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INVESTIGATING THE IMPACT OF NEW PAYMENT TECHNOLOGIES ON MONEY DEMAND IN INDIA USING DUMMY VARIABLE

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Abstract: *In this paper, we estimate a conventional money demand model with currency in circulation (M2) as dependent variable denoted by MD and gross domestic product (GDP, constant international US$), interest rate (IR) as independent variables over the period 1990-2015. We apply Vector Error Correction Model to estimate money demand. We expect that the formation of National Payments Corporation of India (NPCI) has stimulated the development of electronic banking such as electronic clearing products including National Electronic Funds Transfer, ECS (Debit), and Card Products. Based on the estimates of a VAR system, we conclude that introducing new electronic banking following the formation of National Payments Corporation of India (NPCI) do not have a significant influence on the money demand. However, there exists a long-term equilibrium relationships between variables, and also, these variables do have influence on MD in the long run. The disparity between the value of money demand in period (t-1) and its long run equilibrium value is corrected by 56.2 percent. This means that the deviation of money demand from long run value is corrected in about 2 years. Also, there is short term causality running from GDP and IR to MD.*

Keywords: *India, Money Demand, VECM, Restricted VAR, Financial Innovation, Dummy Variable, NPCI*

Introduction

It is the payments mechanism of an economy that allows smooth functioning of its financial and real sectors. An efficient payments system is the one that offers real time settlement of financial transactions and facilitate the exchange of goods and services in a speedy, secure and reliable manner.

The emphasis on cash as a major payment channel has been reduced significantly mainly due to introducing alternative payment systems in the last two decades which itself owes to the improvement in information and telecommunication technology. There have been intensive researches to investigate how emerging alternative payment systems have impacted the currency demand.

Huge cost savings can be achieved by migrating from paper-based payments to electronic payments. Improved efficiency of the payment system due to these innovations will enhance the efficiency to the entire economy. Manual processing of cash and cheques requires a huge amount of resources while electronic payments does not. Electronic payment help improve productivity levels and lower the cost of doing business. Moreover, extended financial services to the unbanked communities as a result of using electronic payments will enable them to benefit from lower cost of financial services. More intensive use of electronic payments plays a vital role in achieving higher economic growth and improving the competitiveness of the economy.

Financial innovations can have either positive impact or negative impact on the money demand depending on the payment instruments. While ATMS/ Debit cards could lead to a decline in demand for cash through reduced transaction costs, the use of cell phone technology does not necessarily reduce cash demand. ATM concentration, bank concentration, M2/M1 and M3/M1 and dummy variables capturing periods of innovation, growth rate in private sector credit are examples of the proxies that have been used by researchers to measure financial innovation indirectly.

The purpose of this paper is to empirically evaluate the money demand function in India, focusing on two primary issues. The first is to test whether or not the money demand function in India is affected following the formation of NPCI using dummy variable in the context of an error correction model. The second is to investigate the long run and short run relationship between real money demand and its determinants, real income and real interest rates.

Customer interacts with banks is most influenced by technology (including developments such as ATMs, cards, internet banking and mobile banking) in Indian Banking. Although traditional branch channel still exists, it is increasingly are being replaced by electronic channels (non-cash transactions). However, diffusion of electronic channels is much higher compared to that in developing countries. Shifting from traditional channel to electronic channels benefits both customers and banks. Customers enjoy greater convenience while banks befits from huge cost saving. Also, banks need to take action against the possibility of frauds associated with electronic banking. In order to catch up with the evolution in banking industry, National Payments Corporation of India was formed to oversight and regulate retail electronic payment products with the objective of promoting the growth of electronic payments in India. This paper seeks to investigate if the formation of National Payments Corporation of India and consequently, the initiation of Immediate Payment Service (IMPS) has made any significant difference with regard to the demand for money.

Through Immediate Payment Service (IMPS) money can be transferred immediately from one account to the other account, within the same bank or accounts across other banks. An MMID (Mobile Money Identifier) Code are assigned to individuals upon registering at their respective banks for instant transfer of money from the account of sender to the account of receiver on a 24X7 basis.

Plan of the paper is to provide a review of literature in section 2. Theoretical background, empirical model and measurement of variables is mentioned in section 3. Estimation results are discussed in section 4. Lastly section 5 is reserved for summary, conclusions and policy implications. We contribute to the existing literature by formulating an equation that integrates long-run properties with short-run dynamics, based on the recent merging of the theories of error correction and cointegration for the case of India.

Literature Review

A large body of literature exists regarding empirical investigations of the demand for money. Although the study of the demand for money is substantial on its own right, interest in the demand for money became huge as economists seek to investigate if financial reforms and innovations have adversely affected the stability of the demand for money. Drake and Chrystal (1994) found a stable money demand using weighted monetary aggregates for the UK. Hafer and Jansen (1991) revealed a long-run cointegrated money demand for the USA. Miyao (1996) investigates the case of Japan and come to the conclusion that the data do not support the stability of money demand in Japan. Bahmani-Oskooee (2001) show that M2 in Japan is cointegrated with the demand for money and the relationship is stable as well. Padhan (2011) study Indian data for the period 1996Q2-2009Q2, and find a long run cointegration relationship between money demand and its determinants using a number of monetary aggregates. Achsani (2010) investigate the M2 demand for money for the case of Indonesia and reach the same result.

Some other money demand researches were also carried for African countries. A study of the Kenyan case by Adam (1992), for example, reveals the existence of a long run cointegrating relationship between a number of monetary aggregates and the arguments in money demand function. Using quarterly data for the period 1995-2007, Awad (2010) studied the money demand function for Egypt and it was found to be unstable. The majority of the studies on money demand support the existence of a long run cointegration relationship for money demand that is largely stable. Ahmed Y. Abdulkheir (2013) investigate the cointegrating property of money demand in Saudi Arabia using annual data for the period 1987-2009 and applies the vector error correction model (VECM) technique. They conclude that a long run cointegration relation exists between the demand for money (M2) and its explanatory variables, namely real GDP, the interest rate, the real exchange rate and the inflation rate.

