DO CURRENCY EQUIVALENT MONETARY AGGREGATES HAVE AN EDGE OVER THEIR SIMPLE SUM COUNTERPARTS? SOME STYLISED FACTS

2.1. Introduction

Theoretically meaningful constructs of monetary aggregates should be based on economic aggregation and index number theory. In fact, the monetary aggregates that are consistent with economic theory should approximate the quantity chosen by representative economic agent that maximise his utility. Simple aggregation, used to compute the official monetary aggregates, does make little economic sense since it fails to account for the difference in the utility provided by different monetary assets. Moreover, simple sum aggregates are joint products of monetary assets having varying degrees of ‘moneyness’. By treating all assets as perfect substitutes, simple sum aggregates do not distinguish the non monetary services from monetary services generated by them. Thus, money stock measures using simple sum aggregation procedure compounds the non monetary service with monetary services. Use of such variables in the policy framework is inappropriate since the errors in the measurement of variables may distort the dynamic relationships which are relevant for policy analysis. These errors become wider as more interest bearing assets are being used for transaction purposes. Recent developments in the financial market such as financial innovations and improvements in the payment mechanism tend to increase the use of interest bearing assets for transaction purposes thereby increasing their ‘moneyness’.
In this context, the currency equivalent (CE) aggregates derived by Rotemberg, Driscoll, and Poterba (1995) can be considered as an appropriate candidate for money. CE aggregates are considered as a stock measure of money that measures the share of discounted monetary services provided by an aggregate due to Barnett (1991). Barnett’s definition of economic stock of money includes the monetary services provided by the current and future holdings of monetary assets. Further, decomposing Barnett’s economic stock of money Kelly (2009, 2011) derived the discounted stock of monetary expenditure incurred only by the current portfolio of monetary assets which he defined as current stock of money (CSM). By definition CSM isolates the portion of each asset that functions as currency and can be considered as aggregation theoretic measure of narrowly defined money. In this context, Kelly (2011) proved that CE aggregates are unbiased estimates of CSM. CE aggregates as aggregation theoretic measures of money stock are far more superior to simple sum aggregates and use of such measures may be more appropriate in policy analysis.

2.2. Theoretical Foundations of CE Monetary Aggregates

The CE monetary aggregates was first proposed by Hutt (1963) and subsequently developed by Rotemberg, Driscoll, and Poterba (1995) as an alternative measure of transaction services. The CE aggregates constructed by assigning time varying weights to monetary assets included in an aggregate. The weights for each monetary assets depends on the own interest rate of respective assets relative to the return on a benchmark asset which provides no monetary services. CE aggregates can be treated as stock of currency that yields same transaction services of an aggregate consisting of different monetary assets. Accordingly, currency equivalent index assigns a weight equal to one for currency and the asset with higher rate of return receives a lower weight.

Rotemberg, Driscoll, and Poterba (1995) formally derived CE aggregates from a utility framework and proved that CE aggregates approximates the aggregator function of liquidity services under certain assumption.¹ The representative consumer

¹ Dutkowsky (1999) examined the correspondence of Divisia and CE aggregates to the theoretically meaningful measures of money under cotemporaneous taxation of interest income and showed that Divisia and CE aggregate exactly tracks the monetary aggregator function. Here we explain the
is assumed to derive utility from the consumption of goods and leisure. Further, the
intertemporal utility function contains monetary assets and the consumption of goods
and are assumed to be weakly separable. The intertemporal utility function so defined
of a representative consumer is given by

\[ V = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, T_t, l_t), \quad T_t, u_j > 0, \quad j = 1, 2, 3, \ldots \] (2.1)

where \( u() \) gives instantaneous utility and concave is in all arguments , \( E_0 \) is
expectation at period 0, \( \beta \) is an intertemporal discount factor (\( 1 > \beta > 0 \)). The aggregate
of liquidity services \( (T_t) \) can be described as linearly homogenous function in
component assets

\[ T_t = f(m_{1t}, m_{2t}, \ldots, m_{nt}, \alpha_t), \] (2.2)

where \( m_{1t} \) is the amount of currency, \( m_{2t}, \ldots, m_{nt} \) are other monetary assets held at the
period \( t \) and \( \alpha_t \) captures the changing physical characteristics of monetary assets over
time. Therefore any meaningful measure of money should approximate the aggregator
function in equation 2.2.

The consumer maximizes the utility function given a wealth constraint. The
contemporaneous real wealth of a consumer consists of principal and interest income
from assets held by him over a period of time, wages and other income received at the
beginning of the period \( t \), minus the consumption expenditure at time period \( t \)
following Dutkowsky (1999) the wealth constraint after tax is defined as follows

\[ A_t + \sum_{i=1}^{n} m_{it} = \frac{[1 + R_{t-1}(1 - \tau_t)]}{(1 + \pi_t)} A_{t-1} \]
\[ + \sum_{i=1}^{n} \frac{[1 + r_{it-1}(1 - \tau_t)]}{(1 + \pi_t)} m_{it-1} + w_t(1 - \tau_t)(H - l_t) + OY_t - c_t, \] (2.3)

where \( A_t \) is real holdings of benchmark asset at time period \( t \); \( r_{it-1} \) and \( R_{t-1} \) are
nominal interest rates on \( i \)th the monetary asset and the benchmark asset, respectively. \( \pi_t \) is
inflation rate and is defined as \( \pi_t = (P_t/P_{t-1}) - 1 \), \( \tau_t \) is the tax rate at period \( t \), \( w_t \) is

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Derivation of CE aggregate from a consumer’s utility following Rotemberg, Driscoll, and Poterba
real wage rate at time $t$; $H$ refers to total number of hours within the period; and $OY$ denotes incomes from other sources at period $t$.

Dutkowsky (1999) derives the first order condition for the choice of benchmark asset and monetary assets by maximizing the intertemporal utility function subject to the wealth constraint as follows

$$\beta(1 + R_t)E_t \left[ \frac{(\lambda_{t+1}/\lambda_t)}{1 + \pi_{t+1}} \right] - \beta R_t E_t \left[ \frac{(\lambda_{t+1}/\lambda_t)\tau_{t+1}}{1 + \pi_{t+1}} \right] - 1 = 0,$$

(2.4)

$$\beta(1 + r_{it})E_t \left[ \frac{(\lambda_{t+1}/\lambda_t)}{1 + \pi_{t+1}} \right] - \beta r_{it} E_t \left[ \frac{(\lambda_{t+1}/\lambda_t)\tau_{t+1}}{1 + \pi_{t+1}} \right] + \frac{u_{2t}T_{1,t}}{\lambda_t} - 1 = 0,$$

(2.5)

for $i = 1, 2, ..., n$, and $\lambda_i$ is the Lagrange multiplier associated with the wealth constraint.

