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Estimation of price level in India through state-space model

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Abstract

This paper explores to estimate two alternative models for the price level in India using certain economic variables and tests the stability of the parameters over time through the application of state-space model for the period April 1994 to March 2007. In the paper, price level is measured by the Wholesale Price Index - excluding the Fuel, Power, Light and Lubricants group. The first model explores the impact of only domestic variables on price level, while the alternative model explores both domestic as well as selected international variables. Empirically, money supply, manufacturing sector output and prices of industrial raw materials are found to have significant impact on domestic price level. The metal price in the international market has also emerged as an important determinant of the domestic price level in the recent years.

Key words: State-space model; Time varying parameter; X-12-ARIMA; Inflation; Money supply

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1 Introduction

One of the major objectives of the monetary and fiscal policy is to keep control of the price level in the economy. The price level is influenced by various factors that may include both domestic as well as international factors. For this purpose, the policy makers need to assess the possible impact of these factors on the domestic price level, which can be measured through a stable model. The objective of the paper is to develop a model for the price level in India and test the stability through the time varying parameter approach, which is a particular case of the state-space model. This approach captures the changes in the parameters of the model due to structural changes in the economic systems. Brown *et. al* (1997) applied the time varying parameter approach to forecast house prices in the United Kingdom. Singh (2005) estimated the annual price level in India through the time-varying parameter approach under the co-integration framework wherein the long-run relationship for the price level was postulated as a function of broad money and real output.

In India, two alternative measures of price indices are compiled – the Wholesale Price Index (WPI) and Consumer Price Index (CPI). Officially, inflation is measured through WPI as the coverage in the WPI basket is broader than the CPI basket. For empirical analysis, WPI has been used to represent the price level in India in the present paper.

The remainder of the paper is organized as follows. Section 2 describes potential variables that may play a vital role in determining the price level in India, along with the data sources with some statistical analysis. Section 3, describes the methodology of the time varying parameter approach under the state-space model, briefly. Section 4 covers formulation of the model to estimate the price level in India. Results based on the empirical analysis are discussed in Section 5. Finally, Section 6 concludes.

2 Description of the variables, data sources and analysis

2.1 Description of the potential variables used in the study

The WPI series is divided into three major groups – the Primary Articles (PA), Fuel Power Light & Lubricants (FPLL) and Manufactured Products (MP). For empirical analysis in this paper, the WPI series after excluding FPLL, has been used to represent the price level in India.

Instability in the domestic price level can occur due to various factors, *viz*. demand factors, cost factors, supply factors and movement in certain international commodity prices. A rise in the demand and cost factors is expected to push up the price level. Similarly the prices of certain commodities in the domestic market are expected to move in tandem with the international market prices. On the other hand, increase in the supply factors is expected to ease pressure on the domestic price level.

In the paper, the demand factor is presented through money supply. An increase in the money supply is expected to increase the demand in the economy and in turn put pressure in the price level. The monetary policy in India speaks about two alternative measures of money supply - the Narrow Money (M1) and Broad Money (M3) [1]. Empirically, it has been found that M1 is more closely related to WPI than M3 in India (Pethe and Samanta, 2001 and Bordoloi, 2005). For further analysis, M1 has been used to represent the money supply.

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1 See Appendix-I for different measure of money supply compiled in India.

An increase in the cost of production is expected to lead to an increase in the price of the final product. The cost of production is represented by the wholesale market based industrial raw material prices.

From the supply point of view, an increase in the supply is expected to ease the price level. The prices of the commodities covered under the primary articles and manufactured products group depend on the agricultural production and the production in the manufacturing sector, respectively. As the agricultural production data are available on an annual basis, foodstocks with the Government of India agencies (comprising of rice and wheat stocks) has been used as a proxy for the agricultural production. The Index of Industrial Production of the manufacturing sector (IIPMAN) has been used to represent the manufacturing sector output.

The various external sector reforms initiated by the Government of India since the first half of the 1990's, led to higher integration of movement of domestic commodity prices with the international commodity prices. For measuring the possible impact of the international commodity prices on the domestic price level, two groups of commodities *viz.*, metals and edible oils, have been selected. An increase in the prices of these two groups of commodities in the international market is expected to result in a corresponding increase in the domestic price level in India.

An appreciation of the domestic currency lowers the import cost and is expected to lowers the prices of imported commodities. In India, two alternative measures of index of nominal effective exchange rate of the Indian Rupee are compiled based on the trade based weights. The first is based on 6-countries trade based weights, while the second is based on 36-countries. An increase in the index value indicates an appreciation of the Indian Rupee, which is expected to lower the domestic price level. In this paper, the Nominal Effective Exchange Rate (NEER) of the Indian Rupee based on 36-countries trade based weights has been selected for further analysis.

2.2 Data Sources

The monthly data for the variables Wholesale Price Indices, M1, production in the manufacturing sector and Nominal Effective Exchange Rate are collected from the *Handbook of Statistics on Indian Economy* published by the Reserve Bank of India. Data on Foodstocks with the Government of India agencies are obtained from the Ministry of Food, Consumer Affairs and Public Distribution, Government of India. Data on the two selected international commodity prices, *viz.*, metals and edible oils are collected from the International Monetary Fund Database on commodity prices. Table-1 presents the data sources of the selected variables covered in the study. The sample covers the period from April 1994 to March 2007.