Odularu and Okunrinboye (2008) Model the impact of financial innovation on the demand for money in Nigeria using the Engle and Granger Two-Step Cointegration technique. Though the study revealed that demand for money conforms to the theory that income is positively related to the demand for cash balances and interest rate has an inverse relationship with the demand for real cash balances, it was also discovered that the financial innovations introduced into the financial system have not significantly affected the demand for money in Nigeria.

Ahad (2015) investigate money demand function incorporating financial development, industrial production, income and exchange rate over the period of 1972-2012 for Pakistan using VECM and conclude that there exists a long run relationship between money demand, financial development, income, industrial production and exchange rate. Financial development is the main factor to determine the money demand function in both long and short run.

Huang (1994) construct an ECM model to evaluate the dynamic adjustment process in China in the reform period (1979-1990). The cointegration tests suggest that some long-run relationships exists among money demand, real income, price and the real interest rate. The ECM model shows that the dynamic adjustment process of money demand maintains stable and significant relationships to most of its determinants.

Bilyk (2006) apply Vector error-correction model in order to study the relationship between financial innovations, real volume of industrial production, nominal interest rate, expected depreciation of Ukrainian hryvnia (the national currency of Ukraine), the level of dollarization in the economy, expected inflation, and real money balances in accordance with the theoretical concepts, as well as to investigate the response of money demand to financial innovations shock by means of the impulse response function. Robustness check indicates that financial innovations impacts the demand for money in Ukraine (positive impact in the long run and negative impact in the short run).

Using the robust time series techniques, Hye (2009) examine the relationship between money demand and financial innovation in Pakistan during the period of 1995-1 to 2007-12 and conclude that a long run relationship between money demand, interest rate, economic activity, inflation, financial innovation and exchange rate exists. The results also indicate that the financial innovation has positive effect on money demand in the long run as well as in the short run but short run elasticity is more than the long run elasticity.

Using cointegration and error correction modelling, Mannah-Blankson and Belnye (2004) investigate the effect of financial innovation resulting from the Financial Sector Adjustment Program (FINSAP) launched in September 1987 on money demand in Ghana. The study demonstrates that the development of the economy’s transaction technology over time has affected the demand for real money balances with positive influence in the long-run. Stability test results indicate that both M1 and M2 are stable despite the growth in financial innovation in Ghana.

Researchers have to use various proxies to measure financial innovation as it is difficult to measure it directly. Lippi and Secchi (2009), Fischer (2007), Sichei and Kamau (2012) and Attanansio et al. (2002) are among those who used ATM concentration as proxy. In order to take shifts in money demand into account, dummy variable was used by Hafer and Kutan (2003). Bank concentration was considered by Nagayasu (2012) while growth in private sector credit as a percent of GDP was used by Michalopoulos et al. (2009). Arrau et al. (1995) used a time trend and a stochastic trend that follows a random walk and Hye (2009) and Mannah-Blankson and Belyne (2004) used M2/M1 for capturing financial innovation. Most of these studies however, indicate that financial innovation has had a negative effect on the demand for money justifying the importance of inclusion of this factor in the money demand specification.

Methodology

Background

Unit root

The theory behind ARMA estimation is based on stationary time series. A series is said to be (weakly or covariance) stationary if the mean and autocovariances of the series do not depend on time. Any series that is not stationary is said to be nonstationary. A common example of a nonstationary series is the random walk:

$$y_t = y_{t-1} + \varepsilon_t \qquad (1)$$

Where ε is a stationary random disturbance term. The series y has a constant forecast value, conditional on t, and the variance is increasing over time. The random walk is a difference stationary series since the first difference of y is stationary:

$$y_t - y_{t-1} = (1\text{-}L)\, y_t = \varepsilon_t \qquad (2)$$

We denote a difference stationary series by I(d) where d is the order of integration (the number of unit roots contained in the series, or the number of differencing operations it takes to make the series stationary). For the random walk above, an I(1) series means that and I(0) means that the series is stationary. We cannot apply standard inference procedures to regressions which contain an integrated dependent variable. Therefore, before using series in a regression, we need to make sure (by using unit root test) whether they are stationary or not.

There is a variety of powerful tools for testing a series (or the first or second difference of the series) for the presence of a unit root. In addition to Augmented Dickey-Fuller (1979) and Phillips-Perron (1988) tests, the GLS-detrended Dickey-Fuller (Elliot, Rothenberg, and Stock, 1996), Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992), Elliott, Rothenberg, and Stock Point Optimal (ERS, 1996), and Ng and Perron (NP, 2001) unit root tests are available as a view of a series. In this paper, however, we use Augmented Dickey-Fuller test for this purpose. The following discussion outlines the basics features of unit root tests. Consider a simple AR(1) process:

$$y_t = \rho y_{t-1} + x_t^{'}\delta + \varepsilon_t \qquad (3)$$

x_t are optional exogenous regressors, ρ and δ are parameters that we are going to estimate, and we assume that the ε_t are white noise. If $|\rho| \geq 1$, y is a nonstationary series. If $|\rho| < 1$, y is a stationary series. The null hypothesis H_0: ρ = 1 is tested against the one-sided alternative H_1: ρ < 1 using unit root tests.

3.1.2. The Augmented Dickey-Fuller (ADF) test

First, we subtract y_{t-1} from both sides of the equation (3) and then the standard DF test is done after estimating it:

$$\Delta y_t = \alpha y_{t-1} + x_t^{'}\delta + \varepsilon_t \qquad (4)$$

Where α = ρ -1. The null and alternative hypotheses is as follow,

H_0: α = 0

H_1: α < 0 (5)

and evaluated using the conventional *t*-ratio for α:

$t_\alpha = \hat{\alpha} / (se(\hat{\alpha}))$ (6)

$\hat{\alpha}$ is the estimate of α, and se($\hat{\alpha}$) is the coefficient standard error. If the series is an AR(p) process, then the Augmented Dickey-Fuller (ADF) test (that constructs a parametric correction for higher-order correlation) has to be applied instead;

$$\Delta y_t = \alpha y_{t-1} + x_t^{'}\delta + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \ldots + \beta_p \Delta y_{t-p} + v_t \quad (7)$$

If sufficient lagged difference terms are included in the test regression, the ADF test is asymptotically valid in the presence of a moving average (MA) component (Said and Dickey (1984).