In order to obtain CE aggregates the aggregator function $(T_i)$ is assumed to be linearly homogeneous in monetary arguments and additively separable in currency. Given this assumptions the exceptional terms equations 2.5 and 2.6 can be solved for currency $(m_{1i})$ given $r_{it} = 0$

$$E_t \left[ \frac{(\lambda_{t+1}/\lambda_t)}{1 + \pi_{t+1}} \right] = \left( \frac{1}{\beta} \right) \left[ 1 - \frac{u_{2t}T_{1,t}}{\lambda_t} \right],$$

(2.6)

$$E_t \left[ \frac{(\lambda_{t+1}/\lambda_t)\tau_{t+1}}{1 + \pi_{t+1}} \right] = \left( \frac{1}{\beta} \right) \left[ 1 - \left( 1 + \frac{1}{R_t} \right) \left( \frac{u_{2t}T_{1,t}}{\lambda_t} \right) \right],$$

(2.7)

Substituting these exceptional terms into equation 2.7 for all $i = 2, 3, ... n$

$$\frac{T_{i,t}}{T_{1,t}} = \frac{R_t - r_{it}}{R_t}.$$

(2.8)

The assumption of additively separable currency in the aggregator function allows us to normalise this equation by setting $T_{i,t}=1$. Further, making use of the assumption of linear homogeneity in the aggregator function $(T_i = f(i))$, it is possible to derive at CE aggregate by multiplying the equation by $m_{ii}$ and adding the various monetary assets as follows
\[ T_t = \sum_{i=0}^{n} \left( \frac{R_t - r_{it}}{R_t} \right) m_{it} \equiv CE_t. \quad (2.9) \]

The weights assigned to each asset in the CE aggregate can be interpreted as marginal utility of that asset relative to that of currency as it is derived from utility function that satisfies optimality condition. Besides Rotemberg, Driscoll, and Poterba (1995) argues CE aggregates captures the changes in the monetary services provided by monetary assets due to changes in their characteristics. However, as a measure of transaction services CE aggregates make strong assumptions on aggregator function compared to Divisia aggregates. Yet, as Barnett (1991) showed CE aggregates can be considered as a stock measure of money with aggregation theoretic foundations.

### 2.2.1. CE Aggregate as Stock of Money

To arrive at CE aggregate Rotemberg, Driscoll, and Poterba (1995) assumed aggregator function to be additively separable in currency. Barnett (1991) observed that this assumption was far more restrictive to treat CE aggregate as a measure of flow of monetary services than what is required for Divisia quantity index proposed by Barnett (1980). However, he showed that the CE aggregate can be treated as a special case of Economic Stock of Money (ESM) which he defined as “sum of discounted present value of expenditure on the services of monetary assets.” Moreover, Economic Stock of Money so derived is consistent with aggregation theoretic foundations of Divisia quantity index. He defined ESM as it enters into discounted single Fisherine wealth constraint under perfect foresight as follows

\[ ESM_t = \sum_{s=t}^{\infty} \sum_{i=1}^{n} \left[ \frac{p_s^i}{\rho_s} - \frac{p_{s+1}^i}{\rho_{s+1}} \right] m_{is}, \quad (2.10) \]

where \( p_s^i \) is the true cost of living index at period \( s \), \( m_{is} \) is quantity of monetary asset, \( r_{is} \) own interest rate of monetary asset \( i \) and the discount rate \( (\rho_s) \) for the period \( s \) is defined as

\[ \rho_s = \begin{cases} 1, & \text{for } s = t \\ \prod_{u=t}^{s-1} (1 + R_u), & \text{for } s > t. \end{cases} \quad (2.11) \]
Substituting equation 2.11 into equation 2.10 gives

\[ ESM_t = \sum_{s=t}^{\infty} \sum_{i=1}^{n} \left[ \frac{p_s^z (R_s - r_{is})}{\prod_{u=t}^{s-1} (1 + R_u)} \right] m_{is} = \sum_{s=t}^{\infty} \sum_{i=1}^{n} (\psi_{ls} m_{ls}) / \rho_{st} \]  

(2.12)

where \( \psi_{ls} = p_s^z ((R_s - r_{ls}) / (1 + R_s)) \)

Assuming \( R_s, r_{is} \) and \( m_{is} \) follows martingale process (i.e. \( R_s = R, r_{is} = r_{it}, m_{is} = m_{it} \)) the above equation reduces to CE aggregates

\[ ESM_t = \sum_{i=0}^{n} \left( \frac{R_t - r_{it}}{R_t} \right) m_{it} \equiv CE_t. \]  

(2.13)

Taking uncertainty into consideration the definition of ESM is modified by applying consumption based capital asset pricing model. Following Barnett, Chae, and Keating (2006) and Barnett, Keating, and Kelly (2008) it is given as

\[ ESM_t = E_t \left[ \sum_{s=t}^{\infty} \left( \Gamma_s \sum_{i=1}^{n} \psi_{ls} m_{ls} \right) \right], \]  

(2.14)

where \( \Gamma_s = \beta^{s-t} \frac{\partial u}{\partial C_s} / \frac{\partial u}{\partial C_t} \), is the subjectively discounted marginal rate of inter-temporal substitution between consumption in the current period \( t \) and the future period \( s \).

However, Barnett, Chae, and Keating (2006) showed that CE aggregates still exhibits a small downward bias since the total expenditure of monetary services assumed to follow a martingale process. In this context, Kelly (2011) showed that CE aggregate can be treated as current stock of money (CSM) which is defined as the discounted present value of the monetary services implied by the current portfolio of monetary assets. CSM is derived from the ESM by excluding expected future monetary services. The current stock of money captures the portion of each monetary asset that functions as currency. Thus the current stock of money can be treated as an aggregation theoretic measure of narrowly defined money. Moreover CSM is a better measure of narrowly defined traditional measures like M1 since it includes a wider
range of assets. In order to derive CSM, Kelly (2009, 2011) decomposed current and future holdings of monetary assets by defining quantity of monetary asset as follows

\[ m_{i,t+s} = \begin{cases} 
0 & \text{if } j = 0 \\
\sum_{r=1}^{j} \Delta m_{i,t+r} & \text{if } j > 0
\end{cases} \quad \text{and} \quad m_{i,s} = m_{i,t} + \tilde{m}_{i,s} \ \forall \ s \geq t. \quad (2.15) \]

Substituting equation 2.15 into 2.14 gives

\[
ESM_t = E_t \left[ \sum_{s=t}^{\infty} \left( \Gamma_s \sum_{i=1}^{n} \psi_{is} \left( m_{i,t} + \tilde{m}_{i,s} \right) \right) \right] \\
= E_t \left[ \sum_{s=t}^{\infty} \left( \Gamma_s \sum_{i=1}^{n} \psi_{is} m_{i,t} \right) \right] + E_t \left[ \sum_{s=t}^{\infty} \left( \Gamma_s \sum_{i=1}^{n} \psi_{is} \tilde{m}_{i,s} \right) \right]. \quad (2.16)
\]

The first term in the equation captures the present value of discounted monetary services of current portfolio of monetary assets therefore the CSM is given as follows

\[ CSM_t = E_t \left[ \sum_{s=t}^{\infty} \left( \Gamma_s \sum_{i=1}^{n} \psi_{is} m_{i,t} \right) \right]. \quad (2.17) \]

The CSM so defined can be equated with CE aggregates given certain assumptions.