Table 1: Variable description and data sources

Variables	Description	Data Sources
WPI – excluding FPLL	WPIE	Reserve Bank of India
Manufacturing sector output	IIPMAN	Reserve Bank of India
Foodstocks	FOOD	Ministry of Food, Consumer Affairs & Public Distribution, Government of India
Narrow Money	M1	Reserve Bank of India
Industrial raw materials price	INDRM	Reserve Bank of India
International metals price	IMP	International Monetary Fund
International edible oils price	IEO	International Monetary Fund
Nominal Effective Exchange Rate	NEER	Reserve Bank of India

2.3 Deseasonalisation of data

All the variables are deseasonalised using the X-12-ARIMA technique, developed by the US Bureau of Census (1999). Initially all the variables are tested for presence of seasonality using F-test, as proposed in the X-12-ARIMA technique. Assuming a multiplicative model, the original series y is assumed to be represented by the three components,

$$y = TC \times S \times I$$

where TC, S and I represents the trend-cycle, seasonal and irregular Components respectively.

The first step is to compute an estimate of the Trend-Cycle component using a 12 term moving average for y. The estimate for the Trend-Cycle (say TC_1) is divided into y to eliminate the TC term from the decomposition. This result in unmodified SI (Seasonal-Irregular) ratios:

$$\frac{y}{TC_1} = S \times I$$

The next step is to treat the extreme values of these SI ratios. Preliminary seasonal factors (S_1) are computed by using moving average of like months. This estimate of the seasonal components is then divided into the SI ratios to give a preliminary estimate of the Irregular component:

$$\frac{S \times I}{S_1} = I_1$$

The X-12-ARIMA technique applies various filters to derive the final SI-ratios. Let SI^F denote the estimated final SI ratios. The statistical definition of seasonality is defined as,

$$SI_{it}^{F} = SI_{it}^{F*} + u_{it}$$

where SI_{it}^{F} = estimated final SI-ratio for the i^{th} month in the t^{th} year

SI_{it}^{F*} = mean value of the SI- ratio for the i^{th} month

u_{it} = residual part

Test for the presence of seasonality is the standard ANOVA test for equality among the final SI-ratios. Rejection of the null hypothesis indicates the presence of seasonality.

Table-2 presents the summary of the empirical results. The F-statistic's are found to be significant at 1 percent level of significance, suggesting existence of seasonality for all the variables. Further empirical analysis has been done based on the seasonally adjusted data for all the variables.

Table-2: Test for the presence of seasonality[2]

Variables	F-test	Remark
WPIE	36.43*	Presence of seasonality
IIPMAN	129.40*	Presence of seasonality
FOOD	21.02*	Presence of seasonality
M1	57.66*	Presence of seasonality
INDRM	2.99*	Presence of seasonality
IMP	3.99*	Presence of seasonality
IEO	3.21*	Presence of seasonality
NEER	6.43*	Presence of seasonality

* indicates significance at 1 percent level.

[2] See Appendix-II for detailed F-test results.

2.4 Testing for stationarity

After adjusting for seasonality, all the variables are tested for non-stationarity using the Augmented Dickey- Fuller (ADF) test. The general form of the ADF test is estimated by using the regression,

$$\Delta y_t = a_0 + bt + \alpha y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta y_{t-i} + \varepsilon_t$$

where a_0 is a constant, t represents deterministic trend and the lag length *'m'* of differences are incorporated to ensure that error term ε_t becomes white noise. The lag length *'m'* is determined based on the Akaike's Information Criterion (AIC).

The null hypothesis to be tested is defined as:

$$H_0 : \alpha = 0$$

against the alternative hypothesis,

$$H_1 : \alpha < 0$$

The null hypothesis assumes that the variable in the examined form is non-stationary, *i.e.* has a unit root. The test statistic is defined as,

$$t_\alpha = \frac{\hat{\alpha}}{se(\hat{\alpha})}$$

where $\hat{\alpha}$ is the estimate of α and $se(\hat{\alpha})$ is the standard error.

Dickey and Fuller (1979) showed that under the null hypothesis of a unit root, this statistic does not follow the conventional Student's t-distribution and they derived asymptotic results and simulate critical values for various test and sample sizes. Later, MacKinnon (1991, 1996) implements a much larger set of simulations than those tabulated by Dickey and Fuller. Further, MacKinnon estimated response surfaces for the simulation results, permitting the calculation of Dickey-Fuller critical values and *p*-values for arbitrary sample sizes.

The empirical results pertained to the ADF-test are presented in Table-3. The *p*-values for all the variables, except NEER, are found to be quite large, which lead to the acceptance of the null hypothesis of non-stationarity in case of all the variables at the levels.

Table 3: ADF test results

Variables	Appropriate Lag Length (m)	AIC	ADF Test Statistic	Critical Value (at 5% level)	*p*-value*
WPIE	1	1.72	5.67	-1.94	1.00
IIPMAN	24	4.78	3.57	-2.88	1.00
FOOD	5	3.58	-2.25	-2.88	0.19
M1	16	19.99	4.84	-3.44	1.00
INDRM	1	4.01	-2.12	-3.44	0.53
IMP	12	5.82	1.94	-3.44	1.00
IEO	1	11.40	-0.02	-1.94	0.67
NEER	1	2.84	-3.23	-3.44	0.05

*The *p*-values are MacKinnon (1996) one-sided *p*-values.