Cointegration

The non-stationary time series are said to be cointegrated, if a linear combination of two or more non-stationary series is stationary (Engle and Granger (1987). This cointegrating equation can be interpreted as a long-run equilibrium relationship among the variables. To test if there is a statistically significant connection between two or more series, cointegration test is applied. If we found evidence of cointegration, then Vector Error Correction (VEC) can be used to estimate the cointegrating equation.

Johansen cointegration test

VAR-based cointegration tests use the methodology developed in Johansen (1991, 1995). Consider a VAR of order p:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \varepsilon_t \quad (8)$$

Where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables, and ε_t is a vector of innovations. We may rewrite this VAR as,

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma \Delta\, y_{t-i} + Bx_t + \varepsilon_t \quad (9)$$

where:

$$\Pi = \sum_{i=1}^{p} A_i - I, \quad \Gamma_i = - \sum_{j=i+1}^{p} A_j \quad (10)$$

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank r < k, then there exist k * r matrices α and β each with rank r such that $\Pi = \alpha\beta^{'}$ and $\beta^{'} y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The adjustment parameters in the VEC model are denoted by α. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of Π.

Vector error correction model

A vector error correction (VEC) model is a restricted VAR designed for use with nonstationary series that are known to be cointegrated. The VEC has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. Regarding the fact that deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments, it is called the error correction term.

The next thing is to restrict certain coefficients of VAR model. In practice, the best way to describe the dynamic interrelationship among stationary variables is the use of vector autoregressive (VAR) model. Therefore, determining whether or not the levels of the data (data at their level) are stationary would be the first thing to do. If not, we need to use the first differences of the series and try if they are stationary. Usually, taking the first difference make them stationary. Having said that, the advantage of VECM over VAR (which you estimate ignoring VECM) is that it produces more efficient estimates. Another advantage of VECM is that it has a good interpretation with long term and short term equations. If data is non stationary, forecasting with VAR is not possible due to violating stationarity assumption which adds to the benefit of using VECM. In short, if series are cointegrated, there exists a long-term equilibrium relationship among them and therefore, we can apply VECM to evaluate the short run properties of the cointegrated series.

This problem is well handled using VECM. The cointegration rank in VECM actually is the number of cointegrating vectors. For example a rank of two means that two linearly independent combinations of the non-stationary variables will be stationary. If the coefficient of the ECM is negative and significant, it means that short-term fluctuations among the explanatory variables and the dependant variable will lead to a stable long run relationship among the variables. If there are more than one endogenous variable in a relationship, using VECM is recommended. VECM helps to establish long-term relationship and short-term dynamics of the endogenous variables or the achievement of long-term equilibrium and the rate of change in the short term is so that to achieve equilibrium in the long-term. Endogenous variables should converge to their co-integrated in the long run relations. First we need to test the stationarity of the series. Then, determine the order of integration of variables via Augmented Dickey Fuller test (ADF) and if the variables are integrated in the same order, (eg I(1)), we apply the Johansen method of co-integration, technique with the goal to find long-term relationship and short-term dynamics. To take the simplest possible example, consider a two variable system with one cointegrating equation and no lagged difference terms. The cointegrating equation is:

$$y_{2,t} = \beta y_{1,t} \tag{11}$$

The corresponding VEC model is:

$$\Delta y_{1,t} = \alpha_1 \left(y_{2,t-1} - \beta y_{1,t-1} \right) + \epsilon_{1,t}$$

$$\Delta y_{2,t} = \alpha_2 \left(y_{2,t-1} - \beta y_{1,t-1} \right) + \epsilon_{2,t} \tag{12}$$

The error correction term is the right-hand side variable. However, this term is zero in long run equilibrium. The error correction term will be nonzero if y_1 and y_2 deviate from the long run equilibrium. Therefore, each variable adjusts to partially restore the equilibrium relation. The coefficient α_i measures the speed of adjustment of the i^{th} endogenous variable towards the equilibrium.

Economic variables, such as demand, gross domestic product, etc, usually move together over time. In these cases, using standard statistical techniques such as OLS may lead to a spurious relationship between the variables. We need to find an estimation method that can counteract it, and VECM is such a model. VECM identifies a long-run relationship (based on economic theory) between the variables, while allowing for short-run deviations from this relationship. VECM just like ARDL can be simply manipulated to incorporate panel data. In the equation below, there is a long-run relationship between the variables y and w, which both contain a unit root (by assumption), but the short-run relationship is affected by w and x (as another variable,), which does not contain a unit root.

$$\Delta y_t = \sum_{k=1}^{p} \rho_k \Delta y_{t-k} + \sum_{j=0}^{q} \beta_j x_{t-j} + \sum_{i=0}^{r} \gamma_r \Delta w_{t-1} + \gamma(y_{t-1} - \theta w_{t-1}) + \varepsilon_t \quad (13)$$

ρ, β, γ, and λ are the parameters we want to and ε_t is a random error term. The advantage of this method is that we can derive both short- and long-run elasticities from this flexible model that can also handle variables that contain a unit root. However, there is a price to pay for using this method. Because of the two-stage conceptual framework of the model, long-run relationship has to be identified first and then we may proceed to determining the short-run dynamics which makes the specification of the model rather complex. Data requirements for this type of model are the same as those in the standard requirements for model estimation, however, in order to identify the lag structure a longer time series are required.

Conventional money demand function

In this section we focus on the factors that have influenced the development of the research on modeling and estimating money demand functions. In order to do so, we examine measurement issues variable-by-variable, and consider the fact that there is adjustment costs in the short-run concept of the demand for money while adjustment costs is not incorporated in the long-run demand for money and that is what distinguishes short-run from long-run demand for money.