Let us now assume the expectation of the stochastic discount factor in time period \( t \) as

\[ E_t(\Gamma_s) = \prod_{u=t}^{s} \left[ 1 + E_t(R_u) \right]^{-1}. \quad (2.18) \]

Then the equation for CSM becomes

\[ CSM_t = \sum_{s=t}^{\infty} \frac{E_t(\sum_{i=1}^{n} \psi_{is} m_{i,t})}{\prod_{u=t}^{s} \left[ 1 + E_t(R_u) \right]} + \text{cov} \left( \sum_{i=1}^{n} \psi_{is} m_{i,t}, \Gamma \right). \quad (2.19) \]

Setting \( \text{cov} (\sum_{i=1}^{n} \psi_{is} m_{i,t}, \Gamma) = 0 \) and assuming the return on benchmark follows a martingale process ie \( E_t(R_s) = R_t \ \forall \ s \geq t \) then equation 2.19 can be written as
\[ CSM_t = \sum_{s=t}^{\infty} \frac{\left( \sum_{i=1}^{n} E_t(\psi_{is}) m_{it} \right)}{(1 + R_t)^{s-t}}. \] (2.20)

Now if the \( \psi_{is} \) is assumed to follow a martingale process \( \forall i = 1,2, \ldots n \) the equation 2.20 can be rewritten as

\[ CSM_t = \sum_{s=t}^{\infty} \sum_{i=1}^{n} \left[ \frac{(R_t - r_{it})}{(1 + R_t)^{s-t+1}} \right] m_{it} = \sum_{i=0}^{n} \left( \frac{R_t - r_{it}}{R_t} \right) m_{it} \equiv CE_t \] (2.21)

In this context, Kelly (2011) empirically analysed and observed that CE aggregate is an unbiased estimate of CSM and it can be considered as an appropriate measure of narrowly defined money.

To consider simple sum aggregates as an appropriate measure of money stock we need to assume the return on monetary assets \( (r_{it}) \) to be zero. In reality, the simple sum aggregates tend to overestimate the actual money stock and inclusion of interest bearing assets will increase this upward bias considerably. Following Barnett, Chae, and Keating (2006), Barnett, Keating, and Kelly (2008), and Kelly (2009, 2011) it can be showed that the simple sum aggregates compounds both discounted present value of monetary services and the discounted present value of return yielded by the monetary assets. Thus the simple sum aggregates (SSI) can be decomposed as follows

\[ SSI_t = \sum_{i=1}^{n} m_{it} = \sum_{i=0}^{n} \left( \frac{R_t - r_{it}}{R_t} \right) m_{it} + \sum_{i=0}^{n} \left( \frac{r_{it}}{R_t} \right) m_{it}, \] (2.22)

where first summation term is Current Stock of Money (CSM) and the second term is defined as Investment Stock of Money (ISM). Investment stock money is the present value of discounted return yielded by the monetary assets at time period \( t \). Compounding CSM and ISM in the simple sum aggregate makes is inappropriate as it smoothens the actual money stock. Because of the noise in the simple sum aggregates

\[ 2 \text{ Kelly}(2009,2011) \text{ derived ISM through the application of asset pricing theory and is defined as } ISM_t = E_i(\sum_{s=i}^{\infty} \Gamma_s \sum_{k=1}^{n} r_{ik} m_{it}), \text{ where } \Gamma_s, \text{ mit stands for discount rate, own interest rate and quantity of monetary asset. Given the following assumptions; } E_i(\Gamma) = \prod_{s=1}^{\infty} [1 + E_i(R_{is})]^{-s}, \text{ cov}(\sum_{k=1}^{n} r_{ik} m_{it}, \Gamma) = 0 \text{ and } r_{is} \text{ follows a martingale process } \forall i = 1,2,3, \ldots n \text{ the above equation becomes } \sum_{s=0}^{n} \left( \frac{\Gamma s}{R_t} \right) m_{it} = ISM_t. \]
it may obscure the dynamic link between other economic variables of interest like output, interest rates etc. Similarly, the velocity behaviour of money stock based on simple sum aggregates will be erratic and may signal wrong information.

Empirical studies have documented the properties of CE aggregates and compared its performance relative to simple sum and other weighted monetary aggregates. Rotemberg, Driscoll, and Poterba (1995) computed CE aggregates using United States (U. S.) monetary data and empirically examined its performance in predicting real economic activity. They found the CE aggregates have better predictive power than their simple sum counterparts. Also Serletis and Molik (2000) using monthly data on Canadian and U. S. simple sum, Divisa and CE aggregates for a period from 1974:1 to 1999:12 observed that aggregation procedures are crucial in evaluating relationship between money and economic activity. Likewise, Serletis and Koustas (2001) found supporting evidence for long run neutrality for CE aggregates using quarterly U.S. data over the period from 1960:1 to 1996:2.

In addition, Barnett, Chae, and Keating (2006) empirically examined the properties CE aggregates in terms of Barnett’s economic stock of money and found that it approximates money stock with reasonable accuracy relative to simple sum aggregates. Similarly, money stock measures as defined by CE aggregates found to contain more explanatory information on output gap than their simple sum counterparts (Kelly 2009). Also, the errors in measurement of simple sum explain the failure of monetary policy disturbance to create negative short run correlations between nominal interest rates and money stock (Kelly, Barnett, and Keating 2011). Recently, some studies attempted to examine the Chaotic monetary dynamics using data on CE aggregates along with Divisia and simple sum aggregates. For instance, Serletis and Urtskaya (2007) investigated the dynamical structure of simple sum, Divisia and CE aggregates using detrended fluctuation analysis using monthly data of United States for a period from 1959:1 to 2006:2 for U.S. According to them the Simple sum and Divisia are more appropriate for measuring long term tendencies while CE aggregate are related to short term process in the economy (also see Serletis and Shintani 2006).
So far only a few studies have constructed CE aggregates using Indian data. Acharya and Kamaiah (1998) constructed CE aggregate (M3) using monthly data of currency, demand deposits, time deposits and postal deposits from 1985:04 to 1998:09. The CE aggregate so constructed performed better than its simple sum counterparts in terms of information content and money demand stability. Similarly, Acharya and Gopalaswamy (2007) also found that CE aggregate, constructed using components of M3 recommended by third working group on money supply (Reserve Bank of India 1998) over a period from 1999:03 to 2005:05, dominate its simples sum aggregates in terms of expected properties of money demand function. This chapter attempts to add to this existing literature and documents the stylized facts of CE aggregate in Indian context.

2.3. Sample and Description of Variables

This chapter uses both monthly and quarterly simple sum and CE aggregates of different aggregation levels to document their properties and performance based on conventional statistical criteria. The simple sum and CE aggregates are constructed using monthly data on a number of monetary assets ($m_{it}$) that figure in the official measures of money stock in India and appropriate rate of returns ($r_{it}$) for the period from April 1993 to June 2009. There are two reasons to choose this sample: (i) availability of consistent time series data on the components of new monetary aggregates as recommended by Third Working Group on Money Supply (1998); and (ii) this period covers the liberalized financial regime. The data on seasonally adjusted monetary components ($m_{it}$) and respective rate of returns ($r_{it}$) of the new monetary aggregates such as M1, M2, M3 and L1 are collected for constructing the monetary aggregates\(^3\). The details of monetary aggregates constructed are given in Appendix A. The quarterly estimates of both simple sum and CE aggregates are also constructed by taking average of monthly data in the respective quarters.

Details of various components and the corresponding interest rate proxies used in the construction of CE aggregates are given in Appendix A. The data on the components of monetary aggregates, interest rates, yield on long-term government securities, Gross Domestic Product (GDP) and the wholesale price index (WPI) are

\(^3\) The components are adjusted for seasonality using X-12 ARIMA method.
collected from the *Handbook of Statistics on Indian Economy* and other publications of the Reserve Bank of India, and the interest rate on time deposits and benchmark prime lending rate of SBI, which are obtained from State Bank of India (SBI) on request.

