

Study
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MODELLING CURRENCY DEMAND IN INDIA: AN EMPIRICAL STUDY



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Needless to say, we retain full responsibility for any shortcomings and (what we hope would be venial) failings.

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EXECUTIVE SUMMARY

The main objective of this study was to examine the evolving determinants of currency demand in the Indian context and develop a suitable framework for modelling currency demand at the aggregate level as well as for the denominational composition.

The study presents an extensive survey of literature on various aspects of currency demand from the central bank's perspective of currency management. The review of the literature focuses on the international evidence due to paucity of studies in the Indian context. The study has identified various factors influencing currency demand in India and analysed the behaviour and characteristics of currency circulation and its relationships with the major determinants such as output growth, consumption, inflation, interest rates and growing usage of non-cash payment instruments. It has examined the relationships between currency circulation and various explanatory variables and established existence of co-integrating relationships in a vector error correction model (VECM) framework for aggregate currency demand as well as for various currency groups.

The modelling of the demand for currency at the aggregate level for both annual and quarterly frequencies has allowed examination of the long-term behaviour as well as short-term dynamics. In view of considerable volatility of circulation of individual denominations and limitations relating to the availability of quarterly data, the study has identified suitable denomination groups of banknotes that are amenable to the development of similar models based on annual data.

Some of the important findings of the study are:

- At the aggregate level, currency circulation has increased at a faster pace in comparison to the growth in nominal GDP. Despite the emergence of various alternatives to cash-based transactions, currency retains its pre-dominance.
- The increase in currency, broad money and household financial saving in relation to GDP is reflective of the transition of a low income underdeveloped economy towards an economy characterized by increasing monetisation and commercialisation.
- During the past four decades, there has been a significant change in the composition of currency circulation across denominations. The average value of a currency note (for denominations of Rs.10 and above) increased nearly eight-fold while there was a 18 fold rise in the price level. Thus, the average value of a note did not keep pace with inflation.
- The trends in currency circulation at individual denomination level show considerable fluctuations, which rendered econometric modelling complex. Its analysis needs further refinement to take into account other factors, such as currency substitutes for payment (such as credit/debit cards, internet banking and cheque payments).

- There exists a co-integrating relationship between currency circulation, GDP, WPI and deposit rates based on annual data. The income elasticity of currency was found to be somewhat higher in comparison to the long-term elasticity observed in similar studies for advanced countries.
- The study has also established co-integrating relationships between different groups of currency notes with per capita GDP, WPI and other explanatory variables, although the findings were not very robust.

A few limitations of the study arose from the non-availability of relevant data pertaining to, *inter alia*, the distribution pattern of the size of currency based transactions, the shadow economy and the regional dimensions of currency demand.

The study also makes a few suggestions for future improvements in the framework for currency analysis in India as under:

- Efforts may be made to design a system to capture the magnitude of mismatches between the demand and supply of currency in the economy.
- A system of regular surveys to elicit information on public behaviour and preference for various denominations of currency may be useful. Also, changes in the micro level determinants of currency requirement, especially for smaller denominations, such as transport tariff structure, etc. may be considered.
- Estimation of regional demand for currency could be attempted though the data requirements for such an exercise would be formidable.

Modelling Currency Demand in India: An Empirical Study

D M Nachane, A B Chakraborty, A K Mitra and Sanjib Bordoloi¹

1. Introduction

Currency is an integral component of modern civilization. In historical times, currency began as coins of precious metals. In modern usage, the term “currency” embraces both coins and banknotes (with the former constituting a progressively dwindling share). In spite of the emergence of many alternate substitutes, it still retains its importance in the payments mechanism as the “ultimate mode of settlement” apart from its historical role as the oldest form of circulation media. While the original motives for currency holdings were mainly for conducting transactions (transactions motive) and as a store of value for contingencies (precautionary motive), with the continuous evolution of the financial system, other motives have emerged. Thus as Keynes so graphically depicted in the *General Theory* (1936), the speculative demand for currency plays a critical role in prolonging depressions, while as pointed out later by Cagan (1956) in hyperinflations the velocity of currency circulation can reach truly astounding magnitudes. Finally, the unchecked growth of the “shadow economy” in the latter half of the 20th century has created a new source of demand for currency, as a medium of circulation which leaves no trail. Given its important role in everyday economic life, the potential for dislocation associated with its mismanagement can be serious, and several episodes in history bear ample testimony to the severity of such disruptions.

Recognizing the important role that currency plays in the smooth functioning of an economy, its management has in modern times (say mid-19th century onwards) been vested with the central bank of a country, in the expectation that such an arrangement will lead to a standardization of the currency and prevent its “debasement” either by private merchants or by governments. The Bank Charter Act (1844) for example, made the Bank of England the sole issuer of new banknotes, which were to be backed by 100 per cent gold reserves. Similarly, the Preamble to the Reserve Bank of India Act 1934 specifies the central bank’s objective as regulating “the issue of Bank notes and the keeping of reserves with a view to securing monetary stability in India ...” Thus currency management, which was originally the primary function of a central bank, still continues to be one of its major functions.

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From the point of view of central banks, currency derives its importance from being the narrowest monetary aggregate and with the central bank exercising full control over its supply. The central bank is entrusted with the responsibility of ensuring that the aggregate supply as well as the denominational structure closely corresponds to what is demanded by residents. Hence the need for paying close attention to the factors that influence currency demand by households, firms, financial intermediaries, the government sector and (to some extent) the external sector. In India, Reserve Bank is entrusted with the responsibility of currency management. The Reserve Bank endeavours to ensure the availability of adequate quantities of reasonably good quality notes and coins to meet the demand for cash transactions in the country. To this end, Reserve Bank has set up a nation-wide network comprising Issue Offices and designated bank branches and State Government Treasuries known as *currency chests* for issue and distribution of currency notes and coins. Currency management activities include planning for printing/minting capacity for notes/coins, arrangements for issue and distribution of notes, disposal of soiled notes returned by the public from circulation and so on.

As noted above, the demand for currency primarily relates to transactions demand, *i.e.*, the need to carry out cash transactions in both the official and unofficial sectors. Besides the transactions demand, a part of currency, being the most liquid form of money, is also held by the public and the firms as a precautionary measure. Currency can very often be “hoarded” especially in the unofficial sector. Currency circulation is influenced by a host of factors primarily among them being the per capita income levels of people, prices of goods and services, opportunity cost of holding cash *vis-à-vis* other forms of money, financial innovations leading up to alternative non-cash means of payment (e.g. smart cards, debit cards, credit cards, etc.), degree of monetization, extent of financial inclusion and the size of the underground economy. With continuous changes in macroeconomic parameters, not only does the demand for the aggregate value of currency undergo changes, its composition also shifts towards higher denominations. Estimation of the evolving demand for currency in the economy and understanding its relationship with various macroeconomic parameters is an essential element in the planning of the issue and distribution of currency. Notwithstanding this importance, the literature on modelling currency demand functions constitutes a very small fraction of the literature on estimating money demand functions. The current study has been undertaken with the motivation of attempting to fill this lacuna in the Indian context.

Estimation of demand for different denominations of notes and coins in the short term and long term has a crucial bearing on various macroeconomic activities. Short term (less than 1 year) estimates of currency in circulation are useful to track the seasonal variation and unexpected but transitory rise/fall in the requirement of currency. Medium term (1 to 2 years) forecasts are useful for planning annual requirement of fresh notes and coins. Long term demand (5 to 10 years) is required for capacity planning of the note presses and mints and has to take into account the possibility of changes in the denomination structure.

There has been a phenomenal growth in both the value and volume of currency circulation over the years. The value of currency in circulation rose from ₹172 crore in March 1935 when the Reserve Bank was established, to over ₹9,35,000 crore in March 2011². During the same period, the number of notes in circulation has gone up from 124 million pieces to over 64,000 million pieces. Historically, there has been a marked preference for cash in India, notwithstanding the growth in banking and use of cheques and the more recent developments in alternate non-cash forms of payment such as credit/debit cards and electronic fund transfers. The long term annual growth rate of currency circulation has in fact gone up from around 12 per cent during 1971-81 to 14 per cent during 1981-91 and nearly 15 per cent in the last decade. In a vast country like India with its wide geographical spread, predominance of cash as a mode of payment and a high degree of regional variation in income, expenditure and spending patterns, management of currency is undoubtedly a challenging task.

An efficient system for management of currency needs to be based on a prior knowledge of not only the future demand for the total value of currency but also for the demand for various denominations of banknotes and coins. In an ideal scenario, given the size distribution of cash transactions in the economy within a specified time frame, the total value of currency and its denominational composition should match the currency needs to carry out those transactions without significant mismatches at the denomination level. Further, the gradual shift in the denominational composition over time needs to be captured so as to optimize the total volume of currency required to meet the demand in terms of value.

Generally, the denominational structure of currency comprises 4 to 5 coin categories in the lower denomination and 5 to 6 note categories in the higher denomination. Considering that the lower denomination currencies are used for small value transactions, which account for a major part of the cash transactions, these denominations have a greater degree of velocity of circulation. This is why the lower denomination currencies are issued in the form of coins having a much longer life than notes. In the short and medium term, the structure of denominations may not undergo change and, therefore, the estimation problem essentially relates to determining the value and volume of requirement of the existing denominations. However, in the long term, the issues such as introduction of new higher denomination notes, discontinuance of low denomination coins and *coinisation* of lower denomination notes etc assume importance and require careful attention in keeping with the objective of managing the volume of currency in circulation. The long, medium and short term demand estimates serve a useful purpose in planning the network and infrastructure for issue, distribution and servicing of the notes and coins.

²RBI Annual Report 2010-11, Chapter on Currency Management.

The main objective of this study is to examine the evolving determinants of currency demand at aggregate level as well as for various denominations. The Indian economy has undergone significant structural transformation, especially in the last two decades since the onset of economic reforms. While economic growth has accelerated and consequently per capita income has gone up at a faster pace as compared with the 1970s and 1980s, inflation dynamics has also changed and in the wake of deregulation, interest rate cycles have emerged with their own cyclical impacts on currency demand. More importantly, there has been significant advancement in the field of non-cash payment systems, presumably an important factor in containing the need for cash.

The study focuses on two distinct but related aspects of currency demand *viz.* aggregate currency demand and denomination-wise currency demand. For aggregate currency demand, we attempt both annual and quarterly models, while in the case of denomination-wise demand, our focus is on notes and the absence of quarterly data means that only an annual exercise can be undertaken. As is well known, the task of modelling currency demand is quite challenging as currency holdings are remarkably volatile (at least in the short run), lending a measure of instability to currency demand functions. Additionally, the lack of high frequency data in the Indian case means that some of the more advanced econometric techniques like VARs have to be used with a measure of caution. In this study, our primary reliance has been on VECMs (Vector Error Correction Models) with an attempt to identify equilibrium cointegrating relationships.

While a number of candidate variables could affect aggregate currency demand, the five most commonly used are (i) national income or private consumption (to account for transactions demand), (ii) inflation (to account for the “carrying costs” of currency holdings), (iii) interest rates (opportunity cost of holding currency), (iv) financial innovations (ATMS, credit cards, etc), and (v) the size of the underground economy. Use of cash for the underground economy is also a well known phenomenon and, as such, the size and share of black economy also impacts currency demand, especially of higher denominations. However, by its very nature, the size of the shadow/underground economy is difficult to estimate and good proxies are hard to come by. Some authors have attempted to include various proxies for the shadow economy such as the tax-GDP ratio (e.g. Dotsey (1988)) or “bad behaviour” variables (Drehmann and Goodhart (2000)). However, since a substantial portion of the “black money” is held abroad in foreign currency or domestically in precious metals or real estate, the link between currency demanded and the size of the shadow economy is likely to be a highly tenuous one. So much of the literature usually ignores this aspect, in spite of its obvious importance for a country like India. Hence the shadow economy does not figure in our formal analysis. In our analysis of currency demand, we did not distinguish between the currency needs of the formal and the underground economy, as data on the latter is virtually non-existent. In line with the general approach, we then concentrate on the first three candidate variables using dummy variables to capture the effect of financial

innovations. The econometric results that we obtain are quite promising especially those based on the quarterly models estimated over 1996-97 to 2010-11.

We also attempt to model the denomination-wise components of currency demand. One of the important assumptions in estimating currency demand is that authorities' currency supply adequately reflects underlying demand conditions. While this assumption is reasonable for aggregate currency demand, at the disaggregated level the validity of this assumption depends on whether different denominations are supplied without any restriction to the people or the denomination-mix of the currency supplied are subject to the need to contain overall volume. Following the lead from the received literature, we group the different denominations into "small", "medium" and "large" categories. For each of these, separate cointegration models are postulated. Since the categories are substitutable at the margin, we attempt to supplement these separate models with a simultaneous equation SURE (Seemingly Unrelated Regression Equations) model. Once again we find that the econometric results are in consonance with what theory leads us to expect.

The empirical exercises have been carried out for annual data for the period 1971 to 2011. While data on aggregate currency circulation are published on monthly basis, denomination-wise data are published on annual basis (March end). The denomination-mix of currency has undergone considerable change during these four decades. While high denomination notes (₹1000, ₹5000 and ₹10000) were demonetised in 1978, subsequently, the ₹500 note was introduced in 1987, which started being issued in substantial quantity since 1996 and ₹1000 was reintroduced in 2000. The denominational distribution of currency has evolved significantly. ₹1, ₹2 and ₹5 notes have been progressively coined since 1990s although both notes and coins in these denominations co-existed for several years, which also complicated the estimation problem.

The scheme of presentation is as follows. In chapter 2, some international evidence and a review of literature on demand for currency has been presented. The discussion is mostly oriented towards international research as, surprisingly, there have not been many published studies on currency demand in India. Chapter 3 provides a descriptive analysis of the evolution of currency circulation in India and discusses the trend in currency-GDP ratio, its relationship with growth, inflation, interest rates and so on. In chapter 4, an overview of the trends in denomination-wise currency circulation is presented. Chapter 5 deals with the problem of modelling currency demand at aggregate level and chapter 6 throws some light on the problem of estimating circulation of different denomination-groups. Chapter 7 concludes with some policy suggestions for currency management.

