NONLINEAR EXCHANGE RATE PASS THROUGH INTO INFLATION: THE CASE OF PAKISTAN

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THESIS COMPLETION CERTIFICATE

This is to certify that this thesis entitled "Nonlinear Exchange Rate Pass-Through into Inflation: The Case of Pakistan" submitted by Habiba Fatima, is accepted in its present form by the department of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the Degree of Master of Philosophy in Economics.

DECLARATION

This thesis is my own work, and contains no material which has been accepted for the award of any other degree in any other university or previously published or written by another person, except due reference has been made to the best of my knowledge and belief.

DEDICATION

This thesis is dedicated to my Parents and my Husband

For their endless love, support and encouragement

ACKNOWLEDGMENT

All commend to ***ALLAH*** whose blessing and splendor thrive my thoughts, and prospered my aims by giving me brilliant teachers, supporting husband, ***Waseem***, extraordinary friends, helpful sister, ***Javeria*** for giving me potential to successfully completing research. I would like to state here my utmost gratefulness to the people who have helped and supported me during my research.

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ABSTRACT

The degree of exchange rate shocks that are passed through to prices is one of the central questions in international economics. This research work investigates the empirical evidence on nonlinearity of exchange rate pass-through into inflation for Pakistan. Smooth transition regression is used to model the nonlinearities in exchange rate pass-through with respect to different transition variables which could potentially influence exchange rate pass-through. The estimation results suggest that the exchange rate pass-through has asymmetric relationship with inflation, exchange rate, output growth, and macroeconomic instability.

1. INTRODUCTION

Exchange rate is the worth of one country's currency determined with reference to another country's currency O'Sullivan et al. (2003). The stability of exchange rate and its awareness is very important in economic decisions. Inflation, interest rate, general economic condition, and political stability are among few factors which can manipulate exchange rate. The exchange rate plays dominant role to transmit its effect on the real activity of the economy through changing the worth of home currency prices (the pass-through of prices), the external sector, macroeconomic stability, capital inflow and outflow and the financial constancy Mishkin (1995).

Exchange rate variation affects the behavior of inflation; this effect is known to be Exchange rate pass through. If one percent variation occurs in exchange rate of two countries trading with each other and due to this variation the percentage deviation of import prices in local currency is basically exchange rate pass through. Monetary authorities consider the magnitude of exchange rate passthrough to design an effective monetary policy. If the monetary policy of the country stabilizes and inflation decreases, in that case the exchange rate pass- through also decreases according to Taylor (2000). An effective monetary policy results in case of a low exchange rate pass-through which in turn helps to achieve low inflation. The effects of exchange rate pass through become of more importance in emerging economies as it impacts the monetary policy. Therefore central banks are more concerned about exchange rate while designing the monetary policy Okello and Brownbridge (2013).

Exchange rate pass-through plays a significant role while setting the monetary policy of the country. According to Ghosh and Rajan (2006) as compared to 1970s and 1980s exchange rate pass through was lesser in 1990s and with the passage of time it has continued to decline not

only in developed countries but also in developing countries. Since this timing coincides to a time when inflation is not only low but also stable, it is assumed that this reduction in exchange rate pass- through is in some way connected to the rate of inflation, Shintani et al. (2012). Taylor (2000) agreed to the same thought that low exchange rate pass through is not something outside of inflationary environment. Junior and Leon-Ledesma (2008) are of the opinion that exchange rate pass- through affects current and expected inflation, the capability to adjust trade imbalances and macroeconomic stability and designing monetary policies by exchange rate variations. How exchange rate pass-through responds to different variables requires due consideration.

Exchange rate pass through is assumed to be nonlinear in spite of testing the nonlinearities in majority of past studies. The nonlinearity of exchange rate pass through is an issue getting more and more attention in empirical literature. More accuracy and precision can now be provided by using new tools and techniques. In recent years there is an increased interest in examining the role of nonlinearity and asymmetry in exchange rate pass through on inflation. Several studies recently have shown that amount of exchange rate pass through in prices is nonlinear in both emerging and developed economies. Existing literature provides varied evidence for exchange rate pass-through's nonlinearities. Marazzi et al. (2005), empirically analyzed the data for U.S. They could not discover any proof of nonlinear exchange rate pass through. Feinberg (1989), Athukorala (1991) and Herzberg et al. (2003) also could not find evidence of nonlinearity in exchange rate pass-through. On other hand, Webber (2000), Mahdavi (2002), Bussiere (2006), Kihc (2010), and others discovered various nonlinearities. Taylor (2000), Choudhri and Hakura (2006), Gagnon and Ihrig (2004) have found that an environment with low inflation results in a lower exchange rate pass through. However to Junior and Leon-Ledesma (2008), higher inflation