The selection of an appropriate benchmark interest rate is very crucial in the estimation of CE aggregates. Theoretically it is a rate of return on a benchmark asset that provides no liquidity services and is used to transfer wealth from one period to another. Thus, benchmark asset cannot be traded in the secondary market. In practice, it is either proxied by the rate of return on a least liquid asset/long maturity assets or maximum rate of return among a range of assets\(^4\). Following Barnett and Spindt (1982) in this study the benchmark rate of interest \(R_t\) is chosen as the maximum rate among a set of market rates such as prime lending rate (PLR) of SBI, yield on long-term government securities \((r_{gs})\) and the rate of return on components of the broadest aggregate (i.e. L1) and is given as

\[
R_t = \text{Max}\{r_{it} (i = 1, 2, 3, \ldots n), r_{gs,t}, BPLR_t\}. \tag{2.23}
\]

Since call money rate and rate on certificate of deposits were extremely high and volatile during a few months of the chosen sample period, call/term borrowings by financial institutions and certificate of deposits issued by commercial banks are excluded in the construction of CE aggregates\(^5\).

### 2.4. Some Stylized Facts

To begin with, we plot the CE constructs along with their simple sum counterparts. Figures 2.1(a) to 2.1(d) describes the monthly aggregates for the period April 1993 to June 2009 with solid lines indicating simple sum aggregates and dotted line their CE aggregates. Since CE aggregates measure only the discounted share of

\(^4\) See Barnett (2003) and Anderson and Jones (2011) for further discussion on the issues involved in calculating rate of return on benchmark assets.

\(^5\) The call rate and rate on certificate of deposits were as high as 35 percent during some periods. This affects the calculation of benchmark rate and thereby the measurement of CE aggregates. We can overcome this by adding a constant to benchmark rate as it is done by Acharya and Gopalaswamy (2007). However, we decided to exclude these components since the proportion of call and term borrowings and certificate of deposits are negligible in the respective monetary measures (M2, M3, and L1).
monetary services, the difference between Simple sum and CE aggregates can be interpreted as the stock of investment yield contained in respective simple sum aggregate. This can be measured by the vertical gap between solid and dotted lines in the figures. The share of investment yield increases as more and more assets that provide non-monetary services are included in the aggregate.

The share of investment yield in the Simple M1 as given by the vertical gap between CE M1 and M1 in Figure 2.1 is comparably smaller but constantly increases since 1999. But the vertical gap between CE aggregates and simple sum aggregates become wider as the level of aggregation increase (Figures 2.1 to 2.4). Note that the divergence between CE aggregate and simple sum is more pronounced at higher level of aggregation. The size of the graph grows rapidly particularly at M3 and L1 aggregates (Figures 2.3 and 2.4). However the gap seems to decrease since October 2008. It is evident from the plots that the time paths of money stock measured by simple sum and CE aggregate are different even for M1. The error in the simple sum aggregates, as measured by the vertical distance between two series, may affect the short run and long run dynamics of money growth rates given the varying nature of vertical shift particularly at higher level of aggregation. A similar inference can be arrived at using quarterly data which are plotted in Figures 2.5 to 2.8

**Figure 2.1: Monthly Series of CE M1 and M1**

![Figure 2.1: Monthly Series of CE M1 and M1](image)
Figure 2.5: Quarterly Series of CE M1 and M1

Figure 2.6: Quarterly Series of CE M2 and M2

Figure 2.7: Quarterly Series of CE M3 and M3
To make sense of this difference in the simple sum and CE aggregates the following section documents some of the stylised facts of CE and simple sum aggregates using monthly and quarterly estimates of aggregates. A comparative analysis of CE aggregates with respect to their simple sum counterparts in terms of the correlation with inflation and money growth rates, information content tests, velocity behaviour and cyclical behaviour.

2.4.1. **Correlation between Money Growth and Inflation**

The direction and strength of association between growth rate of monetary aggregates and inflation is analysed using correlation coefficients. The estimates of correlation coefficients for monthly and quarterly data are given in Table 2.1 and 2.2 respectively. The monthly growth rate of monetary aggregate is measured as

\[ x_t = \left( \frac{M_t - M_{t-1}}{M_{t-1}} \right) \times 100 \]

and inflation rate based on seasonally adjusted wholesale price index \((p)\) is measured as

\[ \pi_t = \left( \frac{p_t - p_{t-12}}{p_{t-12}} \right) \times 100. \]

The correlation coefficients for the contemporaneous and three to twelve month lagged growth rates of various monetary aggregates \((x_t)\) and inflation \((\pi_t)\) for monthly and quarterly data are presented in Table 2.1 and Table 2.2.
Table 2.1: 
Correlation (\( \rho \)) between Annual Growth Rate of Money (\( x_t \)) and Inflation (\( \pi_t \)): 
Monthly Data

<table>
<thead>
<tr>
<th></th>
<th>( x_t ) &amp; ( \pi_t )</th>
<th>( x_{t-3} ) &amp; ( \pi_t )</th>
<th>( x_{t-6} ) &amp; ( \pi_t )</th>
<th>( x_{t-9} ) &amp; ( \pi_t )</th>
<th>( x_{t-12} ) &amp; ( \pi_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m1 )</td>
<td>0.22*</td>
<td>0.40*</td>
<td>0.34*</td>
<td>0.24*</td>
<td>0.19*</td>
</tr>
<tr>
<td>( cem1 )</td>
<td>-0.03</td>
<td>0.14</td>
<td>0.31*</td>
<td>0.34*</td>
<td>0.29*</td>
</tr>
<tr>
<td>( m2 )</td>
<td>0.01</td>
<td>0.16*</td>
<td>0.20*</td>
<td>0.24*</td>
<td>0.25*</td>
</tr>
<tr>
<td>( cem2 )</td>
<td>-0.47*</td>
<td>-0.31*</td>
<td>0.03</td>
<td>0.36*</td>
<td>0.51*</td>
</tr>
<tr>
<td>( m3 )</td>
<td>-0.04</td>
<td>0.11</td>
<td>0.19*</td>
<td>0.24*</td>
<td>0.21*</td>
</tr>
<tr>
<td>( cem3 )</td>
<td>-0.49*</td>
<td>-0.25*</td>
<td>0.08</td>
<td>0.32*</td>
<td>0.38*</td>
</tr>
<tr>
<td>( l1 )</td>
<td>-0.05</td>
<td>0.10</td>
<td>0.18*</td>
<td>0.25*</td>
<td>0.21*</td>
</tr>
<tr>
<td>( cem )</td>
<td>-0.48*</td>
<td>-0.25*</td>
<td>0.07</td>
<td>0.32*</td>
<td>0.38*</td>
</tr>
</tbody>
</table>

* indicate statistical significance at 5% level.

The growth rate of simple sum M1 has statistically significant contemporaneous correlation with inflation. While, the correlation coefficients between growth rates of all other simple sum aggregates (M2, M3 and L1) and inflation is found to be statistically insignificant. The growth rates of all CE aggregates, except CEM1 have significant association with inflation. However, considering the time lags in the monetary transmission it is ideal to look at correlation between current inflation and lagged growth rate of monetary aggregates. Accordingly, we have calculated correlation between current inflation and three to twelve months lagged growth rate of various monetary measures.