In the preparation of this monograph, we have received unstinted support from all past Directors and other members of the DRG, DEPR of the Reserve Bank. Our thanks in particular are due to Dr. Nishita Raje and Shri S. Arunachalam. We are also grateful to Dr. Amlendu Dubey (currently Assistant Professor, IIM-

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2: Currency Demand – Cross-country Evidence and Review of Literature

Internationally, there is a substantial literature that analyses various aspects of currency demand from the point of view of currency management. Many of these studies focus on modelling aggregate currency demand taking into account macroeconomic factors, payment mechanisms, local behavioural factors and (especially in the case of the US and Euro area) foreign demand for domestic currency. Studies devoted to estimating demand at denominational levels are, by contrast, relatively few. In India, however, there is surprisingly a paucity of studies on modelling currency demand. This chapter presents a survey of literature along with a broad overview from a cross-country perspective of the various issues that have a bearing on currency demand.

2.1 Determinants of Currency Demand: Cross-country Evidence

Currency represents a unique combination of liquidity, security and privacy. Cross-country studies of the demand for currency aim to analyze how differences in economic activity levels, opportunity costs of holding currency (as reflected in interest rate and inflation differentials) and financial innovations in carrying out transactions affect currency demand. They also mirror differences in national taxation systems, the importance of the informal economy as well as heterogeneous payment habits, which are likely to be related to the different structure of banknote denominations and cashless payment instruments (Fischer, *et al*, 2004). Additionally, differences in the demand for currency may result from the foreign demand for some of the currencies.

As noted in Chapter 1, the key determinants of the demand for currency are the transactions motive and the desire to have a liquid medium for storing value. Domestic transaction balances that comprise cash are used to purchase goods and services and hence have a direct relationship with transactions in the real economy. By not leaving a paper footprint, cash transactions permit anonymity and hence constitute a preferred medium of transactions in the shadow economy – either for transactions of contraband products or to evade taxes, *e.g.*, in the housing sector.

Cash hoarding may be characterized essentially as the holding of currency as a store of value.³ As in the case of transactions demand for currency, there are two forms of hoarding: one associated with the official economy and the other associated with the black/shadow/underground economy. The advantage of using currency as an instrument for store of value is its liquidity and anonymity, the latter factor being particularly important in the case of the black economy. Currency tends to be used for hoarding in the *official* economy when the income on alternative assets, costs of currency storage in a locker and the risk of loss (*via* theft, soilage and most importantly inflation) is smaller than the transactions costs associated with portfolio transformation.

³On grounds of efficiency, high denomination banknotes are most likely to be used for hoarding.

Somewhat surprisingly, over the years, currency has retained its importance, even in advanced economies, notwithstanding the introduction of more efficient payment instruments, such as the cheque book facility and electronic modes of payment, such as EFT, credit and debit cards, and the setting up of ATMs, and instruments that serve as alternate stores of value. The aggregate currency demand, measured in terms of the ratio of stock of currency outstanding to GDP, was decreasing for most countries throughout the 1970's and much of the 1980's. However, it flattened out since then reflecting, in part, successful stabilization of inflation during the period of Great Moderation (Amromin and Chakravarti, 2009). Overall, the 1990s and 2000s (at least for non-Euro OECD countries) may be said to be characterized by stable currency-GDP ratios (Table 2.1).

Table 2.1: Currency-GDP Ratio: Cross-country Evidence

(per cent)

Year	USA	Euro Area	Japan	UK	Indonesia	Thailand	India
2001	5.9	4.1	14.7	2.5	5.5	9.5	11.6
2002	6.1	5.4	16.3	2.5	5.4	10.3	12.1
2003	6.2	6.0	16.6	2.5	5.6	10.7	12.5
2004	6.1	6.6	16.5	2.3	5.5	11.0	12.4
2005	6.0	7.2	16.7	2.4	5.2	10.6	12.7
2006	5.9	7.6	16.6	2.4	5.3	9.9	12.8
2007	5.6	7.8	16.7	2.6	5.6	9.9	12.9
2008	5.9	8.6	17.1	2.7	5.3	10.2	13.1
2009	6.4	9.3	18.2	3.1	5.0	11.1	13.0
2010	6.5	9.5	18.1	3.1	5.0	11.0	13.0

Source: International Financial Statistics, IMF and RBI.

There is, however, substantial cross-country heterogeneity. In the US, currency-GDP ratio remained stable around 6 per cent in the last decade, whereas in Euro area, it went up gradually to over 9 per cent in 2010. Prior to introduction of common currency in the Euro area, the ratio of currency in circulation to private consumption declined from 10.0 per cent in 1980 to 8.0 per cent in 2001 (Fischer, 2004). Among the Euro area countries, the ratio of currency in circulation to private consumption varied from 3.9 per cent in Finland to 13.1 per cent in Spain in 2001. Further, such heterogeneity does not disappear over time. For example, the currency-GDP ratio in the UK remained in a narrow range of 2.3-3.1 per cent during 2001-10. In contrast, this ratio for Japan rose from 14.7 per cent to 18.1 per cent over the same period, fueled partly by the extremely low or negative inflation environment.

In many emerging market economies, especially in India, there has been a secular increase in currency demand in relation to GDP, partly reflecting increasing monetisation and commercialisation of the economy while the introduction of electronic modes of transactions has been relatively recent and is yet to be reflected

in a lowered currency demand. In India, the decadal average currency-GDP ratio hovered around 10 per cent in the 1970s, 1980s and 1990s, but increased to over 13 per cent in the last decade. Notably, currency to private consumption ratio also has gone up substantially from 12.6 per cent in the 80s to 14.8 per cent in the 90s to 19.1 per cent in the last decade, despite rapid spread of non-cash payment modes. It is worth noting that these aggregate measures are, however, unable to distinguish between the store of value and payment functions of the currency.

Currency demand, as noted above, depends on country specific circumstances. Economic, technological, cultural and sociological factors that influence currency demand differ across countries. The cross-country variations in growth, inflation and interest rates, the rate of direct and indirect taxes, the share of informal and underground economy in the overall economic activity and the organization of economic activity (*viz.*, dominance of retail *vis-à-vis* large-scale business), regulation of various modes of payment, proportion of migrant workers, the nature of currency ('soft' or 'hard'), etc. are among the important explanatory economic factors. The extent and type of financial innovations also impact currency demand. The growing acceptance of cash substitutes, *viz.*, electronic modes of payment and use of credit/debit cards, particularly in the developed countries has not, however, necessarily resulted in an offsetting reduction in the total stock of currency outstanding. Variations in annual growth of currency in circulation (in value terms) over time and across countries in the last decade may be seen in Table 2.2. In the recent years, currency growth has been low in Japan and moderate in the US and Euro area. On the other hand, it was relatively higher in India, Indonesia and Thailand.

Table 2.2: Currency in Circulation: Annual Growth Rate

(per cent)

	USA	Euro Area	Japan	UK	Indonesia	Thailand	India
2002	6.9	37.5	8.9	3.3	7.8	14.1	12.6
2003	5.4	14.7	1.9	6.8	14.6	13.8	15.8
2004	4.3	14.8	1.4	-1.9	12.6	12.3	12.7
2005	5.4	12.6	1.6	8.0	14.2	5.4	16.5
2006	3.3	11.0	0.7	7.1	23.3	2.7	17.3
2007	1.1	7.7	1.8	13.2	23.6	8.9	17.2
2008	7.3	12.6	0.2	7.1	19.8	9.7	17.0
2009	4.7	5.7	-0.6	8.8	5.5	8.9	15.7
2010	6.1	4.2	1.6	4.6	14.2	10.8	18.8

Source: International Financial Statistics, IMF and RBI.

The degree of monetisation, however, as reflected in the currency to broad money supply ratio has been quite stable in both mature and emerging market economies (including India) in the recent years (Table 2.3).

Table 2.3: Currency- Broad Money Ratio*(per cent)*

	USA	Euro Area	Japan	UK	Indonesia	Thailand	India
2001	8.1	5.2	7.2	2.7		7.5	16.7
2002	8.3	6.8	7.8	2.6		8.4	16.4
2003	8.3	7.3	7.9	2.6		9.0	16.3
2004	8.2	7.9	7.9	2.4	12.3	9.6	16.4
2005	8.0	8.2	8.0	2.3	12.0	9.5	15.8
2006	7.6	8.3	8.2	2.2	12.9	9.0	15.2
2007	6.9	8.0	8.2	2.2	13.4	9.2	14.7
2008	6.8	8.3	8.2	2.0	13.9	9.3	14.4
2009	7.2	8.8	8.0	2.8	13.0	9.5	14.3
2010	7.8	9.0	8.0	2.8	12.9	9.5	14.6

Source: International Financial Statistics, IMF, ECB and RBI.

2.2 Modelling Currency Transactions Demand

According to Roseman (2010), domestic demand for currency in the US is largely based on the use of currency for transactions and is influenced primarily by income levels, prices of goods and services, the availability of alternative payment methods, and the opportunity cost of holding currency in lieu of an interest-bearing asset. Consumers frequently use smaller-denomination notes for small transactions and alternative payment methods (for example, debit and credit cards) for larger purchases. In contrast, foreign demand for US currency is influenced primarily by the political and economic uncertainties associated with certain foreign currencies, which contrast with the U.S. dollar's historically relatively high degree of stability. Because U.S. currency is held abroad primarily as savings, foreigners tend to hold high-denomination notes.

Doyle (2000) estimated the overseas demand for US dollars based on data for 1960-1996 using a cointegrating framework between real currency balance, interest rates and retail sales. The dynamic OLS method was adopted. The exercise was carried out for the US as also several other countries, which were likely to hold US dollar cash balances. The estimation results showed that in case of most countries, for aggregate currency demand, coefficients were positive for retail sales and negative for interest rates and both were significant. When currency data were split into large and small denominations, the signs flipped for small denominations. The study also found evidence that the equations were stable for the period 1960-1996.

In the European context, there has been a large number of studies for estimating currency demand. Nenovsky and Hristov (2000) model transactions demand for currency as follows:

$$C/P = c(Y, R, N) \text{ and } R = [I, \pi^e, \text{Var}(\pi)];$$

Where C = currency circulation in nominal terms (proxy for currency demand);

P = general price level;

Y = variable approximating real sector developments,

R = vector of asset prices in economic agents' portfolio;

π^e = projected inflation rate;

Var(π) = variance of inflation;

N = proxy of payment system development and financial intermediation.

In contrast to the general models of demand for money, where the demand is estimated in real terms, demand for banknotes and coins is estimated in nominal terms. Under these conditions, in order to estimate the influence of price level on demand for currency, inflation rate (measured via the consumer price index) is added as an explanatory variable (Nenovsky and Hristov, 2000). Usually, household money expenses - rather than money income - is more closely connected with demand for currency in circulation (*Boeschoten, W., 1992*). Attanasio *et al* (2002) estimated the demand for money in Italy between 1989 and 1995 using a dataset of detailed information about households and firms. The study found that demand for money by households was significant with respect to elasticity of consumption and interest rate.

2.3 Modelling Currency Demand for Hoarding

There are a limited number of studies that have examined currency demand for the purpose of hoarding. In fact, hoarding does not fit well into any theoretical framework for currency demand⁴. Thus, the Baumol-Tobin inventory approach where individuals try to minimise the transactions and opportunity cost of holding cash, does not provide any room for hoarding. Nevertheless, studies related to hoarding of currency show a large proportion of aggregate currency held as hoards. In view of extreme liquidity of currency, it is an attractive form of precautionary balances if the cost of transferring alternative financial assets into cash proves to be prohibitive (Van Hove and Vuchelen, 1996). The desire for secrecy may be based on legitimate motives (Anderson, 1977), although it is more likely to be associated with tax evasion or other illegitimate activities.

When currency is used as a store of value, there can be a strong elasticity of the demand for cash with respect to interest rates (and, in open economies, exchange rates). Holders may even economize on transaction cash balances when interest rates rise. The most commonly used method for modelling hoarding demand for currency is the age of bank notes or the lifetime method. Under this method, the average life of various denominations of bank notes serves as an indicator of

⁴ These studies include Anderson (1977), Kimball (1981) and Sumner (1990) for the US and Boeschoten and Fase (1992) for the Netherlands, Van Hove and Vuchelen (1996) for Belgium and Krueger (2000) for Germany.

currency usage for transactions/hoarding, with a relatively high note life of a particular denomination indicating lower intensity of use (for transactions purposes), and a greater use for hoarding. The life-time method has been a popular method for estimating the volume of hoarded banknotes. Studies of this genre assume that smaller denomination currencies are used only for transactions and assuming that the average life of small denomination notes is the normal average life of the banknotes, the percentage of notes of a higher denomination used for hoarding is calculated. The average life of denominations is defined as the average period between the banknotes' issue and destruction.

Kippers (2004), Boeschoten and Fase (1992) and Boeschoten (1992), report on several studies regarding the hoarding of bank notes. In these studies, the hoarding percentage of banknotes in the Netherlands was estimated to be around 50 per cent, and even 70-80 per cent for the then existing highest denomination (1000 - guilder bank note). They used two methods to arrive at these estimates, *viz.* a comparison of the return rates of bank notes to return rates of bank notes that are mainly used for transaction purposes. Also, they compare the average life of bank notes to a benchmark life of non-hoarded bank notes. Boeschoten (1992) extends this analysis to 13 other countries. The highest hoarding percentages were found in the countries with the highest denominations (the Netherlands, Switzerland and Germany). One drawback of this method is its lack of precision power since over time, there can be changes both in the treatment of banknotes as well as in the replacement procedures of central banks.

2.4 Modelling Financial Innovations and the Implications for Currency Demand

There have been rapid financial innovations, in both advanced economies and EMEs, especially in the last two decades, which have had implications for currency demand. In advanced economies, while cheques never became prominent in retail expenditure to rival the use of cash, the use of electronic payment media like debit and credit cards permitting electronic fund transfer at point of sale (EFT-POS) has successfully challenged currency as an alternate transaction medium (Markose and Loke, 2002). The usage of credit and debit cards in transactions depends, however, on the ratio of firms that accepts such payment, which varies across countries.