3 Methodology of Time Varying Parameter approach under state-space model

The Time Varying Parameter approach is based on the assumption that parameters are assumed to follow some underlying processes over time. These time varying parameters are formulated under the state-space model and estimated using the Kalman filter algorithm. The state-space model originated in the field of engineering (Kalman, 1960) and was later applied into economics by Rosenberg (1973). Kalman filter is applied to work with non-stationary data as the filters produce distribution of the unobservable variables, also known as state variables. The general form of the Kalman filter model comprise of two equations – the measurement and transition equations.

The measurement equation is given by –

$$A_t = B\alpha_t + e_t, \quad \text{var}(e_t) = R \tag{3.1}$$

and the transition equation is given by –

$$\alpha_t = T\alpha_{t-1} + v_t, \quad \text{var}(v_t) = Q \tag{3.2}$$

The measurement equation (3.1) is an ordinary regression equation with time-varying parameter α_t, while the transition equations (3.2) define the evolution of the parameters over time. Here A_t represents the *(n*x*1)* vector of n- observable variables and α_t is a *(r*x*1)* vector of r unobservable components. B and T represent matrices of order *(n*x*r)* and *(r*x*r)* respectively. e_t and v_t are Gaussian error vectors of order *(n*x*1)* and *(r*x*1)* respectively.

If one has an estimate of α_{t-1} and its mean square error, P_{t-1}, then the updated estimate of α_t, given A_t and B_t, is estimated by the following Kalman-filter algorithm:

$$\left.\begin{aligned} S_t &= TP_{t-1}T' + Q \\ P_t &= S_t - K_t B S_t \\ \alpha_t &= T\alpha_{t-1} + K_t(A_t - B\alpha_{t-1}) \end{aligned}\right\} \tag{3.3}$$

The matrix K_t, referred as the Kalman gain matrix, is defined as,

$$K_t = S_t B'(BS_t B' + R)^{-1} \tag{3.4}$$

The problem is to develop appropriate estimates for the four unknown parameters of the model $\beta = \{B, T, R, Q\}$ and make inference about the state vector α_t.

For implementation of the Kalman filter, one has to specify initial values for the state vector α_0, its mean squared error P_0, and the parameters $\beta^{(0)} = \{B_0, T_0, R_0, Q_0\}$. Given these initial values, the sequence of state vector α and the mean square error P is computed using Kalman filter. These are then used to evaluate the Gaussian log-likelihood function,

$$\log L(\beta) = -\frac{nq}{2}\log(2\pi) - \frac{1}{2}\sum_t \log\left|BP_t B' + R\right| - \frac{1}{2}\sum_t e_t'(BP_t B' + R)^{-1} e_t \tag{3.5}$$

and find the next set of parameters $\beta^{(1)}$ and this completes one iteration. The next iteration starts with initial values α_0, P_0 and $\beta^{(1)}$ to obtain $\beta^{(2)}$ and so on, until convergence is achieved. In equation (3.5), 'q' represents the number of observations.

4 Formulation of the model under state-space methodology

In the present paper, at attempt has been made to explore two alternative models for the price level in India. The first model assumes that the domestic price level is influenced by the domestic variables only, while the second model assumes that the price level is influenced by both domestic as well as international variables.

The time varying parameter approach has been applied to estimate and test the stability of the two alternative models. The models are formulated through state-space model and the estimates are obtained by maximizing the log-likelihood function through a recursive algorithm. The specification of the model based on the domestic variables, has been formulated under the state-space form as,

$$\log(WPIE_t) = b_{0t} + b_{1t}\log(M1_t) + b_{2t}\log(IIPMAN_t) + b_{3t}\log(FOOD_t) + b_{4t}\log(INDRM_t) + e_t \tag{4.1}$$

$$b_{0t} = b_{0,t-1} + u_{0t} \tag{4.2}$$

$$b_{1t} = b_{1,t-1} + u_{1t} \tag{4.3}$$

$$b_{2t} = b_{2,t-1} + u_{2t} \tag{4.4}$$

$$b_{3t} = b_{3,t-1} + u_{3t} \tag{4.5}$$

$$b_{4t} = b_{4,t-1} + u_{4t} \tag{4.6}$$

Equation (4.1) is the measurement equation. It states that the price level depends on the money supply, manufacturing sector output, foodstocks and industrial raw material prices. The coefficients b_{1t}, b_{2t}, b_{3t} and b_{4t} measures the elasticity of money supply, manufacturing sector output, foodstocks and industrial raw material prices on the domestic price level respectively at time 't'. Equations (4.2) through (4.6) are the transition equations that consist of the entire regression coefficient.

Similarly, the specification of the model based on both domestic and international variables, can be formulated under the state-space form as[3],

$$\log(WPIE_t) = b_{0t} + b_{1t}\log(M1_t) + b_{2t}\log(IIPMAN_t) + b_{3t}\log(INDRM_t) + b_{4t}\log(IEO_t) + b_{5t}\log(IMP_t) + b_{6t}\log(NEER_t) + e_t \tag{4.7}$$

$$b_{0t} = b_{0,t-1} + u_{0t} \tag{4.8}$$

$$b_{1t} = b_{1,t-1} + u_{1t} \tag{4.9}$$

$$b_{2t} = b_{2,t-1} + u_{2t} \tag{4.10}$$

$$b_{3t} = b_{3,t-1} + u_{3t} \tag{4.11}$$

$$b_{4t} = b_{4,t-1} + u_{4t} \tag{4.12}$$

$$b_{5t} = b_{5,t-1} + u_{5t} \tag{4.13}$$

$$b_{6t} = b_{6,t-1} + u_{6t} \tag{4.14}$$

Equation (4.7) is the measurement equation, which states that the price level depends on the money supply, manufacturing sector output, industrial raw material prices, international edible oil prices, international metal prices and nominal effective exchange rate.

