both in the banking sector and the non-banking sector. Our Divisia M3 (DM3) includes the components of DM2 along with NCDs and repurchase agreements (repos). Finally, our Divisia M4 (DM4) incorporates Treasury bills into Divisia M3. Our credit-card-augmented Divisia indexes are computed by incorporating credit card transactions into each level of aggregation hence, we also report DM1a, DM2a, DM3a, and DM4a.

**Table 2.** Nesting Components in Monetary Aggregates.

| m | Asset | M1 | M2 | M3 | DM1 | DM2 | DM3 | DM4 |
|---|---|---|---|---|---|---|---|---|
| 1 | Currency | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | Demand Deposits | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | Fixed Deposits in Commerce Banks | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 4 | Negotiable CDs in Commerce Banks | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 5 | Saving and Other Deposits in Commerce Banks | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 6 | Fixed Deposits in Finance Companies | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 7 | Saving and Other Deposits in Finance Companies | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 8 | Deposits in Post Office Saving Bank * | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 9 | Overnight and Term Repurchases | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 10 | Treasury Bills (all T-bills and SGSs) | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

* Since the details on interest rates for POSB are not available, we split the quantities into fixed deposits and saving deposits and incorporate them into banking sector.

*Data on levels*: The data on levels of components are in current values, and the unit is million of Singapore dollars. Net deposits in finance companies are included in M2, but the break-down components, fixed deposits, and savings (and other) deposits, are not separately reported. We directly investigated the assets and liabilities of finance companies to obtain the break-down components. We recovered the fixed deposits and savings and other deposits in finance companies by using the proportion of net deposits in total deposits.

Since there were no available interest rates for deposits in POSB, we assumed that these rates are the same as those in the banking sector. The data on the POSB level (up to Oct 1998) are incorporated into the banking sector. We calculated the proportion of fixed deposits and savings (and other) deposits out of total deposits in both the banking sector and the non-banking sector. We then used those proportions to split the net deposits in POSB into fixed deposits and savings (and other) deposits and then added them into the banking sector.

In the series for the level of NCDs during the period from Aug 2009 to Jun 2010, the quantities reported are zeros, which does not seem credible. We smoothed the data on NCDs for the above period by approximating the zero-quantities by the average of the quantities 12 months before and 12 months after that period.

*The benchmark rate*: In theory, the benchmark rate is the rate of return on pure capital. Its rate of return cannot be less than the rates of return on any monetary assets that provide services to depositors along with investment yield. In this paper, we follow Barnett et al. (2013) in choosing the short-term lending rate as the benchmark rate. Banks cannot be expected to pay higher rates of interest to their depositors than they earn on their investments. Indeed, in the case of Singapore, the prime lending rate is always higher than the interest rates on the component monetary assets, as shown in Figure 1. It is noted that the credit card interest rates are much higher than the benchmark rate and all other rates of return. This is true for the cases of the US, Singapore, and other economies in the world. The reason is clear. Credit card interest rates are the interest rates charged to credit card users, who are borrowing money from credit card companies as unsecured loans with high default and fraud risk. Those interest rates are always higher than the rates of return on monetary assets, which are paid to the owners of monetary assets.

*Data on rates of return*: Since currency and demand deposits do not yield interest rate, we set their interest rates at zero. Short-term fixed deposits typically include 3-month CDs, 6-month CDs, and 12-month CDs. We do have data on their interest rates; however, we do not have the corresponding interest rates on fixed deposits in banks and finance companies. Hence, we used 3-month CD interest rates for banks and finance companies to represent the rates of return on fixed deposits in banks and non-banking institutions. For T-bills, we added together all T-bills and imposed the 12-month T-bill yield as their rate of return.

