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REAL EXCHANGE RATE EFFECTS ON OUTPUT IN INDIA

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Abstract

In this paper we model real per capita GDP growth for India as a function of real exchange rate, inflation and US interest rates, foreign exchange reserves and government expenditure. We find evidence of non-linearity in this relationship and we capture that through a smooth transition regression model. Using annual data for the period 1970-2006, we find that depreciations may have negative effects on growth and appreciations may have positive effects on growth. These results support the existing literature.

Keywords: Real exchange rate, GDP growth, inflation, interest rate

JEL classifications: E4, E31,F31

I. Introduction

It is very important to know the effect of real exchange rate on output for developing countries like India. Diaz-Alejandro (1963), Krugman and Taylor (1978) argue that in a typical semi-industrialised economy, inputs for manufacturing are largely imported and working capital from banks is subject to rationing. In this context a sudden devaluation will sharply increase firms' input costs and the need for working capital which could only be obtained at high interest rates. These effects may offset the positive impact of depreciation on international trade and firms may choose to reduce production (Lizondo and Montiel,1989)

We have empirical evidence that contractions in output are frequently preceded by overvaluation of real exchange rate, with the positive growth episodes accompanied by appreciation of the real exchange rate (Kiguel and Liviatan, 1992; Razin and Collins, 1997; Kamin and Rogers, 2000). On the other hand, Edwards (1986, 1989b) and Ahmed (2003) find that real exchange rate depreciations have negative effects on growth..

Agenor (1991) and Ahmed et al. (2002) underline the difference between expected and unexpected changes in the exchange rate and between developed and developing economies, respectively.

The present study contributes to the literature on the effects of changes in real exchange rate by applying non-linear models to study output in India. We use smooth transition regression (STR) approach in this paper as it is sufficiently flexible to capture possibly asymmetric effects and to explore whether real depreciations vs. real appreciations or the magnitudes of these have different effects.

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The paper is developed as follows. Section 1 gives the introduction and a very brief literature review, Section 2 describes the economic framework, The STR methodology is discussed in Section 3. Results are presented and discussed in Section 4 and the final Section concludes.

2. The Economic Framework

We use the economic framework suggested by Kamin and Rogers (2000).

On the basis of a model where real output depends on domestic demand and net exports, they obtain the specification

$$y = f\left(e, \pi, i^{us}, y^{us}\right) \quad \text{... (1)}$$

where y is real output, e is real exchange rate, π is domestic rate of inflation, i^{us} is the US interest rate and y^{us} is the US real income. We add two more explanatory variables in our estimation that is foreign exchange reserves as a share of GDP (forex) and government expenditure[2] as a share of GDP. Inflation rate affects output negatively because it provokes inefficient allocation of resources due to distortions in relative prices and higher administration cost of firms (De Gregorio, 1992; Sarel, 1996) .The international interest rate is expected to have negative effect due to its impact on net capital inflows (Calvo et. al, 1996). We can anticipate a positive effect for world real income thorough a higher demand for exports (Agenor, 1991).

The effects of the real exchange rate are ambiguous. Positive effects on net export can be offset by negative effect on output linked to higher cost of imported inputs and working capital. An increase in foreign exchange reserves causes an increase in supply of foreign currency and builds up liquidity pressure in the economy. Such pressure causes exchange rate to appreciate.

A stylized result in open economy macroeconomics is that an increase in government expenditure adds to private consumption, thus deteriorating current account and appreciate real exchange rate; real appreciation crowds out foreign demand, if all goods are internationally traded and shifts resources to home goods sector.

Following Edwards (1989b,c) and other researchers in this field we compute real exchange rate as $e = E * \left(\frac{P_t^*}{P_n}\right)$ where the bilateral nominal exchange rate with US is denoted by E and P_t^* is measured by US whole sale price index and P_n is measured by domestic (Indian) whole sale price index.