Unlike EFT-POS that reduce currency demand, the impact of ATMs on currency demand is ambiguous. The expansion of ATM networks by banks has enhanced the convenience yield of cash and reduced *shoe leather costs* by increasing accessibility to cash closer to point of sale. For the first time, historically, this has reduced the transaction costs of use of cash while making payments. The lowering of the transaction costs enables economic agents to reduce their outstanding transaction balances (in terms of Baumol's model). At the same time, the cost effectiveness of ATM cash dispensation has enabled cash to maintain its competitiveness *vis-à-vis* EFT-POS instruments such as credit cards and debit cards (Markos and Loke, 2002). Furthermore, the increase in the number of ATMs impacts directly the volume of banknotes in circulation due to a growing need of greater

volumes of banknotes to be kept as reserves in ATMs. Interestingly, in some countries such as Bulgaria, this effect occurs in certain specific denominations which are used for the ATMs (Nenovsky and Hristov, 2000).

In one of the early studies dealing with various forms of financial transactions, Akhand and Milbourne (1986) used credit card usage as an alternate transaction medium in a model of money demand. The study concluded that credit cards allow agents to hold less in money balances and more in bonds as postulated in the standard Baumol-Tobin model. Various studies have pointed to different conclusions on the role of currency in the presence of alternative payment instruments. While a few studies have hypothesised the demise of currency as a medium of exchange in view of EFT-POS instruments, other studies have noted that on both theoretical and empirical grounds, cash use is likely to persist for the foreseeable future because of the cost competitiveness of ATM networked cash to the consumer relative to electronic POS card substitutes.

In estimating the effect of payment cards on money demand, a log-linear money demand specification of the form $y = f(X, r, Card)$ is assumed as a theoretical starting point where, y typically represents the log of currency in circulation, X an appropriate scale variable like income or wealth and r represents a measure of the opportunity cost of money holdings. $Card$ typically contains several variables measuring payment card “intensity”, usually approximated by the number of outstanding payment cards, the number of EFT-POS terminals or the number of ATMs and number and volume of transactions conducted via ATMs. A study by Drehmann *et. al.* (2002) analyzed a panel of 16 OECD countries and separately studied the impact of credit card usage on the demand for small and large denominations. They also find that the number of POS terminals and ATMs have significant effects on cash demand.

2.5 Demand for Currency and the Underground Economy

Many of the studies in the literature on currency demand for non-transactions purposes relate to the role of currency in facilitating underground economic activity. Attempts at estimating the shadow economy through the currency in circulation have a long history (Cagan, P., 1956 and P. Gutman, 1977). In the standard view, the importance of currency stems from its special characteristics, such as anonymity and secrecy as currency, unlike other means of payments, does not leave a paper/byte trail. Goodhart (1989) noted that “... much of such demand probably relates to nefarious activities, the ‘black economy’, gambling, prostitution and drugs, where anonymity of currency is prized; indeed a large portion of outstanding notes is never caught in surveys.”

Faced with the alternatives of (i) paying tax on legitimate income/profits and earning interest by placing the surplus with banks as deposits on the one hand and (ii) paying no tax and holding assets in the form of currency hoards on the other, there can be a strong incentive for tax evasion by hoarding currency especially for

shorter periods. Firms operating in the underground might be inclined to hold large amounts of money in the form of currency, either because they have no access to the legal credit market (Martino, 1981) or because they are waiting to have their black profits laundered. Further, the illegally acquired income – as opposed to unreported but otherwise legally earned income – has to stay unreported and the accumulation of currency can, therefore, be meaningful for those engaged in illegal activities.

A crude method of estimating the change in the size of the informal economy over time is to study the change in cash to deposit ratio using monetary approach (trend of the cash ratio) (Gutman 1977, Feige 1979, Tanzi 1983). This method involves several strong assumptions (e.g. constant cash-deposit ratio in the official sector) and the results are, therefore, not very reliable (Porter and Bayer 1984, Lafleche 1994).

In the more sophisticated method used by Tanzi (1983), the cash to M_2 ratio has been regressed on the tax rate, income, interest rate and the ratio of wages and salaries to national income, where the average weighted tax rate (direct and indirect taxes) was used as a proxy for the shadow economy. The Tanzi method has been widely used in developed and developing countries. As per this method, the coefficient of the tax rate gives the effect of cash holdings in the underground economy on the cash to M_2 ratio. By re-estimating the model assuming taxes to be zero, the difference between the two estimates of the demand for currency is the proxy for the shadow economy. The second step in Tanzi's method is based on the assumption of the constant velocity of circulation in the shadow economy and in the official economy. Based on the above assumption, the shadow economy is quantified and compared with the official GDP (Schneider and Enste, 2000). Surely, Tanzi's method involves strong and implausible assumption, *viz.*, any rise in tax above zero shifts income into the informal sector. Tanzi's estimates are also biased since his method does not allow for the use of currency as a means of hoarding. The hypothesis of the equal velocity of currency in the shadow and in the official economy is a major weakness of the approach to measuring the underground economy through the currency in circulation (Thomas, 1999). Porter and Bayer (1989) using different methods have challenged Tanzi's findings (of 15-20 per cent currency absorbed in the underground economy).

2.6 Select Country Studies

We now present the findings of a few country-specific studies.

New Zealand

A study on forecasting currency demand by the Reserve Bank of New Zealand (RBNZ) was motivated by the need to comprehend the sudden unanticipated increase in demand for currency at a time when spectacular progress in the application of electronic technology in the retail payments area was occurring, particularly in terms of number and spread of automated teller machines (ATMs) and

electronic funds transfer at point of sale (EFT-POS) (Vincenzo *et al*, 1997). Contrary to the anticipated fall in currency demand, there was a rise as ATMs made currency accessible to the public round the clock.

The RBNZ study used two approaches - currency demand function approach and an ARIMA model-based approach. The first approach is a standard money demand function based on the transactions- and portfolio demand for currency. The study revealed that seasonal ARIMA models proved superior to a structural demand function in forecasting the demand for currency, particularly over short-term horizons. In particular, the moving average method, which was found to provide the most accurate forecast, was successfully incorporated in the RBNZ's currency forecasting exercise.

European Union Countries

The extent to which payment cards are actually used vary widely among the countries of the EU with Finland, for example, displaying very advanced usage while Greece, Italy, Spain and Austria all show modest usage. At the aggregate level, the declining ratio of currency in circulation to M1/M3 since 1980s reflects the increased use of cashless payment instruments. Also, in some countries such as France, Belgium and Netherlands, there are legal regulations that enforce the use of cashless payments. In countries in the European Union, payment cards can substitute for cash payments as they are mainly used for small and medium-value purchases (Fischer *et al*, 2004).

There have been several studies on currency demand for European Union countries that investigate the effect of non-cash payment instruments. Markose and Loke (2002) observed that among the early developers of EFT-POS networks *viz.* USA, Denmark, Canada, France and Finland, the latter three have experienced a resurgence of ATM cash use since the mid-1990s. This is despite an overall trend towards an increasing proportion of card-financed to cash purchases (Humphreys *et al.*, 1996, and Markose and Loke, 2000).

That credit/debit cards/ATMs have a strong offsetting effect on transactions demand for currency was found in Finland (Viren, 1992), and Netherlands (Boeschoten, 1992).⁵ In case of Finland, however (along with Canada and France), there was a resurgence of ATM cash since the mid-1990s (Markose and Loke, 2002). In case of Italian households, estimation results based on a money demand equation indicate that ATM users hold significantly lower cash balances than non-users (Attanasio, Jappelli and Guiso, 2002). In Austria, individuals who access POS terminals for payments and ATMs hold 20 per cent and 18 per cent less purse cash,

⁵ Based on household survey data, Boeschoten concluded that frequent debit card payments and ATM withdrawals reduce average cash holdings by 15 per cent and 18 per cent, respectively. Further, the adoption of debitable accounts and guaranteed cheques were responsible for 40 per cent of the fall in currency ratio between 1965 and 1975 in the Netherlands. However, this trend reversed from 1975 to 1990 indicating an increased role for banknotes as a store of value.

respectively (Stix, 2004). However, due to the relatively small share of frequent users, aggregate purse cash demand was not very strongly affected by EFT-POS payments. In case of Belgium and Iceland, it was found that the cost efficiency of the cash payment system is low compared to a payment system based on cards (De Grauwe *et al.*, 2000). Using Baumol-Tobin cash balances approach, it was observed that at low interest rates, the interest rate elasticity for cash-cards substitution varies directly with the density of card network (Markose and Loke, 2000).

A study spanning the period 1960-99 for *Belgium* (a period representing the transition, from pure cash based society to a technology based payment system) estimated a money demand function for retail transactions through cointegration analysis. In addition to standard variables (GDP and interest rate), variables like bankcards (credit/debit cards, electronic purses), points of sale that accept cards and ATMs were included to study currency substitution (Rinaldi, 2001). Real per capita currency holdings (defined as per capita currency with the public, *i.e.* outside the banking system) corrected for the share used for hoarding purposes was used as the dependent variable. The variables y , X , r and $Card$ were shown to be non-stationary and co-integrated. In this long-run equilibrium relationship, the number of EFTPOS terminals, credit and debit cards and the number of ATMs showed a negative impact on currency in circulation. Rinaldi (2001) also estimated an error-correction model (ECM) in which the number of ATMs was found to have a positive short-run effect on currency demand. While economic theory defines the long run equilibrium, the short term dynamic adjustment process is determined from the data under an ECM framework. The study concludes that currency demand increased following an increase in ATM in Belgium and that E-money has taken off much slower than expected in European Union countries as a whole implying that payment habits of consumers and traders take time to adapt, so that high cost currency provision would most likely continue for quite some time.

Using a dataset comprising 11,945 payments in France made from March to May 2005, Bounie and Francois (2006) attempted to assess the role of transaction characteristics in the choice of payment instruments - cash, check or bank card - at the POS by characterizing the probability of a transaction being paid by one of these instruments. Controlling for individual characteristics, their main results were: i) a *differentiated* effect of the transaction size regarding payment instruments; and ii) a *specialization* effect between payment instruments according to the type of goods/services purchased and the place of spending.

A panel study for ten European countries found strong evidence of a substitution effect between cash and cards, ATMs and POS terminals (Snellman, Vesala and Humphrey, 2001). Gompertz S-curve analysis that accounts for product-cycle nonlinearities was applied. The study used estimated elasticity to derive the S-shaped learning curve and generate forecasts through extrapolating the curve. The development of infrastructure facilitating the new technologies had a bearing on the process of substitution. Thus, cash transactions accounted for about 60 per cent of

the value of point-of-sale payments in countries with a mature card payment network, like Belgium, Finland, France and Denmark. On the other hand, Germany, UK and Italy were slow in cash substitution with cash rate use at 95 per cent. In countries with a high cash share at the POS and relatively immature card payment networks, the aggregate cash share was significantly higher but projected to slowly decrease due to the impact of payment cards.

In Finland, the use of cards, especially debit cards, has increased substantially. For example, in 1984, some 80 per cent of total purchases (in value terms) were made with cash, whereas by 2002 the corresponding figure had dropped below 50 per cent. A study on cash substitution in Finland showed rapid saturation with the use of cash remaining high in retail payments and was forecast not to fall below 65 per cent during the next ten years (Snellman and Vesala, 1999). However, another study found that the error correction model and its special-case partial adjustment model, coupled with independent explanatory variables, seem to do a better job than the learning curve models for explaining electronification of payment methods in Finland (Jyrkönen, 2004). A forecast based on the former indicates that electronification would lower the cash-share of total value of point-of-sale payments over time.

United States

Before the passage of the Federal Reserve Act of 1913, which established the Fed, the supply of currency in circulation was inelastic and did not respond to seasonal and cyclical changes in demand (Federal Reserve Bulletin, September 2001). The Congress passed the Federal Reserve Act to remedy this problem, which mandated an elastic currency that would expand and contract in response to public demand. The Federal Reserve Act also authorises the Federal Reserve to issue Federal Reserve notes to depository institutions through the Federal Reserve Banks. The Federal Reserve Board prepares and submits an annual order to the Bureau of Engraving and Printing (BEP). The order is based on the Federal Reserve System's estimate of the amount of currency that would be demanded by the public in the following year and reflects the estimated changes in currency usage and destruction rates of unfit currency.

The estimation of demand for currency is the joint responsibility of the staff of the Federal Reserve Banks and the Federal Reserve Board. Each Federal Reserve Bank takes into account local economic and environmental conditions that affect demand for currency. Environmental conditions have varying impact on physical appearance and longevity of bank notes. These conditions are taken into account in each district to determine the amount of currency needed to satisfy the daily payment requirements of the public and to maintain a safety stock to meet natural contingencies that might disrupt normal distribution channels. Board staff members study Federal Reserve data to reconcile variations and evaluate trends, consider the amount of currency held in vaults at the BEP and at the Reserve Banks, and calculate overall growth rates of net payments and currency destruction rates. Board

staff members compare their currency demand estimates with Federal Reserve Bank forecasts and reconcile differences until a consensus print order is approved by the Board.

Another study (Judson and Porter (2004)) estimates US currency demand based on regional currency demands using a panel dataset covering the 37 Federal Reserve Cash Offices over 25 years from 1974 to 1998. The study finds strong support for the transaction specification, in which currency depends on a transaction measure and nominal interest rate.⁶ This result is generally robust to the inclusion of a wide variety of additional economic and demographic variables. Beyond the traditional transaction terms, seven other variables stand out in the specifications: the age distribution of the population, bankruptcies, crime, employment, housing permits and starts, and transfer payments. It also shows that international currency demand was generally an important influence during the period; when its influence is disregarded, the findings are considerably muted.

Studies using US household survey data concluded that credit cards allow households to reduce their transactions and precautionary demand for money (Duca and Whitesel, 1995 and Blanchflower *et. al.* 1998). The studies followed a cross-section approach and analysed the effect of credit cards on the demand for various balances at banks (like checking balances). There are similar studies in respect of other countries such as Bulgaria, Malaysia and Turkey.

2.7 Denomination-wise Demand for Currency

The aggregate demand for currency fails to account for the fact that different denominations of currencies may be affected by distinct sets of factors/variables and the aggregate picture could be somewhat misleading for planning the supply of currencies of various denominations if the impact (actual and potential) of the various factors differentially impacting the various denominations are not considered. Thus, larger denominations may be in demand for use in ATMs and for the purpose of hoarding. Smaller denominations, on the other hand, tend to be used more for transactions.

