Currency demand stability in the presence of seasonality and endogenous financial innovation: Evidence from India

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Abstract

Based on the *money-in-the-utility* function, this paper intends to examine the stability of the currency demand function for India with real private consumption expenditure, tax-GDP ratio and deposit rate as explanatory variables by applying the seasonal cointegration technique developed by EGHL (1993) and HEGY (1990) for the period 1996:1 to 2014:4. The empirical findings show that there is absence of long-run cointegrationg relationship among the variables at the zero and annual frequency, however, there is evidence of a relationship among the variables at the biannual frequency. Moreover, the time-varying coefficient of deposit rate elasticity, used to test the Gurley-Shaw hypothesis, suggests that innovations in financial markets, especially improvements in the payment technology, raises the deposit rate elasticity, beginning from 2010 onward.

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1. Introduction

Currency in circulation, consisting of both coins and banknotes, is the most liquid and narrowest measures of monetary aggregates. From the monetary policy perspective, demand for currency is important because it is closely related to transaction demand, i.e., the need to carry out cash transactions in both the legal and illegal sectors and hence, to price development in an economy (Fischer, Koehler, & Seitz, 2004; Nachane, Chakraborty, Mitra, & Bordoloi, 2013). Besides the transactions demand, a part of currency is also held by the public as a precautionary measure and may also be used for hoarding especially by the illegal sector of the economy.

Considering the role it plays in an economy, estimating demand for currency in an economy and understanding its relationship with various macroeconomic variables is an essential element in the planning of the issue and distribution of currency (Nachane et al., 2013). However, with continuous changes in the macroeconomic environment in an economy, estimating a stable currency demand function is a challenging task. The main reason for instability in the currency demand can be attributed to the improper specification in view of the continuous innovations in the financial system.

A poorly specified currency demand function might yield spurious inferences on the underlying stability of currency demand. With the introduction of cointegration technique (Engle & Granger, 1987; Johansen & Juselius, 1990), an error correction mechanism has been suggested to be a proper specification of demand for currency for the last two decades. The presence of cointegration between real currency and its determinants implies that the currency demand function is stable and vice-versa. The prerequisite for applying cointegration technique is that the relevant variables must have unit roots at the zero-frequency. However, economic data have some inherent problems of their own, one of which is the presence of stochastic seasonality that cannot be eliminated by seasonal dummy variables (Chung-Hua & Tai-Hsin, 1999; Hamori & Tokihisa, 2001). The stochastic seasonality, characterized by the presence of unit root at a seasonal frequency, renders the conventional cointegration tests inappropriate at the non-seasonal frequency. Engle, Granger,

& Hallman (1989) show that the conventional cointegration estimate is inconsistent if unit roots of distinct seasonal frequencies are regressed. Additionally, the long-run relationships among seasonal frequencies are also ignored in the conventional cointegration test.

For the empirical estimation of the currency demand function, it is necessary to have a solid theoretical underpinning in line with the monetary theory. So far, only a few studies have empirically applied general equilibrium framework of money demand like *cash-in-advance* model (Clower, 1967), *money-in-the-utility function* (Sidrauski, 1967) and *overlapping generation* model (Wallace, 1978). In the case of currency demand, money-in-the-utility function seems to be suitable in comparison with cash-in-advance model (Holman, 1998) because this kind of model allows for transactions as well as precautionary and store-of-value motives for holding money. However, cash-in-advance model has been an equally popular method to estimate money demand in a general equilibrium framework (Bohl & Sell, 1998; Bohn, 1991; Sill, 1998).

Another issue accountable for instability in the currency demand function is the innovation in the financial sector, especially the changing payment system mechanism. It is argued that advances in payment technology like the spread of ATM's, bankcards, POS terminals, etc. have resulted in a substitution of non-cash payments for cash (Snellman, Vesala, & Humphrey, 2001). However, due to limited availability of data related to the modern payment technology in most developing countries, various proxies have been used in the literature to take into account the process of financial innovation. Arestis, Hadjimatheou, & Zis (1992), Arrau & De Gregorio (1993) and Arrau, De Gregorio, Reinhart, & Wickham (1995) have used deterministic trend and stochastic trend as a random process as a proxy for financial innovation. While some studies (Cesarano, 1990; Chowdhury, 1989; Hafer & Hein, 1984; Hasan, 2009; Stracca, 2003) intend to test the Gurley & Shaw (1960) hypothesis, henceforth Gurley-Shaw hypothesis, that financial innovation increases the interest elasticity of money demand. It means that as new interest-bearing substitute of money is made available, money holding (in our case currency holding) becomes more sensitive to changes in interest rates, thus raising the interest elasticity of money/currency demand. Though these approaches do not require a detailed accounting of all possible sources of financial innovation, it is also too general to be helpful in tracing the origin of the innovation process (Arrau et al., 1995). On the other hand, by eliminating a fundamental source of misspecification, these approaches allow one to recover the parameters of interest- the determinants of currency demand.

Against this background, this study has twin objectives. First, we use the modified version of the *money-in-the-utility function* for the theoretical foundation of our study. Furthermore, based on the theoretical background, we examine the stability of the currency demand function for India by applying the seasonal cointegration technique developed by Engle, Granger, Hylleberg, & Lee (1993), thereafter EGHL (1993), and Hylleberg, Engle, Granger, & Yoo (1990), thereafter HEGY (1990), to seasonally unadjusted quarterly data. Second, a time-varying parameter model is estimated with Kalman filter to detect the possible presence of changes in the interest elasticity of currency demand over time as hypothesized by Gurley & Shaw (1960). This study contributes to a promising line of standard research in several ways. First, previous studies on currency demand literature have relied on seasonally adjusted data for investigating the stability of currency demand in India. We, for the first time in our knowledge, apply seasonal cointegration and seasonal error correction technique for our analysis. Second, we also try to gauge whether tax evasion (a proxy for illegal activities), measured by a tax-GDP ratio, have any role to play in estimating long-term currency demand in India. Third, we try to test the evidence of financial innovation in India by testing the Gurley-Shaw hypothesis. In this regards, we represent the currency demand equation in state-space form and solve it by Kalman filter algorithm using maximum likelihood estimation technique.

The remaining paper is organized as follows. Section 2 presents the analytical framework that underpins the empirical analysis. Section 3 explains the data, presents the empirical methodology and discusses the empirical results based on seasonal error correction model and state space modeling. Section 4 concludes the study along with limitation and future direction of the present study.

2. Analytical Framework

We broadly follow Rogoff, Giavazzi, & Schneider (1998) and Sidrauski (1967) version of the *money-in-the-utility function*.