International variables are considered as exogenous to domestic growth. Although the domestic and international factors influence the real exchange rate, we take the view of Ahmed (2003) that real exchange rate is causally prior to output since feed back effects from output to real exchange rate through changes in domestic compared with foreign productivity is a long run phenomenon. According to Kamin and Rogers (2000) also real exchange rate is causally prior to output. We include lagged values of inflation in order to avoid endogeneity problem with this variable.

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2 We use data of total expenditure of central government, obtained from Reserve Bank of India website

3. Smooth Transition Regression (STR) Methodology

In contrast to discrete switching models (for example, Hansen 1999), smooth transition regression (STR) models transition as a continuous process dependent on the transition variable. This allows for incorporating regime switching behaviour both when the exact time of regime change is not known with certainty and when there is a short transition period to a new regime. Therefore STR models provide additional information on the dynamics of the variables that show their value even during transition period.

Capturing non-linearities and regime switching makes STR models good candidates for analysis of numerous economic variables. STR models naturally lend themselves to modeling structural breaks.

We model output, measured by growth in per capita GDP (Δy_t), as a function of change in real bilateral exchange rate with US (Δe), log inflation (π) and nominal US interest (i^{us}), total expenditure of central government as a share of GDP and foreign exchange reserves as a share of GDP. As we want to capture the dynamics of growth, we consider lags of all variables including dependent variables. The estimation period is 1970-2006. We use annual data of total expenditure of central government and foreign exchange reserves, obtained from Reserve Bank of India website and other data are obtained from International Financial Statistics for this study. We check the stationarity property of the variables (Table 1) before starting the modeling exercise.

Table 1. Unit root tests

Variables	*ADF test statistics*
Indian WPI	4.937288 (level) -6.013866 (first difference)
Real output of India	4.495512 (level) -3.079384 (first difference)
Real exchange rate of India	-1.202513 (level) -8.211711 (first difference)
US WPI	-2.345686 (level) -2.644271 (first difference)
US real GDP	4.065431 (level) -3.363267 (first difference)
US interest rate (discount rate)	-2.306874 (level) -4.454824 (first difference)
Foreign exchange reserves as a proportion of GDP (Forex)	1.139939 (level) -2.155787(first difference)
Government expenditure as a proportion of GDP (Govexp)	-2.104355 (level) -5.323954 (first difference)

The STR model can be defined as follows

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{n} \beta_i x_{ti} + F(z_t)\left(\alpha_1 + \sum_{i=1}^{n} \eta_i x_{ti}\right) + \varepsilon_t \qquad \text{... (2)}$$

where the dependent variable Δy_t is the annual growth rate in per capita real GDP, x_{it} are the observations on n explanatory variables (i=1,….n), ε_t is an independent and identically distributed disturbance with mean zero and variance σ^2. Non-linearity is captured through the transition function, $F(z_t)$ which is a function of an explanatory variable, denoted by z_t. This function F is bounded by $0 \le F \le 1$, with the extremes $F = 0$ and $F = 1$ corresponding to distinct regimes. A distinct linear relationship applies between y_t and the explanatory variables within each regime, with x_{it} having coefficient β_i, when $F = 0$, whereas when $F = 1$, this coefficient becomes $\beta_i + \eta_i$, with a corresponding shift for the intercept.

Intermediate values of F define situations where the model is a mixture of linear models corresponding to these two regimes. Terasvirta (1998) discusses the regression counterpart we use in equation (2).

We do not specify a priori the transition variable z_t that determines the regimes in equation (2). Nevertheless for plausible transition variables such as real depreciation or lagged growth, we anticipate regimes associated with high vs. low values of z_t. This could reflect regimes associated with the business cycle, [Sensier et al. (2002)]. To ensure that F is a monotonically increasing function of z_t, we use the logistic function.

$$F(z_t) = \frac{1}{1 + \exp\{-\gamma(z_t - c)\}}, \gamma > 0 \qquad \text{... (3)}$$

where γ is the slope of the transition function and c is the threshold parameter that indicates its location in relation to observations on z_t at $z_t = c$, then $F = 0.5$

We use the methodology of Ocal and Osborn (2000) and Sensier et al. (2002) to specify the STR model.