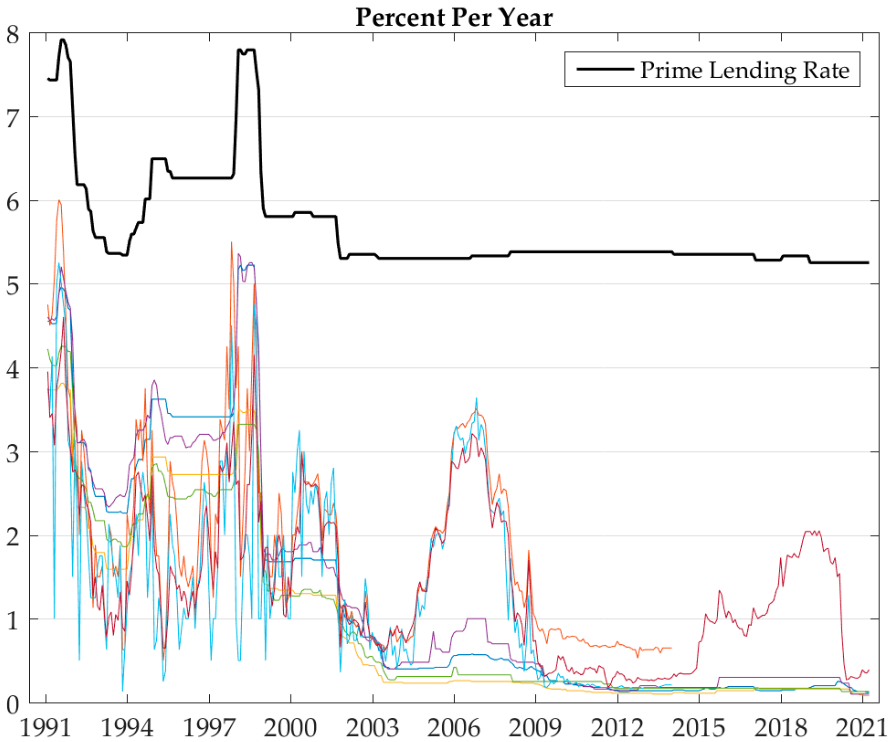


**Figure 1.** Benchmark rate versus other interest rates.

Since the rate of return on NCDs is not reported, we used the rate on 3-month commercial paper as a proxy. The rates of return series for 3-month commercial paper and repurchase agreements were discontinued from Jan 2014. The missing observations were estimated by a regression of each series on the 12-month T-bill yield.

### 3.2. Data Construction and Results

Based on our clustering of components into different levels of aggregation as presented in Table 2, we computed the growth rates of the Divisia monetary aggregates and their credit-card-augmented variants at the levels of aggregation we had chosen. Corresponding interest rate aggregates and user cost aggregates were also computed.

Divisia M1 (DM1) contains the same two components as its simple sum counterpart, and their corresponding interest rates are equal to zero. Hence, the user cost prices for these components are the same. Under those conditions, the Divisia quantity index becomes the simple sum. The growth rate of DM1 and its level (normalized to equal 100 in Jan 1991) are the same as those of M1, as shown in Figure 2. However, when we take into account the credit card transactions, the augmented Divisia indexes behave a little differently from the conventional Divisia indexes, which can be seen in Figure 3.