Consider a small, open economy in which domestic currency is a sole legal tender. The representative individual is endowed each period with y units of output and can borrow and lend at the real interest rate r. The agent has a utility function given by:

$$U = \sum_{s=t}^{\infty} \beta^{s-1} u(c_s) \quad (1)$$

Where c is consumption in period s, $\beta < 1$ is the time discount factor, and $u' > 0, u'' < 0$. The individual is endowed each period with gross real income y.

In addition to receiving income, the agent also faces a proportional tax on earned income y at notional rate τ. For simplicity we assume that interest income is not taxed. The tax rate is notional in that agent can reduce his or her effective tax rate by holding a higher level of real balances $\frac{M}{P}$ (Where *M* is the total currency and *P* is the price level). The idea is that using currency helps avoid detection of income by the tax authorities. Additionally, it is usually assumed that the majority of payments in the shadow economy is settled with cash. Thus, the real net tax paid by the individual are:

$$\tau g(M_t/P_t y) \tag{2}$$

Where $g(0) = 1, g'(.) < 0, g''(.) > 0$, and $lim_{\frac{M}{Py} \to \infty} g\left(\frac{M}{Py}\right) \geq 0$. (Obviously we do not need to think of every individual as engaging in tax evasion, but thinking of the representative agent as wearing two hats is a useful shortcut to analyzing a more heterogeneous economy).

Our assumption on tax evasion implies that the individual budget constraint can be written in money terms as:

$$P_t b_{t+1} + M_t = P_t(1+r)b_t + M_{t-1} + P_t y\left[1 - \tau g\left(\frac{M_t}{P_t y}\right)\right] - P_t c_t \tag{3}$$

Where b_{t+1} denotes the individual's holding of real bonds, and M_t his or her money holdings at the end of period t.

The first-order conditions for Individual utility maximization of (1) subject to (4) imply:

$$u'(c_t) = \beta(1+r)u'(c_{t+1}) \tag{4}$$

and

$$\left(\frac{1}{P_t}\right) u'(c_t)\left[1 + \tau g'\left(\frac{M_t}{P_t y}\right)\right] = \left(\frac{1}{P_{t+1}}\right) \beta u'(c_{t+1}) \tag{5}$$

Equation (4) is standard consumption/Euler equation while equation (5) determines the allocation of income between money and consumption. Combining (4) and (5) yields:

$$-\tau g'\left(\frac{M_t}{P_t y}\right) = 1 - \frac{P_t}{P_{t+1}(1+r)} = \frac{i}{1+i} \tag{6}$$

Which, given our assumption on g', implies a standard demand function for real balance, increasing in y, decreasing in nominal interest rate i[1]. The one important difference, however, is that currency demand also depends positively on the marginal tax rate and consumption expenditure.

To see the implications of the model more clearly, it is helpful to see the specific functional forms:

$g\left(\frac{M}{Py}\right) = exp - (\frac{1}{\eta})(\frac{M}{Py})$

In this case (6) reduces to:

$$\frac{M_t}{P_t} = \eta y \left\{\log\left(\frac{1}{\eta}\right)(\tau) - \log\left(\frac{i}{1+i}\right)\right\} \tag{7}$$

In the case of currency demand, we use consumption expenditure instead of income level as one of the determinants. Hence, the currency demand equation in general form can be written as:

$$log\left(\frac{M_t}{P_t}\right) = \alpha + \beta\log(\frac{C_t}{P_t}) - \gamma(\frac{i_t}{1+i_t}) + \mu\tau_t \tag{8}$$

For notational simplicity, equation (8) can be written as follows:

$$log(m_t) = \alpha + \beta\log(c_t) - \gamma r_t + \mu\tau_t \tag{9}$$

Where m_t and c_t is currency in circulation and private final consumption expenditure respectively deflated by private final consumption expenditure, τ_t is tax-GDP ratio and $r_t = \frac{i_t}{1+i_t}$ is opportunity the cost of holding currency i.e. deposit rate[2].

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[1] The nominal interest rate i is defined as:
$1+ i=\frac{P_{t+1}}{P_t}(1 + r)$.

[2] The elasticity of currency demand with respect to the nominal deposit rate is:

$$-(\frac{dM_t}{dr_t})(r_t/M_t) = \gamma r_t$$

Empirical work often estimates currency demand equations in which log of real currency is a function of log income/consumption, the level of the nominal interest rate and other variables like tax-GDP ratio. The coefficient on the nominal deposit rate is then equal to the semi-elasticity of currency demand with respect to the nominal deposit rate$\left(\frac{M^{-1}dm}{dr}\right)$, which for equation (9) is γ (See Walsh (2010) pp. 48-49 for more detail).

The Data, Empirical methodology and Empirical results

The data

In accordance with the analytical framework, as described in the previous section, we estimate a currency demand function for India using unadjusted quarterly data for the period 1996:1 to 2014:4. The usage of seasonally unadjusted data has many advantages vis-à-vis seasonally adjusted data. The practice of applying a seasonally adjusted data is criticized in the literature because it may distort the actual relation between the variables that may result in loss of valuable information about economic time series. A recent study (Bhattacharya & Singh, 2014) on currency in circulation for India and the USA finds that currency in circulation is characterized by the strong seasonal pattern. Therefore, it is relevant to use seasonally unadjusted data to estimate currency demand function in the macroeconomic framework. Table 1 presents data, definitions, and their sources.

<Insert Table 1 here>

Seasonal unit root and seasonal cointegration approach

When using quarterly seasonally unadjusted data, there is a possibility that there may be the presence of unit root at zero as well as seasonal frequency. To test whether each variable has seasonal unit root, we follow HEGY (1990) test for seasonal integration. The following transformation is defined for any given variable, $\{Z_t\}t = 1, 2, \ldots, T$,

$$Z_{1,t} = (1 + B)(1 + B^2)Z_t = (1 + B + B^2 + B^3)Z_t \tag{10}$$

$$Z_{2,t} = -(1 - B)(1 + B^2)Z_t = -(1 - B + B^2 - B^3)Z_t \tag{11}$$

$$Z_{3,t} = -(1 - B^2)Z_t \tag{12}$$

Where B is the lag operator. Note that $Z_{1,t}$ is the observed series adjusted for the seasonal unit root at$\theta = \frac{\pi}{2}, \pi, \frac{3\pi}{2}$, $Z_{2,t}$ is the observed series adjusted for the unit root at $\theta = 0, \frac{\pi}{2}, \frac{3\pi}{2}$, and $Z_{3,t}$ is the observed series adjusted for the unit root at $\theta = 0, \pi$. The test for seasonal unit root is based on following auxiliary regression:

$$Z_{4t} = deter + \pi_1 Z_{1,t-1} + \pi_2 Z_{2,t-1} + \pi_3 Z_{3,t-2} + \pi_4 Z_{3,t-1} + \sum_{i=1}^{p} \varphi_i Z_{4,t-i} + u_t \tag{13}$$