5 Estimates of the Price Model

The estimate of the state-space models have been carried out in the software E-Views Version 5.0. The empirical results of the two models are discussed in the following two sub-sections.

[3] Attempt was also made to estimate the model incorporating the variable FOOD in the model. However, the estimates were not found to be stable and hence the variable FOOD was dropped under this framework.

5.1 Model Estimates - domestic variables

The estimates of the variances of the residuals corresponding to the transition equations [equations (4.1) through (4.6)], estimated through the Kalman filter, are provided in Table-4. The variance estimates of the residuals of the state variables (co-efficients in the measurement equation) are found to be almost equal to zero. This indicates that the estimated values of the co-efficients b_{0t}, b_{1t}, b_{2t}, b_{3t} and b_{4t} are stable in nature.

Table 4: Variances estimates of the residuals of state variables

var(u_0)	var(u_1)	var(u_2)	var(u_3)	var(u_4)
1.74e-05	3.22 e-12	5.39 e-35	1.76 e-18	1.32 e-23

Figure 4.1 and Figure 4.2 presents the estimates of the co-efficients in the measurement equation and its standard errors at different time points. The standard errors for all the co-efficients of the variables have shown a declining trend, indicating tendency towards stability in the estimate of the co-efficients for all the variables. In the case of FOOD and INDRM, the standard errors remained almost constant since December 2003. From Figure 4.1-A, the co-efficient of the constant term since March 2000, moved within the range of 2.7 to 3.0, indicating the stability of the mean of the domestic price level. The co-efficients of the money supply are estimated to be positive during the sample period, indicating the positive impact of money supply on price level. The co-efficient of IIPMAN throughout the sample period is found to be positive, which violates the basic economic assumption '*increasing production reduces the price level'*. The positive co-efficients estimated for IIPMAN may be attributed to the fact that due to the increase in the domestic demand, producers tend to increase their production. In fact, it is the high domestic demand that leads to increase in the industrial production, which ultimately leads to an increase in the price level. Also, the co-efficient of INDRM has been showing an increasing trend, indicating emergence of cost of production as an important variable in determining the domestic price level in the recent period. The coefficients of INDRM are estimated to be positive suggesting that an increase in the cost of production leads to a further rise in the domestic price level. The estimate of the co-efficient of FOOD has been found to be negative, suggesting that the higher foodstocks helps in curbing the rising price level. Throughout the sample period, the parameter b_3 is found to be statistically non-significant, implying that possibly the impact of foodstocks in determining the domestic price level is negligible. One possible reason could be that foodstocks, comprising of only rice and wheat, does not properly represent the agricultural production in India.

Table-5 presents the estimates of the parameters of the model for March 2007. The estimates for the other months have not been reported due to space constraints, but the same can be observed from Figure-4.1 and Figure-4.2. The column $Co-efficient_t$ and

σ_t^2 presents the estimated value of the co-efficients in the measurement equation of the variables along with their variance for March 2007. During March 2007, the sign of all variables confirms economic theory. The positive sign found with the co-efficient of M1, IIPMAN and INDRM indicates that an increase in these variables is expected to push up the price level. During March 2007, the elasticity of money supply, manufacturing sector output and industrial raw materials prices on domestic price level are found to be 0.099, 0.034 and 0.178 respectively with estimate of the variance at 0.025, 0.021 and 0.034 respectively. However, the impact of IIPMAN on price level during March 2007 is found to be insignificant. On the other hand, no significant impact of FOOD on domestic price level could be established.

Table 5: Estimate of the price model (for t =March 2007)

Variables	Parameter	Co-efficient$_t$	σ_t^2	$Z-$statistic$_t$	$p-$value$_t$
Constant	b_0	2.730	0.342	7.990	0.000
M1	b_1	0.099	0.025	3.885	0.000
IIPMAN	b_2	0.034	0.021	1.603	0.109
FOOD	b_3	-0.002	0.006	-0.346	0.729
INDRM	b_4	0.178	0.034	5.318	0.000

5.2 Model Estimates - domestic and international variables

The estimates of the variances of the residuals corresponding to the transition equations [equations (4.8) through (4.14)] are provided in Table-6. The variance estimates of the residuals of the state variables (i.e. the co-efficients in the measurement equation) are found to be very small, approximately equal to zero. This suggests that the estimated values of the co-efficients in the model are stable in nature.

Table 6: Variances estimates of the residuals of state variables

var(u_0)	var(u_1)	var(u_2)	var(u_3)	var(u_4)	var(u_5)	var(u_6)
4.75 e-72	1.81 e-52	3.73 e-43	1.28e-16	2.25 e-16	6.35 e-49	9.05 e-07

Figure-4.3 and Figure-4.4 presents the time plot of values of the co-efficients along with its standard errors at different points of time. The standard errors for all the co-efficients show a declining trend, indicating tendency towards stability in the estimate of the co-efficients. The co-efficients of the money supply are estimated to be positive with a declining trend, indicates the lower impact of money supply on price level during the recent period. Similarly the co-efficients of IIPMAN have shown a declining trend but with positive co-efficients. The co-efficient of INDRM moved in a narrow range between 0.17 and 0.20 during the period. The estimates of the co-efficient of IEO and IMP have shown an increasing trend during the sample period. This suggests the emergence of IEO and IMP as important variables in determining the domestic price level. The co-efficient of NEER has the correct sign, but is found to be insignificant. Thus an appreciation in the value of the Indian Rupee helps in curbing the domestic price level in India, though not significantly.