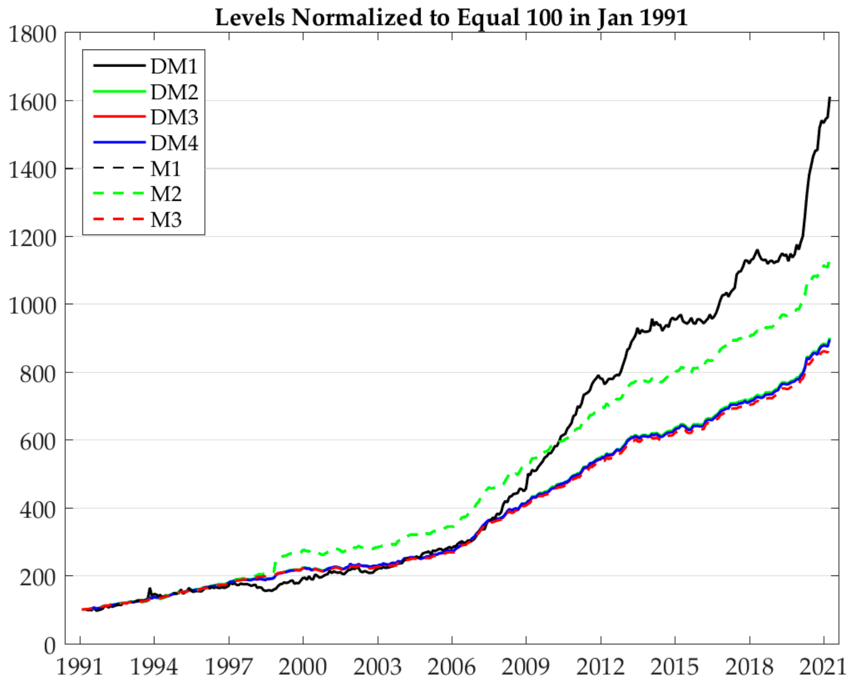


**Figure 2.** Divisia versus simple sum aggregates, 1991–2021.

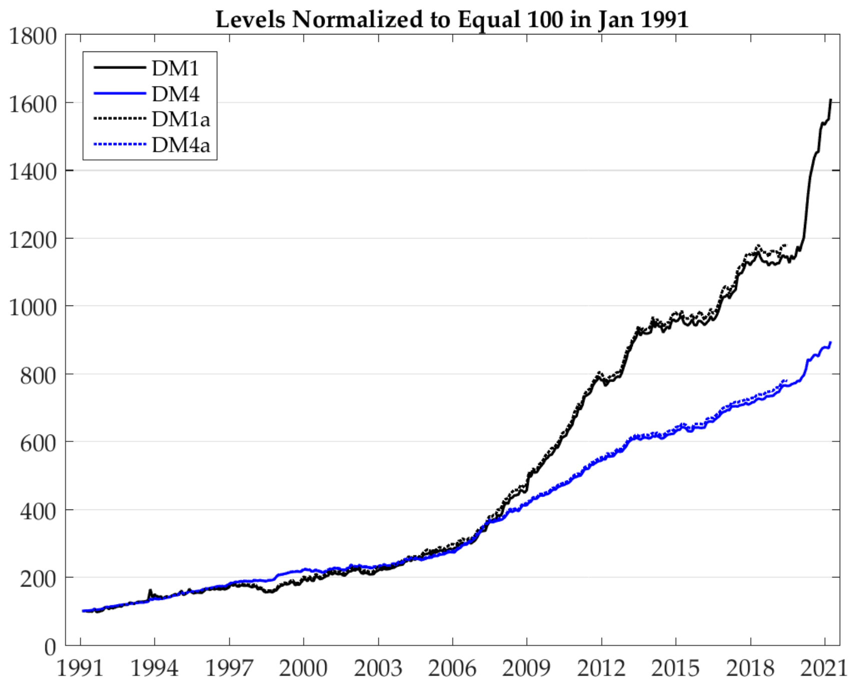


**Figure 3.** Divisia and credit-card-augmented Divisia monetary aggregates, 1991–2021.

DM2, DM3, and DM4 have almost identical growth rates, but they are substantially different from the growth rate of DM1. As shown in Figure 2, DM2, DM3 and DM4 almost lie on top of each other. To explain this fact, refer to Tables 3 and 4 for the growth-rate weights of the components in the Divisia monetary aggregates. While DM1 contains only two components, currency and demand deposits, their weights for the latest months in our sample (Mar 2021) are 20.66% and 79.34%, respectively, as presented in Table 3. These weights are quite different from those of DM2, DM3, and DM4, which are about 7% and 28%, respectively. The major components that contribute to the growth rates of DM2, DM3, and DM4 are three components of the banking sector: demand deposits, fixed deposits in commercial banks, and savings (and other) deposits in commercial banks. These three components account for 60% of the fluctuation in the growth rates of DM2, DM3, and DM4. Finance companies provide a moderate contribution to the growth rates of those Divisia monetary aggregates. Although DM3 and DM4 incorporate additional components into DM2, namely NCDs, repos, and T-bills, their weights are almost negligible.

**Table 3.** Growth-rate Weights in the Last Month (Mar 2021), Percentages.

| m | Asset | DM1 | DM2 | DM3 | DM4 |
|---|---|---|---|---|---|
| 1 | Currency | 20.658 | 7.622 | 7.555 | 7.526 |
| 2 | Demand Deposits | 79.342 | 29.281 | 29.024 | 28.913 |
| 3 | Fixed Deposits in Commerce Banks | 0 | 26.290 | 26.059 | 25.960 |
| 4 | Negotiable CDs in Commerce Banks | 0 | 0 | 0.018 | 0.018 |
| 5 | Saving and Other Deposits in Commerce Banks | 0 | 35.038 | 34.730 | 34.598 |
| 6 | Fixed Deposits in Finance Companies | 0 | 1.708 | 1.693 | 1.687 |
| 7 | Saving and Other Deposits in Finance Companies | 0 | 0.061 | 0.061 | 0.060 |
| 9 | Overnight and Term Repurchases | 0 | 0 | 0.860 | 0.857 |
| 10 | Treasury Bills (all T-bills and SGSs) | 0 | 0 | 0 | 0.381 |
| | | 100 | 100 | 100 | 100 |