and low credibility would raise exchange rate pass nonlinearly. According to Goldfajn and Werlang (2000), exchange rate pass through reacts nonlinearly over the business cycle. It is argued that there are two potential sources of asymmetric behavior of exchange rate pass-through, i.e. direction of exchange rate changes Gil-Pareja (2000) and magnitude of exchange rate movements Coughlin and pollard (2004). Cheikh (2012) reported the same. Different tools and econometric techniques are developed to estimate the nonlinearity to enhance quality of results. Smooth transition regression model is becoming popular in conducting asymmetries or nonlinearities because of its reliable and dependable results. Few studies have been carry out to test asymmetric behavior of exchange rate pass-through for example, Junior and Leon-Ledesma (2008), Shintani et al. (2009), Kihc (2010), Cheikh (2012; 2013). As far as Pakistan is concerned there is little or no research available on nonlinear exchange rate pass-through.

1.1. Objective of the Study

The question under consideration is whether exchange rate pass-through into inflation shows asymmetric behavior as is assumed in recent literature. This research is conducted to provide new experimental proof on exchange rate pass-through with especial focus on the nonlinearity of the relationship. A broad spectrum of variables which have the potential to influence exchange rate pass- through for Pakistan are taken into account to analyze exchange rate nonlinearities.

This study is based on the following objectives:

- To estimate the effect of exchange rate on prices of Pakistan
- To estimate exchange rate pass through into inflation for Pakistan by using Smooth-transition-regression model

- To test some potentially important transition variables in order to capture possible nonlinearities.

Lot of research has been conducted on exchange rate pass-through not only for Pakistan but all around the world due to its utility and significance in taking various economic decisions. Exchange rate pass through is studied by monetary authorities for the formulation of effective monetary policies. Exchange rate pass through is also studied for taking different economic prosperity and stability measures. From current text on exchange rate pass through for Pakistan, it is obvious that on inflation, exchange rate's behavioral impact has not yet been addressed. In developed countries relatively more research is done as compared to developing countries like Pakistan on how exchange rate pass through responds to inflation. In this research work, the focus is on studying the issue of asymmetries and nonlinearities in exchange rate pass through. For achieving this goal not only the exchange rate, but a broad spectrum of threshold variables are considered that can have a significant impact on exchange rate pass through in Pakistan.

Amongst the advancement of knowledge, new tools and models have been developed which provide more accuracy and precision. To increase the quality and reliability of results, Smooth-transition-regression model has been used. Smooth-transition-regression model has been used for estimation of nonlinear behavior regarding exchange rate pass through. Smooth transition regression model not only allows smooth and slow changes of parameters from one to another regime but also let internal regime alterations. This is a plausible and viable technique in helping monetary authorities by telling when and why policy should be changed. This technique is used to make the results more significant.

This research is targeted to fill the following literature gaps found with respect to exchange rate pass- through in Pakistan:

- Most of the existing literature in Pakistan on exchange rate pass through has ignored exchange rate's behavioral impact on inflation. A lot of weight has been given by researchers to the importance of exchange rate pass- through, but unfortunately in emerging economies like Pakistan this factor has remain neglected. In this research work the nature of responsiveness of exchange rate pass through is assessed taking into consideration the case of Pakistan.
- Most of the studies conducted to date have focused on the relationship and the effect of exchange rate on inflation while ignoring some potential variables which could have significant role on how exchange rate pass-through behaves. This thesis has also considered output growth and real interest rate in addition to exchange rate and inflation in addition to used differential as potential transition variables for estimating nonlinearity of exchange rate pass through where as an indicator of macroeconomic instability, real interest rate is used.
- As time passes new techniques and models evolve and become available for use to make the results more dependable by increasing their precision and accuracy. Smooth Transition Regression Model has become popular for analyzing nonlinearities because of its reliable output. In this thesis Smooth Transition Regression Model is applied to see if it makes any significant difference in the results.