The correlation coefficients between inflation and three months lagged growth rates of all simple sum monetary aggregates, except the growth rate M2, are statistically insignificant. However, correlation coefficients turn out to be statistically significant when the lag length of growth rates of simple sum aggregates increases from three to six months. But the magnitude of correlation coefficients decreases as the level of aggregation increases. On the other hand, three months and six months lagged growth rates of CE aggregates are found to have statistically insignificant association with inflation with an exception of the six months lagged growth rate of CEM1. Nonetheless, correlation coefficients turn out to be statistically significant as lag length of growth rates of monetary aggregates increases to nine to twelve months. Further, the magnitudes of correlation in the case of growth rates of CE aggregates are relatively larger as compared to their sum counterparts.
Table 2.2: Correlation ($\rho$) between Annual Growth Rate of Money ($x_t$) and Inflation ($\pi_t$): Quarterly Data

<table>
<thead>
<tr>
<th></th>
<th>$x_t &amp; \pi_t$</th>
<th>$x_{t-1} &amp; \pi_t$</th>
<th>$x_{t-2} &amp; \pi_t$</th>
<th>$x_{t-3} &amp; \pi_t$</th>
<th>$x_{t-4} &amp; \pi_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m1$</td>
<td>0.18</td>
<td>0.34*</td>
<td>0.28*</td>
<td>0.15</td>
<td>0.07</td>
</tr>
<tr>
<td>$cem1$</td>
<td>-0.04</td>
<td>0.14</td>
<td>0.30*</td>
<td>0.31*</td>
<td>0.22</td>
</tr>
<tr>
<td>$m2$</td>
<td>0.08</td>
<td>0.19</td>
<td>0.18</td>
<td>0.16</td>
<td>0.13</td>
</tr>
<tr>
<td>$cem2$</td>
<td>-0.48*</td>
<td>-0.31*</td>
<td>0.09</td>
<td>0.41*</td>
<td>0.57*</td>
</tr>
<tr>
<td>$m3$</td>
<td>0.04</td>
<td>0.15</td>
<td>0.21</td>
<td>0.21</td>
<td>0.13</td>
</tr>
<tr>
<td>$cem3$</td>
<td>-0.52*</td>
<td>-0.26</td>
<td>0.10</td>
<td>0.32*</td>
<td>0.39*</td>
</tr>
<tr>
<td>$ll$</td>
<td>0.02</td>
<td>0.15</td>
<td>0.21</td>
<td>0.21</td>
<td>0.13</td>
</tr>
<tr>
<td>$cell$</td>
<td>-0.51*</td>
<td>-0.26</td>
<td>0.08</td>
<td>0.31*</td>
<td>0.38*</td>
</tr>
</tbody>
</table>

*indicate statistical significance at 5% level; Sample period: - Quarterly observations- 1997 Q1 to 2009Q2

The evidence from quarterly data given in Table 2.2 clearly shows that the CE aggregates have a clear edge over their simple sum counter parts\(^6\). The growth rate of all simple sum aggregates has statistically insignificant contemporaneous correlation with inflation. Similarly none of the lagged growth rates of simple sum aggregates except simple sum M1 has statistically significant correlation with inflation. Whereas, there is statistically significant correlation between CE aggregates and inflation and it become more pronounced as the lag length of money growth increases.

Major inferences that emerge from Tables 2.1 and 2.2 can be summarized as follows: (i) the magnitude of correlation between growth rates of money and inflation increases as the lag length of monetary growth increases; (ii) the lagged growth rates of CE aggregates have strong correlation as compared to that of simple sum aggregates with inflation. (iii) evidence from quarterly data clearly indicates strong association between inflation and money growth when we use CE aggregates. This evidence is also consistent with the findings of Ramachandran, Das, and Bhoi (2010).

2.4.2. Velocity Behaviour

Apart from growth rate of money observing trends in velocity movements may provide important insights for the policy makers. As Barnett, Offenbacher, and Spindt

\(^6\) The sample period for Quarterly data is set from 1997 Q1 to 2009 Q2 since all other analysis reported in this study such as information content test, velocity behavior and cyclical behavior of aggregates were carried out considering the availability of quarterly estimates of GDP for India
(1984) observed the trends in velocity can give useful inference about the stability of demand for money functions. Similarly, if aggregate velocity measure shows a predictable relationship with interest rates then it can also be considered in the implementation of monetary policy (McCullam 1989). However, by compounding the discounted non monetary services with monetary services estimates of velocity from simple sum aggregates tend to underestimate the true velocity measures.

The plots of velocities of various aggregates used in this chapter is given in Figures 2.9 to 2.12. Velocity of each aggregate is estimated as a ratio of annualised nominal GDP to nominal money for a period from 1997 Q1 to 2009 Q2. Prior to estimation of velocity both the annualised nominal GDP and various aggregates were transformed into logarithmic scale. Besides, each velocity estimates were normalised to unity in the first observation i.e. 1997 Q1. Descriptive statistics of velocity estimates for CE and simple sum aggregates are given in Table 2.3.

<p>| Table 2.3: Descriptive Statistics of Income Velocities of Simple Sum and CE Monetary Aggregates |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE M1</td>
<td>0.941</td>
<td>0.061</td>
<td>0.229</td>
<td>0.810</td>
<td>1.038</td>
</tr>
<tr>
<td>CE M2</td>
<td>0.823</td>
<td>0.094</td>
<td>0.350</td>
<td>0.650</td>
<td>1.000</td>
</tr>
<tr>
<td>CE M3</td>
<td>0.729</td>
<td>0.164</td>
<td>0.521</td>
<td>0.479</td>
<td>1.000</td>
</tr>
<tr>
<td>CE L1</td>
<td>0.723</td>
<td>0.170</td>
<td>0.531</td>
<td>0.469</td>
<td>1.000</td>
</tr>
<tr>
<td>M1</td>
<td>0.923</td>
<td>0.065</td>
<td>0.188</td>
<td>0.824</td>
<td>1.011</td>
</tr>
<tr>
<td>M2</td>
<td>0.775</td>
<td>0.125</td>
<td>0.421</td>
<td>0.579</td>
<td>1.000</td>
</tr>
<tr>
<td>M3</td>
<td>0.558</td>
<td>0.244</td>
<td>0.861</td>
<td>0.139</td>
<td>1.000</td>
</tr>
<tr>
<td>L1</td>
<td>0.532</td>
<td>0.259</td>
<td>0.894</td>
<td>0.106</td>
<td>1.000</td>
</tr>
</tbody>
</table>

The results show that simple sum aggregates underestimate the velocity at all level of aggregation. The mean values of CE aggregates are higher than the simple sum aggregates at all levels of aggregation. Similarly, the difference between CE and simple sum aggregates become more pronounced as the level of aggregation increases. The dispersion of velocity around its mean as measured by standard deviation is higher with respect simple sum aggregates at all levels aggregation except M1. This shows that the velocity measured by CE aggregates are relatively stable than velocity measure of simple sum aggregates especially at higher level of aggregation.
Similarly the range of values of velocity of simple sum at higher level of aggregation (i.e. M3 and L1) is almost twice that of CE aggregates.

