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IN SEARCH OF EXCHANGE RATE UNDERSHOOTING IN PAKISTAN

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ABSTRACT

Exchange rate behavior does not follow very obvious and predicted pattern. Many attempts have been made to predict its behavior as much as possible. This research re-examines the Dornbusch model of exchange rate overshooting caused by price rigidities. Dornbusch’s assumption of full employment in economy has been violated in this research which creates the possibility of exchange rate undershooting. In response to positive monetary shock, interest rate decreases and exchange rate undershoots its long run equilibrium. This research explains the dynamics of anti-intuitive exchange rate undershooting. Apart from theoretical formations of exchange rate undershooting, this research also analyses Pakistani data for exchange rate undershooting or overshooting in response to increase in money supply. Quarterly data of twenty three years for exchange rate, nominal interest rate, price, real output and money have been taken and vector autoregressive technique (VAR) has been used. Evidence of exchange rate undershooting in response to positive money supply shock was found. This paper is an important contributor towards the advancement of literature. It also gives an important insight into policy making by identifying some probable behavior of exchange rate.
1. **INTRODUCTION**

Countries sometimes face many issues in implementation of monetary and fiscal policies whereas theoretical and policy recommendations do not give expected results. Actual evidence sometimes differs from the theory suggested by monetarists and fiscal policy makers. Opening of world trade and global economies have made one country vulnerable to policies of other countries. Correspondingly the conductance of macroeconomic tools to affect the economy has not remained simple. Mundell (1963) and Fleming (1962) model explained the conductance of monetary and fiscal policy in different exchange rate regimes. Mundell’s model is still the basis of many ideas and theories of international finance but it was really back dated. When there was a roar and excitement of introduction of flexible exchange rate in open economy macroeconomics, it was found that exchange rate is more volatile than it was supposed to be. Dornbusch explained the phenomena with simple theory and told price rigidity to be the reason of abnormal behavior of exchange rate overshooting towards positive monetary shocks. There are few ideas or rationales present in economics which are true and not very obvious. Dornbusch’s explanation of exchange rate overshooting is one of those phenomena. Dornbusch (1976) advanced the theory by explaining the phenomena of significant depreciation of exchange rate when money supply is increased. The development in literature advancement is slow regarding this topic because of lack of consensus on reliable method to measure the phenomenon and many researchers find difficulty in finding reliable data when they go into deep core of the topic. Researchers also find evidence of exchange rate undershooting in response to monetary shocks. There is gap in literature regarding clear explanation of exchange rate undershooting and also the phenomena of exchange rate overshooting or undershooting have not been frequently tested for Pakistan. The idea behind theory was; the stickier prices of good market, the more consistent the change in real exchange rate. When a persistent monetary shock is applied, given that the prices are slow to adjust, exchange rate over-reacts, the phenomena known as exchange rate overshooting. Dornbusch theory assumes that purchasing power parity is held in long run, exchange rate is determined in flexible exchange rate market and also there is perfect capital mobility considering domestic and foreign bonds as perfect substitutes. Perfect foresights of expectations are held and economy operates at full employment level. (Dornbusch, 1976). When assumption of full employment is replaced by more realistic assumption where real output is held variable, exchange rate overshooting phenomena does not remain simple. Prices are sticky and real output is also considered to be sluggish in response, which causes exchange
rate to either overshoot or undershoot in response to increase in money supply. Undershooting phenomena needs theoretical explanation and empirical testing. This research focuses on exploring the possibilities of exchange rate undershooting dynamics and finding possibilities of exchange rate overshooting or undershooting for data of Pakistan. This research will open new avenues for further researchers and will be an important contributor in advancing literature. It will also give insights towards behavior of exchange rate through different perspective by using VAR (vector autoregressive) techniques in consideration that this econometric technique can betterly explore the behavior of exchange rate.