The Basic Specification

There are different money demand theories. Each of these theories is based on different ideas and suggests different theoretical hypotheses that can be put to test. Despite differences, however, there are common elements in these theories. One of the most important of these common elements is that they express a relationship between the quantity of money demanded and some variables that are the main determinants of the level of economic activity. The general form of the theory of money demand can be represented as below:

$$\frac{M_t}{P_t} = \Phi(R_t, Y_t)$$

where M_t is the demand of nominal money balances, P_t is the price index that is used to convert nominal balances to real balances, Y_t is the scale variable relating to activity in the real sector of the economy (here, GDP as the best proxy for such a variable), and R_t is the opportunity cost of holding money (here, the interest rate as the best proxy). Different theories of the demand for money suggest different variables. Next, we discuss these possibilities. More detailed discussions on the choice of variables in different theories can be found in Edgar Feige and Douglas Pearce (1977), Judd and Scadding (1982), Laidler (1993), and Goldfeld and Sichel (1990).

Definition of money

Empirical estimation of money demand functions involve in the selection of an explicit measure of money in the first place that represents a challenge. Theories of the demand for money that are based on transaction theories mainly focus on narrow definitions of money that include currency and checkable deposits. Theories of the demand for money that are based on transaction theories have problems with determining which monetary assets belong to which monetary aggregate. Most central banks around the world use the monetary aggregates approach that is based on the simple-sum method of aggregation which is the target of criticism. The method of monetary aggregation is heavily based on this fact that it assigns a constant and equal weight to all monetary components. This index is M_t in

$$M_t = \sum_{j=1}^{n} x_{jt}, \tag{14}$$

where x_{jt} is one of the n monetary components of the monetary aggregate M_t. This summation index means that all monetary components have been given equal weights. In other words, they contribute equally to the money total. This index indicates an index of the stock of nominal monetary wealth, but does not imply a suitable structural economic variable for the services of the quantity of money. Since the introduction of the theory of the demand for money, some attempts were made aiming at assigning a proper weighting to monetary components of a simple-sum aggregate. Assigning weight, however, should be based on a sound theory, otherwise it is questionable. Barnett (1980) was the first one who managed to derive the theoretical foundation that is able to link monetary theory to aggregation and index number theory. Using economic aggregation and index number theory, he constructed monetary aggregates based on Erwin Diewert's (1976) class of superlative quantity index numbers. Divisia quantity indexes formulate the new aggregates that are fundamentals of the superlative class. The Divisia index (in discrete time) is:

$$\log M_t^D - \log M_{t-1}^D = \sum_{j=1}^{n} \omega_{jt}^* (\log x_{jt} - \log x_{j,t-1}) \tag{15}$$

Equation (15) indicates that the growth rate of the aggregate is the weighted average of the growth rates of the component quantities. It applies the Divisia weights that is the expenditure shares averaged over the two periods of the change,

$$\omega_{jt}^* = (1/2)(\omega_{jt} + \omega_{j,t-1})$$

for j = 1, · · ·, n, where

$$\omega_{jt} = \frac{p_{jt} x_{jt}}{\sum_{k=1}^{n} p_{kt} x_{kt}}$$

where ω_{jt} is the expenditure share of asset j during period t, and p_{jt} is the user cost of asset j, derived in Barnett (1978)

$$p_{jt} = \frac{(R_t - r_{jt})}{(1 + R_t\ )} \tag{16}$$

where p_{jt} is the opportunity cost of holding a dollar's worth of the jth asset. In the above equation, R_t is the yield available on a benchmark asset that is held only to carry wealth between multi-periods and r_{jt} is the market yield on the jth asset. Rotemberg (1991) and Rotemberg, Driscoll, and Poterba (1995) suggested the currency equivalent (CE) index

$$CE_t = \sum_{j=1}^{n} \frac{R_t - r_{jt}}{R_t} x_{jt} \quad (17)$$

In equation (17), units of currency are added together with a weight of one. Other assets are added to currency as long as currency yields no interest, however, this addition is done with a weight that declines toward zero as their return increases toward R_t. Obviously, the problem of the definition of money is an aggregation problem.

Scale variables

In order to measure transactions that are related to economic activity, we need to include the scale variable in the money demand function. Income is viewed as the relevant scale variable according to the transactions theories of money demand. However, in asset theories, it is the wealth that is considered as a relevant scale variable. The problem with asset theories is that it is not easy to measure wealth. Long time series on financial wealth have been collected and recorded only in few countries such as USA and UK. Besides, these measures are not good enough compared to Friedman's (1956) modern quantity theory which includes the value of human and nonhuman capital. Cagan's (1956) model of adaptive expectations paved the way for measuring expected income which for the unobserved expected level of income at time t, Y_t^e is:

$$Y_t^e - Y_{t-1}^e = \theta\,(Y_t^e - Y_{t-1}^e)$$

where $0 \le \theta \le 1$. By rearranging the above adaptive expectations model, we have:

$$Y_t^e = \theta Y_t + (1-\theta)\, Y_{t-1}^e$$

where Y_t^e as shown in above formula implies that the expected level of income at time t is a weighted average of the current actual level of income and last period's expected value of income. The weights are the adjustment parameters θ and 1−θ. By continuous back-substitution, finally it yields the second presentation of the adaptive expectations model:

$$Y_t^e = \theta Y_t + (1-\theta)\, Y_{t-1} + \theta(1-\theta)^2 Y_{t-2} + \dots ,$$

This formulation indicates the unobserved expected level of income at time t is a weighted average of the current actual level of income and already known income levels of the past, Y_{t-1}, Y_{t-2}, and so on. θ, θ (1 − θ), $\theta(1-\theta)^2$, and so on that are the weighting scheme, represents a memory that is the influence of past income levels on the formation of expectations. For instance, if θ is close to zero, the weights decline slowly and the economic agent has a long memory. In other words information from the distant past considerably impacts the formation of expectations. Alternatively, if θ is close to one, the weights decline quickly and the agent has a short memory meaning that only information from the recent past impacts the formation of expectations. The problem with the adaptive expectations model is that it doesn't suppose enough rationality on the part of economic agents meaning that only current and past values of the variable in question are used by economic agents when it formulates expectations for the future. John Muth's (1961) rational expectations hypothesis is considered as an alternative hypothesis for the above analysis. Rational expectations imply that economic agents when forming their expectations for the future use all of the available information, including relevant economic theory. Lucas (1973), Sargent and Wallace (1975), and Barro (1976) made significant contributions to the concept of rational expectations. Using the rational expectations for empirical work requires quantifying the concepts of 'available information' and 'relevant economic theory.' This quantification is very helpful but it is not an easy task to do. As Barro (1978) states, for empirical work it is necessary to deal with many issues such as structural shifts in the income growth process. Current income can be a good representation for the scale variable in the money demand function.