Table-7 presents the estimates of the parameters of the model for March 2007. The signs of all the co-efficients of the selected variables confirm economic theory. In March 2007, the variables IEO and NEER are found to have no significant impact in determining the domestic price level. All other variables are found to have play a major role in determining the price level. The introduction of the three international variables, *viz.* IEO, IMP and NEER into the model have not destabilizes the model. Though no significant impact of the two variables IEO and NEER on the domestic price level could be established, estimate of the model without these two variables are found to have been quite unstable towards the end of the sample. Hence, both the variables IEO and NEER have been kept in the model.

Table 7: Estimate of price model (for t = March 2007)

Variables	Parameter	Co-efficient$_t$	σ_t^2	Z-statistic$_t$	$p-$value$_t$
Constant	b_0	2.287	0.326	7.006	0.000
M1	b_1	0.107	0.024	4.455	0.000
IIPMAN	b_2	0.049	0.020	2.422	0.016
INDRM	b_3	0.192	0.032	5.986	0.000
IEO	b_4	0.011	0.007	1.585	0.113
IMP	b_5	0.022	0.011	2.132	0.033
NEER	b_6	-0.009	0.027	-0.354	0.723

6 Conclusions

This paper explores to estimate alternative models for the price level in India using certain macro-economic variables and tests the stability of the parameters over time through state-space model. Both domestic and international variables are explored in the paper. The first model incorporates domestic variables only, while the second model incorporates both domestic and selected international variables. Both the models have been found to be stable in nature. Empirically, money supply, manufacturing sector output and prices of industrial raw materials are found to have significant and stable impact on domestic price level. Further the prices of international edible oil and metals were found to have emerged as significant determinant of domestic price level in the recent years.

The second model suggests the emergence of the international variables as important variable in determining the domestic price level and as such this model may be a better option from monetary and fiscal policy point of view.

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Figure 4.1: Plot of the estimates of the parameters (state series) – domestic variables model

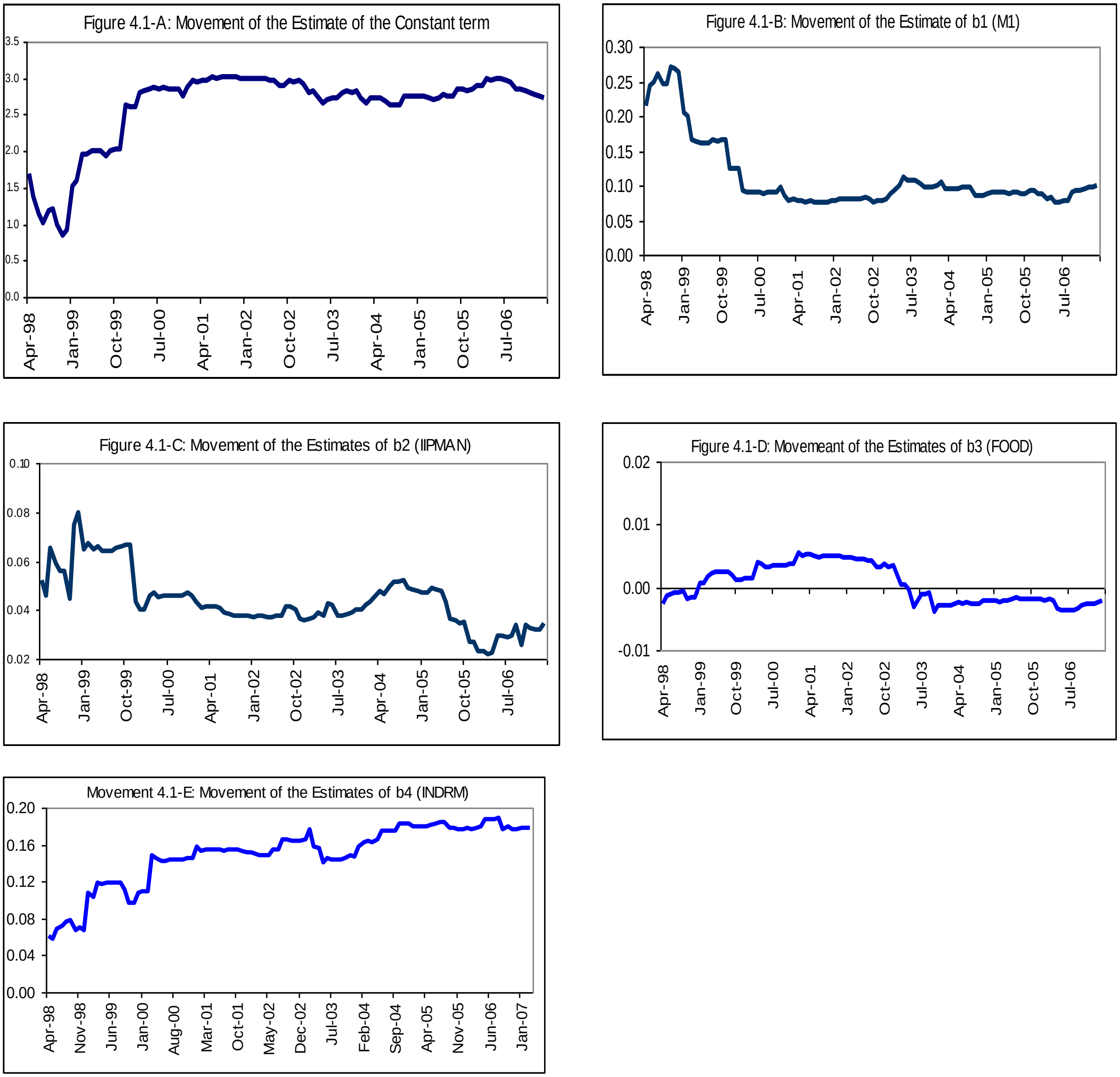


Figure 4.2: Plot of the estimates of Standard Error of the parameters (state series) – domestic variables model