2. LITERATURE REVIEW

Dornbusch’s first publication of exchange rate overshooting came as an essay naming “expectation and exchange rate dynamics” in Journal of political economy (1976) which became the starting point of field of study of international macroeconomics. This model assumes perfect capital mobility where the country under analysis is small and lacks the power to affect the interest rate of other country and takes interest rate as given. This perfect capital mobility also refers to presence of uncovered interest arbitrage. Domestic output is imperfect substitute of foreign imported good. Purchasing power parity holds in the long run. When money supply is increased, the response is shown by exchange rate more than prices. Thus the rigidities of price and their slow responsiveness lead to overshooting of exchange rate (Dornbusch, 1976). Stockman in 1980 presented the empirical evidence that nominal exchange has effects due to monetary shocks. This idea was supported by Fischer and Startz (2004) who found that apart from existence of exchange rate overshooting phenomena; exchange rate after overshooting comes back to its equilibrium after some time instead of immediately coming back towards its equilibrium and concluded that exchange rate overshooting is persistent for some time.

Fleming (1962) and Mundell (1963) discussed the response of exchange rate to monetary shock but they did not consider the phenomenon of price stickiness. Dornbusch (1976) did consider price stickiness while explaining the response of exchange rate to monetary shock. Mundell and Fleming did static analysis whereas dynamics were added by Rogoff and Obstfeld in 1995. Mussa in 1982 also did dynamic analysis. Rogoff and Obstfeld (1995) took the price behavior discussion away from price taking behavior and introduced monopolistic competition. They discussed special type of price stickiness that firms will not change their prices unless they get some external signal. Rogoff (1996)
focused on labour market rigidities where prices are rigid due to labor contracts and due to dominance of trade union; labor market wages cannot be easily changed. However the importance of labor market is usually ignored in empirical testing.

Whenever money supply is increased, interest rate falls. Intuition says that exchange rate should overshoot. Prices and output both are sluggish. The counter intuitive argument is that exchange rate can undershoot because of complex formation of expectations. Complex expectations are formed because of sluggish behavior of exchange rate. When the assumption of full employment considered in model of Dornbusch and is replaced by more realistic assumption of variable output, exchange rate can either overshoot or undershoot given the condition that income elasticity of money demand should be high and it overcome the effect of increase in money supply. (Levin, Exchange rate undershooting, 1999) One time money supply increase or money supply growth both creates possibility of exchange rate overshooting or undershooting. Money supply growth decreases interest rate creates price gap between current price and long run price level. Expectations of currency depreciation and interest rate increase are created and thus require exchange rate undershooting in order to nullify the expectations. (Levin, 1997).

If the assumption of instantaneous adjustment of asset market is relaxed with its sluggish behavior and continuous purchasing parity with long run purchasing power parity then it creates possibility of exchange rate overshooting and undershooting. If the product of income elasticity of money demand and real exchange rate elasticity of domestic output is greater than 1 then the saddle path between real and nominal exchange rate will be negatively sloped. Hence there will be clear undershooting of exchange rate in response to increase in money supply. Monthly data from January 2001 to December 2010 of Korea was used and found through simulations possibility of undershooting or overshooting. It was found that adjustment towards equilibrium is delayed due to sluggish behavior of output. (RYOU, December 3, 2012)

When economy is operating at level less than full employment but has variable output, exchange rate can overshoot and undershoot. When prices and output both adjust sluggishly in response to increase in money supply, exchange rate overshooting and undershooting both can occur. When money supply is increased, interest rate decrease as is explained by Dornbusch model, prices are expected to increase in the long run also people expect that currency will appreciate. If the expectation of appreciation of currency is very strong then exchange rate undershoots in order to
reduce the expectation of exchange rate appreciation and to maintain interest rate parity (Wang, 2005).

3. FEASIBILITY CHECK OF DORNBUSCH'S MODEL ASSUMPTIONS IN PAKISTAN

There is evidence that purchasing power parity (PPP) holds in Pakistan. Quarterly data from 1982-2005 was taken and exchange rate of Pakistan vis-à-vis United States was taken. Vector error correction model and cointegration technique was used and found that weak form PPP holds in Pakistan. Speed of adjustment is very slow and it taken almost 4-5 years for exchange to move towards its equilibrium after some exogenous shock. (Khan & Qayyum, 2008) Monthly data of exchange rate, consumer prices, imports and exports was taken for the period of 2000-2004. It was found that PPP is held in the long run. (Kemal & Haider, 2004)