Laidler (1993) mentions that as gross national product series, net national product series and gross domestic product series move rather closely together over time, they all can be used as the scale variable so that the measurement of this variable won't be a problem. Measure of transactions is a more comprehensive compared to the measure of income. We give an example for clarification purpose. Gross national product (GNP) does not include transactions in financial assets, sales of intermediate goods, transfers, and purchases of existing goods despite the fact that they all have impact on the demand for money. That justifies why it is important to use more general measures of transactions to build scale variables. However, there is no guarantee that this action helps better explanation of aggregate money demand. Regarding the fact that all the transactions are not equally money intensive, GNP has to be disaggregate into several scale variables. Gregory Mankiw and Lawrence Summers (1986) believe that for the purpose of estimating money demand functions, consumption is preferred to GNP and that the disaggregation of GNP into components that replicate the nature of international transactions is important for open economies. The fact that disaggregation of GNP improves the performance of money demand functions is not yet backed by empirical evidence.

Opportunity costs

The opportunity cost of holding money is defined as the difference between the rate of return on assets alternative to money and the own rate on money. The question is that what is the best choice for the rate of return on alternative assets? Economists adopt a transactions approach and a narrow definition of money (short term interest rates, such as the Treasury bill rate, the commercial paper rate, or the saving deposit rate) is used for this purpose. By adopting asset approach, on the other hand, broader definition of money (longer-term rates of interest) is used. Now we turn our attention to the own rate on money. Most economists believe that it is actually zero meaning that the explicit rate of return on most forms of money (i.e., currency, demand deposits, etc.) is zero. This is questionable, because even if it is the case (the explicit return is zero), money earns an implicit rate of return (gifts, services, or reduced transactions fees) by maintaining a minimum level of deposits. The problem is that it is not easy to measure the implicit rate of return so many researchers have ignored it. See Benjamin Klein (1974) and Richard Startz (1979) for exceptions. However, some other variables might have impacts on the money demand function. Goldfeld and Sichel (1990), Laidler (1993), and Subramanian Sriram (1999) provide further references.

The Long-run function

We start the empirical estimation of money demand functions with introducing the long-run, log linear function that is of the form

$$\text{Log}\left(\frac{M_t^*}{P_t}\right) = \alpha + \beta_1 \log Y_t + \beta_2 R_t + \varepsilon_t \qquad (18)$$

where desired stock of nominal money is denoted by M^*, P is the price index that we use to convert nominal balances to real balances, Y is the scale variable, and R is the opportunity cost variable.

Money demand dynamics

Dynamic aspects of the money demand specification used to be ignored in most of the early research papers. The need to take into account the fact that money holders adjust in a sluggish way to fluctuations in the determinants of money demand, prompt researchers to consider this fact based on the assumption that agents behave as posited by the partial adjustment model. This model posits the existence of a desired level of real money balances M^*/P that reflects the real money demand without any adjustment costs based on the assumption that the actual level of money balances adjusts in each period only part of the way toward its desired level. In other words, it adjusts partially. If the adjustment of actual to desired money holdings is in real terms, the adjustment mechanism is:

$$\log\left(\frac{M_t}{P_t}\right) - \log\left(\frac{M_{t-1}}{P_{t-1}}\right) = \boldsymbol{\lambda}\left[\log\left(\frac{M_t^*}{P_t}\right) - \log\left(\frac{M_{t-1}}{P_{t-1}}\right)\right] \qquad (19)$$

The actual value of real money balances denoted by M_t/P_t and λis the speed of adjustment, with $0 \leq \lambda \leq 1$; $\lambda = 1$ means full immediate adjustment and if it is less than one, it means slower, more sluggish, adjustment. Real partial adjustment model uses the assumption that log (M_t^* / P_t) is given by an equation of the form (18) and by substituting equation (18) into equation (19) in order to derive the short-run demand for money function with real [e.g., Chow (1966)] partial adjustment

$$\log\left(\frac{M_t}{P_t}\right) = \lambda\alpha + \lambda\beta_1 \log Y_t + \lambda\beta_2 R_t + (1-\lambda)\log\left(\frac{M_t}{P_t}\right) + e_t \qquad (20)$$

where e_t is a random error term. The real partial adjustment model mentioned in equation (19) has a few shortcomings that can be seen by rewriting (19) as follows

$$\log M_t - \log M_{t-1} = \lambda\left[\log\left(\frac{M_t^*}{P_t}\right) - \log\left(\frac{M_{t-1}}{P_{t-1}}\right)\right] + \Delta \log P_t$$

According to this equation, since the coefficient of $\Delta\log P_t$ is unity, the real partial adjustment specification assumes that an adjustment will be done immediately after changing in the price level. Most probably, this assumption does not hold so nominal adjustment model is used instead which is of the following form

$$\log M_t - \log M_{t-1} = \lambda[\log M_t^* - \log M_{t-1}] \qquad (21)$$

Nominal adjustment model in equation (21) functions by using the assumption that log(M_t^* /P_t) is given by an equation of the form (19) and substituting equation (19) into equation (21) to obtain the short-run demand for money function with nominal [e.g., Goldfeld (1976)] partial adjustment

$$\log\left(\frac{M_t}{P_t}\right) = \lambda\alpha + \lambda\beta_1 \log Y_t + \lambda\beta_2 R_t + (1-\lambda)\log\left(\frac{M_{t-1}}{P_t}\right) + v_t \quad (22)$$