1.2. Organization of the Study

The next chapter discusses different sources of nonlinearities in exchange rate pass through in addition to some factors which affect exchange rate pass through. Literature related to exchange rate pass through in Pakistan and other countries is reviewed in the same chapter. In third chapter theoretical framework, research model, hypotheses of research are explained. In addition data and variables description is given while chapter four explains the results. The last chapter of this thesis concludes the research outcomes and presents the findings of this research.

2. LITERATURE REVIEW

2.1. Exchange Rate Pass Through

Exchange rate pass through directly affects the import prices, consumer price index (CPI), and producer price index (PPI). Changes in exchange rate affect the domestic prices due to the imports of the consumer commodities directly through the effect of pass-through alternatively, exchange rate movements affect the cost of production of importing intermediate goods through pass-through effect, which affect the domestic price level. Likewise, foreign firms produce different products in domestic country, if the prices of the product are in foreign currencies then changes in exchange rate raise the local price level, vivid changes in the prices can be seen in the economy due to exchange rate movement, Kara (2005). Amount of exchange rate pass through have indirect consequences on inflation through changing prices in the economy.

Smooth transition type threshold effects of exchange rate pass through be able to distinguished by two extreme regimes either partially or completely. In first regime, if exchange rate changes by the same proportion as the change in the import prices, then the pass through is complete. Conversely, if exporters change prices in local currency by the lower proportion than change in exchange rate it leads to is partial or incomplete pass through. The degree of exchange rate pass-through is able to used, to the exchange rate as a monetary policy variable, as it can be used to forecast the inflation. Thus exchange rate has important implications in monetary policy to predict inflation.

2.2. Sources of Nonlinear Exchange Rate Pass Through

The work done on nonlinearity is not enough in the empirical literature of exchange rate pass through although being one of the core issues. Very rare are studies done that emphasis on the

nonlinearities aspects, rather assume it is nonlinear. To study the impacts of exchange rate in generating nonlinearities several important sources in characterizing the nonlinear features in exchange rate pass- through need to be studied. Among them is the course of changes in exchange rate which is the response of exchange rate pass- through with respect to currency appreciation and depreciation. Webber (2000) found asymmetric exchange rate pass through and observed that exchange rate pass through is elevated under depreciations than in appreciations of the domestic currency for seven Asia Pacific countries. Marazzi et al. (2005) did not find any type of nonlinearity in context of direction of exchange rate changes. Kılıc (2010) has found the nonlinear dynamics between import prices and exchange rate changes specifically the level of exchange rate pass through to import prices tends to be higher during appreciation than depreciation periods of a currency. At the industry level, Kadiyali (1997) and Goldberg (1995) found a higher pass-through for depreciation in the photographic industry and in the automobile industry respectively. Considering thirty manufacturing industries in the U.S., Pollard and Coughlin (2004) found asymmetry in exchange rate pass-through in half of these industries.

Nonlinearity between the size and the magnitude of exchange rate changes also affects exchange rate pass- through. Japanese export prices respond more frequently to large exchange rate changes than small changes according to Ohno (1989). Marazzi et al. (2005) find no clear endorsement for the existence of nonlinearities, however, the scale of exchange rate pass through may as a result be symmetrical. Pollard and Coughlin (2004) captured possible asymmetries in exchange rate pass through with use of threshold dummy variables in order to differentiate between magnitudes of exchange rate changes. They found that nineteen out of thirty industries followed large exchange rate changes in exchange rate pass through which means that firms respond positively to the magnitude of changes in exchange rate.

2.3. Factors Affecting Exchange Rate Pass Through

There are some important factors have an effect on the exchange rate pass through and its stability.