In this regard, a few studies have pursued the distinction between different denominations, especially large and small denomination bills, and different holding groups.⁷ These studies show that the currency denominations in Euro/OECD countries are linked to the per capita GDP in terms of purchasing power parity (PPP). Thus, low value legacy banknotes were particularly important in Greece and Portugal. Second, continued high inflation, which leads to a decline in the purchasing power of a banknote, also leads to an increased concentration among the higher

⁶The conclusion holds for aggregate currency demand as well as separately for large denominations and US \$20 bills.

⁷These studies include: De Nederlandsche Bank (1994), and Boeschoten and Fase (1992), for the Netherlands; Virén, (1993) for Finland and Drehmann *et al.*, 2002, Porter and Judson (1996) and Amromin and Chakravorti (2009) for several OECD countries.

denominations, if there is no change in the denomination structure over the period. Third, countries that have high value banknotes in real terms become attractive for hoarding and foreign demand. High value banknote in real terms may be viewed as indicative of low past inflation (since denomination of currencies is not frequently changed). Lower inflation makes such currencies attractive for hoarding. Fourth, the demand for high-value banknotes is relatively strong among non-residents.

Thus, in the Euro-area, whereas the transactions motive was seen to dominate the demand for low-value currencies, the demand for large-value bank notes, which are well-suited as a store of value, was found to be positively affected by a fall in the opportunity costs of holding currency (Fischer *et al*, 2004). Hence, currencies were used for hoarding purposes in those countries where the inflation rate was low. This is seen from the fact that in countries where the average annual inflation during 1970-98 was high, the average legacy value of a banknote (i.e. the total value of banknotes in circulation divided by the number of banknotes in circulation), converted to Euro, was low in 2000. Thus, an increase in inflation increases transactions demand for lower denomination currencies, but reduces hoarding demand for larger denomination currencies and also tends to reduce the average real value of a bank note and usually causes concentration of fresh printing of notes of various denominations at the larger end (in the absence of introduction of higher denominations) (Fischer *et al*, 2004). Their results point towards lower levels of transaction balances used within the euro area of around 25 per cent to 35 per cent of total currency.

A study using panel estimation techniques to analyze the change in transactional demand for various currency denominations resulting from improvements in payment technology in 13 OECD countries from 1988 to 2003, classified currencies into three types: small, medium and large denominations (Amromin and Chakravorti (2009)). The study observed that ATMs typically dispense medium denomination currencies and found evidence that greater penetration of ATMs (signifying lower transaction costs incurred in a visit to ATM) has, on net, reduced the demand for the ATM dispensed notes. Second, they found that currency demand varies directly with the share of small merchants (self-employed) in an economy. This effect is primarily observed through demand for small denomination currency, suggesting that high fixed costs of installing electronic payments terminals and not illicit activity influence cash demand by small merchants. It follows that demand for small denomination currency decreases with greater debit card usage and with greater retail market consolidation. Third, the demand for small (as also large) denomination currency is positively associated with the extensiveness of the banking network. Fourth, the demand for larger denomination notes is affected by the short-term interest rate, but not by the adoption of point-of-sale (POS) debit card terminals. This suggests that these denomination notes are essentially used for non transactional purposes. On the other hand, short-term interest rate has little effect on the demand for small denomination currencies.

Structural Model - Bundesbank

The Bundesbank has developed a Structural model (vector error correction model) to determine the contribution made by various determinants to the volume of banknotes in circulation (Deutsche Bundesbank, 2009). The analysis was carried out based on classification of the bank notes on three criteria, viz., small denominations (€5 to €20 and DM5 to DM50), medium denominations (€50 and €100 as well as of DM100 and DM200) and large denominations (€200 and €500 as well as DM500 and DM1,000). Cash consumption - considered to be those subcategories of private consumption that are largely settled in cash - was counted among the determinants of cash demand. The opportunity cost of holding cash was taken into account via the interest rate level. The complete interest rate range is incorporated into the analysis as a shift parameter from an estimated yield curve to represent the generally prevailing interest rate level.

Empirically, as expected, it was found that the small and medium denominations were used for transactions purpose in Germany as reflected in cash consumption. The large denominations (where the non-resident motives seem to be important) appeared to be unaffected by this factor, but were affected via a long-term impact of the house prices in the euro area, whose dynamics are determined mainly by the real estate market outside Germany and also via private consumption in the euro area excluding Germany. Additionally, demand from non-euro-area countries emerged as important in the long term for all denominations. Moreover, an influence of the shadow economy on banknote demand could not be ruled out for any of the three banknote categories. Finally, opportunity costs in the form of the interest rate level seemed to be of relevance only for the small denominations. Alternative means of payment, too, evidently influence only the small denominations. Alternative payment media determine the fluctuations around the long-term equilibrium, which is defined by cash consumption, demand from non-residents, and interest rates. The cash changeover dummies show a highly significant influence in all the specifications.

Statistical Models on Currency Distribution - D-metric approach

In the D-Metric model (Payne and Morgan, 1981), the independent variable of overriding importance in determining the most efficient sequence of values of notes and coins in use is the amount of the average day's pay (D) for the country in question. In order to achieve an optimal system, it is necessary, according to the D-Metric approach, that the minimum coin denomination has a value of about $D/5000$, that the maximum note denomination has a value of about $5D$, and that the note-coin boundary (between the highest-value coin and the lowest-value note) is between $D/20$ and $D/50$.

2.8 Denominational Currency Demand Forecasting and Inflation

Inflation affects the aggregate value of currency in circulation as also the denomination shares. On the one hand, inflation raises nominal income and hence the transactions demand for currency (in nominal terms). On the other hand, by

raising the opportunity cost of holding currency as a store of value, inflation may result in a shift in the allocation of the consumer's portfolio away from currency, whose return is inversely related to the rate of inflation.

Inflation has implications from the point of view of currency management by a central bank. As inflation erodes the purchasing power of a currency, the optimal level of various denominations of currency keeps changing. Under inflationary circumstances, the central bank needs to continuously alter the denominations of currency (as well as quantity of currency in any given denomination) to facilitate efficient cash transactions with smaller denominations going out of circulation and larger denominations taking their place. First, the existing denominational structure may not be suited to effect a straightforward response. Second, each denomination has a different volume. Although there have been studies to correlate note-coin volumes and denominational structure with a wide range of economic-demographic variables, they were not really amenable to yield a coherent theory of currency structure (see Payne and Morgan (1981)). Currency management, therefore, remains a matter of pragmatic adjustments combined with some form of trend analysis.

2.9 Currency Demand in India

The Reserve Bank estimates the quantum of banknotes that needs to be printed, based on the requirement for meeting the demand for banknotes based on various factors like inflation, GDP growth, replacement of soiled banknotes and reserve stock requirements. Further, the Reserve Bank also estimates the quantity of banknotes that are likely to be needed denomination-wise and accordingly, places indents with the various printing presses. Banknotes received from banks and currency chests are examined and those fit for circulation are reissued and the others (soiled and mutilated) are destroyed so as to maintain the quality of banknotes in circulation.

There have been very few published studies on currency demand in India conducted outside the Reserve Bank. One of the major studies worth mentioning is that by Coondoo⁸ *et al.* This study aimed at regression models for aggregate value of currency in circulation using explanatory variables such as income, per capita income, prices, interest rate, etc. Thereafter, a simulation approach was employed for estimating the denomination-wise composition. In the absence of data on the distribution of cash transactions, a parametric distribution (e.g. Lognormal) model was assumed for size distribution of cash transactions and random samples were drawn from the assumed distribution. A rule was formulated to determine the number of different denominations needed to carry out the transactions and the required currency composition for each sample of cash transactions were obtained and averaged across the samples. The resulting denominational composition of currency was matched with the actual aggregate circulation for determining the appropriate parameters of the underlying distribution.

⁸Unpublished Note

3: Currency Circulation in India – Aggregate Analysis

Among the important determinants of the demand for currency, as we have seen above, the following deserve special attention: (i) volume of transactions demand arising in the formal economy; (ii) transactions demand arising from the underground economy; (iii) precautionary, prudential and speculative demand; (iv) the type and pace of financial innovation and (v) use by other countries (in case of India, primarily Nepal and Bhutan). The focus of this chapter is on reviewing the broad trends in currency demand in India over the last four decades reflecting changes in the macroeconomic scenario and financial factors.

As regards the transactions demand for currency in the formal sector, it is expected that with the development of alternative modes of payment (cheques, electronic modes of payment), shift in the GDP composition from agriculture to services, spread of bank branches, and increased ATMs network reducing transaction costs, there would be a decline in the transactions demand for currency with the public, in relation to aggregate output (GDP)/private final consumption expenditure, and financial saving of households. On the other hand, progressive monetisation of the economy, reduced opportunity cost of holding currency with the secular decline in inflation, high taxation rates, wider ATM network rendering easy access to cash and increase in underground economy transactions would most likely lead to an increase in the transactions and hoarding demand for currency.

While there has been considerable variability in the annual growth rates of currency in circulation (in value terms) during the last four decades (1971-2011), the decadal average growth has been surprisingly stable. After an average annual growth of 11.2 per cent during the 1970s, currency exhibited a near trend growth of around 15 per cent during the 1980s, 1990s and 2000s. Nominal GDP growth, however, declined sharply during the 2000s to 12.8 per cent from around 15 per cent during the 1980s and 1990s. The decline in the rate of growth of nominal GDP during the 2000s mainly reflected deceleration in average inflation (till 2009) even as real GDP growth accelerated (Table 3.1).

**Table 3.1: Currency and Proximate Variables in India
– Trend in Growth Rates & Ratios**

(per cent)

Growth rate (y-on-y)	1971-80	1981-90	1991-00	2001-10	2010-11	1971-2011
Currency in Circulation	11.9	14.6	15.2	15.1	18.8	14.4
Population	2.3	2.2	2.0	1.6	1.4	2.0
GDP at factor cost at current prices	11.2	14.9	15.0	12.8	19.1	13.7
GDP at factor cost at constant prices	2.7	5.6	5.7	7.3	8.5	5.5
WPI Inflation	9.4	7.9	8.1	5.3	9.4	7.7
GDP Deflator Inflation	8.4	8.8	8.8	5.1	9.8	7.8
Per Capita real GDP	0.4	3.4	3.6	5.7	7.1	3.4
Nominal PFCE	10.9	13.6	14.3	11.3	19.1	12.7
Real PFCE	2.7	4.6	4.6	6.4	8.6	4.7
Per Capita Real PFCE	0.4	2.4	2.5	4.8	5.0	2.6
Real Deposit Rate (WPI based)	-2.7	0.9	2.6	1.7	-2.4	0.6
Per Capita real currency holding (WPI)	0.7	4.1	4.5	7.6	5.0	4.3
Per Capita real currency holding (GDP deflator)	1.2	3.2	3.8	7.8	4.6	4.1
Ratio						
Currency-GDP Ratio	10.0	10.2	10.5	12.4	13.0	10.8
Currency-PFCE Ratio	11.7	12.6	14.8	19.1	21.1	14.8
Currency-M1 Ratio	55.9	57.3	54.7	53.2	55.9	55.3
Currency – M3 Ratio	31.7	21.6	18.7	15.1	14.1	21.6

As noted earlier, there have been significant fluctuations in the annual currency growth over the period 1971-2011. From 1970-71 onwards, the Indian economy experienced three phase of high growth (> 17 per cent) of currency in circulation, each phase lasting 3 to 4 years (Table 3.2). These phases were generally characterized by relatively high GDP growth and inflation, the effects of which might not have been neutralized by a positive real deposit rate.

Table 3.2: High growth phases of currency in circulation during 1971-2011

Phase	Currency in Circulation (Growth Rates)		GDP* at current prices	GDP* at constant prices	Inflation (WPI)	Deposit Rate
	Average	Range	(Growth Rates)		(per cent)	
1987-88 to 1989-90 (3 years)	17.3	14.2 - 20.4	16.0	6.6	7.7	9.5
1993-94 to 1995-95 (3 years)	19.8	17.1 - 22.6	16.7	6.5	9.6	11.0
2006-07 to 2010-11 (4 years)	17.2	15.7 - 18.8	16.6	8.4	6.5	7.7

*at factor cost.

On the other hand, there was some evidence of significant slowdown in currency circulation (< 10 per cent) in at least four years during this period (Table 3.3). A lower growth in currency in circulation in these years indicates, in general, a lower GDP growth and lower inflation.

Table 3.3: Low growth phases of currency circulation during 1971-2011

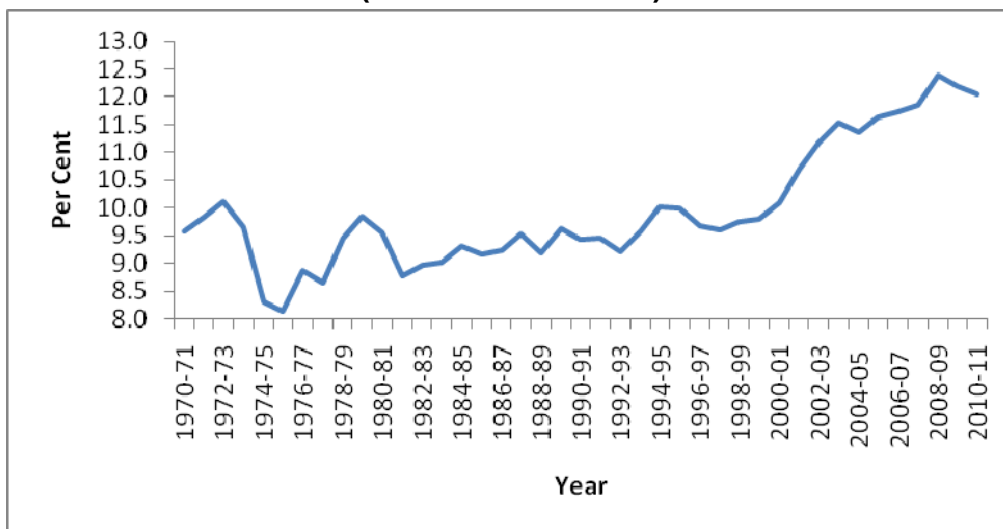
Year	Currency Circulation (Annual Growth Rates)	GDP* current prices	GDP* constant prices (Annual Growth Rates)		Inflation (year-on-year %)		Deposit Rate (per cent)
			current yr	next yr	current yr	next yr	
1971-72	9.9	6.4	1.0	-0.3	5.6	10.1	6.0
1974-75	1.6	17.7	1.2	9.0	25.2	-1.1	7.4
1975-76	5.3	6.2	9.0	1.2	-1.1	2.1	8.0
1981-82	7.7	17.1	5.6	2.9	9.2	4.1	8.5

*at factor cost

On a decadal average basis, the currency-GDP ratio remained stable during 1970s to 1990s at around 10.5 per cent. Reflecting the deceleration in nominal GDP growth and stable currency growth during 2000s, the currency-GDP ratio increased in recent years to an average of 12.4 per cent during 2001-10. Apart from this fact, there could be several additional reasons for this increase. First, the decline in inflation could have lowered the opportunity cost of holding currency contributing to the increase (in the currency-GDP ratio). Secondly, the opportunity cost of holding currency also fell because of a decline in the real rate of return on bank deposits during the 2000s reflecting the sharper fall in nominal deposit rates *vis-à-vis* that of the inflation rate as compared with the previous decade. Thirdly, growth in consumption expenditure levels in both rural and urban sectors (as reflected in the NSSO data) may have led to some increase in currency holding among the poorer section of society. Fourthly, an improvement in the supply position of currency via the pro-active currency- management policy pursued by the Reserve Bank in recent years might have also been a contributing factor. Finally, the availability of ATMs by providing relatively easy access to currency could also have increased its demand as in the case of European countries.