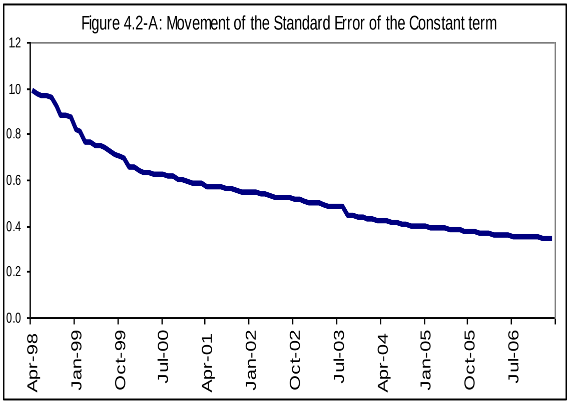


Figure 4.2-A: Movement of the Standard Error of the Constant term

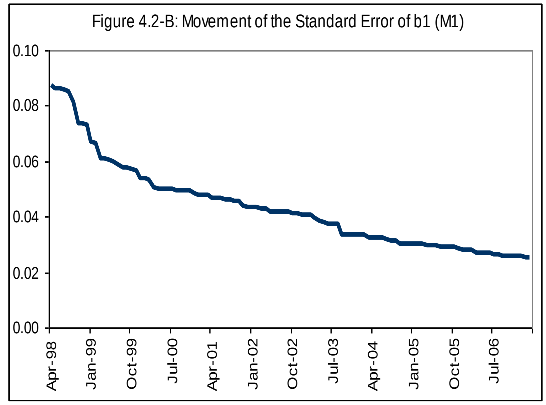


Figure 4.2-B: Movement of the Standard Error of b1 (M1)

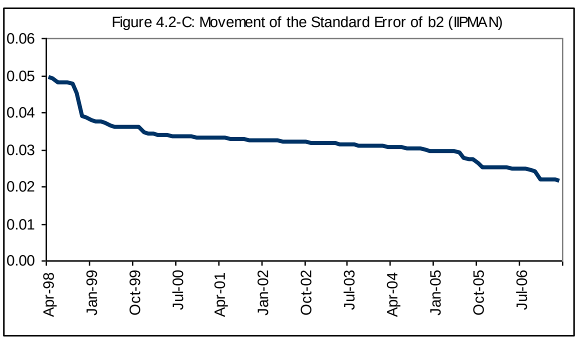


Figure 4.2-C: Movement of the Standard Error of b2 (IIPMAN)

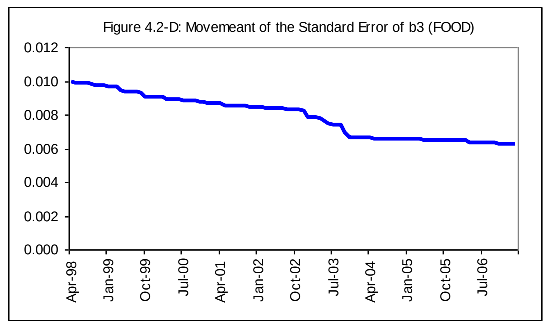
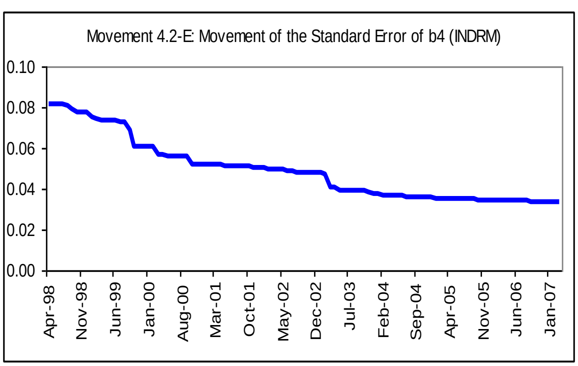


Figure 4.2-D: Movemeant of the Standard Error of b3 (FOOD)



Movement 4.2-E: Movement of the Standard Error of b4 (INDRM)

Figure 4.3: Plot of the estimates of the parameters (state series) – domestic & international variables model

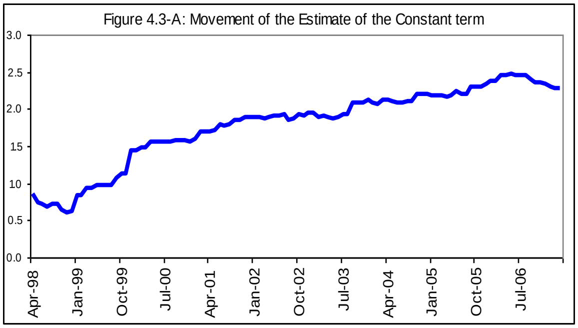


Figure 4.3-A: Movement of the Estimate of the Constant term

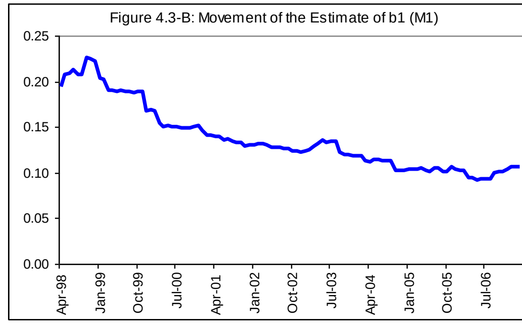


Figure 4.3-B: Movement of the Estimate of b1 (M1)