The velocity of simple sum and CE aggregates are plotted in Figures 2.9 to 2.12. The velocity of simple sum M1 and CE M1 are plotted in Figure 2.9. Even at this lower level of aggregation the behaviour of velocity of both aggregates exhibits difference. The velocity of simple sum seems to stable for a period from 1997 Q1 to 1999 Q1 and steadily declines afterwards. On the other hand the velocity of CE M1 is stable for a period from 1997 Q1 to 2001 Q1. The values of velocity of CE M1 are higher compared to Simple sum M1 since the first quarter of 1997. As the level of aggregation increase the divergence between simple sum and CE aggregates become more noticeable. The velocity of simple sum M2, M3 and L1 secularly decline throughout the sample period. On the other hand, declining trend of the velocity measure of CE M2, M3 and L1 are comparably less. More over the velocity measure of these aggregates are stable since 2004. Similarly difference between velocity of simple sum and CE aggregates are higher for M3 and L1 levels of aggregation. This is expected as the investment yield of assets included in simple M3 an L1 causes a downward bias in these aggregates.

Figure 2.9: Log Normalised Velocity of CE M1 and M1
As Barnett, Offenbacher, and Spindt (1984) observed that existence of a stable demand for money function or the shifts in parameters of the function can be easily traced by the cross plots of interest rates and velocity. If velocity and nominal interest rates move in the same direction then it can be inferred that the interest elasticity has correct sign. These issues are probed by plotting the velocity against interest rate variables (90 days treasury bill rate and yield on long term government securities) and is depicted in Figures. 2.13 to 2.28. Since the velocity behaviour of simple sum and CE aggregates differ considerably after second quarter of 2004 (see Figures 2.9 to 2.12) sample period was divided into two. The first period covers data from 1997 Q1 to 2004 Q1 and second period from 2004 Q2 to 2009 Q2. The periods were differentiated using different symbols in the cross plots.

The cross plot between velocity and 90 days Treasury bill rates for both simple sum and CE M1 is depicted in Figures 2.13 and 2.14. The functional shift in the velocity of both aggregates is very evident since the slope of the scatter plot between 90 days Treasury bill rate and velocity of simple sum M1 turns to be negative during 2004 Q2 - 2009 Q2. Similarly Figures 2.15 and 2.16 show that same results hold even for yield on long term government securities. Figures 2.17 to 2.20 depict analogues plots for simple sum and CE M2 aggregates. The plot shows significant difference between simple sum and CE M2. The shift in the velocity of simple sum M2 is very much evident whether it is against 90 treasury bill rate or yield on long term government securities. On the other hand, the scatter plots of velocity of CE M2 against the interest rates (both 90 days treasury bills arte and yield of long term government securities) exhibits a stable functional relation.
Figure 2.16: Simple Sum M1 Velocity *versus* Yield on Long Term Government Securities

![Graph showing the relationship between log-normalized velocity of M1 and yield on long-term government securities.](image)

Figure 2.17: CE M2 Velocity *versus* 90 days Treasury Bill Rate

![Graph showing the relationship between log-normalized velocity of CE M2 and 90 days Treasury Bill Rate.](image)

Figure 2.18: Simple Sum M2 Velocity *versus* 90 days Treasury Bill Rate

![Graph showing the relationship between log-normalized velocity of M2 and 90 days Treasury Bill Rate.](image)
Figure 2.19: CE M2 Velocity *versus* Yield on Long Term Government Securities

![Graph](image1)

Yield on Long Term Government Securities

Figure 2.20: Simple Sum M2 Velocity *versus* Yield on Long Term Government Securities

![Graph](image2)

Yield on Long Term Government Securities

Figure 2.21: CE M3 Velocity *versus* 90 days Treasury Bill Rate

![Graph](image3)

90 days Treasury Bill Rate
Figure 2.22: Simple Sum M3 Velocity versus 90 days Treasury Bill Rate

Figure 2.23: CE M3 Velocity versus Yield on Long Term Government Securities

Figure 2.24: Simple Sum M3 Velocity versus Yield on Long Term Government Securities
Figure 2.25: CE L1 Velocity *versus* 90 days Treasury Bill Rate

Figure 2.26: Simple Sum L1 Velocity *versus* 90 days Treasury Bill Rate

Figure 2.27: CE M3 Velocity *versus* Yield on Long Term Government Securities
Similar plots for simple sum and CE M3 are given in Figures 2.21 to 2.24. Plots of CE M3 against 90 days Treasury bill rate and yield on long term government securities continue to have a positive relation. Particularly a stable and linear function appears to exist between the velocity of CE M3 and yield on long term government securities. Whereas the velocity of simple sums M3 exhibits shifts and is unstable during the sample period. The velocity measures of simple sum and CE L1 shows similar patterns. The results in general show that the velocity estimates derived from money stock measures using Simple sum aggregates at all levels of aggregation appears to give wrong signals. Whereas the velocity measures form CE aggregates particularly at higher level of aggregation makes economic sense and are relatively stable over the time period.

2.4.3. Information Content Test

Information content tests following Tinsely, Spindt, and Friar (1980) and Mills (1983) are used to assess the information contained in monetary aggregates about future values goal variables. Accordingly, the information content of a vector of goal variables \( \mathbf{y} \) in terms a vector of indicator variable \( \mathbf{x} \) measured in terms of reduction expected uncertainty. In a univariate framework the measure of information content is defined as

48
\[ I(y_t/x_t) = -\frac{1}{2} \ln(1 - R^2), \]  \hspace{1cm} (2.24)

where \( R^2 \) is coefficient of determination from the simple linear equation as follows

\[ y_t = \beta_0 + \beta_1 x_t + \epsilon_t. \]  \hspace{1cm} (2.25)

In a multivariate dynamic framework this measure of information content is modified to capture the information contained in indicator variable \( x_t \) over and above the information contained in the past values of goal variable \( y_t \). Thus, the information content measure of \( x_t \) relative to \( y_t \) in a dynamic framework is given by

\[ I_m(y_t|x_t) = -1/2 \ln \left[ \frac{1 - R^2_{**}}{1 - R^2} \right] \]  \hspace{1cm} (2.26)

where \( R^2 \) and \( R^2_{**} \) are the multiple correlation coefficients from the following regressions

\[ y_t = \alpha(L)y_t + \epsilon_t, \]  \hspace{1cm} (2.27)

\[ y_t = \alpha(L)y_t + \beta(L)x_t + \epsilon_t, \]  \hspace{1cm} (2.28)

where \( \alpha(L) \) and \( \beta(L) \) are finite polynomials in lag operator \( L \). The maximum order of autoregressive process was selected based on AIC criteria. However as Pierce (1979) observed the use of multiple correlation coefficient from equation 2.28 can lead to ambiguous inference by compounding between-variable effect with within-variable effect. In order to overcome such problems the conventional \( R^2 \) is replaced by the statistic \( R^2_1 \) as suggested by Pierce (1979) and is defined as

\[ R^2_1 = (RSS_1 - RSS_2)/RSS_1, \]  \hspace{1cm} (2.29)

where RSS\(_1\) is the residual sum of square from equation 2.28 and RSS\(_2\) is the residual sum of square from equation 2.29. \( R^2_1 \) measure the information contained in indicator variable after accounting for the effect of past values of goal variable. The unambiguous measure of information content thus defined is

\[ I_*(y_t/x_t) = -\frac{1}{2} \ln(1 - R^2_1) \]  \hspace{1cm} (2.30)
The results of information content tests with respect to the growth rates of CE and simple sum aggregates about output growth and inflation are given in Table 2.4 and 2.5. Inflation and annual growth rate of Index of Industrial production (IIP), proxy for output growth, are taken as goal variables for the monthly data. Similarly, inflation and growth rate of nominal GDP (annualised) are considered as goal variables for the quarterly series. All the growth variables were mean differenced before estimating equations 2.27 and 2.28 and optimum lag length was selected using AIC criteria. The results of information content test for monthly and quarterly data is reported in Table 2.4 and 2.5