The year to year movements in currency-GDP ratio (Chart 3.1) reveal an increasing trend, particularly since mid-1990s. The rise in the Currency-GDP ratio has, interestingly, occurred at about the same time that there have been developments in alternative modes of payments, a marked increase in the proportion of services to GDP, increased opportunity cost and lower transactions costs of holding currency (higher rate of return from bank deposits and a rise in the number of ATMs, respectively). However, the ratio has started showing a decline in the last three years.

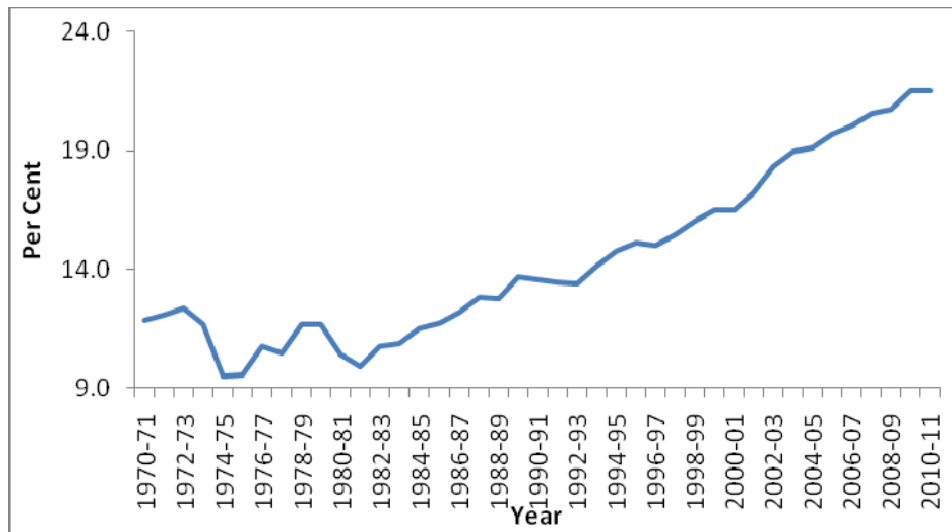
Chart 3.1: Currency to GDP (current prices, factor cost) Ratio (1970-71 to 2010-11)



The ratio of currency in circulation to private final consumption expenditure (PFCEdom) in India has increased from 11.5 per cent in 1970-71 to 23.8 per cent in 2008-09 (Chart 3.2). Since $Cu/GDP = Cu/PFCEdom * PFCEdom/GDP$, the sharp increase in $Cu/PFCEdom$ was only partially offset by the decline in $PFCEdom/GDP$ (with commensurate increase in the saving rate) resulting in a modest increase in currency/GDP ratio during the 2000s.⁹ It may also be indicated that during the periods of high inflation, there was a decline in the ratio from 12.1 per cent in 1972-73 to 9.8 per cent in 1974-75 and again from 12.5 per cent in 1979-80 to 11.1 per cent in 1981-82. This decline could be attributed to the inability of the authorities to keep pace with inflation during years of high inflation while printing currency notes, thereby resulting in a decline in real currency growth.

⁹There is a cross-country difference between the ratios of currency in circulation to private consumption. For e.g., among Euro area countries, the ratio varied from 3.9 per cent (in case of Finland) to 13.1 per cent (in case of Spain) in 2001 and from 3.8-16.9 per cent in 1980. However, for the Euro area as a whole, the ratio remained relatively stable between 1980 and 2000, at a level of around 9-10 per cent.

Chart 3.2: Movements in Currency-PFCE Ratio



3.1 Opportunity Cost of Holding Currency

Judging by the rate of return on average commercial bank term deposits (of maturity 1-3 years), the opportunity cost of holding currency went up from the 1970s till 1990s. Subsequently, however, the real deposit rate declined in the last decade. As average inflation declined from over 9 per cent during 1970s to about 8 per cent during 1980s and 1990s and further to just over 5 per cent in the last decade, the opportunity cost of holding currency decelerated with the reduction in inflation and decline in real deposit rate.

Other factors having a bearing on currency demand include: significant changes in the sectoral distribution of income in favour of services and away from agriculture, and greater availability of alternative modes of payment (including credit cards).

3.2 Factors Influencing Per Capita Currency

The increase in the rate of growth of real per capita currency holding from 0.7 per cent in 1970s to 7.4 per cent in 2000s occurred in two phases and reflected two sets of factors. In the first phase, there was a sharp increase in the rate of growth of real per capita currency holding from 0.7 per cent in 1970s to 4.0 per cent -4.5 per cent during 1980s/1990s. This reflected the increase in the growth rate of (aggregate nominal) currency in circulation from 11.6 per cent in 1970s to around 15 per cent in 1980s/1990s while population growth and inflation remained broadly stable. During 2000s again, there was a spurt in per capital real currency growth to 7.4 per cent. This time, however, nominal aggregate currency growth remained stable at around 15 per cent and the growth in per capita real currency holding reflected deceleration in both population growth and inflation.

3.3 Conclusion

At the aggregate level, the supply of currency has increased at a faster pace in comparison to growth in nominal GDP. Over the same period, however, broad money has increased at an even faster pace than currency reflecting household savings in bank time deposits. Overall financial saving of households have also increased at a faster pace than currency and GDP, as an increasingly larger proportion of the populace emerged from mere subsistence on a day-to-day basis. The increase in currency, broad money and household financial saving in relation to GDP is reflective of the transition of a low income underdeveloped economy towards an economy characterized by increasing monetisation and commercialisation of the economy. Rise in literacy and income level coupled with the spread of bank branches in a growing market economy has led to a bank based financial intermediation system. India's financial sector development has yet to mature as in developed economies towards financial disintermediation. Despite the emergence of various alternatives to cash-based transactions (credit/debit cards, cheques, internet-based payments, etc.), currency retains its pre-dominance as the use of currency substitutes is associated with a significantly higher level of literacy, awareness and income than prevailing currently. The use of currency as a mode of transaction is also encouraged by government social sector expenditure as this contributes to increase in cash based transactions, particularly in rural areas. From the supply side, the pursuit of a clean note policy during the 2000s has contributed to the increased availability of currency notes as against the use of fewer notes with resultant higher velocity and forced longevity in the earlier decades. Further, as we shall see in the next section, the denomination-wise distribution of currency notes has not been sufficiently altered to compensate for the rise in income/consumption and inflation.

4: Currency in Circulation – Denomination-wise Analysis

Changes in the underlying structure of household and firm-level denomination-wise demand for currency (by value) are attributable to a multiplicity of factors. While the most significant factors in this regard could be the rate of inflation and change in real GDP, other factors having a bearing could be: changes in the distribution of income across individuals and sectors, extent of monetisation of the economy, availability of alternative modes of payment, changing motives for holding currency, *etc.* Ideally, the projections of supply of currency of various denominations need to take into account these various factors so as to match the underlying demand by consumers for the various denominations.

Apart from its dependence on the underlying demand, the supply of currency denomination-wise can be effectively constrained by the availability of production facilities. Specifically, production capacity of printing presses, distribution networks, security concerns and administrative lags, can all in conjunction serve to delay the process of introduction of higher denomination notes. Public preferences for certain denominations arising from ease of use and distribution of cash transactions may also influence the demand-supply position at denominational level. One consequence of the existence of demand-supply mismatches in the denominational distribution of currency is that when a desired denomination is not available in sufficient volume, it may have to be substituted with the nearest available denomination. For example, one may have to use two ₹10 notes instead of one ₹20 note for a transaction worth ₹20. The use of combinations of various denominations of currencies, therefore, does not necessarily always reveal the 'true' preference of users. Hence, using data on denomination-wise structure of currency for modelling currency demand, particularly, at the disaggregated level, may be fraught with serious difficulties for statistical estimation. In India, for example, although currency supply can be assumed to meet the underlying demand at the aggregate level, the same may not be the case when we consider the trend in the various denomination-wise shares of currency. In case of supply-demand mismatches, the velocity of circulation of banknotes goes up resulting in quicker soiling and reduction of life of notes. The deterioration in the quality of notes is likely to be reflected in the quantity of soiled notes returned by the public to the issuing authority, which can be a useful variable to watch for estimating issue requirement of notes.

In what follows, we shall see how the supply of currency denominations (in relative terms, i.e. in relation to the aggregate value of currency in circulation) has changed over the years in India. Since annual data on different denominations are available since 1970-71, our study focuses on the period 1970-71 to 2010-11. Secondly, we shall see how the share of the value of the various currency denominations has changed to reflect changes in the price level – as captured by the wholesale price index (WPI).

There has been a significant change in the distribution of currency (supply) across denominations, during the past four decades (1970-71 to 2010-11) (Chart 4.1). Besides, new currencies were introduced to reflect the changing payment pattern, viz., ₹20 (1972-73), ₹50 (1975-76), ₹500 (1987-88) and ₹1000 (2000-01).¹⁰ It is important to examine as to what extent the changing proportion of various currency denominations reflects the underlying demand for currency denominations. Some important changes in the denominational composition of currency are as follows:

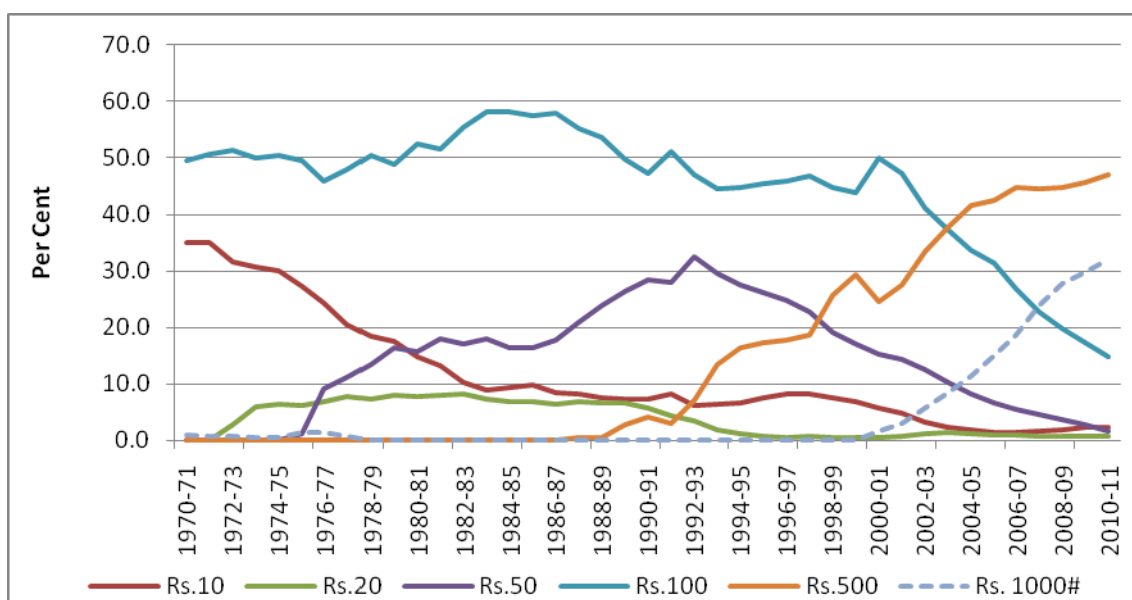
1970s: With the introduction of notes of ₹20 denomination in 1972-73 and ₹50 denomination in 1975-76, there was a migration to these denominations from the smaller denominations.

1980s: There was a significant migration from the smaller denominations (₹20 & below) to ₹50 and from ₹100 to ₹500 – the latter introduced in 1987-88

1990s: There was a significant migration from the smaller denominations (₹50 & below) to ₹100 and from ₹100 to ₹500, resulting in a significant increase in the share of ₹500 denomination note followed by other denominations.

2000s: After remaining relatively unchanged in the previous decades, the share of ₹100 denomination declined significantly in 2000s with the introduction of ₹1000 denomination in 2000-01 and the increasing share of ₹500 denomination.

Chart 4.1 Trends in denominational share in aggregate currency (by value)



¹⁰ ₹1000 and notes of higher denomination were demonetised in 1978, since higher denomination notes were being used for hoarding purposes and for carrying out illegal transactions, generating black income and wealth. Henceforth, changes in the denomination-wise proportion of currency (in value terms) largely reflected the changes in the preferences for carrying out transactions. Inflation also lowers the importance of using currency for hoarding purpose. In India, the reluctance to introduce higher denomination notes, even when warranted by inflation (as we shall see below) be explained by the authorities' desire to control use of currency for hoarding purposes.