- Inflation and its volatility
- Effectiveness of the monetary policy
- Stability of macroeconomic environment
- Changes in exchange rate mainly due to
    - Magnitude of the exchange rate movements
    - Course of exchange rate changes which is in response to currency appreciation and depreciation
- Composition of imports
- Trade distortions resulting from tariffs and quantitative restrictions
- Periods of appreciation and depreciation
- Size of exchange rate changes during sub periods
- Income and transportation costs

2.4. Background

There has been an enduring interest in studying the macroeconomics exchange rate movements which reflected in prices. A lot of the presented studies concentrate on the connection with changes in exchange rates and prices. Interest in this issue, however, was revived at the end of World War II, in which the Bretton Woods Agreement was endorsed. The Bretton Woods Agreement originated a system of fixed exchange rates in which the currencies of all states were pegged to the US dollar, which lasted from 1946 to 1973. After the collapse of the Bretton

Woods system of fixed exchange rates, the exchange rates between currencies have been extremely unstable. Since 1973, the floating exchange rates were determined. The instability of floating exchange rates and rising inflation not only surprised but also disappointed many economists. This high inflation and large currency depreciation period increased expected future inflation. In this alarming situation during 1980s and early 1990s when currency depreciation could worsen an inflationary environment, countries began to reduce and stabilize their inflation rates. Monetary policy regimes played an important role to maintain low inflation by the adoption of an inflation targeting (IT) framework. This low inflation period also depreciated exchange rate. However, these exchange rate movements "passed-through" to prices decreased. Inflationary environment being lower leads to low exchange rate pass through, according to Taylor (2000). If there is a downward drift in the exchange rate pass through, it is assumed that the lower and more stable will be inflation. It is due to the timing coincidence in many countries that the period of price stability prevails. A decline in exchange rate pass- through could have suggestions for the option of exchange rate system and monetary policy system in countries.

2.5. Monetary Policy and Exchange Rate Pass Through

Exchange rate pass through depends on exchange rate and monetary policies of a country. If the monetary policy of a country is stable and therefore inflation is lower, then the exchange rate pass- through will be lower, as deduced by Taylor (2000). This assists to maintain lower inflation and in return makes effectual monetary policy. The trustworthiness of a monetary authority and anti-inflationary actions are important factors to reduce pass through of exchange rate changes into inflation as mentioned in Gagnon and Ihrig (2004). They developed a simple theoretical model which illustrates monetary policy effects on inflation expectations and also on exchange rate pass through at a macroeconomic level. Empirical results demonstrate a vigorous link

between the rate of pass through and inflation variability. A monetary policy emphasizing on stabilizing inflation lowers pass through of exchange rate and impacts inflation. Taylor (2000) believes that changes in pass through behavior might be due to modification in the adaptation of monetary policy. Parsley and Popper (1998) evaluate pass through for U.S. non-durable goods by industry, identifying the role that monetary policy establish the link between exchange rates and prices. They also found evidence that monetary policy does influence pass through at the industry-level.

2.6. Nonlinear Exchange Rate Pass Through

Recently, there has been a rising interest in groping the role of nonlinearity and asymmetry in exchange rate pass- through on inflation. Theoretically, it is argued that exchange rate pass through may be nonlinear as oppose to standard linear estimates given in the literature. With the advancement of knowledge, new tools and models have been developed which provide more accuracy and precision. Several studies have shown that the measure of exchange rate pass through in prices is nonlinear in both emerging and developed economies in recent years. There is limited work nonlinear exchange rate pass- through.

Existing literature provides varied evidence for nonlinearities in exchange rate pass through. Marazzi et al. (2005) had affirmation of continuous turn down in exchange rate pass through to U.S. prices of imports and examined nonlinearities in exchange rate pass- through for the U.S. in terms of the size of exchange rate changes, and not found any precise results. Herzberg et al. (2003) established a model for pricing to the market and captures response of nonlinearity in regards to the magnitude and direction of exchange rate pass through for the UK, but no evidence is found. Feinberg (1989) failed to find strong evidence of asymmetric behavior of exchange rate pass through for the US. Athukorala (1991) had examined the relation with

exchange rate and prices of manufactured exports for Korea and not found any documentation of nonlinearity regarding exchange rate.

On the other hand, there have been many intensive research on nonlinear exchange rate pass through in different states, to have general idea of work done on exchange rate pass- through internationally. The possibility of nonlinearities in response to changes in exporting and importing prices to exchange rate for all G7 countries has been observed by Bussiere (2006). The analysis found different nonlinearities out of which most were associated with asymmetric behavior to appreciation or otherwise. The magnitude of exchange rate changes also recommends that nonlinearities cannot be ignored. Kihc (2010) explores connection among exchange rate pass through and exchange rate appreciation or depreciation and inflation rate by estimating smooth transition regression model. He examined the role of deviations of inflation and exchange rate appreciations or depreciations from estimated threshold levels in the time varying dynamics of exchange rate pass through. The findings suggest that magnitude of appreciations or depreciations of a currency and inflation rates both in the long term and short term depending upon the presence of complete and incomplete pass through regimes. Mahdavi (2002) considered many exporting manufacturing industries in the U.S., and give strong proof of nonlinear response of exchange rate changes in almost half, i.e. seven out of thirteen industries. Webber (2000) examined asymmetry of appreciation and depreciation effect on import prices across eight Asia Pacific countries. The results of the empirical analysis confirm that the six out of seven countries found asymmetric exchange rate pass through. They also noticed that exchange rate pass- through is inversely proportional to domestic currency.