In equation (22) above, v_t is a stochastic disturbance term. Based on some empirical tests we conclude that the nominal model is more appropriate. There is a need to include a more general reconsideration of the adjustment process in the real and nominal partial adjustment models. If nominal money supply is exogenously fixed by the central bank, the desired nominal stock of money has to adjust to the given stock by adjustments in the price level. We replace equation (21) with an adjustment equation in prices using the idea mentioned above

$$\log P_t - \log P_{t-1} = \lambda[\log P_t^* - \log P_{t-1}] \quad (23)$$

Equation (23) functions by using the assumption that log(M∗t /Pt) is given by an equation of the form (18) and by substituting equation (23) into equation (18) to obtain the short-run demand for money function with price [e.g., Robert Gordon (1984)] adjustment

$$\log\left(\frac{M_t}{P_t}\right) = \lambda\alpha + \lambda\beta_1 \log Y_t + \lambda\beta_2 R_t + (1-\lambda)\log\left(\frac{M_t}{P_{t-1}}\right) + \zeta_t \quad (24)$$

where ζ_t is a stochastic disturbance term. Equations (20), (22), and (24) differ in the lagged money term. In equation (20), that is the real adjustment specification, the lagged dependent variable is M_{t-1}/P_{t-1}, while in equation (22), that is the nominal adjustment specification, the lagged dependent variable is M_{t-1}/P_t, and in equation (24), that is the price adjustment specification, the lagged dependent variable is M_t/P_{t-1}. Regarding the fact that specifications (20), (22), and (24) cannot be considered as nested hypotheses, each one of them must be evaluated for its stability and its consistency with the theory. Being consistent with the theory means that the signs of the coefficients must be correct and the coefficients have to be statistically significant, and the adjustment coefficient must be subject to its restriction. If the test statistics using OLS estimates indicate model misspecification, it is an indication of the fact that these changes do not repair the money demand function with almost all money measures and for all partial adjustment specifications.

First-difference specifications

If we believe that equations like (20), (22), and (24) would not remain the same with the passage of time, complications arise. We take care of this by adding to each of these equations a trend term, $\lambda\beta_3$t, where the variable is time itself and $\lambda\beta_3$ is the associated coefficient but estimates reveal highly serially correlated disturbances. To solve this statistical problem, we use first-differenced data. Thus, if we add $\lambda\beta_3$t to each of (20), (22), and (24), use the same equation for period t−1, and subtract the latter from the former, we get

$$\Delta\log\left(\frac{M_t}{P_t}\right) = \lambda\beta_1 \Delta\log Y_t + \lambda\beta_2 \Delta R_t + (1-\lambda)\Delta\log\left(\frac{M_{t-1}}{P_{t-1}}\right) + \lambda\beta_3 + \Delta e_t \quad (25)$$

for the real partial adjustment specification,

$$\Delta\log\left(\frac{M_t}{P_t}\right) = \lambda\beta_1\Delta\log Y_t + \lambda\beta_2\Delta R_t + (1-\lambda)\Delta\log\left(\frac{M_{t-1}}{P_t}\right) + \lambda\beta_3 + \Delta v_t \qquad (26)$$

for the nominal partial adjustment specification, and

$$\Delta\log\left(\frac{M_t}{P_t}\right) = \lambda\beta_1\Delta\log Y_t + \lambda\beta_2\Delta R_t + (1-\lambda)\Delta\log\left(\frac{M_t}{P_{t-1}}\right) + \lambda\beta_3 + \Delta\zeta_t \qquad (27)$$

For the case with price adjustment. In each of (25), (26), and (27), $\lambda\beta_3 = \lambda\beta_3 t - \lambda\beta_3(t-1)$. First-difference specifications seems successful in eliminating some of the autocorrelation problems compared to the log-levels specifications, indicating that using differenced data to obtain the econometric estimates is more reliable. The drawback of using first-differenced data is its inconsistency with the theory. This is because the coefficients do not always have correct signs and sometimes the estimated coefficients are not statistically significant. Regarding the fact that the (log) levels of the variables are non-stationary, economists began to carry out the empirical analysis by using data in their first differenced. Using first differenced data to convert non-stationary series to stationary ones migh cause problems as noted by Engle and Clive Granger in their 1987 article "Co-Integration and Error Correction: Representation, Estimation and Testing". They state this approach (inducing stationarity by first differencing) disregards the fact that economic theories supports equilibrium relationships among the levels of the series and not the first difference of these series. Therefore, we need to apply a strategy that is consistent with recent developments in the theory of non-stationary regressors to analyze the money demand variables (Serletis, A. 2007). In conclusion, the conventional theory of money demand is misspecified due to ignoring the effects of financial innovation. That why, we include ATMs to proxy the impact of financial innovation on money demand.

Empirical model

The general form of the theory of money demand can be represented as below:

$$\frac{M_t}{P_t} = \Phi(R_t, Y_t)$$

where M_t is the demand of nominal money balances, P_t is the price index that is used to convert nominal balances to real balances, Y_t is the scale variable relating to activity in the real sector of the economy (here, GDP as the best proxy for such a variable), and R_t is the opportunity cost of holding money (here, the interest rate or IR as the best proxy). We start the empirical estimation of money demand functions with introducing a linear function that is of the form

$$\left(\frac{MD_t^*}{P_t}\right) = \alpha + \beta_1 GDP_t + \beta_2 IR_t + \varepsilon_t$$

Desired stock of nominal money is denoted by MD^*, P is the price index that we use to convert nominal balances to real balances, GDP is the scale variable, and IR is the opportunity cost variable. The conventional money demand $M^d = (Y_t, R_t)$ is misspecified and leads to the bias that gets into the estimated coefficients. Therefore, it has to be enriched with financial innovation so that it can be represented implicitly as $M^d = (Y_t, R_t, r^*)$, (Serletis, 2007). However, we do not have a direct measure of such innovations so we use a dummy variable to capture the effect of these innovations as follow:

$$MD = \alpha + \beta_1 GDP_t + \beta_2 IR_t + \beta_3 D_t + \varepsilon_t$$

MD is the real balance of money demand and D is the dummy variable to take into account the effect of financial innovation on money demand. The data are annually, from 1990 to 2015. D = 0 for the years 1990 to 2008 and D = 1 for 2009 to 2015. The official website of the World Bank and the official website of Reserve Bank of India were used as the source of data.

PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2011 international dollars.