There have been very significant variations in the share of different denominations of currency over the years. An analysis of the movements in the share of the various denominations in value terms (Chart 4.1, Tables 4.1-3) reveals the following:

- a) One particular denomination, viz., ₹100 accounted for close to 50 per cent of the value of the total currency in circulation throughout the three decades 1970s to 1990s (ranging from 44.2 per cent in 1993-94 to 57.4 per cent in 1983-84/1984-85). With ₹500 and ₹1000 emerging as substitutes, its share declined to 14.8 per cent in 2010-11. The share of ₹10, the second most important denomination during the 1970s, progressively declined in importance from 34.3 per cent in 1970-71 to 2.2 per cent by 2010-11.
- b) ₹20 denomination notes which substituted for ₹10 denomination and gained in importance till 1982-83 (accounting for 8 per cent of the total value of currency in circulation) steadily declined in importance, accounting for only 0.6 per cent of the value by 2010-11.
- c) ₹50 denomination notes which substituted for ₹10 and ₹20 denominations - replacing ₹10 to become the second most important denomination (in value terms) during the 1980s and 1990s (up to 1997-98) - peaked at 32.1 per cent in 1992-93 declined to just 1.7 per cent in 2010-11.
- d) ₹500 denomination notes quickly emerged as the second most important denomination since 1998-99 and replaced ₹100 denomination as the most important denomination in 2003-04. Its share in value among all denominations peaked at 47 per cent in 2010-11.
- e) The introduction of ₹1,000 denomination in 2000-01 was followed by its rapid rise to account for 27.8 per cent in 2008-09 replacing ₹100 to be the second most important denomination by 2007-08.

Table 4.1: Share of Various Denominations in currency circulation (in value)
(per cent)

	Up to ₹5	₹10	₹20	₹50	₹100	₹500	₹1000	Total
1970-71	14.4	35.1	-	-	49.6	-	1.0	100.0
1980-81	9.1	14.9	7.7	15.7	52.6	-	-	100.0
1990-91	7.1	7.3	5.7	28.5	47.3	4.2	-	100.0
2000-01	2.6	5.7	0.5	15.2	49.9	24.5	1.7	100.0
2010-11	1.6	2.2	0.6	1.7	14.8	47.0	32.0	100.0

Table 4.2: Share of Small (up to ₹10), Medium (₹20 and ₹50) and Large (₹100 and above) Denomination Notes in Currency Circulation

(per cent)

	Up to ₹10	₹20 and ₹50	₹100 & above
1970-71	49.4	0.0	50.6
1980-81	24.0	23.4	52.6
1990-91	14.3	34.2	51.5
2000-01	8.3	15.6	76.1
2010-11	3.9	2.3	93.8

Note: Notes of ₹20, ₹50, ₹500 and ₹1000 were introduced in 1972-73, 1975-76, 1986-87 and 2000-01, respectively.

Table 4.3: Peak Year for Currency Share of Various Denominations

(per cent)

₹1 – ₹5	₹10	₹20	₹50	₹100	₹500	₹1000
14.4	35.1	8.1	32.5	58.3	47.0	32.0
(1970-71)	(1970-71)	(1982-83)	(1992-93)	(1983-84)	(2010-11)	(2010-11)

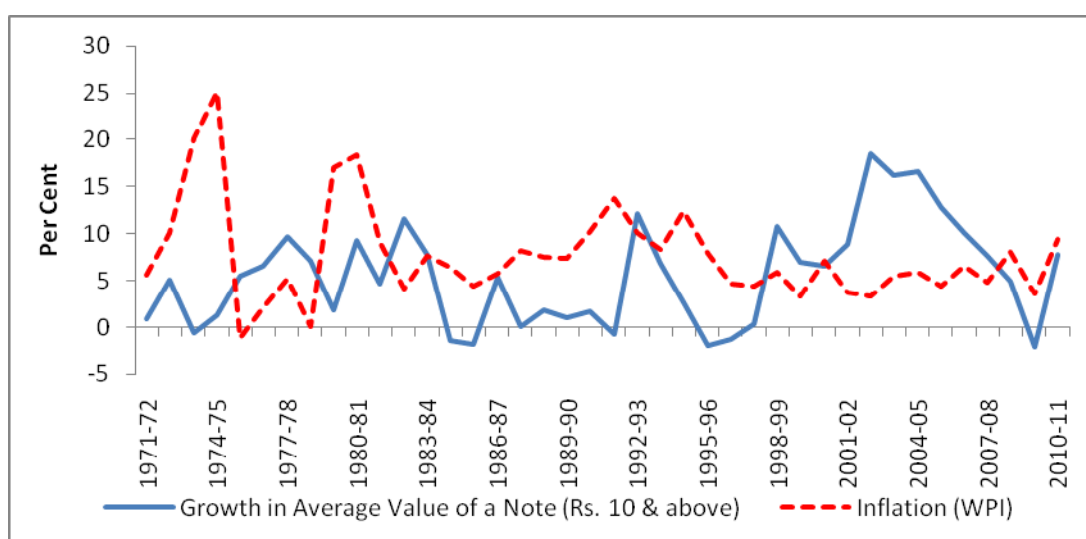
Coins in Circulation:

Despite the introduction of coins of ₹2 and ₹5 denominations in 1990-91 and 1986-87, respectively, the proportion of value of coins (small coins, ₹1, ₹2 and ₹5) in currency in circulation progressively declined from 4.0 per cent in 1970-71 to close to 1 per cent in 2010-11 with the corresponding increase in the proportion of value of notes.

4.1 Currency Denomination and Inflation: Implications for User of Currency

It is expected that the denomination-wise distribution of the supply of currency would change over time to reflect the impact of inflation on currency demand, *ceteris paribus*. In this regard, it is observed that during 1970-71–2010-11, the average value of a currency note (for denominations of ₹10 and above) increased nearly eight-fold from ₹214 to ₹174.3. During the same period, there was a 18 fold rise in the price level (measured by WPI). That the average value of a currency note did not keep pace with inflation is evident from Chart 4.2.

Chart 4.2 Change in average value of currency and inflation 1971-2011



Clearly, the evolving denominational distribution of currency notes, even with the introduction of higher denomination notes (₹500 and ₹1,000) was not commensurate with the underlying demand for the various denominations necessitated by the inflation path. The implication is that a consumer would need to carry a much larger number of currency notes than was the case earlier to purchase the same volume of goods and services. This was particularly evident during the high inflation phases (1973-74 to 1975-76, 1980-81 to 1981-82, and 1991-92 to 1995-96), as the denominational distribution of currency did not keep pace with inflation. It was only during the years of low inflation (16 out of 38, including the ten recent years 1998-99 to 2007-08), that the value of a currency note rose at a rate higher than that of inflation. During 1998-99 to 2007-08, the rise in the average value of currency note was facilitated by the sharp rise in the volume of ₹500 denomination notes and introduction of ₹1,000 denomination notes. Thus, the 2000s is the only decade when the average value of currency increased at a faster rate than inflation (Table 4.4).

Table 4.4: Movements in GDP and WPI (1970-71 to 2010-11) with 1970-71 = 100

Year	GDP deflator*	WPI*	Decade	GDP deflator (per cent)	WPI (per cent)	Average Value of currency (% increase)	
						Notes only	Notes & Coins
1970-71	100.0	100.0	-	-	-	-	-
1980-81	227.7	257.6	1970s	8.4	9.4	6.1	5.3
1990-91	524.3	510.0	1980s	8.8	7.9	4.3	3.1
2000-01	1,138.8	1,073.8	1990s	8.8	8.1	8.6	7.0
2010-11	1,990.0	1,832.2	2000s	5.5	5.6	10.2	8.0

*Derived from GDP at factor cost and WPI with base 2004-05=100.

Assuming that the underlying size distribution of cash transactions in real terms remains the same, the share of a particular currency denomination should

change with inflation over the years, as the higher denomination currency takes up the 'role' of the lower denomination for effecting transactions. Under this hypothetical assumption, as WPI increased ten-fold between 1971 and 2001, the 'role' of ₹10 & ₹100 denominations in 1970-71 would be performed respectively by ₹100 and ₹1000 denominations in 2000-01. However, the share of ₹100 and ₹1000 in 2001 was not quite the same as that of ₹10 and ₹100 in 1971. This could introduce some distortion in the supply-demand balance at denominational level.

However, in reality it is expected that the growth in the average value of currency would not only reflect inflation but, in addition, the increase in per capita real income over time (the latter as a proxy for the trend in the real value of transactions). Accordingly, the real value of an average currency note (defined as the ratio of total value to total volume of notes) should rise over time. In India, the reverse has been the case till 1998-99. Thereafter, the real average value of a note went up with increase in ₹500 and ₹1000 notes; however, it is showing some decline in the recent period (Charts 4.3 and 4.4). Since inflation rate exceeded the growth in the average value of a note, there has been a decline in the average real value of a currency note of ₹10 and above (Base: 1971-72) from ₹21.6 in 1971-72 to ₹5.8 in 1997-98 before a modest rise to ₹8.9 in 2008-09.

Chart 4.3 Trends in average value of notes in real terms

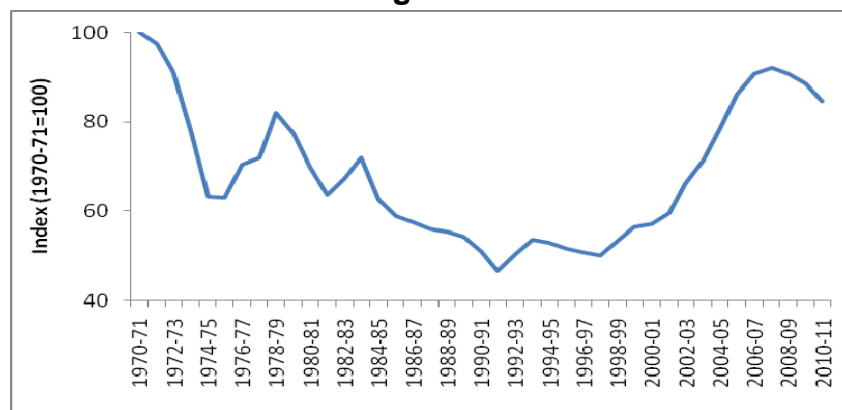
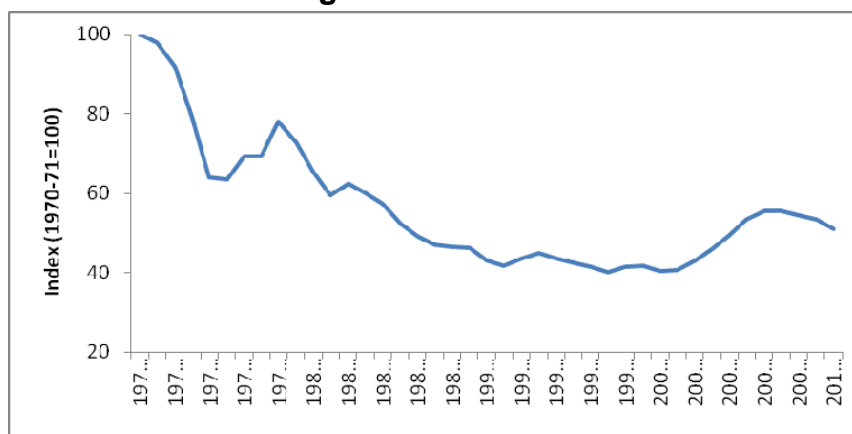


Chart 4.4 Trends in average value of notes and coins in real terms



There could be several different factors behind such trends in the denominational pattern of currency circulation. First, note printing in India was

dependent on the production capacity of the two government presses at Nashik and Dewas till the setting up of two more note presses in Mysore and Salboni in 1995-96. As such, there were supply constraints on meeting the growing demand of notes, which resulted in importing notes in the 1990s. The situation improved significantly from late 1990s and the Reserve Bank adopted a *Clean Note Policy* in 1999. Second, the use of alternative payment channels such as cheques, credit/debit cards and internet banking has been spreading over the years. These are not only more efficient instruments than paper currency but also leave paper/electronic trails facilitating tax audit. Usually, such payment mechanisms act as partial substitutes for high value currency. Third, the possibility of use of high denomination notes for black economy transactions and the demonetisation of ₹1000 and higher denomination notes in 1978 to curb hoarding/circulation of black money might have had a role to play in postponing the introduction of new higher denomination notes for some time.

4.2 Conclusion

In this chapter, we have attempted to present the main trends in the denomination-wise composition of Indian currency over the past few decades. Some of the standard determinants of this composition such as inflation and per capita GDP have also been examined. However, the analysis needs further refinement to take into account other factors, such as the underground economy and currency substitutes for payment (such as credit/debit cards, internet banking and cheque payments). The non-availability of reliable and adequate data on these factors is, however, a major hurdle to such an extensive analysis.

5: Modelling Demand for Currency at the Aggregate Level

In this chapter, various formal approaches to estimation of aggregate currency demand in India are explored against the backdrop of the somewhat descriptive analysis presented in the previous sections. While nominal GDP and private final consumption expenditure reflect the income effect on the demand for currency, the opportunity and transactions costs reflect the substitution effect on the demand for currency. The combined impact of the income and substitution effects and their changes over time have implications for currency demand for transactions in the formal sector – both at the aggregate and per capita levels. In what follows, we try to capture the effect of these factors on aggregate currency demand.

Econometric analysis to explain the role of the various factors in determining the movements in currency demand has to contend with several challenges. First, currency usage patterns can vary significantly across the country due to the vast geographical spread and socio-economic heterogeneity, which has an impact on the cash transaction and currency usage patterns. Second, the penetration of non-cash payment mechanisms vary considerably as between rural and urban areas. Third, incidence of inflation across different income groups could be different thereby impacting their currency requirements differently. This confronts the researcher with formidable challenges as region-wise, sector-wise or income category-wise data on most variables is not available either in a time series or in a cross section format. These empirical difficulties are partially counterbalanced by two mitigating factors. Firstly, India is a moderate inflation country, unlike many Latin American and African countries, which have faced prolonged periods of hyper inflation in the past. Secondly, in view of low levels of financial literacy, payment habits of the population tend to evolve gradually over time. Both these factors impart some stability to the various currency demand equations. This encourages us to investigate some broad approaches to currency estimation which have met with a reasonable degree of success internationally.