Where deter correspondents to deterministic part (intercept, trend, seasonal dummy) of the regression, $\{Z_t\}$ corresponds to the variables under study. The tests for unit at the zero and biannual frequency are based on the t statitistics t_1 and t_2 for the null hypothesis $\pi_1 = 0$ and $\pi_2 = 0$. With the aids of F statistics, F_{34}, we test for the presence of unit root at the annual frequency for the null hypothesis $\pi_3 = \pi_4 = 0$. Critical values for each test are found in HEGY (1990).

The results of the HEGY seasonal unit root test are presented in Table 2. The choice of lag length in equation (13) is based on Akaike information criteria (Akaike, 1974) starting with a maximum lag length of 16. For the robustness of the results, we've tried all the logical combination of the deterministic term in equation (13). As can be observed from Table 2, currency in circulation has unit root at zero and biannual frequency consistently while unit root at annual frequency exists when the deterministic term is taken as only intercept and intercept plus trend. Private final consumption expenditure has the presence of unit root at every frequency. The result for the tax-GDP ratio is similar to private final consumption expenditure, except for one case. On the other hand, the deposit rate has unit root only at zero frequency.

<Insert Table 2 here>

After conducting the seasonal unit root test of the variables under study, the next question to be investigated is whether the variables are cointegrated at some frequency. If the variables do not have unit roots at corresponding frequency, the possibility of a cointegrating relation does not exist.

To estimate and test for cointegration at each frequency, we follow the procedure suggested by EGHL (1993) in this study. The cointegrating regressions are performed using the aforementioned filtersZ_1, Z_2 and Z_3 which adjust the time series m_t, c_t and τ_t for all unit roots except that at the cycle of interest. Since the deposit rate (r) has unit root only at zero frequency, there is no need of using filters in this case. The cointegrating regression at zero, biannual and annual frequency is given by following the equation respectively:

$$m_{1t} = deter + \alpha_{11}c_{1t} + \alpha_{12}\tau_{1t} + \alpha_{13}r_t + u_t \tag{14}$$

$$m_{2t} = deter + \alpha_{21}c_{2t} + \alpha_{22}\tau_{2t} + \alpha_{23}r_t + v_t \tag{15}$$

$$m_{3t} = deter + \alpha_{31}c_{3t} + \alpha_{311}c_{3(t-1)} + \alpha_{32}\tau_{3t} + \alpha_{321}\tau_{3(t-1)} + \alpha_{13}r_t + w_t \tag{16}$$

Where deterministic part may include an intercept, a time trend, and seasonal dummies appropriately based on statistical significance. The test of cointegration at all the three frequencies can be carried out by testing the OLS estimated regression residuals $\widehat{u_t}$, $\widehat{v_t}$ and $\widehat{w_t}$ for the presence of unit roots. These tests are based on the following auxiliary regressions augmented by necessary lagged values:

$$\Delta u_t = \gamma_1 u_{t-1} + \sum_{j=1}^{p} \beta_j \Delta u_{t-j} + e_t \tag{17}$$

$$v_t + v_{t-1} = \gamma_2(-v_{t-1}) + \sum_{j=1}^{p} \beta_j (v_{t-j} + v_{t-j-1}) + e_t \tag{18}$$

$$w_t + w_{t-2} = \gamma_3(-w_{t-2}) + \gamma_4(-w_{t-1}) + \sum_{j=1}^{p} \beta_j (w_{t-j} + w_{t-j-2}) + e_t \tag{19}$$

The tests for non-cointegration at the zero and biannual frequency are based on the t statitistics t_1 and t_2 for the null hypothesis$\gamma_1 = 0$ and$\gamma_2 = 0$. With the aids of F statistics,F_{34}, we test for the presence of noncointegration at the annual frequency for the null hypothesis $\gamma_3 = \gamma_4 = 0$. The critical values for this test statistics can be found from EGHL (1993).

<Insert Table 3 here>

Table 3 presents the results of the seasonal cointegration tests. The cointegrating regression at zero frequency is run with intercept and time trend while cointegration regression at the biannual and annual frequency is run with intercept and three seasonal dummies. The results of cointegration at zero and annual frequency indicates that the predicted residuals from equation (14) and (16) has the presence of unit root. In other words, we may infer that there is the absence of long-run cointegrating relationship among real currency, real consumption, tax-GDP ratio and deposit rate. Similarly, the predicted residuals from equation (15) indicate the absence of unit root at the biannual frequency indicating that our cointegration results support the hypothesis of cointegration at the biannual frequency. This can be interpreted as evidence in favor of a parallel movement in the seasonal components of variables under study (Bohl & Sell, 1998).

Since there is evidence of cointegration only at the biannual frequency, there is a lack of strong statistical foundation for the usage of seasonal error correction model (SECM). However, we use general-to-specific approach, which is a compromise between a pure SECM and a traditional regression-based approach. Hence, we begin with an extremely general model and pare it down by testing various coefficient restrictions (Enders, 2008). Hence after simplification of the general specification and following EGHL (1993) our SECM for demand for real currency is:

$$\Delta_4 m_t = \underset{(-1.01)}{-0.089} + \underset{(0.72)}{0.110 D_1} - \underset{(-4.43)}{0.199 D_2} + \underset{(2.60)}{0.454 D_3} + \underset{(7.41)}{1.880 \widehat{v_{t-1}}} - \underset{(-4.08)}{0.500 \Delta_4 m_{t-1}} + \underset{(5.78)}{0.343 \Delta_4 c_{t-1}}$$
$$+ \underset{(4.04)}{0.265 \Delta_4 c_t} + \underset{(2.26)}{0.705 \Delta_4 \tau_t} + \underset{(0.34)}{0.636 \Delta r_t} \tag{20}$$

Sample 1996:1-2014:4 (N=76); Adj. R-Squared =0.92; Durbin-Watson=2.08; Jarque-Bera=0.77 (p-value); ARCH(1) =0.47 (p-value); ARCH(2)=0.74 (p-value)

We have taken an intercept and three seasonal dummy variables as a deterministic term. The lag selection for the error correction term is based on EGHL (1993). The t-statistics in parenthesis indicate that all estimated coefficients, except deposit rate, are significant at 5% level with the correct sign. As the error correction term in the traditional ECM is required to be negative in order to adjust towards equilibrium, however, the seasonal error correction term $\widehat{v_{t-1}}$ is found to be highly significant but positive. In the conventional ECM, this implies that the adjustment will cause the system to deviate gradually from the equilibrium. However, in the case of SECM, Chung-Hua & Tai-Hsin (1999) and Lee (1992) infer that the sign of speed of adjustment may be non-negative subject to some restrictions. Hence the positive error correction term $\widehat{v_{t-1}}$ in equation (20) does not imply deviation from equilibrium. Additionally, the large coefficients of error correction term imply that the speed of adjustment is quite fast.