Income elasticity of money demand in Pakistan is very high. Annual data from 1975-2009 of Pakistan was taken. Through ARDL (autoregressive distributive lag) approach, long run relationship between real income, interest rate, exchange rate and demand for money was studied. Long run income elasticity of money demand was found to be 4.1614 whereas short run elasticity is 1.14. (Anwar & Asghar, 1-22)

UIP holds continuously in Pakistan. Data from 1971-2000 was taken and UIP was tested. Using cointegration, Alam Butt and Iqbal found that UIP holds continuously in Pakistan. (Alam et al., 2001). Pakistan does not have perfect capital mobility. Data from 1976-2006 was used and ARDL approach was used for analysis. Relationship between domestic investment, real exchange rate, savings, inflation and financial development was seen and found that inadequate mobility of capital exists in the country. (Shahbaz et al., 2010)

Mussa (1982) used VAR (vector autoregressive) based approach seeing variance decomposition and forecast errors. Forecast error variance decomposition has been used to check the variability of exchange rate in response to nominal and real shocks. Nominal shocks include increase in money supply and real shock includes increase in productivity. (Clarida and Gali, 1994; Eichenbaum and Evans, 1995; and Rogers, 1999). In order to see effect of macroeconomic shock coming from real shock, it is necessary that we go deep into economy at micro level if not then at least to sectoral level to see rigidities of price and see the persistence of real exchange rate change in response to external
monetary shock. Crucini and Telmer, 2010, Broda and Weinstein in 2008 and Bergin, Glick and Wu in 2012 have used sector based real exchange rate to analyze the behavior of exchange rate.

Crucini, Shintani and Tsuruga (2010) checked the effect of nominal shock on real exchange rate and found that increase in money supply causes a significant effect in real exchange rate and causes exchange rate overshooting whereas Kehoe & Midirigan (2007) investigated and found that real shock which is change in productivity of labor measured by output has significant impact and causes exchange rate overshooting.

Dornbusch says that right from Mundell to new classical, efforts which have been made to model exchange rate are not enough. The way dollar has moved since 1980s has become extremely unpredictable. When the efforts for making a robust model of exchange rate were being made, debates were carried on suggesting dual exchange rate for different regions whereas some suggested using tax for financial transactions or using managed floating exchange rate. However exchange rate behavior and models being developed and discussed in developing countries were different from that of developing countries. Purchasing power parity has always remained very misleading. (Dornbusch, 1989).

Dornbusch model of exchange rate overshooting has also been tested for different countries including China, Brazil, Russia and India. It was found that exchange rate overshooting does not occur in Brazil, India and Russia whereas in China there was some evidence of exchange rate overshooting was found. It was found that exchange rate affects real output but the model could not explain that direction. (Berg, 2011)

Pakistan’s exchange rate was pegged to U.S dollar but in 1982 it was changed to manage floating exchange rate. During fiscal year 1980-81, overvaluation of rupee was seen. Malik and Rizavi (1982) calculated this appreciation to be around approximately 25% on average against different currencies.

4. **THEORETICAL MODEL**

The following which will explain the phenomena of exchange rate undershooting has been taken from appendix of article of Dornbusch except for equation (1) which is simple extension of the one used in Dornbusch model. (Dornbusch, 1976). We have introduces sluggishness of output which is also been used by Levin. (Levin, Exchange rate undershooting, 1999). Assumption of full
employment that was used in Dornbusch model has been violated. Perfect foresight of expectations has been held. Country is considered to be small where uncovered interest parity is held.

$$\dot{y} = \alpha[\mu + \delta(e + p^* - p) - \sigma(r) - (1 - \gamma)y] \tag{1}$$

$$m - p = -\beta r + \varphi y \tag{2}$$

$$\dot{p} = \pi(y - \bar{y}) \tag{3}$$

$$r = r^* + \dot{\varepsilon} \tag{4}$$

Where,

\(y\) = log of real output
\(e\) = log of exchange rate
\(p^*\) = log of foreign price level
\(p\) = log of domestic price level
\(m\) = log of money supply
\(r^*\) = log foreign interest rate
\(\bar{y}\) = log of natural rate of output

All parameters are positive structural parameters. Equation (1) is goods sector equilibrium condition. We have introduces production lag which explains that output is sluggish and takes some time to adjust. \(\dot{y}\) is the rate at which output expands and it depends on real exchange rate and interest rate. \(\mu\) could be any external factor such as fiscal policy, exogenous shocks etc. \(\alpha\) is the speed of adjustment of output.