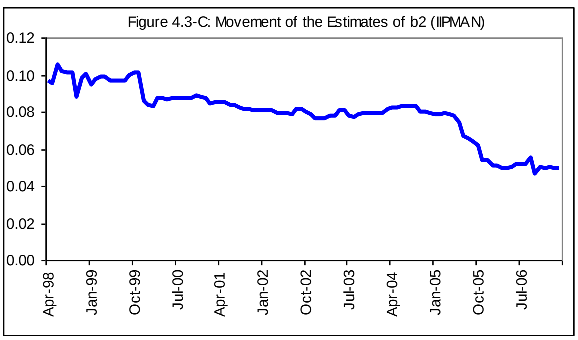


Figure 4.3-C: Movement of the Estimates of b2 (IIPMAN)

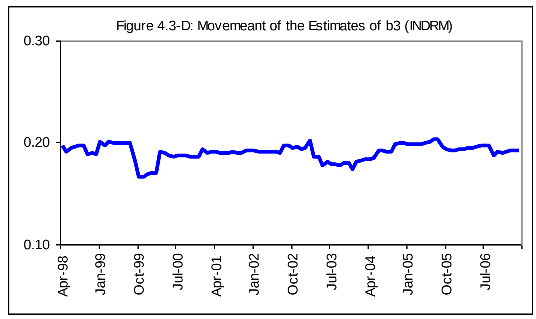


Figure 4.3-D: Movemeant of the Estimates of b3 (INDRM)

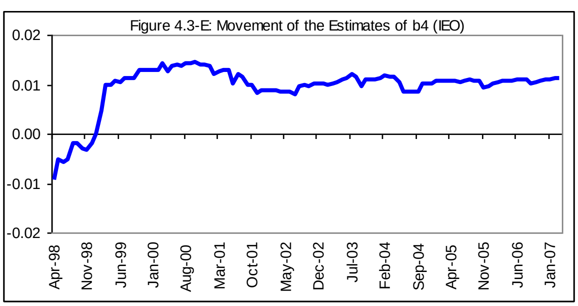


Figure 4.3-E: Movement of the Estimates of b4 (IEO)

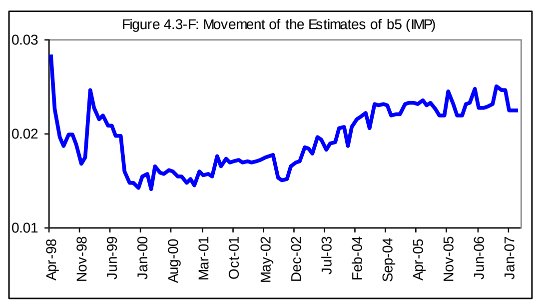


Figure 4.3-F: Movement of the Estimates of b5 (IMP)

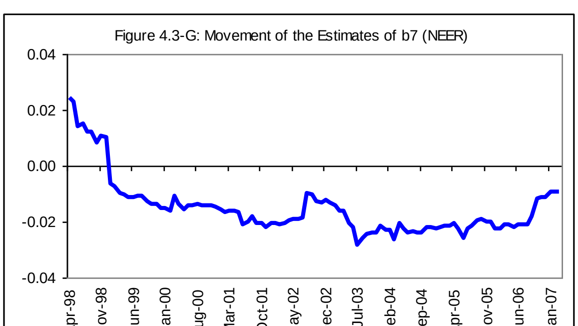
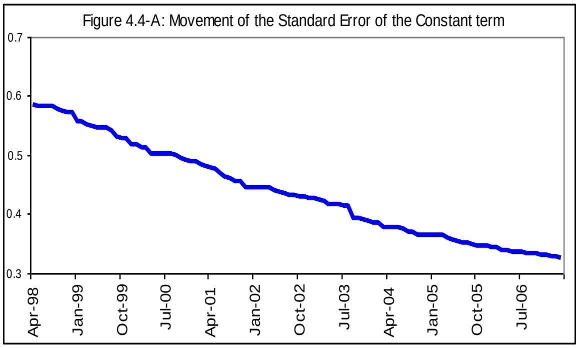
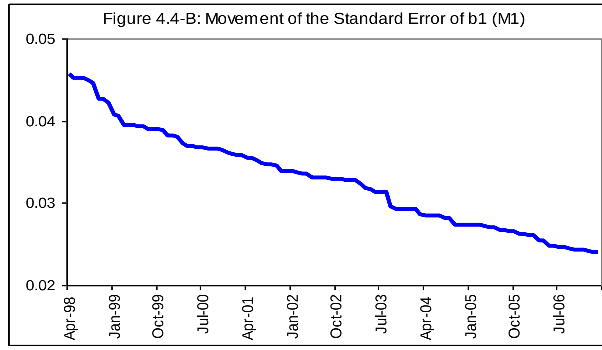
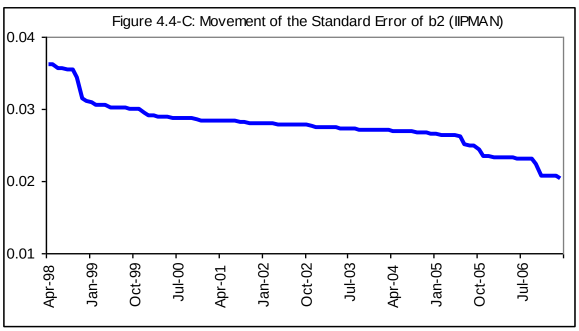