The positive and significant coefficient of consumption (income variable) is in line with the finding of previous literature. Similarly, positive and significant tax-GDP ratio is line with the finding of most of the studies (Cagan, 1958; Drehmann, Goodhart, & Krueger, 2002; Porter & Judson, 1996; Rogoff et al., 1998). However, the insignificant and positive coefficient of deposit rate implies that currency demand is unresponsive to changes in the interest rate variable in the short run. Furthermore, diagnostic tests suggest that the model in equation (20) is well specified with very high adjusted R-squared, and no sign of serial correlation, heteroscedasticity and misspecification is found. In sum, equation (20) captures the behavior of the currency demand quite well in the short run.

Parameter stability

The absence of cointegration at zero and annual frequency among time series variables under study indicates the possibility of the presence of instability in the currency demand equation. Hence, we perform several parameter stability test using equation (20) to confirm it.

The first method to be applied is based on estimating equation (20) by recursive least squares that start from a small data subset and enlarges this subset iteratively by adding the next observation of the time series to the last subset used. After completion of this recursive estimation of the model, various elements have been used to judge the degree to which the hypothesis of parameter constancy has not been fulfilled: recursive residuals, CUSUM, CUSUMSQ and the estimated recursive coefficients.

<Insert Figure 1 here>

Figure 1 presents results of various stability tests. The test for recursive residuals and CUSUMSQ does not reject the null of stability at 5% level while CUSUM test rejects the parameter stability hypothesis. Looking at the coefficients obtained from recursive least square, we find the presence of instability in the error correction terms towards the middle of the sample period, possibly due to access to the internet followed by proliferation of the electronic payment system in the Indian economy. Besides, and more importantly, our sample period (1996-2014) witnessed a number of institutional and structural transformation, especially in the banking sector. Hence, a fixed parameter model does not appear suitable for dealing with fast changing economy; therefore, a time varying parameters model allowing for changes in structural changes, especially related financial innovation, is estimated in the following section.

A state space model incorporating financial innovation

Following Stracca (2003), a state space (time-varying parameters) model is estimated on the demand for currency in India. Apart from its methodological superiority, an analysis by the state space methodology also evaluates the possibility of plausible forms of financial innovation onto currency demand in India. Moreover, Bomhoff (1991) also shows that the state space approach can effectively model some types of financial innovation separately, thereby increasing the explanatory power of the analysis.

By specifying a time varying parameters model, we explicitly allow the possibility of time variation in the deposit rate semi-elasticity of currency demand. The model is specified as:

$$log(m_t) = deter + \beta \log(c_t) - \gamma_t r_t + \mu \tau_t; \qquad \varepsilon_t \sim NID(0, \sigma_\varepsilon) \qquad (21)$$

$$\gamma_t = \gamma_{t-1} + \epsilon_t; \qquad \varepsilon_t \sim NID(0, \sigma_\varepsilon) \qquad (22)$$

Where equation (21) is observation equation and equation (22) is state equation. State equation is modeled as a random walk process. The deterministic term includes constant, seasonal dummies and time trend.

In this specification, like Stracca (2003), a shock is introduced to the deposit rate semi-elasticity of currency demand. The justification for this inclusion can be argued on the basis of some theoretical research (Glennon & Lane, 1996; Gurley et al., 1960; Ireland, 1995) that has shown that the presence of financial innovation may have a significant impact on the interest rate elasticity of demand for the existing monetary assets. For example, access to internet banking might also tend to change the deposit rate elasticity of currency holdings (in particular, increases over time as hypothesized by Gurley et al., 1960), as people may find it less costly to adjust their portfolio of currency and deposits following changes in the interest rate (Stracca, 2003).

We estimate the time-varying parameters model in equation (21)-(22) by means of Kalman filter for the similar sample period. The Kalman filter approach requires maximizing the likelihood functions using an optimization algorithm. The issue of non-stationarity data is also taken care by the Kalman filter technique because states are always taken conditional on their last realization.

<Insert Figure 2 here>

Figure 2 presents the results based on state space model. The model appears to be well specified, and residuals seem to be stationary, well behaved and normally distributed at least at the 5% level of significance (Figure 2(A) and 2(B)). Since the coefficient of deposit rate in equation (21) is semi-elasticity, we also need to calculate the deposit rate elasticity to prove our hypothesis. Figure 2(C) presents the time-varying deposit rate semi-elasticity and deposit rate elasticity that move in a similar direction. The time-varying deposit rate elasticity of currency demand tends to decrease continuously from the year 1998 to 2010 while there has been a gradual increase in the deposit rate elasticity beginning from the year 2010, thus evidence in support of Gurley-Shaw hypothesis. Such an increase can be straightforwardly associated with the acceptability of modern banking systems in terms of payment technology by the general public due to a gradual increase in accessibility of communication technology like internet and mobile. Additionally, the period around the year 2010 also witnessed a proliferation in the e-commerce business, especially in the retail sector, which requires non-cash payments to be made for the transactions carried out. Besides, the period also witnessed a rise in various interest-bearing money-like assets. Hence, we can conclude that the transition to a modern banking regime and the emergence of new financial products brought about an increase in agents' degree of preference for liquidity.

3. Conclusion

Based on the *money-in-the-utility* function, this paper examines the stability of the currency demand function for India with real private consumption expenditure, tax-GDP ratio and deposit rate as explanatory variables by applying the seasonal cointegration technique based on EGHL (1993) and HEGY (1990). The empirical findings show that there is the absence of long-run relation among the variables at zero and annual frequency, however, there is evidence of a cointegrating relationship among the variables at the biannual frequency. Moreover, the coefficients of SECM are found to be correctly signed and statistically significant for the India's currency demand for the period 1996:1 to 2014:4.