**Table 4.** Growth-rate Weights in the Last 12 Months (Apr 2020–Mar 2021), Percentages.

| m | Asset | DM1 | DM2 | DM3 | DM4 |
|---|---|---|---|---|---|
| 1 | Currency | 21.340 | 7.533 | 7.465 | 7.434 |
| 2 | Demand Deposits | 78.660 | 27.811 | 27.558 | 27.447 |
| 3 | Fixed Deposits in Commerce Banks | 0 | 29.046 | 28.781 | 28.663 |
| 4 | Negotiable CDs in Commerce Banks | 0 | 0 | 0.015 | 0.015 |
| 5 | Saving and Other Deposits in Commerce Banks | 0 | 33.737 | 33.430 | 33.295 |
| 6 | Fixed Deposits in Finance Companies | 0 | 1.823 | 1.807 | 1.799 |
| 7 | Saving and Other Deposits in Finance Companies | 0 | 0.050 | 0.049 | 0.049 |
| 9 | Overnight and Term Repurchases | 0 | 0 | 0.896 | 0.892 |
| 10 | Treasury Bills (all T-bills and SGSs) | 0 | 0 | 0 | 0.405 |
| | | 100 | 100 | 100 | 100 |

The credit-card-augmented Divisia aggregates behave similarly to the conventional Divisia monetary aggregates, since the volume of credit card transactions in Singapore is currently relatively small compared to other sources of monetary services. Hence, the growth-rate weight of credit card transaction volumes is currently small, about 9.5% at the M1 level of aggregation and 3.2% at broader levels of aggregation, as shown in Table 5. However, the role of credit card deferred payment services may grow in the future as financial services innovations continue to evolve.

**Table 5.** Credit-Card-Augmented Growth-rate Weights (Jun 2019), Percentages.

| m | Asset | DM1a | DM2a | DM3a | DM4a |
|---|---|---|---|---|---|
| 1 | Currency | 21.979 | 7.321 | 7.278 | 7.261 |
| 2 | Demand Deposits | 68.541 | 22.829 | 22.695 | 22.642 |
| 3 | Fixed Deposits in Commerce Banks | 0 | 33.354 | 33.159 | 33.081 |
| 4 | Negotiable CDs in Commerce Banks | 0 | 0 | 0.005 | 0.005 |
| 5 | Saving and Other Deposits in Commerce Banks | 0 | 31.355 | 31.171 | 31.098 |
| 6 | Fixed Deposits in Finance Companies | 0 | 1.937 | 1.926 | 1.921 |
| 7 | Saving and Other Deposits in Finance Companies | 0 | 0.046 | 0.046 | 0.046 |
| 9 | Overnight and Term Repurchases | 0 | 0 | 0.582 | 0.581 |
| 10 | Treasury Bills (all T-bills and SGSs) | 0 | 0 | 0 | 0.235 |
| 11 | Credit Card Transaction Volumes * | 9.480 | 3.157 | 3.139 | 3.132 |
| | | 100 | 100 | 100 | 100 |

* In Singapore, those volumes are called “Total Credit Card Billings”.

For a comparison of the Divisia and simple sum aggregates, see Figure 2. It is noted that simple sum M2 experiences a sudden peak in Nov 1998, while simple sum M3 and Divisia indexes do not. It happened due to the acquisition of POSB into the banking sector. This is not an expansion of the money supply, but rather a structural change in nesting of components into different levels of aggregation. The Divisia monetary aggregates do not experience this sudden misleading spike. The overall picture becomes clearer when we look at the year over year growth rate of money in Figure 4. The period before 2000 is particularly interesting, because interest rates were higher and more volatile compared to the later period (see Figure 1). There is a huge contraction of money supply during the Asian financial crisis, 1997-1998, as displayed very clearly in the DM3 growth rates, but simple sum M3 does not show it.