Real interest rate (expressed as percent) is the lending interest rate adjusted for inflation as measured by the GDP deflator.

Broad money is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than the central government; bank and traveler's checks; and other securities such as certificates of deposit and commercial paper. Data are in constant 2011 international dollars.

Estimation

Unit root tests show that these series are non-stationary in levels, but become stationary after converting to first differenced. The four variables are found to be integrated of order one. That is, they are I(1) meaning that the levels of these variables are differenced once to achieve stationarity.

Table 1: Unit root tests (Augmented Dickey-Fuller test statistic)

Variables (Level/First Differenced)	Prob.
MD	0.9958 / 0.0199
GDP	0.9998 / 0.0350
IR	0.1137 / 0.0000

Then, we need to find out if these series are cointegrated. The analysis of long-run cointegrating relationships has received considerable attention in modern analysis. However, before proceeding to cointegration test, we have to select the optimal lag using Akaike information criterion. Using a VAR system, we try different lags and obtain Akaike information criterion for each of these lags. We choose the number of lags with corresponding minimum AIC, that is, two. Therefore, we proceed to cointegration test using 2 lags.

Table 2: Unrestricted cointegration rank tests (Trace test)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.688199	47.43279	29.79707	0.0002
At most 1 *	0.580757	20.62884	15.49471	0.0077
At most 2	0.027224	0.634825	3.841466	0.4256

Table 3: Unrestricted cointegration rank tests (Maximum Eigenvalue test)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.688199	26.80395	21.13162	0.0071
At most 1 *	0.580757	19.99401	14.26460	0.0056
At most 2	0.027224	0.634825	3.841466	0.4256

Trace test and Max-eigenvaue test both indicate 2 cointegration equations at the 0.05 level. Therefore, there is strong evidence of existence of cointegration among variables. In other words, the variables have long run association. Now that the cointegration has been detected, there exists long-term equilibrium relationships between variables, therefore, we can apply VECM to evaluate short-run properties of the cointegrated series using lag 2.

Table 4: Co-integrating equations

Cointegrating Eq:	CointEq1	CointEq2
MD(-1)	1.000000	0.000000
GDP(-1)	0.000000	1.000000
IR(-1)	2.88E+09 (2.1E+11) [0.01353]	-7.91E+10 (2.3E+11) [-0.34143]
C	-2.45E+12	-3.15E+12

Table 5: Estimates obtained from Vector Error Correction estimates

Error Correction:	D(MD)	D(GDP)	D(IR)
CointEq1	-0.562674	-0.191069	-2.17E-11
	(0.23729)	(0.29462)	(7.1E-12)
	[-2.37125]	[-0.64853]	[-3.06972]
CointEq2	0.572494	0.270676	1.96E-11
	(0.19888)	(0.24693)	(5.9E-12)
	[2.87859]	[1.09617]	[3.30687]
D(MD(-1))	0.829475	0.371264	1.74E-11
	(0.33288)	(0.41330)	(9.9E-12)
	[2.49182]	[0.89829]	[1.75845]
D(MD(-2))	1.005820	0.300243	6.38E-12
	(0.28339)	(0.35186)	(8.4E-12)
	[3.54923]	[0.85331]	[0.75645]
D(GDP(-1))	-0.226116	-0.172445	-1.74E-11
	(0.28419)	(0.35285)	(8.5E-12)
	[-0.79566]	[-0.48873]	[-2.06343]
D(GDP(-2))	-1.076457	-0.832893	-9.27E-12
	(0.32283)	(0.40083)	(9.6E-12)
	[-3.33443]	[-2.07794]	[-0.96534]
D(IR(-1))	2.75E+10	-4.96E+08	0.356885
	(1.0E+10)	(1.3E+10)	(0.31093)
	[2.63438]	[-0.03821]	[1.14781]
D(IR(-2))	2.47E+10	1.14E+09	0.233758
	(6.1E+09)	(7.6E+09)	(0.18242)
	[4.02728]	[0.14940]	[1.28144]
C	1.89E+11	3.46E+11	0.889782
	(8.9E+10)	(1.1E+11)	(2.65579)
	[2.11810]	[3.11668]	[0.33504]
DUM	-1.40E+11	-9.84E+09	1.145244
	(8.6E+10)	(1.1E+11)	(2.56721)
	[-1.61788]	[-0.09181]	[0.44610]

To know the p-value in the estimated VAR system above, we use the system equation:

D(MD) = C(1)*(MD(-1) + 2876840011.89*IR(-1) - 2.44723718895e+12) + C(2)*(GDP(-1) - 79111676270.5*IR(-1) - 3.14837870777e+12) + C(3)*D(MD(-1)) + C(4)*D(MD(-2)) + C(5)*D(GDP(-1)) + C(6)*D(GDP(-2)) + C(7)*D(IR(-1)) + C(8)*D(IR(-2)) + C(9) + C(10)*DUM

D(GDP) = C(11)*(MD(-1) + 2876840011.89*IR(-1) - 2.44723718895e+12) + C(12)*(GDP(-1) - 79111676270.5*IR(-1) - 3.14837870777e+12) + C(13)*D(MD(-1)) + C(14)*D(MD(-2)) + C(15)*D(GDP(-1)) + C(16)*D(GDP(-2)) + C(17)*D(IR(-1)) + C(18)*D(IR(-2)) + C(19) + C(20)*DUM

D(IR) = C(21)*(MD(-1) + 2876840011.89*IR(-1) - 2.44723718895e+12) + C(22)*(GDP(-1) - 79111676270.5*IR(-1) - 3.14837870777e+12) + C(23)*D(MD(-1)) + C(24)*D(MD(-2)) + C(25)*D(GDP(-1)) + C(26)*D(GDP(-2)) + C(27)*D(IR(-1)) + C(28)*D(IR(-2)) + C(29) + C(30)*DUM

The first one is our target equation. The phrase (MD(-1) + 2876840011.89*IR(-1) - 2.44723718895e+12) + C(2)*(GDP(-1) - 79111676270.5*IR(-1) - 3.14837870777e+12) is the cointegration part of the system equation. Therefore, we estimate it using OLS and obtain the estimated coefficients of the system equation as in table below.