Additionally, we also try to detect the presence of financial innovation in the currency demand equation by testing the Gurley-Shaw hypothesis using a time-varying parameter model. The time varying coefficient of deposit rate elasticity suggests to accept the hypothesis that innovations in the financial markets, especially in the banking sector in terms of improvements in the payment technology, raises the deposit rate elasticity. All these evidence suggest that there would be shrinkage of currency demand in future. From the monetary policy angle, the RBI should be able to adapt adequately to a situation of shrinking demand for currency.

On the whole, the findings of the paper suggest that there are solid theoretical and empirical reasons to incorporate financial innovation when modeling demand for currency. While it is difficult to accurately predict the path of financial innovation by using a proxy, it is still beneficial to model its presence in some way, so as to better recover estimates of the other parameters in the currency demand function. The time-varying parameter of opportunity cost approach adopted in this study presents a fundamental step towards obtaining unbiased estimates of the parameters that characterize currency demand.

There are several limitations to the study, mostly arising from non-availability of relevant data. Though we have used tax-GDP ratio as a measure of the shadow economy, marginal tax rate and unemployment rate, however, would have been most appropriate variable in this regards. Secondly, instead of using a proxy for financial innovation, the actual data on payment technology would have shown more clear direction regarding the impact of modern payment systems on the behavior of currency demand. The actual data on these variables is available only from 2005 onward, which is quite short for robust analysis. However, despite these limitations, our results have given some directions in the scarce currency demand literature.

The future research agenda, apart from carrying out a similar exercise for denomination wise currency in circulation, would be to estimate regional demand for currency for India. However, the data requirements for such an exercise would be challenging. Nevertheless, given the recent advances in data management practices by the RBI, such exercise may be doable.

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Table 1: Variable definitions and their sources (1996:1-2014:4)

Variable	Definition	Source
Currency in Circulation (m_t)	Logarithm of quarterly averages of monthly seasonally unadjusted currency in circulation deflated by private final consumption expenditure deflator	RBI Database on Indian Economy and authors calculation
Consumption (m_t)	Logarithm of private final consumption expenditure at constant price 2011-12	National Accounts Statistics, MOSPI
Opportunity Cost (r_t)	Average commercial bank term deposit (maturity of 1-3 years) rate	RBI Database on Indian Economy
Tax Evasion (τ_t)	Ratio of total tax to GDP at current price	Public Finance Statistics, Ministry of Finance and CMIE

Table 2: Results of seasonal unit root tests

Variable	Deterministic Trend	Zero	Biannual	Annual	lag
CIC	I	-3.10	-1.30	1.19	12
	I, Trend	1.62	-1.89	1.44	9
	I, SD	-2.48	-1.32	6.75*	8
	I, SD, Trend	2.18	-2.10	6.74*	7
PFCE	I	-2.30	-1.14	2.25	12
	I, Trend	-1.40	-1.08	2.22	12
	I, SD	-2.40	-0.04	2.54	12
	I, SD, Trend	-1.32	-0.18	2.40	12
TAX	I	-1.42	0.66	0.22	1
	I, Trend	-1.79	0.66	0.23	1
	I, SD	-1.42	-1.06	5.16*	1
	I, SD, Trend	-1.92	-1.09	5.39	1
Interest	I	-2.33	-3.17*	11.19*	2
	I, Trend	-2.12	-3.15*	10.99*	2
	I, SD	-2.29	-3.51*	12.67*	2
	I, SD, Trend	-2.11	-3.47*	12.42*	2

Notes: * denotes statistically significant at 1%. Test for zero and biannual frequency is based on t-statistics while test for annual frequency is based on F statistics based on HEGY test. Critical values are from HEGY (1990) and Monte Carlo simulation. *I* indicates an intercept and *SD* indicates three seasonal dummies. 'lag' is the number of lag based on AIC criteria.

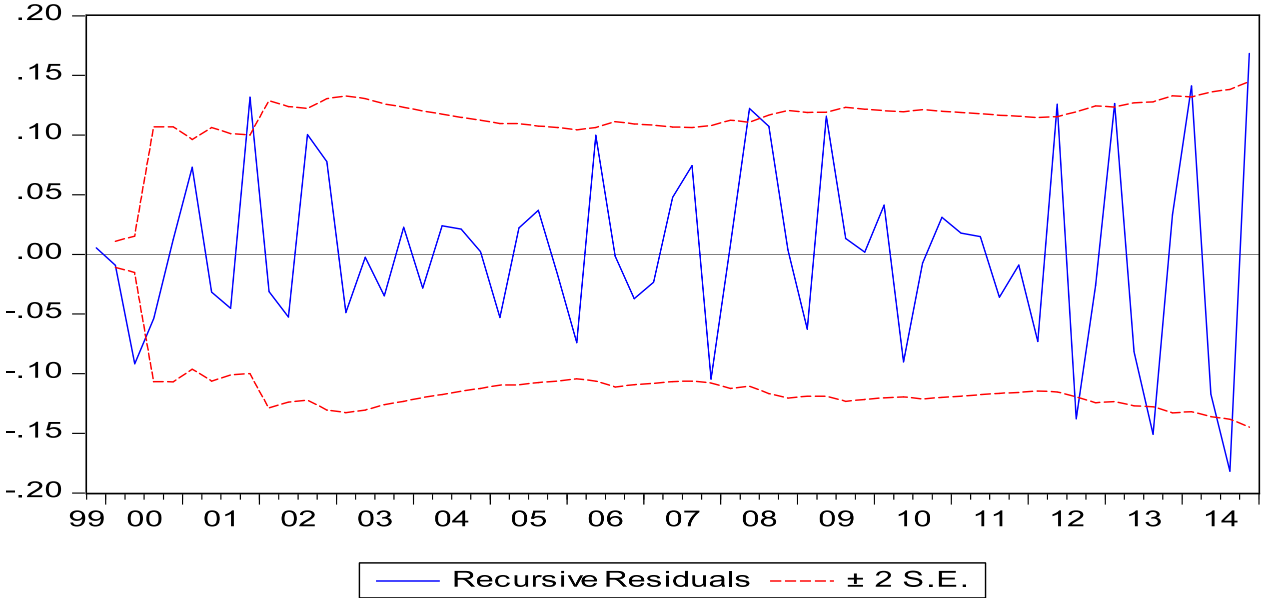
Table 3: Tests for seasonal cointegration at long run and seasonal frequencies