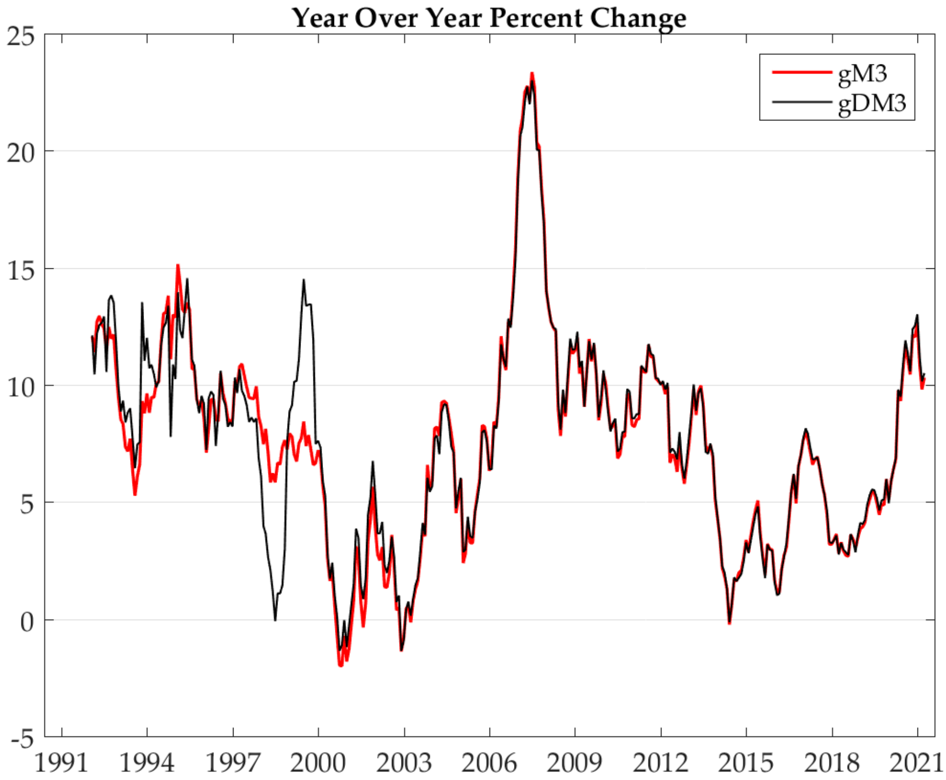


**Figure 4.** Divisia M3 versus simple sum M3 growth rates 1992–2021.

After 2000, the growth rates of the Divisia monetary aggregates and the simple sum versions are close to each other. Again, the reason is the behavior of interest rates in Singapore. After 2000, interest rates for fixed deposits and savings deposits in both commercial banks and finance companies are at very low levels, almost zero, and thereby very similar to each other (see Figure 1). As a result, the user cost prices for those assets are almost identical to each other, so that the Divisia indexes are close to their simple sum counterparts during that period. In the future, simple sum and Divisia measures will again diverge, if interest rates return to higher levels.

Interest rate aggregates and real user cost price aggregates are plotted in Figures 5 and 6. Different levels of interest rate aggregation produce almost identical results and follow the common trend of interest rates in the world, with interest rates becoming very low after 2000. Real user cost aggregates are, in accordance with theory, always positive, and a higher level of aggregation shows higher real user cost.