4. Results

At the first stage, a linear model based on equation 1 (we add forex and govexp also) is estimated by following a ‘general-to –specific’ strategy in order to determine the relevant explanatory variables. The initial general model contains contemporaneous and lagged values of the explanatory variables. We select the final linear model on the basis of the lowest value of the Akaike Information Criterion (AIC) (Table 2).

Based on this linear model, we perform two non-linearity tests (Table 3). Two p-values are given. The first is obtained by testing the joint significance of the cross product terms arising from a first order Taylor series expansion of $F(z_t)$ in Equation (2) and the second one tests a simple version of a threshold model where the intercept only changes in relation to the unknown threshold value of z_t. (Hansen, 1997). We consider the possibility that non-linearity is associated with each explanatory variables one by one. We get p-values for testing the null of linearity against the non-linear alternative where the explanatory variables in the first column acts as the transition variable. Results of non-linearity tests are given in Table 3. We find the evidence of non-linearity.

Table 2. Linear model

Dependent variable: real output (y)

Variables	*Co-efficients*	*T-statistics*
e	0.283532	2.771153
π	-1.896025	-5.214073
i^{US}	-0.941188	-2.107672
y^{US}	1.712351	4.09244
Govexp	0.282213	2.904512
Forex	0.321567	2.941324
R^2	0.817976	
S.E. of regression	0.004501	
AIC	-8.210411	

Table 3. Non-linearity tests

Transition variables	*p-values*
Δy_{t-1}	0.05
	0.04
Δe_t	0.00
	0.02
Δe_{t-1}	0.03
	0.04
π_{t-1}	0.00
	0.00
i^{US}	0.03
	0.04
Forex	0.01
	0.02
Govexp	0.03
	0.05

For each potential transition variable, the results of two tests are presented as p-values. The first test is STR test and the second test is the threshold test.

Estimation of the final model consisting of Equation (2) and (3) is undertaken by non-linear least squares (Table 4). We have transition variable $z_t = e_t$, reinforcing the role found for this variable in the non-linearity test.

The logistic transition functions are centred very close to zero with a steep slope. This indicates that the regimes detected by non-linear model relate to depreciations, with $F(z_t) = 1$, vs. appreciations, $F(z_t) = 0$. This means that we have asymmetric responses of growth to positive and negative Δe.

Table 4 presents the estimated models with the explanatory variables listed in the first column and coefficient estimates and t-statistics are given corresponding to the lower regime ($F = 0$)in the upper part of the table. Estimates associated with higher regime (F=1) are obtained by summing up the values in the upper and lower part of Table 4 for a given explanatory variable.

Table 4 gives the evidence of asymmetric effects. If the real exchange rate appreciates, we have positive effect on output growth. In case of depreciation we have a negative impact.

Table 4. Estimation results for non-linear models

Variable	*Coefficient*	
Intercept	9.78	(2.516)
Δy_{t-1}	-0.517	(-2.016)
Δe_t	0.280	(1.915)
Δe_{t-1}	-0.023	(-3.118)
i_t^{US}	-0.512	(-2.251)
forex	0.674	(2.551)
Govexp	0.576	(2.225)
$F(z_t)$	-9.81	(-2.444)
$F(z_t) * \Delta y_{t-1}$	0.417	(1.419)
$F(z_t) * \Delta e_t$	-0.285	(-1.913)
z_t	Δe_t	
γ	7.171	(1.160)
c	-2.101	(-0.816)

Values in the parentheses are t-ratios.

5. Conclusion

In this paper we study the real exchange rate effects on output in India, using non-linear smooth transition regression models. We find the evidence that we have different growth effects depending on the sign of the real exchange rate changes. In case of real exchange rate appreciation we have a positive effect on output and a negative effect in case of depreciation.

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