5.1 Modelling Currency in Circulation

We distinguish between two concepts of currency *viz.* Currency with the Public (CWP) and Currency in circulation (CIC). Currency in circulation is the sum of (i) notes in circulation which is the principal liability of the Reserve Bank under Section 22 of the Reserve Bank of India Act, 1934 and (ii) government's currency liabilities to the public comprising rupee coins and small coins. Currency in circulation comprises currency with the public (*i.e.* currency outside the banking system) and cash in hand with banks (*i.e.* banking system excluding the Reserve Bank). Two sets of results are presented for each of the two measures of currency one for annual data (1989-90 to 2010-11) and the other for quarterly data. Since official quarterly data on GDP are available only from 1996 onwards, the period of analysis for quarterly model was taken as 1996-97:Q1 to 2010-11:Q4. All the data

are collected from the Database managed by the Reserve Bank and those obtained from other external databases such as Datastream.

There seems to be no explicit theoretical model available for modelling the micro foundations of currency demand. The theoretical model of Rogoff (1998) for money demand has been extended by Fischer *et al* (2004) to currency demand and leads to a specification of currency demand in *real* terms. A real specification as is well known rests on the homogeneity postulate with respect to prices. While perhaps acceptable for money demand, the homogeneity postulate might be too restrictive in the case of a currency demand equation. Hence, in what follows, we model for currency in *nominal* terms, using WPI (or inflation) as a regressor variable to account for the price effect.

5.2 Unit Root Tests - Annual Data

Our preliminary analysis with data over the period 1986-87 to 2010-11, showed evidence of a structural break in 1989-90 and hence the period of analysis for our model was selected as 1989-90 to 2010-11. Table 5.1 shows the results of our unit root testing exercise. Unfortunately, the unit root tests present some conflicting evidence. While both tests indicate that all variables have a unit root in levels, only the ADF test indicates that all series are stationary after first-differencing. Recalling that in the Zivot-Andrews test, the null hypothesis is that the series has a unit root with structural break(s) against the alternative hypothesis that they are stationary with break(s), the right panel of the table under the Zivot-Andrews columns must be taken to imply that except for Log (CIC) and Log (CWP), the first differences of the other series might possibly contain unit roots i.e. the original series are $I(2)$ rather than $I(1)$. This possibility could be difficult to accommodate in a cointegration exercise based on a small sample such as ours. We therefore prefer to proceed towards the cointegration exercise by accepting the ADF results.

Table 5.1: Test for Stationarity (Unit Root test) - Augmented Dickey-Fuller Test

Variable	At level				First Difference				Concl.
	ADF	Zivot-Andrews			ADF	Zivot-Andrews			
		Model A: Intercept	Model B: Trend	Model C: Both		Model A: Intercept	Model B: Trend	Model C: Both	
Log(CWP)	-2.08	-3.38 (1999-00)	-2.10 (2007-08)	-2.53 (1993-94)	-3.98**	-5.00** (1997-98)	-4.16 (2003-04)	-5.29* (1999-00)	I(1)
Log(CIC)	-2.01	-3.13 (1993-94)	-3.12 (2005-06)	-3.17 (2002-03)	-3.95**	-5.04** (1997-98)	-4.10 (2003-04)	-5.32* (1999-00)	I(1)
Log(GDP)	-0.48	-2.00 (2005-06)	-3.77 (2004-05)	-3.76 (2002-03)	-3.71**	-4.69 (2005-06)	-4.31 (2003-04)	-4.88 (2000-01)	I(1)
Log(WPI)	-1.15	-4.08 (1991-92)	-4.41 (1995-96)	-4.41 (1994-95)	-4.24**	-4.49 (1996-97)	-2.47 (2003-04)	-3.20 (1996-97)	I(1)
Avg_Depo sit ¹¹	-1.96	-3.68 (2001-02)	-2.39 (1992-93)	-2.98 (2001-02)	-3.99**	-4.58 (2005-06)	-3.70 (2003-04)	-4.60 (2006-07)	I(1)

Note: The Critical Values for the ADF test at 5 per cent level is -3.65. The Critical values for the Zivot-Andrews test under Model A, Model B and Model C at 5 per cent level are -4.80, -4.42 and -5.08, respectively.

* denotes significance at 5 per cent level.

** denotes significance at 1 per cent level.

5.3 Cointegration Analysis

(a) Modelling Currency in Circulation (Annual data)

In line with the previous discussion, we select the following 4 variables for the cointegration exercise, viz. Currency in Circulation (CIC), Real GDP, WPI and Average Deposit rate (Avg_Deposit). Estimation of cointegration was carried out over the sample period from 1989-90 to 2010-11 for the above variables (Table 5.2).

The Johansen Trace Statistics test indicates the existence of one cointegration relationship between the variables. The Maximum Eigenvalue test indicates existence of a single cointegration relationship at around 7 per cent level of significance (Table 5.3).

Table 5.2: Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None *	0.70	54.65	47.86	0.01
At most 1	0.56	28.26	29.80	0.07
At most 2	0.22	10.30	15.49	0.26
At most 3	0.20	4.80	3.84	0.03

Trace test indicates 1 cointegrating equation(s) at the 0.05 level

¹¹One year deposit rate.

Table 5.3: Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.
None**	0.70	26.39	27.58	0.07
At most 1	0.56	17.95	21.132	0.13
At most 2	0.22	5.51	14.26	0.68
At most 3	0.20	4.80	3.84	0.03

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.1 level

The estimate of the long-run equilibrium relationship (co-integrating vector) is:

$$\log(CIC_t) = -11.48 + 1.38\log(GDP_t) + 0.82\log(WPI_t) - 0.01(Avg_Deposit_t) \quad (1)$$

(t - statistics) (-32.22) (42.22) (26.37) (-2.68)

The income elasticity of currency (demanded for circulation) at 1.38 is quite high in comparison to the long-term elasticity obtained for advanced countries. Fischer *et al* (2004), for example obtain an elasticity of 1.05 for the Euro Area. Correspondingly, the elasticity with respect to the interest rate variable is much lower (see Fischer *et al* (2004), p. 34). This could reflect the fact that India is under-banked but could also indicate that a part of the growth in GDP in recent years might have found its way into the underground economy. Needless to say, this fact needs to be investigated much more closely before arriving at any firm conclusions. The negative sign found in the Deposit Rate indicate an increase in the deposit rate will lead to a fall in the CIC in the long run.

The estimate of the short-run dynamic equation is:

$$\Delta\log(CIC_t) = -0.67ECM_{t-1} + 0.43\Delta\log(CIC_{t-1}) + 0.34\Delta\log(GDP_{t-1}) + 0.33\Delta\log(WPI_{t-1}) - 0.01\Delta(Avg_Deposit_{t-1})$$

(t - stats) (-2.02) (1.60) (0.78) (0.82) (-2.05)

R² = 0.40 (2)

The error correction term in the short-run dynamic equation is found to be significant. From the dynamic equation it can be interpreted that approximately 67 per cent of the error will be corrected in the next year. The positive signs found with the GDP and WPI indicates that an increase in the GDP growth and inflation leads to an increase in the growth in the CIC. In contrast, an increase in the deposit rate is expected to cause a fall in the CIC growth.

The incorporation of the Cheque Clearance variable, in value terms, was found to have led to non-stationarity in the error term and hence was not considered in the final equation. Additionally, the inclusion of both urbanization and cheque clearance variables erodes the significance of the deposit variable. Hence, we thought that the choice of variables for further analysis should be restricted to the three standard variables GDP, WPI and deposit rate. Several authors have used real Private Final Consumption Expenditure (PFCE) as a scale variable instead of real

GDP in the currency demand studies. Unfortunately, in the Indian case, quarterly historical data on PFCE is not available for a long time. Since our interest is in estimating both annual and quarterly models and comparing the results, the variable GDP was used in preference to PFCE.

(b) Modelling Currency with the Public (CWP) (Annual data)

Let us now turn our attention to the other major currency component *viz.*, Currency with the Public (CWP). The methodology followed is similar to the one employed for modelling CIC. The estimation of cointegration was carried out over the sample period from 1989-90 to 2010-11 using the variables – CWP, Real GDP, WPI and Average Deposit Rate. The Trace Statistics test indicates the existence of one cointegrating relationship between the variables. The Maximum Eigenvalue test indicates existence of a single cointegrating relationship at around 6 per cent level of significance.

The cointegration exercise was conducted within the standard Johansen-Juselius framework. Since the data show evidence of a linear trend, we use the cointegration model in which the cointegrating vector includes an (unrestricted) intercept. The results of the Rank and Maximum eigenvalue tests are presented in (Tables 5.4 and 5.5).

Table 5.4: Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None *	0.71	55.14	47.86	0.01
At most 1	0.55	28.16	29.80	0.08
At most 2	0.23	10.49	15.49	0.25
At most 3	0.20	4.85	3.84	0.03

Trace test indicates 1 cointegrating equation(s) at the 0.05 level

Table 5.5: Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.
None**	0.71	26.98	27.58	0.06
At most 1	0.55	17.67	21.13	0.14
At most 2	0.23	5.63	14.26	0.66
At most 3	0.20	4.85	3.84	0.03

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.1 level

The estimate of the long-run equilibrium relationship is found to be:

$$\log(CWP_t) = -11.48 + 1.38\log(GDP_t) + 0.82\log(WPI_t) - 0.01(Avg_Deposit_t) \quad (3)$$

(t - statistics) (-30.73) (40.11) (25.42) (-2.29)

Not surprisingly, the coefficients in (3) are nearly identical to those in (1) (the differences can be observed through the t-statistic). Thus so far as the long-run equilibrium behaviour is concerned, there seems to be little difference between CIC and CWP. The estimate of the short-run dynamic equation is:

$$\Delta\log(CWP_t) = -0.61ECM_{t-1} + 0.39\Delta\log(CWP_{t-1}) + 0.43\Delta\log(GDP_{t-1}) + 0.39\Delta\log(WPI_{t-1}) - 0.01\Delta(Avg_Deposit_{t-1})$$

(t - stats) (-1.96) (1.53) (1.05) (1.00) (-2.29)

$R^2 = 0.40$ (4)

The short run behaviour as shown in the error correction equation is also very similar, except that CIC adjust a bit faster than CWP to equilibrium, possibly due to the fact that banks and FIs which figure importantly in CIC demand may adjust their cash imbalances more efficiently (i.e. faster) than households.

(c) Unit Root Test for quarterly data:

As in the annual model, we select the following 4 variables for the cointegration exercise, viz. Average Currency in Circulation during the quarter (CIC), Real GDP at factor cost with base 2004-05 (GDP), Wholesale Price Index (WPI) and Deposit rate with maturity of 1-year (Avg_Deposit).

The unit root test has been conducted for the sample period 1996-97:Q1 to 2010-11:Q4. All the variables, except the interest rate, are log transformed and seasonally adjusted using the X-12-ARIMA technique. We begin with an analysis of the unit root test properties of the data set. This is presented in the Table 5.6 (for later use we also present the unit root tests for CWP (currency with the public). Both ADF and Zivot-Andrews tests suggest that all series are I(1).

**Table 5.6: Test for stationarity (Unit Root test)
- ADF test and Zivot-Andrews test**

Variable	At level				First Difference				Concl.
	ADF	Zivot-Andrews			ADF	Zivot-Andrews			
		Model A (Intercept)	Model B (Trend)	Model C (Both)		Model A (Intercept)	Model B (Trend)	Model C (Both)	
Log(CWP)	-0.35	-2.66	-3.55	-3.50	-5.86*	-5.41*	-4.56*	-5.76*	I(1)
Log(CIC)	-0.25	-2.50	-3.68	-3.59	-5.87*	-5.41*	-4.45*	-5.82*	I(1)
Log(GDP)	-1.80	-3.41	-4.00	-4.25	-9.37*	-6.90*	-5.90*	-6.82*	I(1)
Log(PFCE)	-1.09	-2.70	-4.75**	-5.00	-10.52*	-5.77*	-5.19*	-5.91*	I(1)
Log(WPI)	-0.02	-2.40	-3.60	-3.57	-5.24*	-6.49*	-6.90*	-7.28*	I(1)
Avg_Deposit	-1.10	-2.77	-3.34	-3.63	-7.33*	-5.40*	-4.84*	-5.22*	I(1)
Critical value at 5%	-3.49	-4.80	-4.42	-5.08	-2.91	-4.80	-4.42	-5.08	

* denotes significance at 5 per cent level. ** denotes significance at 1 per cent level.

5.4 Cointegration analysis for quarterly data:

While the annual model analyzed above is certainly useful for examining long-term currency demand, policymakers often need a shorter focus for planning their strategies. Hence, most of the available literature in this area has paid close attention to modelling quarterly currency demand behaviour. In India, the official quarterly GDP series commences only from 1996-97:Q1 Hence our quarterly modelling exercise spans the period 1996-97:Q1 to 2010-11:Q4.

The cointegration exercise was once again conducted within the standard Johansen-Juselius framework.

(a) Modelling Currency in Circulation (CIC) (Quarterly data)

The cointegration exercise was conducted over the sample period over the sample period 1996-97:Q1 to 2010-11:Q4 using the variables – CIC, GDP at factor cost at constant prices (denoted as GDP below), WPI and Average Deposit Rate. Further a dummy variable has been used to capture the impact the electronic mode of payments. The dummy variables take a value ‘0’ from 1996-97:Q1 to 2006-07:Q4 and a value ‘1’ from 2007-08:Q1 to 2010-11:Q4.

The Johansen Trace Statistics and the Maximum Eigenvalue test unanimously indicate the existence of one cointegrating relationship between the variables (Tables 5.7 and 5.8).

Table 5.7: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None *	0.44	59.62	47.86	0.00
At most 1	0.27	26.53	29.80	0.11
At most 2	0.07	8.19	15.49	0.44
At most 3	0.06	3.72	3.84	0.05

Trace test indicates 1 cointegrating equation(s) at the 0.05 level.

Table 5.8: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.
None *	0.44	33.09	27.58	0.01
At most 1	0.27	18.34	21.13	0.12
At most 2	0.07	4.47	14.26	0.81
At most 3	0.06	3.73	3.84	0.05

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 0.05 level

Table 5.9: Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None *	0.43	58.47	47.86	0.00
At most 1	0.27	26.34	29.80	0.12
At most 2	0.07	8.04	15.49	0.46
At most 3	0.06	3.62	3.84	0.06

Trace test indicates 1 cointegrating equation(s) at the 0.05 level

Table 5.10: Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.
None *	0.43	32.13	27.58	0.01
At most 1	0.27	18.29	21.13	0.12
At most 2	0.07	4.42	14.26	0.81
At most 3	0.06	3.62	3.84	0.06

Max-eigenvalue test indicates 1 cointegration equation(s) at the 0.05 level

Both Tests recommend a single cointegration vector.