Dependent Variable	Cointegrating Equation				Auxiliary regression	
	Independent Variable		Deterministic Components	Adj. R-squared	Lag	Unit root test in residuals
(1) CIC1t	PFCE1t	1.292***	I, Trend	0.99	2	-1.12
	TAX1t	5.799***				
	INT1t	-7.378***				
(2) CIC2t	PFCE2t	0.069	I, SD	0.63	3	-3.46**
	TAX2t	2.055***				
	INT2t	0.295				
(3) CIC3t	PFCE3t	0.470***	I, SD	0.62	3	1.38
	PFCE3(t-1)	-0.056				
	TAX3t	-0.533				
	Tax3(t-1)	1.200**				
	INT3t	0.304				

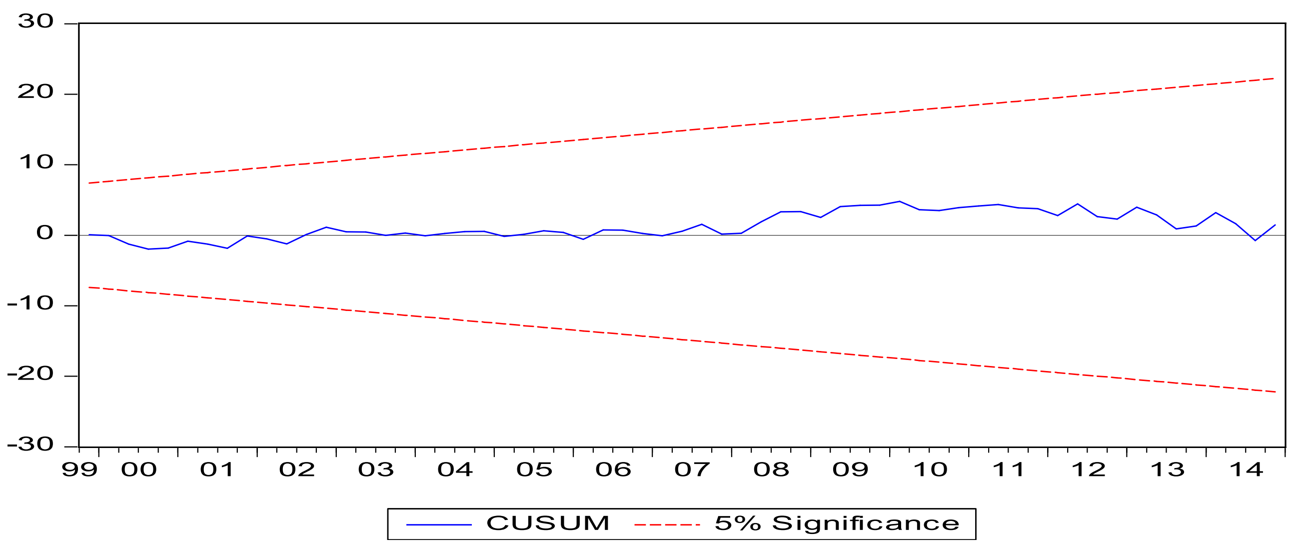
Notes: (1), (2) and (3) are based on equation (13), (14) and (15) respectively. *, ** and *** indicates statistically significant at 10%, 5% and 1% respectively. Critical values are from HEGY (1990) and Monte Carlo simulation. *I* indicates an intercept and *SD* indicates three seasonal dummies. 'lag' is the number of lag based on AIC criteria.

Figure 1: Stability test for seasonal error correction model (A) Recursive residuals (B) CUSUM (C) CUSUMSQ (D) Recursive estimates of the coefficients in equation (19)

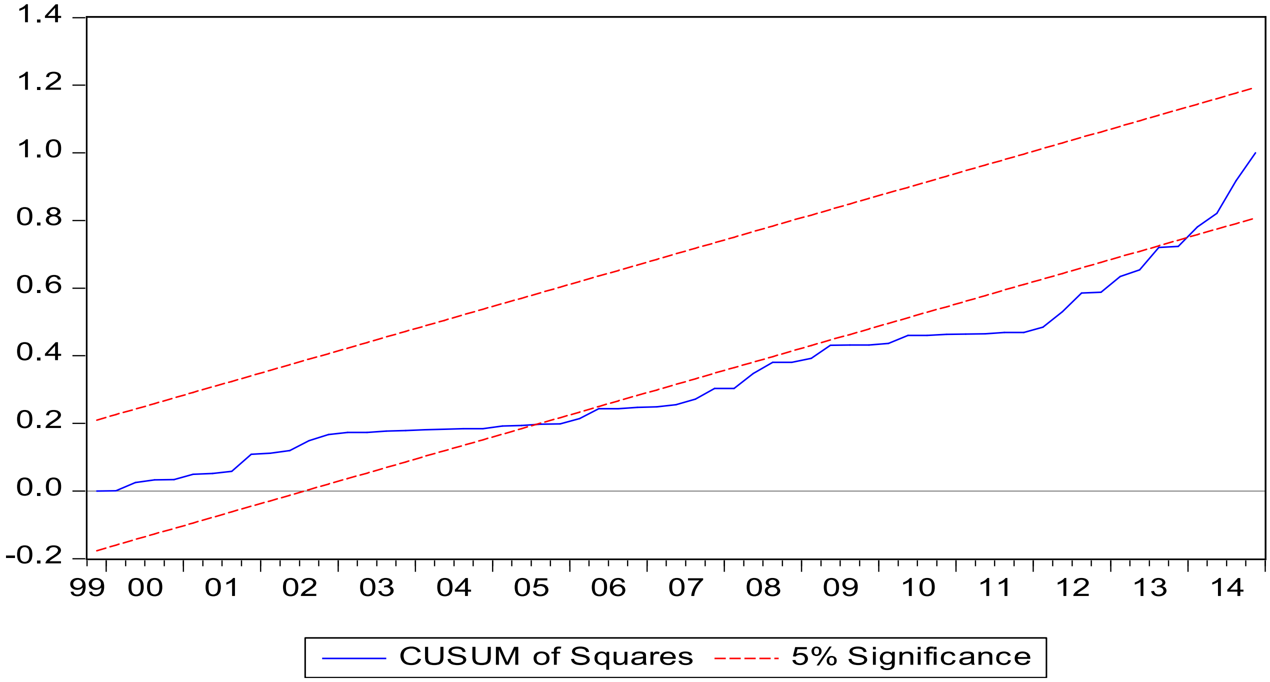
(A)



(B)



(C)


1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14
CUSUM of Squares
5% Significance

(D)