According to Cheikh (2012), the affects of exchange rate is higher when inflation rate exceed a threshold level. He has critically analyzed the nonlinear mechanism of exchange rate pass-

through relating to CPI inflation for twelve European countries. His results provide a support to the observation of Taylor which recommends that exchange rate pass-through decreases in lower and more stable inflation environment. He also finds that eight out of twelve European countries reveal a positive link along with exchange rate pass-through and inflation. Junior and Leon-Ledesma (2008) studied empirical facts on exchange rate pass-through regarding CPI inflation for selected emerging and developed countries which adopted inflation targeting by using flat transition regression models and test several transition variables to grasp possible nonlinearity and also investigating the output gap, inflation level, the size of changes in exchange rate, and measure macroeconomics stability. The findings of the study conclude that higher inflation and low credibility raises exchange rate pass-through in a nonlinear way. They found that higher inflation leads to higher exchange rate pass-through, and thus the lower exchange rate pass-through in 1990s may be due to the fall in the rates of inflation. Cheikh (2013) has shed light on nonlinearity with respect to business cycle and found strong evidence that the response of exchange rate pass-through is nonlinear to economic activity in six out of twelve Euro Area countries and significant differences in the scale of exchange rate pass-through between the periods of boom and recession. In some countries, during recessions high exchange rate pass-through is observed and vice-versa. These differences in cross country are the nonlinear mechanism of exchange rate pass-through would have substantial suggestions for the control of inflation and the design of monetary policy.

Different econometric methods tools and are developed to enhance the results quality for estimation techniques. Smooth transition regression model is becoming popular in conducting asymmetries or nonlinearities in exchange rate pass-through because of its reliable and dependable results. To our knowledge, there are very few studies using a smooth nonlinear

regression models for testing the asymmetries and nonlinearities in the exchange rate. Shintani et al. (2009) used smooth transition autoregressive models to estimate dynamics of exchange rate pass-through. They used some U-shaped transition functions in evaluation of time varying exchange rate pass-through to imports of U.S. and data of local price and past inflation rate used as transition variables. They found the exchange rate pass-through decline during 1980s and 1990s would be linked with low inflation level. Kihc (2010) studied the link between exchange rate appreciation or depreciation and inflation rate and exchange rate pass-through by estimating smooth transition pass-through regression model.

In a similar way, Cheikh (2012) checked the existence of nonlinear behavior in the exchange rate pass through by using logistic smooth transition models framework for the Euro Area (EA) countries. He discovered a convincing evidence of nonlinearities with respect to inflation environment in eight out of twelve Euro Area countries, i.e. spread of exchange rate becomes higher in fewer European countries, when inflation rate surpasses some threshold. Junior and Leon-Ledesma (2008) studied on inflation targeting (IT) countries to test feasibility of nonlinear exchange rate pass- through. They use smooth transition regression (STR) models to test several macroeconomic factors, output growth, inflation level, magnitude of exchange rate changes, and macroeconomic instability in order to capture possible nonlinearity. Cheikh (2013) investigated the feasible nonlinear mechanism in the exchange rate pass-through respecting CPI inflation for twelve Euro Area countries by using logistic smooth transition models. He analyzed the existence of nonlinearities to the business cycle and found strong evidence that pass-through respond nonlinearly to economic activity in six out of twelve Euro Area countries

2.7. Literature on Exchange Rate Pass-Through in Pakistan

Exchange rate pass-through into inflation has formerly discussed in many studies for Pakistan as well. The existing studies provide varied results in regard to the relation between exchange rate and prices. Akhtar and Siddique (1999) have critically analyzed the collision of transformation in different variables of monetary policy and transformation in overseas prices on local prices. To established the long run relation and causality among the local prices and exchange rate. The analysis has found no bond between local prices, and variation in exchange rate and money supply and the level of domestic the activity affect domestic prices