### Table 2.4:
Results of Information Content $[I_c(y_t/x_t)]$ of Simple Sum and CE Aggregates about Growth Rate of IIP and Inflation: Monthly Data

<table>
<thead>
<tr>
<th>Growth rate of IIP</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SS</td>
</tr>
<tr>
<td>M1</td>
<td>0.070</td>
</tr>
<tr>
<td>M2</td>
<td>0.027</td>
</tr>
<tr>
<td>M3</td>
<td>0.001</td>
</tr>
<tr>
<td>L1</td>
<td>0.002</td>
</tr>
</tbody>
</table>

### Table 2.5:
Results of Information Content $[I_c(y_t/x_t)]$ of Simple Sum and CE Aggregates about Growth Rate of Nominal GDP (annualized) and Inflation: Quarterly Data

<table>
<thead>
<tr>
<th>Growth rate of NGDP</th>
<th>Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SS</td>
</tr>
<tr>
<td>M1</td>
<td>0.064</td>
</tr>
<tr>
<td>M2</td>
<td>0.001</td>
</tr>
<tr>
<td>M3</td>
<td>0.001</td>
</tr>
<tr>
<td>L1</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Note: Sample period, Quarterly observations: 1997 Q1 to 2009Q2*

Even though the information contained in monetary aggregates regarding respective goal variables are at best modest, CE aggregates in general performs better compared to simple sum aggregates. Monthly estimates of information content test shows that growth rates of CE aggregates particularly at higher aggregation levels (i.e. M3 and L1) contains more information regarding inflation relative to their simple
sum counterparts. However there is no considerable difference between CE aggregates and simple sum aggregates in predicting growth rate of IIP. On the other hand, quarterly estimates of information content measures show that CE aggregates performs better than Simple sum aggregates at all levels of aggregation. Thus, the CE aggregates contain more information about the growth rate of GDP as well inflation and considerable reduction in prediction risk can be achieved by using CE aggregates as indicators.

2.4.4. Cyclical Behavior of Monetary Aggregates

Empirical description of business cycle facts is important since it gives a summary of cyclical co-movements of economic aggregates and is useful to identify the leading, lagging and coincident indicators of economic activity. The Business cycle facts as defined by Lucas (1977) refer to the statistical properties of the co-movement of cyclical components of economic aggregates with the cyclical component of real aggregate output. Similarly co-movement of cyclical components of monetary aggregate and real aggregate output can have important implication in the selection of competing models (Serletis and Krause 1996). This section attempts to document the pattern of cyclical behavior of monetary aggregates and examine whether aggregation procedure makes any difference in the inference.

The procedure of Hordick and Prescott (1997) is applied to extract cyclical components of real GDP at quarterly frequency and real IIP and monthly frequency and of various monetary aggregates at monthly and quarterly frequencies. The Hordick and Prescott filter extract the trend component \( (\tau_t) \) of a series \( (X_t) \) by minimizing the following equation

\[
\min_{\tau_t} \sum_{t=1}^{T} (X_t - \tau_t)^2 + \mu \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2
\]  

(2.31)

where \( X_t - \tau_t \) is the filtered series, the cyclical component was computed by setting \( \mu = 14400 \) for monthly series and \( \mu = 1600 \) for Quarterly series. All the variable are log transformed prior to the estimation.
### Table 2.6: Cross Correlations of H-P filtered Simple Sum and CE Monetary Aggregates (Mₜ) with Real IIP (Yᵢᵣ): Monthly data

<table>
<thead>
<tr>
<th>Mₜ</th>
<th>t-6</th>
<th>t-5</th>
<th>t-4</th>
<th>t-3</th>
<th>t-2</th>
<th>t-1</th>
<th>0</th>
<th>t+1</th>
<th>t+2</th>
<th>t+3</th>
<th>t+4</th>
<th>t+5</th>
<th>t+6</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE M1</td>
<td>-0.04</td>
<td>-0.09</td>
<td>-0.14</td>
<td>-0.12</td>
<td>-0.08</td>
<td>-0.08</td>
<td>-0.10</td>
<td>-0.09</td>
<td>-0.07</td>
<td>-0.03</td>
<td>-0.08</td>
<td>-0.11</td>
<td>-0.08</td>
</tr>
<tr>
<td>CE M2</td>
<td>-0.09</td>
<td>-0.13</td>
<td>-0.19*</td>
<td>-0.19*</td>
<td>-0.14</td>
<td>-0.09</td>
<td>-0.10</td>
<td>-0.09</td>
<td>-0.05</td>
<td>-0.05</td>
<td>-0.06</td>
<td>-0.09</td>
<td>-0.11</td>
</tr>
<tr>
<td>CE M3</td>
<td>-0.09</td>
<td>-0.11</td>
<td>-0.14</td>
<td>-0.13</td>
<td>-0.06</td>
<td>0.00</td>
<td>0.02</td>
<td>0.01</td>
<td>0.03</td>
<td>0.02</td>
<td>-0.02</td>
<td>-0.08</td>
<td>-0.12</td>
</tr>
<tr>
<td>CE L4</td>
<td>-0.09</td>
<td>-0.11</td>
<td>-0.14</td>
<td>-0.12</td>
<td>-0.05</td>
<td>0.01</td>
<td>0.03</td>
<td>0.01</td>
<td>0.04</td>
<td>0.02</td>
<td>-0.02</td>
<td>-0.08</td>
<td>-0.12</td>
</tr>
<tr>
<td>M1</td>
<td>0.14</td>
<td>0.14</td>
<td>0.10</td>
<td>0.02</td>
<td>0.00</td>
<td>-0.01</td>
<td>-0.07</td>
<td>-0.10</td>
<td>-0.15*</td>
<td>-0.08</td>
<td>-0.12</td>
<td>-0.13</td>
<td>-0.12</td>
</tr>
<tr>
<td>M2</td>
<td>0.06</td>
<td>0.01</td>
<td>-0.07</td>
<td>-0.17*</td>
<td>-0.22*</td>
<td>-0.25*</td>
<td>-0.31*</td>
<td>-0.34*</td>
<td>-0.36*</td>
<td>-0.29*</td>
<td>-0.29*</td>
<td>-0.26*</td>
<td>-0.19*</td>
</tr>
<tr>
<td>M3</td>
<td>0.00</td>
<td>-0.05</td>
<td>-0.10</td>
<td>-0.17*</td>
<td>-0.19*</td>
<td>-0.20*</td>
<td>-0.22*</td>
<td>-0.25*</td>
<td>-0.24*</td>
<td>-0.19*</td>
<td>-0.19*</td>
<td>-0.19*</td>
<td>-0.13</td>
</tr>
<tr>
<td>L1</td>
<td>0.01</td>
<td>-0.04</td>
<td>-0.09</td>
<td>-0.17*</td>
<td>-0.18*</td>
<td>-0.19*</td>
<td>-0.22*</td>
<td>-0.25*</td>
<td>-0.24*</td>
<td>-0.19*</td>
<td>-0.19*</td>
<td>-0.19*</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

* indicate statistical significance at 5% level.