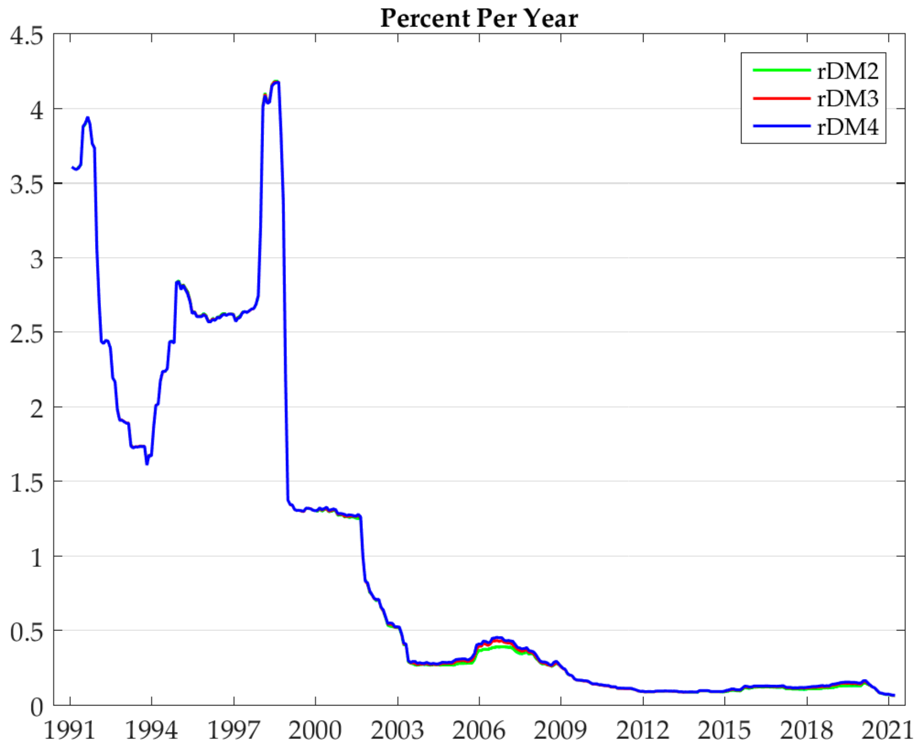


**Figure 5.** Interest rate aggregates 1991–2021.

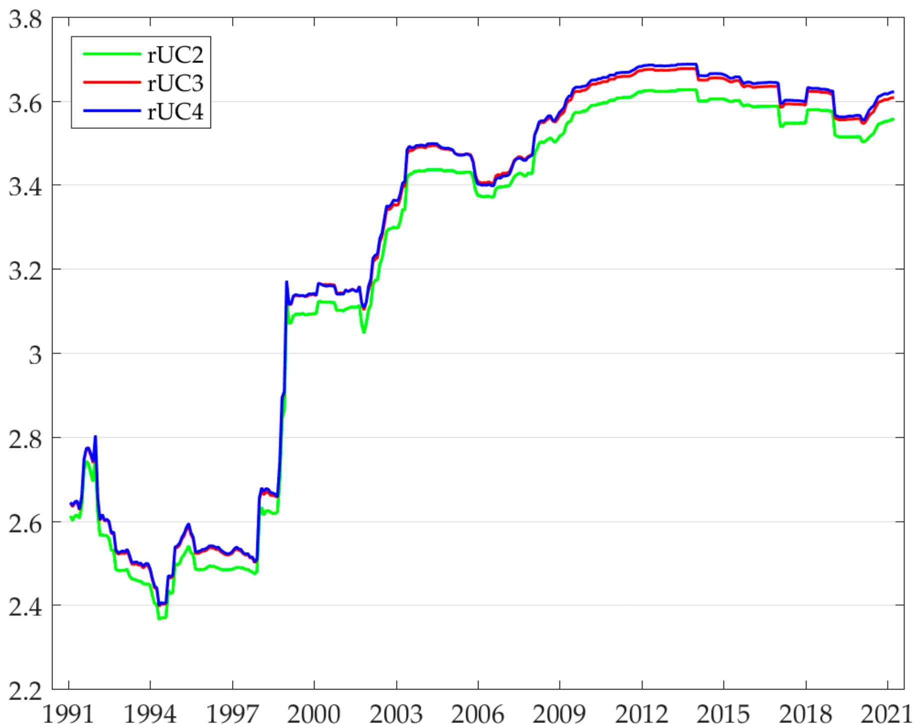


**Figure 6.** Real user cost aggregates 1991–2021.

## 4. Conclusions

Although aggregation theory and index number theory have been extensively applied in economic measurement for more than a century, monetary aggregation theory has appeared and been applied more recently. Large numbers of theoretical studies as well as empirical studies have repeatedly shown that Divisia monetary aggregates are superior to their simple sum counterparts, which have no competent foundations in economic theory. Nevertheless, many central banks in the world, including the Monetary Authority of Singapore, continue reporting money supply as a simple sum. This may be part of the reason that the quantity of money has been ignored in recent empirical macroeconomic research in Singapore. This paper provides the construction of Divisia monetary aggregates for Singapore and thereby will serve as the first step for research on the role of monetary services in the important Singapore economy.

We encourage others to use our Divisia Singapore data in their studies. We ourselves plan to use the data to examine cyclical correlations and Granger causality relation between different measures of money and real economic variables. Furthermore, we hope to build a New Keynesian model for a small open economy with a banking sector to examine the role of monetary aggregates as a possible policy target in Singapore, as opposed to the current trade-weighted exchange rate target.

**Author Contributions:** Conceptualization, V.H.N. and W.A.B.; methodology, V.H.N. and W.A.B.; software, V.H.N. and W.A.B.; validation, V.H.N. and W.A.B.; formal analysis, V.H.N. and W.A.B.; investigation, V.H.N. and W.A.B.; resources, V.H.N. and W.A.B.; data curation, VHN; writing—original draft preparation, VHN; writing—review and editing, V.H.N. and W.A.B.; visualization, V.H.N. and W.A.B.; supervision, W.A.B.; project administration, W.A.B.; funding acquisition, W.A.B. All authors have read and agree to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author. The data are not publicly available due to continuing research on developing these data.

**Conflicts of Interest:** The authors declare no conflict of interest.

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