Eatzaz and Saima (1999) have traced out the association among prices and exchange rate and furthermore other economic variables for Pakistan. This paper explores pattern and adjustment rate in exchange rate and price-level with respect to different type of shocks. Co-integration and 2SLS method is used for the model estimation. They suggest that there is no unidirectional connection with exchange rate and price level. Rather the short term consequences of deflation on inflation are expected to be slighter than the consequences of inflation on deflation. It also recommends external price shocks and exchange rate devaluation increase the domestic prices in Pakistan.

The exchange rate pass-through regime within Pakistan is resolute by Hyder and Shah (2004). They have shed light on the consequence of exchange rate movements on domestic wholesale price index (WPI) and consumer price index (CPI) inflation in Pakistan. The authors have applied recursiveVAR, variance decomposition method and impulse response functions (IRF) to examine the impact of exchange rate movement on domestic prices. The analysis has found the ER movement has moderate effect on inflation of domestic prices. The end result illustrates a small exchange rate pass-through to local prices. Jaffri (2010) has study the impact of exchange

rate pass through on consumer prices in Pakistan. The typical exchange rate pass-through model specification approach is used to study the long term and short term ERPT in Pakistan. Real exchange rate miss alignment (RERM) is considered. The findings reveal with the intention the exchange rate pass-through regarding inflation of consumer prices is extremely low down in Pakistan. To handle the exchange rate regime he found an important role of collision of the preceding phase miss alignment on inflation. Nevertheless, miss alignments do not influence inflation on the whole sample. Overseas inflation on home country inflation collision is positive and the results are significant.

In case of Pakistan, application of smooth transition autoregressive (STAR) models on behalf of exchange rate was formerly investigated by Tayyab et al. (2012). For real exchange rate modeling they used smooth transition autoregressive (STAR) model and found that real exchange rate series is nonlinear in nature and have exponential and logistic STAR specification. To analyze the impact of nonlinearity in inflation in Pakistan, Rehman et al. (2011) carries out a study and applied smooth transition autoregressive (STAR) model to estimate possible asymmetry in CPI inflation in Pakistan. The study found inflation in Pakistan possesses logistic and exponential STAR nonlinearities. ESTAR is more appropriate for the case of Pakistan and it is better than AR (p) model.

3. RESEARCH METHODOLOGY AND DATA

3.1. Theoretical Framework

To stimulate a nonlinear regression method an uncomplicated theoretical model based on macro-economical environment is formulated. The structure of this model is derived from a model made by Junior and Leon-Ledesma (2008) on nonlinear exchange rate pass-through. Supposing a perfect market competition situation in which a country exports its goods to a country demanding those goods considering prices equal to marginal cost at time interval t. The exporting country objective is to maximize its profits, the equation yielding following expression:

$$P_t = E_t C_t^* \qquad (1)$$

Where; p is the domestic price, E is the exchange rate, C^* is the marginal cost of exporter.

When the perfect competition assumption is relaxed, a mark-up θ over marginal cost is also added to the first-order condition of exporter's profit maximization:

$$P_t = \theta_t E_t C_t^* \qquad (2)$$

Mark-up and marginal cost of exporter can behave separately to the exchange rate. Such as, marginal cost may vary due to a change in the cost of input. Exporter's markup can get altered by changes in demand in importing country. Campa and Goldberg (2005), Fujii and Bailliu (2004), Junior and Leon-Ledesma (2008) assumed that mark-up changes in response to changes in demand pressure in importing country. We have assumed the same in addition to the assumption that mark-up depends asymmetrically on importing country's general macroeconomic stability. This dependence is due to the strategy of the firms to take decision that

how it should transfer the exchange rate effect on prices keeping in view the macroeconomic situation of importing country. Therefore mark-up has the functional form as follows:

$$\theta_t = \theta\left(\rho, E^{\omega(Z)}\right) \qquad (3)$$

Where; Z is measure of macroeconomic instability, $\omega(Z)$ function is the mark-up multiplier and ρ is the demand pressure.