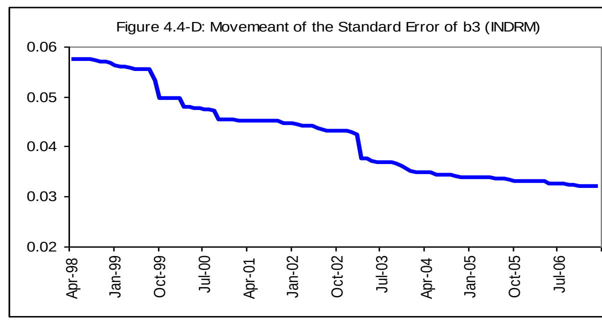
Figure 4.3-G: Movement of the Estimates of b7 (NEER)

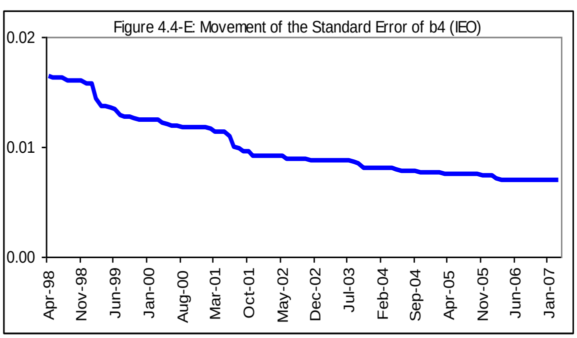
Figure 4.4: Plot of the estimates of Standard Error of the parameters (state series) – domestic and international variables model

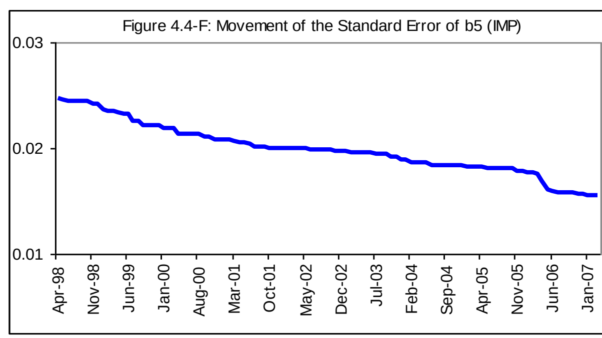


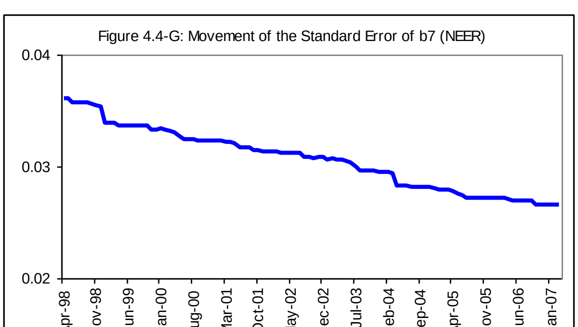












APPENDIX I
Different measures of money supply

In India, different measures of money stock measures are defined as:

M1 = Currency with the Public + Demand Deposits + Other deposits with the RBI
M2 = M1 + saving deposits with the post office saving bank
M3 = M1 + Time Deposits
M4 = M3 + All deposits with the post office,

where, Currency with the public = Notes in circulation + Circulation of coins + Cash in hand with banks.

Demand Deposit includes current deposits, demand portion of saving account deposits, matured fixed deposits, matured recurring deposits, etc.

Time deposit includes recurring deposits, fixed deposits, etc.

As the amounts of deposit with the post office are quite small, M2 and M4 do not differ significantly from M1 and M3, respectively. The Time Deposit constitutes almost 70 percent of M3 and this makes M3 significantly higher than M1.

APPENDIX II
Testing for presence of seasonality through F-test

(a) WPI – excluding FPLL

	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value
Between months	76.27	11	6.93	36.43*
Residual	27.40	144	0.19	
Total	103.67	155		

(b) IIPMAN

	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value
Between months	2524.06	11	229.46	129.40*
Residual	255.36	144	1.77	
Total	2779.42	155		

(c) FOOD

	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value
Between months	941.58	11	85.60	21.02*
Residual	586.44	144	4.07	
Total	1528.02	155		

(a) M1

	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value
Between months	613.29	11	55.75	57.66*
Residual	139.24	144	0.97	
Total	752.53	155		

(b) INDRM

	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value
Between months	19.45	11	1.77	2.99*
Residual	85.05	144	0.59	
Total	104.50	155		

(c) IMP

	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value
Between months	261.45	11	23.77	3.99*
Residual	857.24	144	5.95	
Total	1118.69	155		

(d) IEO

	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value
Between months	419.94	11	38.18	3.21*
Residual	1714.91	144	11.91	
Total	2134.85	155		

(e) NEER

	Sum of Squares	Degrees of Freedom	Mean Squares	F-Value
Between months	80.09	11	7.28	6.43*
Residual	163.10	144	1.13	
Total	243.19	155		

** indicates significance at 1% probability level.

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Note: *The views expressed in the paper are personal only and not that of the Reserve Bank of India.*