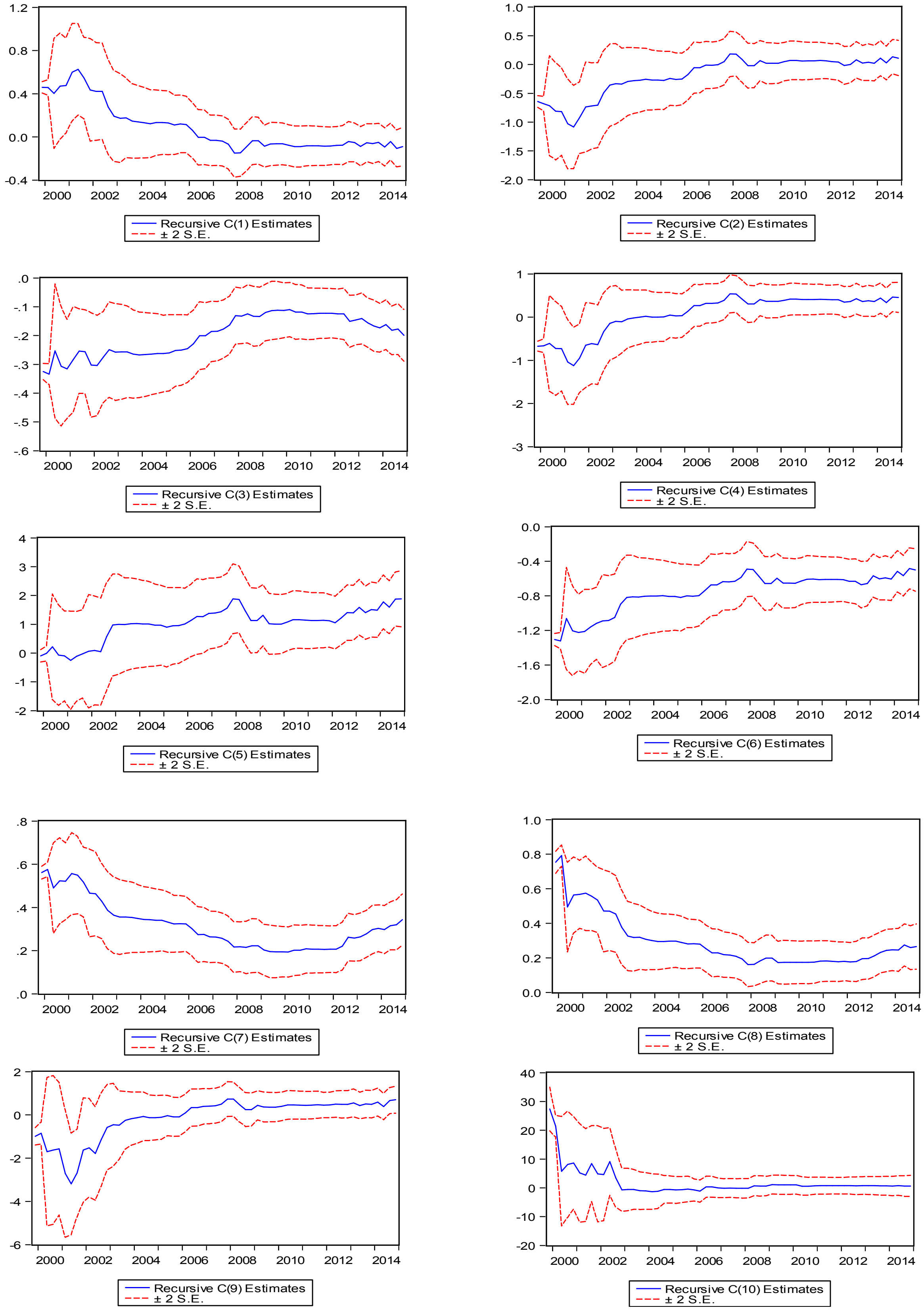
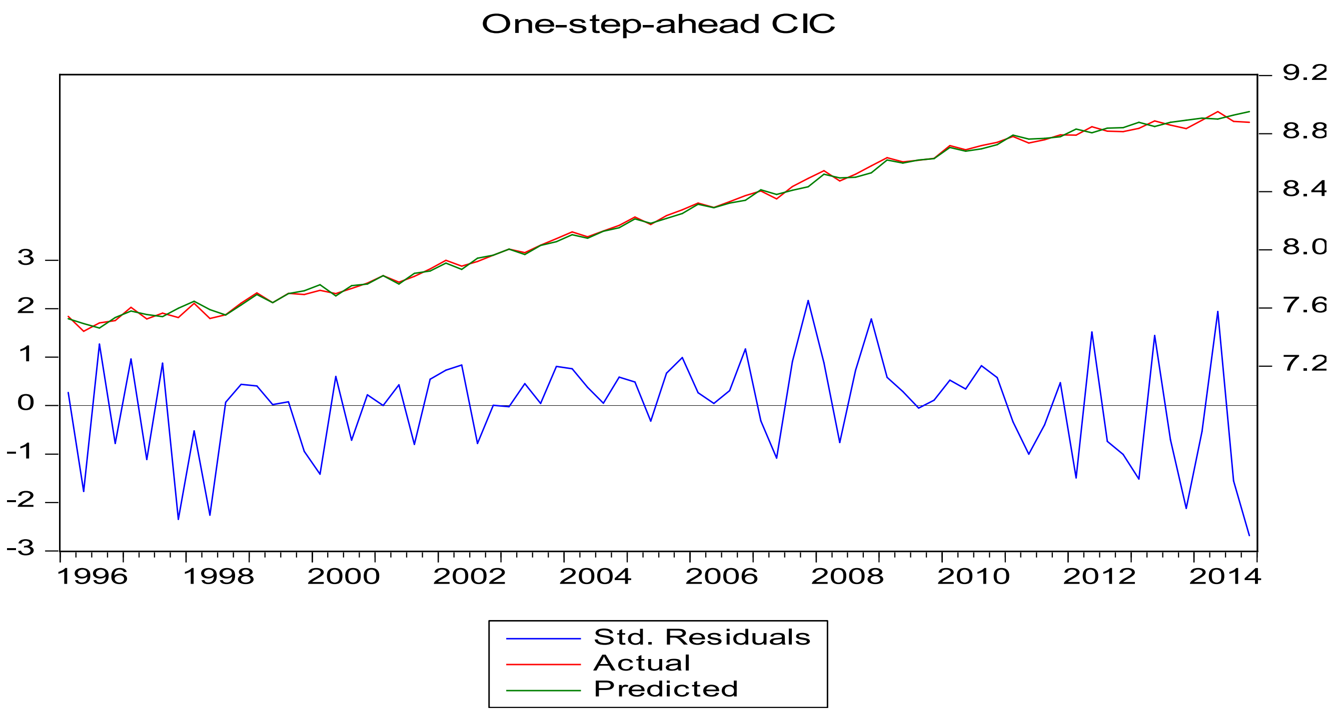
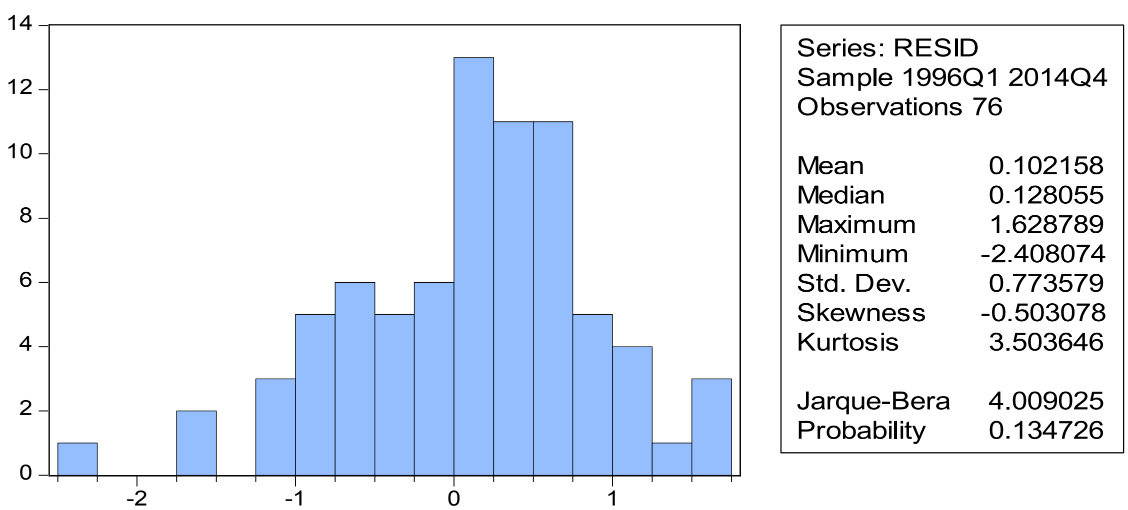