Here high values of Z imply instable macroeconomic environment that is either high inflation or low credibility levels. A firm fixes prices for future periods. If the confidence level of market in economy is low and higher is the inflation rate, then mark-up changes more with respect to changes in exchange rate. Hence when inflation is higher and there is a confidence crisis subsequently exchange rate pass-through increases.

The reduced form equation in logarithms would be:

$$P_t = \alpha e_t + \omega(Z)e_t + \beta c_t^* + \kappa y_t \qquad (4)$$

Where logarithms are denoted by lower cases. In equation (4), exchange rate pass-through has two channels: direct channel and indirect channel. In first channel, the direct exchange rate pass-through is α and it is surrounded by 0 and 1. The direct exchange rate pass-through is complete, if value of α is equal to 1, on the other hand the direct exchange rate pass-through is zero, if α is equal to 0. The indirect channel of exchange rate pass-through is the macroeconomic environment which is represented by $\omega(Z)$ function. We consider the Z^* threshold which is divided into two parts of poor and excellent macroeconomic environments. Where excellent macroeconomic environment is characterized by high level of credibility and low level of

inflation is reflected by low Z value and poor macroeconomic environment which is characterized by low level of credibility and high level of inflation is reflected by high Z value.

$$\omega(Z) = \begin{cases} 0; Z \leq Z^* \\ \psi > 0; Z > Z^* \end{cases} \quad (5)$$

Two different exchange rate pass-through for these two extreme cases can be found. If there is low inflation and credibility of macroeconomic policies in importing country, then exchange rate pass-through be equivalent to α. But if there is low level of credibility and high level of inflation then exchange rate pass-through be equivalent to $\alpha + \psi$. In second part exchange rate pass-through is greater, where $\alpha + \psi > \alpha$. Naturally, when the macroeconomic situation is steady and inflation rate is low down then in importing markets there is a competition between the firms and all changes in exchange rate cannot be passed into prices. Therefore this model says that exchange rate pass-through would rise asymmetrically when inflation is higher and credibility is low.

Rewriting equation 4 in differenced form, we have:

$$\Delta P_t = \beta \Delta c_t^* + \kappa \Delta y_t + [\alpha + \omega(Z)] \Delta e_t \quad (6)$$

For one firm this threshold model may be plausible which may not be for a collection of firms so the nonlinear function should be smoothed out. Therefore, in this empirical research despite of models based on threshold models, smooth transition regression models are considered. Initially this model was used to estimate import prices only but later on it was found suitable to analyze consumer prices as well on exchange rate pass through. The composition of CPI consumer price index is taken as the starting point, extending the model as follows:

$$P_{CPI} = P_H^{\phi} P_T^{1-\phi} \quad (7)$$

Where; price of consumer is P_{CPI}, tradable sector is represented by T and the non-tradable sector by H, and the bounded parameter reflecting the participation of all participants of each sector in this composition of CPI is Φ.

The consumer price index (CPI) inflation equation is:

$$\pi = \phi\pi_H + (1-\phi)\pi_T \quad (8)$$

Considering the lag of one period and we have:

$$\pi_{(H)t} = \delta\pi_{(H)t-1} + \varphi\Delta y_t \quad (9)$$

$$\pi_{(T)t} = \delta\pi_{(T)t-1} + \beta\Delta c_t^* + \kappa y_t + [\alpha + \omega(Z)]\Delta e_t \quad (10)$$

In equation 9 the non-tradable inflation rate relies on the past inflation and output growth. In equation 10 the tradable inflation rate follows the equation 6 along with price inertia. Equation 9 and 10 are substituting in equation 8 and we get:

$$\pi_t = \phi\left[\delta\pi_{(H)t-1} + \varphi\Delta y_t\right] + (1-\phi)\{\delta\pi_{(T)t-1} + \beta\Delta c_t^* + \kappa\Delta y_t + [\alpha + \omega(Z)]\Delta e_t\} \quad (11)$$

After rearranging the above equation, we have:

$$\pi_t = \delta\pi_{t-1} + [(1-\phi)\kappa + \phi\varphi]\Delta y_t + (1-\phi)\beta\Delta c_t^* + (1-\phi)[\alpha + \omega(Z)]\Delta e_t \quad (12)$$

This is the fundamental model to estimate the exchange rate pass-through into CPI inflation. It can be explained on the basis of nonlinear backward looking Phillips curve. In subsequent section a more proper econometric specification model is developed from it.