### Table 2.7: Cross Correlations of H-P filtered Simple Sum and CE Monetary Aggregates (Mₜ) with Real GDP (Yᵢᵣ): Quarterly Data

<table>
<thead>
<tr>
<th>Mₜ</th>
<th>t-4</th>
<th>t-3</th>
<th>t-2</th>
<th>t-1</th>
<th>0</th>
<th>t+1</th>
<th>t+2</th>
<th>t+3</th>
<th>t+4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE M1</td>
<td>-0.15</td>
<td>-0.10</td>
<td>0.00</td>
<td>-0.03</td>
<td>-0.08</td>
<td>-0.07</td>
<td>-0.11</td>
<td>-0.11</td>
<td>-0.08</td>
</tr>
<tr>
<td>CE M2</td>
<td>-0.08</td>
<td>-0.10</td>
<td>-0.13</td>
<td>-0.27</td>
<td>-0.40*</td>
<td>-0.38*</td>
<td>-0.40*</td>
<td>-0.40*</td>
<td>-0.35*</td>
</tr>
<tr>
<td>CE M3</td>
<td>-0.25</td>
<td>-0.26</td>
<td>-0.29*</td>
<td>-0.43*</td>
<td>-0.56*</td>
<td>-0.57*</td>
<td>-0.57*</td>
<td>-0.53*</td>
<td>-0.45*</td>
</tr>
<tr>
<td>CE L4</td>
<td>-0.26</td>
<td>-0.27</td>
<td>-0.29*</td>
<td>-0.44*</td>
<td>-0.56*</td>
<td>-0.57*</td>
<td>-0.57*</td>
<td>-0.53*</td>
<td>-0.45*</td>
</tr>
<tr>
<td>M1</td>
<td>0.52*</td>
<td>0.60*</td>
<td>0.71*</td>
<td>0.78*</td>
<td>0.75*</td>
<td>0.61*</td>
<td>0.40*</td>
<td>0.19</td>
<td>0.00</td>
</tr>
<tr>
<td>M2</td>
<td>0.04</td>
<td>0.16</td>
<td>0.28*</td>
<td>0.43*</td>
<td>0.53*</td>
<td>0.56*</td>
<td>0.48*</td>
<td>0.36*</td>
<td>0.25</td>
</tr>
<tr>
<td>M3</td>
<td>-0.22</td>
<td>-0.11</td>
<td>0.01</td>
<td>0.17</td>
<td>0.30*</td>
<td>0.40*</td>
<td>0.42*</td>
<td>0.40*</td>
<td>0.39*</td>
</tr>
<tr>
<td>L1</td>
<td>-0.20</td>
<td>-0.09</td>
<td>0.03</td>
<td>0.19</td>
<td>0.33*</td>
<td>0.42*</td>
<td>0.41*</td>
<td>0.37*</td>
<td>0.34*</td>
</tr>
</tbody>
</table>

* * indicate statistical significance at 5% level.
The movement of contemporaneous and non contemporaneous cyclical co-movements are measured by cross correlation coefficients between cyclical component of money and cyclical component of real IIP and real GDP are computed for monthly and quarterly respectively. For monthly data up to 6 month leads and lags of H P filtered cyclical series of real IIP and for quarterly estimates up to four quarter leads and lags of H P filtered cyclical series of real GDP are considered. The contemporaneous, leading and lagging natures of co-movement of various monetary aggregates with cycle is decided depending on the magnitude of correlation coefficient in absolute terms. If the correlation coefficient given by \( \rho(M_t, Y_{t+i}) \) is absolute sense is largest when \( i=0 \) then the monetary aggregate is contemporaneously correlated with the cycle. Similarly the series leads the cycle by \( i \) months/quarters if the absolute value of \( \rho(M_t, Y_{t+i}) \) is largest when \( i<0 \), and lags the cycle by \( i \) months/quarters when \( i>0 \). Similarly, the monetary aggregates are classified into acyclical when the correlation \( \rho(M_t, Y_{t+i}) \) equals zero, procyclical when \( \rho(M_t, Y_{t+i}) \) is significantly positive and countercyclical when \( \rho(M_t, Y_{t+i}) \) is significantly negative.

Cross correlation coefficients for cyclical components of monetary aggregates \( (M_t) \) and real IIP\( (Y_{t+i}) \) for monthly data are reported in Table 2.6. The CE aggregates at all levels of aggregation except CE M2 are acyclical whereas, the simple sum aggregates are counter cyclic. Further the simple sum M1 and M2 lag the cycle by two months and M3 and L1 lags the cycle by one month. Table 2.7 reports the results for quarterly data. The results show an entirely different inference on the cyclical behaviour of monetary aggregates. The CE aggregates except CE M1 counter cyclically lag by two quarters. On the other hand the Simple sum M1 is contemporaneously procyclical and simple sum M2 and M3 procyclically lags by one quarter. The simple sum M3 also procyclically lags but by two quarters.

There are considerable differences across simple sum and CE aggregates. The CE aggregates is acyclical in monthly frequency where as it found to lag counter cyclically at Quarterly frequency. On the other hand the simple sum aggregates lags counter cyclically at monthly frequencies but are procyclical at quarterly frequencies.
2.5. Conclusion

This chapter reviews the theoretical foundations of the currency equivalent monetary aggregates proposed by Rotemberg, Driscoll, and Poterba (1995) and documents some stylised facts on the performance of CE aggregates in application of policy interest. The currency equivalent monetary aggregates are interpreted as aggregation theoretic money stock measures by Barnett (1991) and Kelly (2009). Currency equivalent aggregates measure the discounted present value of monetary services of monetary assets. But the simple sum aggregates exhibit considerable error in variables as it compounds non monetary services with monetary services. This leads to erroneous inference regarding the relationship between money and other economic variables that are relevant to policy makers.

In this context, three alternative measures of monetary aggregates - M1, M2 and M3 - and one liquidity measure - L1 - as recommended by Third Working Group on Money Supply are constructed for India. The study constructs monthly currency equivalent monetary aggregates for the sample period from April 1993 to June 2009, covering fairly the liberalized financial regime. Quarterly estimates of currency equivalent aggregates are obtained by taking quarterly averages of monthly aggregates. The empirical evidences are found to support the theoretical superiority of currency equivalent monetary aggregates over their corresponding simple sum aggregates.

The simple correlation coefficient indicated that there is a strong association between inflation rate and growth rate of currency equivalent monetary aggregates when we allow for lags in monetary transmissions. The velocity behaviour of currency equivalent aggregates seem to be more stable. The information context test also indicates currency equivalent aggregates in general contain more information than simple sum aggregates regarding output at quarterly frequencies and inflation at monthly and quarterly models. Similarly, cyclical behaviour of currency equivalent and simple sum aggregates exhibits considerable difference, proving that inference with CE aggregates are in sharp contrast to that with simple sum aggregates.