Equation (2) is money market equilibrium condition. Demand for real balances depend on interest rate and real income. Money market equilibrium requires money demand to be equal to money supply. “m” is log of nominal money, “p” is the log of price level, “r” is nominal interest rate and “y” is the log of real income.
Equation (3) is Phillips curve used by Dornbusch in his model. Inflation rate increases as output moves towards its equilibrium. Phillips curve is the relationship between unemployment and wage inflation whereas Okun’s law is the relationship between unemployment and difference between actual and potential output. Equation (3) represents Phillips curve combined with Okun’s law.

Equation (4) is uncovered interest parity. Whenever people expect currency to depreciate, interest rate on domestic currency denominated assets exceeds foreign interest rate by amount of expected depreciation rate. \( \dot{e} \) is a dynamic variable and expected rate of depreciation/appreciation.

These equations have been taken from appendix of article of Dornbusch (1976) except for equation (1) which is simple extension of the one used in Dornbusch model. We have introduced sluggishness of output which is also been used by Levin (Levin, Exchange rate undershooting, 1999).

Rearranging equation (2) gives

\[ p = m + \beta r - \varphi y \]  \hspace{1cm} (5)

Putting value of (p) from equation (5) in equation (1)

\[ \dot{y} = \alpha [\mu + \delta (e + p^* - (m + \beta r - \varphi y)) - \sigma r - (1 - \gamma) y] \] \hspace{1cm} (6)

\[ \frac{\partial \dot{y}}{\partial y} = \alpha \delta \varphi - \alpha (1 - \gamma) > 0 \text{ only if } \delta \varphi > 1 \text{ and } 1 < \gamma > 0 \]

Setting \( \dot{y} \) locus equal to zero, we find,

\[ \frac{\partial e}{\partial y} = \frac{[(1 - \gamma) - \delta \varphi]}{\delta} < 0 \text{ only if } \delta \varphi > 1 \]

\[ \frac{\partial \dot{y}}{\partial m} = -\alpha \delta < 0 \]

Rearranging equation (2) gives

\[ r = \frac{1}{\beta} (p - m + \varphi y) \] \hspace{1cm} (7)

Rearranging equation (4) gives
\[ \dot{e} = r - r^* \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (8) \]

Putting value of \( \dot{e} \) from equation (7) in equation (8)

\[ \dot{e} = \frac{1}{\beta} [p - m + \varphi y] - r^* \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (9) \]

Setting \( \dot{e} \) locus equal to zero, we find,

\[ \frac{\partial \dot{e}}{\partial y} = \frac{1}{\beta} \varphi > 0 \]

\[ \frac{\partial \dot{e}}{\partial m} = -\frac{1}{\beta} < 0 \]

**PHASE DIAGRAM**

When observation is on the right side of exchange rate locus output will increase and vice versa. If observation is on the right side of output locus, exchange rate will increase and vice versa.

Increase in money supply shifts both locus and saddle path to left. Exchange rate moves from point A to B and eventually reaches C. When money supply is increased output increases but the growth is constant at that time due to its sluggish behavior. Exchange rate appreciates in that period. Output and its growth decreases when exchange rate depreciates.
Dynamics of exchange rate undershooting are: when money supply increases, interest rate decreases immediately. Cost of production decreases and negative gap between price and its long run level is created. Country becomes competitive and also at given interest rate, lower prices increase real money balances and require higher level of output to maintain equilibrium in money market. Output and aggregate demand increases. Considering income elasticity of money demand to be high, money demand increases. Money demand becomes greater than money supply and exchange rate appreciates. Appreciation of currency creates expectations of currency depreciation so interest starts increasing towards \( r^* \) in order to maintain uncovered interest parity. Increase in interest rate increases cost of production and prices. Gap between prices and their long run equilibrium starts shrinking. In effect, aggregate demand and output decreases. It raises current account deficit and currency ultimately depreciates towards its long run level.