The estimate of the long-run equilibrium relationship is:

$$\log(CWP_t) = -5.11 + 0.82\log(GDP_t) + 1.47\log(WPI_t) - 0.01(Avg_Deposit_t) \quad (7)$$

(t - statistics) (4.32) (5.89) (-2.49)

The estimates for CWP differ only marginally from those obtained in the case of CIC. The elasticity of GDP and WPI on CWP in the long run is estimated to be at 0.82 per cent and 1.47 per cent respectively. The negative sign found in the Deposit Rate is as expected. The estimate of the short-run dynamic equation is:

$$\Delta \log(CWP_t) = -0.11ECM_{t-1} + 0.17\Delta \log(CWP_{t-1}) + 0.03 - 0.01Dum$$

(t - stats) (-1.84) (1.28) (5.35) (-1.92)

$$R^2 = 0.20 \quad (8)$$

The error correction term in the short-run dynamic equation is found to be significant. From the dynamic equation it can be interpreted that approximately 11 per cent of the error will be corrected in the next quarter which is consistent with the 61 per cent found in the annual model. The introduction of electronic mode of transaction has been found to have a significant negative impact on the growth of CWP in line with our a priori expectations.

6: Modelling Denomination-wise Circulation of Currency

As noted in the previous chapters, the trends in circulation of individual denominations in India exhibit considerable fluctuations, making the denomination-wise data less amenable to time series modelling. In mature economies, by contrast, with reasonable stability in growth and inflation, denomination-wise trends are expected to be relatively smoother. This property helps estimation of individual denominations using time series/econometric methods. However, even in advanced economies, the trends in circulation of different denominations show some interactions in general.

The main difficulty in modelling denomination-wise currency stems from the fact that the motives for use of different denominations, *viz.*, small, medium and large vary considerably. As small and medium denominations are used mainly for cash transactions, their demand is more likely to be influenced by income or consumption variables. On the other hand, large denomination notes are likely to be used as a store of value and, as such, are more likely to be influenced by the opportunity cost of holding banknotes *viz.* risk-free interest rates on bank deposits.

We attempt to estimate the overall factors determining the demand for various types of currency denominations. For this purpose, we classify notes/coins up to ₹20 as *small* denominations, ₹50 and ₹100 as *medium* denominations and ₹500 and ₹1000 as *large* denominations. In order to capture the demand for these three groups, we have explored the existence of cointegrating relationship between per capita currency circulation of each of these groups with GDP, inflation and deposit rate. Additionally, we have also tried to model the real per capita currency circulation for each of these groups. Because denomination wise data is available in India only on an annual basis, the cointegration exercise was restricted to annual data from 1970-71 to 2010-11.

Definition of Variables

Per_Small_Note = Per *Capita* Nominal Small Currency in Circulation (₹1, ₹2, ₹5, ₹10 and ₹20)

Per_Medium_Note = Per *Capita* Nominal Medium Currency in Circulation (₹50 and ₹100)

Per_Large_Note = Per *Capita* Nominal Large Currency in Circulation (₹500 and ₹1000)

PC_GDP = Per Capita GDP at factor cost at constant prices

Avg_Deposit = Average Deposit Rate

WPI = WPI at base 2004-05

Cheque = Value of cheque clearance in ₹ crore

The results are as follows:

(i) Annual Co-integrating model for Per Capita Nominal Small Currency in Circulation (1970-71 to 2010-11)

Based on the Trace and Maximum Eigenvalue statistics, a single cointegration vector is suggested. This is presented below

$$\log(Per_Small_Note)_t = -7.33 + 1.09\log(PC_GDP_t) + 0.13\log(WPI_t) + 0.10(Avg_Deposit_t)$$

(t - stats) (3.22) (0.80) (4.63) (9)

With the short-run dynamic equation given by

$$\Delta\log(Per_Small_Note_t) = 0.01 + 0.30\Delta\log(Per_Small_Note_{t-1}) - 0.01\Delta\log(PC_GDP_{t-1}) - 0.03\Delta(Avg_Deposit_{t-1})$$

(t - stats) (0.33) (1.97) (-0.02) (-1.60)

$$+ 0.31\Delta\log(WPI_{t-1}) - 0.26ECM_{t-1}$$

(0.89) (-2.78)

$$R^2 = 0.31$$

(10)

The cointegrating equation confirms our prior hypothesis that small denomination notes (being used primarily for transactions purposes) should respond positively to changes in (per capita) real GDP. The perverse sign on the deposit rate in the cointegrating equation may simply be indicative of the fact that in the long run equilibrium there is no demand for small notes as a store of value.

(ii) Annual Co-integrating model for Per Capita Nominal Medium Currency in Circulation (1970-71 to 2010-11)

Once again, the Johansen technique suggests a single cointegration equation which is presented below.

$$\log(Per_Medium_Note)_t = 33.35 - 3.76\log(PC_GDP_t) + 2.16\log(WPI_t) + 0.15(Avg_Deposit_t)$$

(t - stats) (-3.58) (4.55) (2.32) (11)

The negative sign found with the PC_GDP in the long-run indicates that with rising income levels, people may prefer to make transaction through alternative payment mechanisms. This inference is strengthened by the negative sign on cheque clearance in the following short-run dynamic equation:

$$\Delta\log(Per_Medium_Note_t) = 0.13 + 0.03\Delta\log(Per_Medium_Note_{t-1}) - 0.01\Delta\log(PC_GDP_{t-1})$$

(t - stats) (4.29) (0.15) (-0.03)

$$- 0.01\Delta(Avg_Deposit_{t-1}) - 0.54\Delta\log(WPI_{t-1}) - 0.07ECM_{t-1} - 0.01\Delta\log(Cheque_{t-1})$$

(-0.58) (-2.55) (-4.90) (-0.16)

$$R^2 = 0.63$$

(12)

(iii) Co-integrating model for Per Capita Nominal Large Currency in Circulation

In view of the fact that one of the major constituents of large currency group, viz., ₹500 was introduced in 1987, the model for the large currency in circulation has been estimated over the sample period from 1990-91 to 2010-11. The Johansen technique suggests existence of cointegration relationship.

The long-run relation is

$$\begin{aligned} \log(\text{Per_Large_Note}_t) = & 0.77 - 1.90\log(\text{PC_GDP}_t) + 0.02(\text{Avg_Deposit}_t) - 0.11\log(\text{Cheque}_t) \\ (t\text{-stats}) & \quad (-1.21) \quad (0.67) \quad (-0.90) \\ & + 5.67\log(\text{WPI}_t) + 0.05\text{Trend}_t \\ & (7.48) \quad (0.40) \end{aligned} \quad (13)$$

The short run dynamic equation is,

$$\begin{aligned} \Delta\log(\text{Per_Large_Note}_t) = & 0.40 + 0.49\Delta\log(\text{Per_Large_Note}_{t-1}) - 5.40\Delta\log(\text{PC_GDP}_{t-1}) \\ (t\text{-stats}) & \quad (1.29) \quad (3.57) \quad (-1.58) \\ & + 0.06\Delta(\text{Avg_Deposit}_{t-1}) - 0.35\Delta\log(\text{Cheque}_{t-1}) + 0.19\Delta\log(\text{WPI}_{t-1}) - 0.74\text{ECM}_{t-1} \\ & (1.31) \quad (-1.48) \quad (0.08) \quad (-2.47) \\ R^2 = & 0.74 \end{aligned} \quad (14)$$

While the cointegration exercises above are useful in analysing the long-term equilibrium movements of the banknotes of various denominations, they fail to account for one important fact *viz.* the interrelatedness (i.e. substitution at the margin) between banknotes of different denominations. This drawback may be overcome by resorting to the SURE (seemingly unrelated regression equations) method, which satisfactorily accounts for such substitution possibilities. However this advantage has to be weighed against the fact that the SURE models are unable to distinguish between the long-run equilibrium and the short-run dynamics (as is the case with cointegration analysis). We now turn our attention to estimating the SURE model. For this purpose, the share of each denomination group (small, medium and large as defined above) in the aggregate currency in circulation (in value terms) has been used as the dependent variables. Following standard SURE methodology, the shares of two such groups (small and medium) have been considered explicitly in the model, with the share of the third group emerging as a residual (so as to avoid singularity problems). The set of explanatory variables comprises:

(i) per capita GDP, (ii) WPI and (iii) Average Deposit Rate.

Once again the model considered is an annual model defined over 1990-91 to 2010-11. The results of the SURE model are presented below:

$$\begin{aligned} \log(\text{Share_Small}) = & 17.60 - 0.10\log(\text{WPI}) - 1.61\log(\text{PC_GDP}) + 0.08(\text{Avg_Deposit}) \\ (t\text{-statistics}) & \quad (3.37) \quad (-0.15) \quad (-2.08) \quad (2.43) \\ R^2 = & 0.87 \end{aligned} \quad (15)$$

$$\begin{aligned} \log(\text{Share_Medium}) = & 37.06 + 0.90\log(\text{WPI}) - 3.81\log(\text{PC_GDP}) + 0.08(\text{Avg_Deposit}) \\ (t\text{-statistics}) & \quad (22.33) \quad (4.35) \quad (-15.50) \quad (0.10) \\ R^2 = & 0.99 \end{aligned} \quad (16)$$

$$\begin{aligned} \log(\text{Share_Large}) = & -44.65 - 0.80\log(\text{WPI}) + 5.42\log(\text{PC_GDP}) - 0.08(\text{Avg_Deposit}) \\ (t\text{-statistics}) & \quad (-8.86) \quad (-1.27) \quad (7.25) \quad (-2.54) \\ R^2 = & 0.97 \end{aligned} \quad (17)$$

It may be seen that per capita GDP is significant in all the three regressions. Price level is found to have significant impact on the medium denomination group only. The sign of WPI coefficients is positive for the medium denomination groups

and negative for the other two groups indicating that with inflation there could be a shift in shares to medium denomination group. On the other hand, with increase in per capita income, share of small and medium denomination groups goes down and the share of large group increases to a large extent. Interestingly, increase in interest rate leads to increase in the share of small and medium denominations, but decreases the share of large denomination group.

Chapter 7: Conclusion and Some Suggestions

This project was undertaken with a view to developing a suitable framework for modelling currency demand in India at the aggregate level as well as for the denominational composition. In the modelling exercise, the importance, dimensions and complexity of currency management, which is a core function of the Reserve Bank, were well recognised. Further, various aspects of currency planning, such as, factors influencing the short-term and long-term demand for currency and issues relating to denomination-wise distribution of currency were kept in view.

The main tasks were identification of the broad approach, formulation of the problems, review of available literature, collection of data, empirical analysis for development of estimation models and analysis of results. The starting point of the study was to identify the factors that influence the demand for currency and carry out a review of the available literature, international as well as in the Indian context and to outline an approach suited to the Indian economy. In this regard, a number of research papers pertaining to currency demand in the US, select European countries and the Eurozone were reviewed.

As a prelude to the modelling exercise, a preliminary analysis of the behaviour and characteristics of the currency circulation in India over the years and the relationships such as cross correlations, partial correlation structures, etc., with the probable candidate variables for modelling the demand for currency was undertaken. The variables, *inter alia*, included output, consumption, inflation and interest rate variables directly affecting growth and composition of currency, currency substitutes / non-cash payment instruments, etc.

On the basis of the descriptive data analysis, various possible model formulations were experimented with both for (i) estimation of the total value of notes and coins in circulation as well as (ii) their denominational composition. The estimation of the aggregate currency demand was relatively straightforward and could be undertaken both at the annual and quarterly frequencies, permitting an examination of the short-term dynamics (from the quarterly model) as well as picking up the long-term trends (from the annual model). Estimation of denomination-wise demand for currency, by contrast, posed considerable problems both at the conceptual and empirical level. The introduction of new denominations and the high degree of variability in the circulation of individual denominations, meant that certain adjacent denominations had to be grouped together. Denomination-wise data on currency usage was available only on a yearly basis and hence only a annual model could be attempted. Several important determinants of denomination-wise demand such as shadow economy transactions, regional distribution of incomes and the distribution pattern of the size of transactions remain masked and hence could not be incorporated into the analysis. Within the limitations imposed by these constraints, we have attempted to build models which replicate the data reasonably well.

There are several limitations to the study, most of them arising from the non-availability of relevant data. The shadow economy, being a zone of ignorance for the analyst, means that a critical determinant of currency demand does not figure in the analysis at all. Secondly, regional aspects are extremely important in determining the distribution of currency across the country. Once again the absence of regional data on private consumption expenditure, cheque clearance, etc. is a formidable obstacle in any endeavour to understand the regional determinants of currency demand. Finally, in spite of our best efforts, we have not been able to obtain a data base spanning a sufficient number of observations to repose a strong confidence in the reported estimates. The annual data series exhibits a major structural break in 1988-89, while the quarterly data base extends only as far back as 1996-97. Within these limitations, however, we feel that our results have thrown up some interesting conclusions, with important implications for policy.

Given the critical importance of currency management, it would be worthwhile to make a few suggestions for future improvements in the framework for currency analysis in India based on our experience with this exercise. First, in an ideal set up, it is desirable to ensure currency supply to meet the demand at both aggregate and denominational level. Considering that some demand supply mismatches are inescapable in the real world, efforts may be made to design a system to capture the magnitude of such mismatches. A direct method for this would be to systematically maintain data on currency demanded and currency supplied at the points of issue and distribution. In addition, an indirect method to capture such information would be through study of soiled notes - in circulation and returned from circulation. The degree of soilage would serve as an indicator of the demand-supply distortion. Second, keeping in view the international experience, a system of regular surveys to elicit information on public behaviour and preference for various denominations of currency may be useful. Also, changes in the micro level determinants of currency requirement, especially for smaller denominations, such as transport tariff structure, etc. may be considered. Thirdly, it may be important to attempt estimation of regional demand for currency, though the data requirements for such an exercise would be formidable.

Currency management in India, given the vastness, geographical and socio-economic heterogeneity and a host of other factors is a very challenging task. It is nevertheless hoped that the findings of this study, subject to the various caveats we have entered at the appropriate places would contribute in a reasonable measure to the analytical framework underlying this process.

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