Recursive C(1) Estimates
± 2 S.E.
Recursive C(2) Estimates
± 2 S.E.
Recursive C(3) Estimates
± 2 S.E.
Recursive C(4) Estimates
± 2 S.E.
Recursive C(5) Estimates
± 2 S.E.
Recursive C(6) Estimates
± 2 S.E.
Recursive C(7) Estimates
± 2 S.E.
Recursive C(8) Estimates
± 2 S.E.
Recursive C(9) Estimates
± 2 S.E.
Recursive C(10) Estimates
± 2 S.E.

Figure 2: Results based on state space model (estimation by Kalman filter technique) (A) Fitted values and residuals (B) Statistics on residuals (C) time-varying deposit rate semi-elasticity and deposit rate elasticity of currency demand

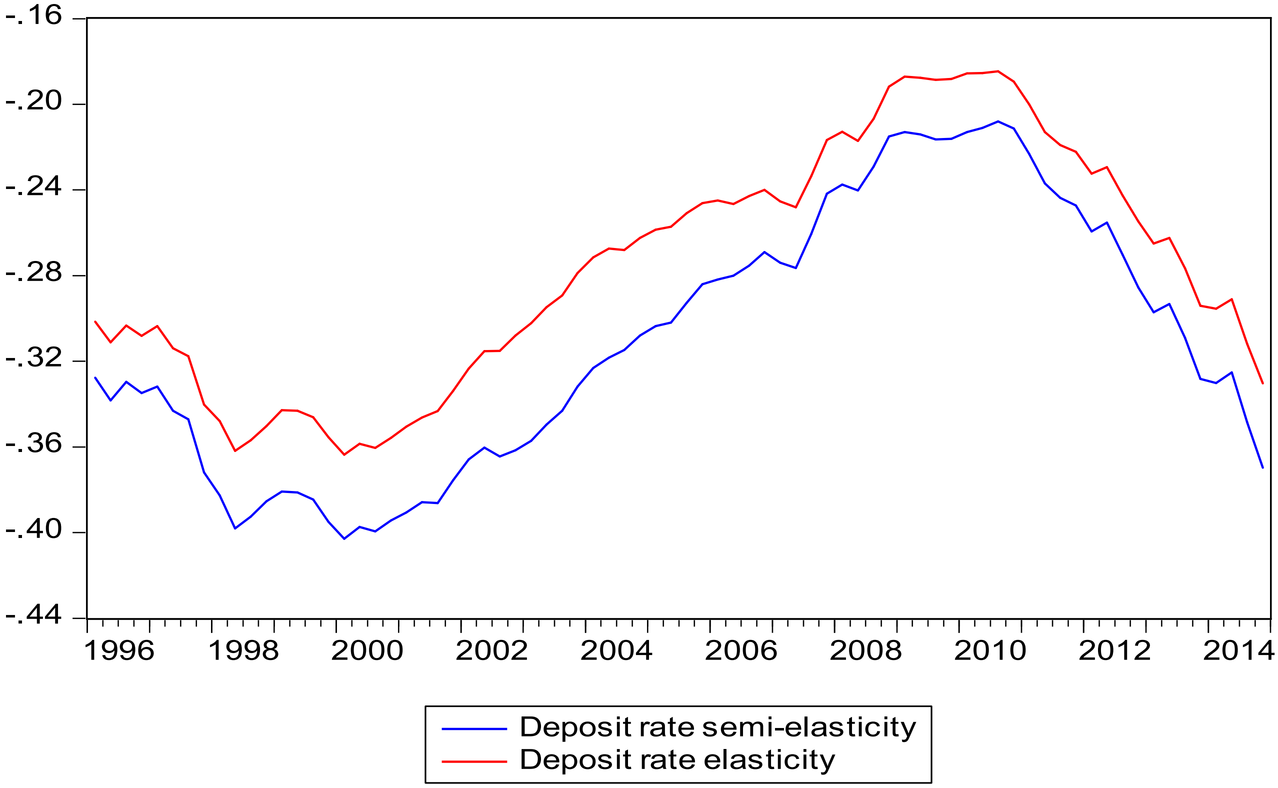
(A)



(B)



(C)


-.16
-.20
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-.40
-.44
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Deposit rate semi-elasticity
Deposit rate elasticity