5. DATA AND METHODOLOGY

5.1. Data

Secondary data has been taken for analysis. Exchange rate overshooting/undershothing has been tested for Pakistan’s data for which quarterly data has been collected. Data of different variables namely money supply, interest rate, exchange rate, real output and prices for Pakistan has been collected for almost 28 years dating from first quarter of 1982 to second quarter of 2010. Total number of observations is 114. Source of data for aggregate variables is International Financial Statistics. This data have been used for calculation of impulse response. Reason for selecting data from 1982 is that until this period, Pakistan’s exchange rate was pegged. After that it was managed floating. Dornbusch’s phenomenon is so true that it also gives results on managed floating exchange rate regime (Rogoff, 1995)

5.2. Methodology

In order to see the behavior of exchange rate in response to money supply, we have used VAR. VAR has been used to see the impulse response of prices, interest rate and exchange rate. Basic VAR has been used. By using VAR, we have tried to analyze the effects of unit shock in money supply on nominal exchange rate, prices, real output and nominal interest rate. In this analysis, we have assumed that interest parity holds in the long run and home country is a small which takes
interest rate and prices of imports as given. Domestic and foreign bonds are also considered as perfect substitutes and interest rate of domestic country and foreign country remains same.

First order of integration of four variables is checked. Four variables are money supply, prices, exchange rate and nominal interest rate.

\[ p = \log \text{ of prices measured by general consumer price index with base of 2005} \]

\[ m = \log \text{ of money supply measured by M2} \]

\[ r = \text{nominal interest rate} \]

\[ s = \log \text{ of exchange rate which is rupees per dollar} \]

\[ y = \log \text{ of Gross Domestic Product at constant factor cost (2005)} \]

After checking order of integration, partial autocorrelation function was drawn in order to determine the number of lags to be used during estimation. After estimation impulse response was seen.

6. **RESULTS**

First we check that whether variables are stationary or not and for that we do unit root testing. Time series data has been used for analysis where usage of stationary series is very important. So we have used Dicky Fuller test to check the order integration of series.

All variables are stationary. VAR requires variables to be stationary. In order to apply VAR, we have first checked order of integration of four variables namely exchange rate, money supply, prices and nominal interest rate. All variables are I(1) except for nominal interest rate and real output as shown in Table 1. Our main focus is to calculate impulse response function. For calculation of impulse response, cointegration needs not to be tested. We have checked partial autocorrelation function in order to determine number of lags to be introduced in estimation of multiple equation models. PACF of all variables show that their first lag is significant for all variables except for real output whose first, second, fourth and fifth lags are significant. Nominal interest rate also has first and fourth lags to be significant. All variables in log except for nominal interest which is in percentage that’s why it has more lags significant than money supply, exchange rate and prices. Quarterly domestic output has quarterly fluctuations so it has more lags significant than any other variable.
Table 1: Unit root testing

<table>
<thead>
<tr>
<th>Variable</th>
<th>At level</th>
<th>At difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Calculated value</td>
<td>Critical values at 5%</td>
</tr>
<tr>
<td>m</td>
<td>-1.535</td>
<td>-3.45</td>
</tr>
<tr>
<td>r</td>
<td>-3.041</td>
<td>-2.89</td>
</tr>
<tr>
<td>p</td>
<td>-1.796</td>
<td>-3.45</td>
</tr>
<tr>
<td>s</td>
<td>-1.919</td>
<td>-3.45</td>
</tr>
<tr>
<td>y</td>
<td>-5.955</td>
<td>-3.45</td>
</tr>
</tbody>
</table>

*-3.45 is the critical value when drift is included in regression.

*-2.89 is the critical value when only constant is included in regression.