Table 6: Estimation of the target model

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.562674	0.237290	-2.371245	0.0339
C(2)	0.572494	0.198880	2.878593	0.0129
C(3)	0.829475	0.332879	2.491822	0.0270
C(4)	1.005820	0.283391	3.549227	0.0036
C(5)	-0.226116	0.284187	-0.795660	0.4405
C(6)	-1.076457	0.322831	-3.334430	0.0054
C(7)	2.75E+10	1.05E+10	2.634375	0.0206
C(8)	2.47E+10	6.13E+09	4.027283	0.0014
C(9)	1.89E+11	8.93E+10	2.118096	0.0540
C(10)	-1.40E+11	8.63E+10	-1.617879	0.1297

C(1) is the speed of adjustment toward long run equilibrium. It must be significant and negative. This means that the disparity between the value of money demand in period (t-1) and its long run equilibrium value is corrected by as much as (C(1)*100) percent (here, 56.2 percent). This means that the deviation of money demand from long run value is corrected in about 1/C(1) years (here, almost 2 years). For this case, C(1) is -0.562674 which is negative and significant. Therefore, there is long run causality running from GDP and IR MD meaning that these variables do have influence on MD. Coefficients of GDP(-1), IR(-1) are long-run coefficients and those of D(GDP(-1)), D(GDP(-2)), D(IRE(-1)), D(IRE(-2)) are short-run coefficients. The only statistically significant coefficients are C(5), C(9) and C(10). In the short-run, for instance, 1 unit increase in money demand in previous year (MD(-1)) results in a 0.82 unit increase in current money demand. However, the estimated coefficient of the dummy variable, C(10), is of great importance as it indicates that launching new innovative products, such as Immediate Payment Services (IMPS), National Automated Clearing House (NACH) and Prepaid Instruments (PPI) after the formation of NPCI has had no significant effect on the real demand for money in India during 1990-2015. Now, we check if GDP and IR have short run causality.

Table 7: Wald test for null hypothesis

	Probability
C(5)=C(6)=0	0.0029
C(7)=C(8)=0	0.0003

From Chi-square statistics that has 0.0029 probability which is less than 0.05, we can reject the null hypothesis meaning that C(5) and C(6) are not jointly zero. In other words, there is short run causality running from GDP to MD. Also, we can repeat the process for IR and we can conclude that there is short run causality running from IR to MD. The summary of the analysis can be described as follow: First, there is long-run causality running from GDP and IR to MD. Second, there is short term causality running from GDP and IR to MD. Next, we have to conduct statistical tests to make sure there is no serial correlation, no ARCH effect and that the residuals are normally distributed. First, we begin with Serial Correlation Test and will be followed by ARCH test and Normality test.

Table 8: Breusch-Godfrey serial correlation LM test, heteroskedasticity (ARCH) test and normality test

	Probability
Breusch-Godfrey serial correlation LM test	0.8032
Heteroskedasticity (ARCH) test	0.0689
Normality test	0.8528

According to Breusch-Godfrey Serial Correlation LM Test (Obs*R-squared of 0.8032), we cannot reject null hypothesis and rather, we accept the alternative hypothesis meaning that the model has no serial correlation. Also, Obs*R-squared of the test above is 0.0689 which clearly indicates that there is no ARCH effect. We also note that the residuals are normally distributed as probability (0.8528) is greater than 0.05).

Summary and Conclusion

It is evident that the formation of National Payments Corporation of India (NPCI) has stimulated the development of electronic banking such as electronic clearing products including National Electronic Funds Transfer, ECS (Debit), and Card Products. Debit cards, electronic fund transfer, mobile payments, internet banking, mobile wallets, and other newly evolved payment channels have paved the way for a cashless economy. National Payments Corporation of India (NPCI) plays a vital role in transition from traditional channel to electronic channels for doing transactions. The paper offers important contributions to the existing literature by investigating the importance of NPCI on shifting traditional way of transactions to paperless or electronic ones.

The periods before and after the formation of NPCI in India is compared to track the development in India made possible by NPCI. A safe, efficient, interoperable, authorized, accessible, inclusive and compliant with international standards payment and settlement systems is ensured by Reserve Bank of India (RBI) as the regulatory body. Promoting innovation and competition in payment system while achieving international standards is the task of RBI. However, we do not observe significant influence of formation of NPCI on the demand for money in India. Banks are to be blamed for this situation.

In order to win the trust of the customers, the security issues have to be addressed by banks. The systems and infrastructure for the e-delivery of services need to be of international standards to win the confidence of their customers. Banks need to be more accessible and to cater to the customers need and to use technology enabled services more than ever. This will guarantee successful shift from paper based economy to a cashless economy.

In this paper, we estimated a conventional money demand model with currency in circulation (M2) as dependent variable denoted by MD and gross domestic product (GDP, constant international US$), interest rate (IR) as independent variables over the period 1990-2015. We apply Vector Error Correction Model to estimate money demand. A vector error correction model (VECM) is a restricted VAR that has cointegration restrictions built into the specification, so that it is designed for use with non-stationary series that are known to be cointegrated. The VEC specification restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

Despite the fact that new financial innovations after the formation of NPCI has not had impact on the demand for money, there exists long-term equilibrium relationships between variables, and also, there is long run causality running from GDP and IR to MD (money demand) meaning that these variables do have influence on MD in the long run. Finally, the disparity between the value of money demand in period (t-1) and its long run equilibrium value is corrected by 56.2 percent. This means that the deviation of money demand from long run value is corrected in about 2 years. In the short run, however, there is short term causality running from GDP and IR to MD.

It is obvious that the above mentioned results are valid only if the estimates are free from statistical issues. In order to diagnosis the possible statistical problems, we conducted the relevant tests. Beginning with Breusch-Godfrey Serial Correlation LM Test and based on the observed R-squared, null hypothesis cannot be rejected and rather, the alternative hypothesis is accepted meaning that the model has no serial correlation. Also, Obs*R-squared of the test indicates that there is no ARCH effect. We also note that the residuals are normally distributed as probability is greater than 5 percent significance level.

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