Figure 1: PACF of money supply
Nominal interest rate is in percentage whereas all other variables are in logarithm form. That’s why we find long bars in PACF of nominal interest rate as compared to money, nominal exchange rate and prices.
Figure 4: PACF of exchange rate

Figure 5: PACF of real output
Impulse response was determined by giving unit shock to money supply. Basic VAR has been used for estimating impulse response where first lag of all variables has been taken. As order of cointegration suggests that VECM (Vector Error Correction Model) should be used, because estimates could be inefficient, we have used VECM and found that both gives the same results. If variables are cointegrated in the long run then VECM (cointegrated VAR) and basic VAR gives the same results and we have also counter checked it by applying both techniques and found the same results.

VAR result shows that money supply shock cause exchange rate to first appreciate and depreciate towards its long run. Prices increase over a period of time. Output increases and then declines. Interest rate first decreases and then increase. When money supply is increased, prices do not replicate money path. Interest rate drops as a result. Unit shock of money supply decreases interest rate right away whereas prices are sticky and output is sluggish. Cost of production increases and negative gap is created between current price and long run price level. This negative gap increase competitiveness of country. Also at given interest rate, lower prices increase money balances and
requires simultaneous higher level of output to maintain equilibrium in money market. So output increases and creates positive increase in money demand and aggregate demand. Appreciation of currency creates expectation of depreciation as ever variable is self-reversing. These expectations cause interest rate to increase in order to maintain uncovered interest parity. Increase in interest rate cause prices and cost of production to increase and hence output declines. Aggregate demand also decreases and it raises current account deficit and currency ultimately depreciates towards its long run level.

7. CONCLUSION AND RECOMMENDATIONS

7.1. Conclusion
Dornbusch model of exchange rate overshooting has many discrepancies but still it has given important insights about exchange rate behavior. Dornbusch assumed economy to be operating at full employment. When this assumption is relaxed, it creates possibility of exchange rate undershooting. Real output is sluggish in economy and prices are sticky. Positive money supply shock decreases interest rate immediately. Prices are sticky and increase over period of time. Negative price gap causes output to increase and hence money demand. Currency appreciates in effect. Shock to any variables implies that it will come back to its equilibrium. So currency appreciation creates expectations of depreciation of currency. These expectations require interest rate to increase in order to maintain interest rate parity. In effect output decreases, current account deficit increases and eventually currency appreciates. Hence undershooting of exchange rate can be the possibility when money supply is increased and interest rate decreases. Pakistan’s quarterly exchange rate shows potential of exchange rate undershooting in response to positive monetary shock. These results have been taken through VAR analysis. Also the dynamics of exchange rate undershooting has also been analyzed through phase diagram which show that money supply increase causes output to react but its growth remains constant when currency appreciates. Output growth declines when currency appreciates. This model uses condition that product of income elasticity of real exchange rate and income elasticity of output should be greater than 1. We can conclude from this research that any monetary shock can lead to enormous changes in prices and output and adjustment of variables towards their equilibrium can take long periods.
7.2. Recommendations

Identification of possibility of undershooting suggests abnormal reaction to exchange rate and large periods of adjustment. Government’s policies should in a way that apart from conductance of monetary policy, they also decrease period of adjustment. Models discussed in this thesis and other models in which money demand is very responsive to output shock conclude that fixed exchange rate should be adopted because flexible exchange rate has large periods of adjustment. These results suggest very active and cautious behavior of government in flexible exchange rate regime economy.

If money supply increases and exchange rate appreciates, its biggest cost will be worsening of current accounts. Exports will decrease as they will become expensive. Imports will decrease and current account deficit will increase which is not good for economy. Current account deficit decreases output and increases unemployment. Benefit of exchange rate appreciation is decrease in foreign debt. While increasing money supply, government has to measure costs and benefits. If government’s aim is to decrease foreign debt whereas it can bear the costs of increasing current account deficit then increase money supply and causing exchange rate to undershoot will be a wise decision whereas if cost of current account deficit outweighs all its benefit then increasing money supply will not be a wise decision.

Identification of possibility of undershooting suggests abnormal reaction to exchange rate and large periods of adjustment. Government’s policies should in a way that apart from conductance of monetary policy, they also decrease period of adjustment. Models discussed in this thesis and other models in which money demand is very responsive to output shock conclude that fixed exchange rate should be adopted because flexible exchange rate has large periods of adjustment. These results suggest very active and cautious behavior of government in flexible exchange rate regime economy.

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