3.2. Empirical Approach

A set of smooth transition regression (STR) models are applied to estimate the exchange rate pass-through nonlinearities. Smooth transition regression models are a general class of nonlinear time-series models that can account for deterministic changes in parameters over time, combined with regime switching behavior.

3.2.1. Smooth Transition Regression Model

The STR model can be roughly described as the weighted average of two linear models, with weights determined by the value of the transition function. The general structure of the smooth transition regression model is as follows:

$$y_t = \beta_1 X_t + \beta_2 X_t . G(S_{t-i}, \gamma, c) + \upsilon_t \quad (13)$$

Where S_{t-i} is the transition variable, G is the transition function, c is the threshold and γ is the speed of transition.

There are two types of transition functions, namely the exponential and logistic forms that allow for nonlinearity and asymmetry dynamics in the exchange rate pass-through relationship. The logistic smooth transition (LSTR) is more common transition function and is given by:

$$G(S_{t-i}, \gamma, c) = [(1 + \exp\{-\gamma(S_{t-i} - c)\})^{-1}] \quad (14)$$

The exponential smooth transition (ESTR) is an alternative specification to the transition function:

$$G(S_{t-i}, \gamma, c) = (1 - \exp\{-\gamma(S_{t-i} - c)^2\}) \quad (15)$$

Junior and Ledesma (2008) narrates that the value of the parameter c is taken as threshold between $G(S_{t-i}, \gamma, c) = 0$ and $G(S_{t-i}, \gamma, c) = 1$ regimes. The nonlinear coefficient of the LSTR model depends on the threshold of the transition variable that would be above or below from that level. Therefore, when $s_t - c$ approaches$-\infty$, $G(S_{t-i}, \gamma, c) \to 0$ the coefficient of the function turn out to be β_1 and when $s_t - c$ approaches$+\infty$, $G(S_{t-i}, \gamma, c) = 1$, the coefficient of the function turn out to be $\beta_1 + \beta_2$ and when the variable s_t is equal to c, then the transition function $G(S_{t-i}, \gamma, c) = 1/2$ the coefficient will be $(\beta_1 + \beta_2)/2$.

In ESTR model scenario the different values of coefficients depends on threshold of the transition variable that can be far away or close. Therefore the inflation coefficient would be $\beta_1 + \beta_2$ when the function $s_t - c$ approaches $\pm\infty$ and the coefficient would be $\beta_1$when s_t is equal to c.

Exchange rate changes are used as transition variable in ESTR model. On the other hand output growth, inflation rate and the measure of macroeconomic stability are used as transition variables in LSTR model because they are more appropriate since it will follow the same pattern as the threshold model however the modification in the LSTR model is smooth.

The smooth transition regression (STR) model approach as explained by Terasvirta (1994), Lundbergh et al. (2000) and Franses, Terasvirta and Van Dijk (2002) is applied here to determined the smooth transition regression model. In this modeling technique the following steps are used.

3.3. Model Specification

The smooth transition regression models are based on the modeling approach of Terasvirta (1994) consisting of multiple steps to determine the STR models. The modeling procedure consists of the following steps:

- To specify the linear autoregressive model.
- To test linearity against smooth transition regression model.
- To selection the transition function form (LSTR or ESTR).
- Finally estimation of the parameters of smooth transition regression models.

The steps are elaborated as under:

Firstly, the linear portion of the autoregressive model is estimated for the given time series to determine the order p by specifying the lags of the autoregressive model provided by the lowest Akaike Information Criteria (AIC) and the highest $AdjR^2$ and obtain the residuals (ε_t). This is the base for the estimation and evaluation of nonlinear model.

Secondly, create the residuals from the selected autoregressive model and test the null hypothesis of linear model against the nonlinear smooth transition regression model. If the null hypothesis of the model is accepted then the model is linear model. On the other hand if the null hypothesis of the model is not accepted then the nonlinear smooth transition regression model is estimated. The estimated model is then estimated against general model miss specification and in case of failure it is further evaluated and estimated against an extended model. Terasvirta (1998), Van Dijk, Franses and Terasvirta (2002) and others recommended that the LM tests are used to test the linear model against the nonlinear smooth transition regression model.

Thirdly, in process of developing smooth transition regression (STR) model, the suitable form of smooth transition function $G(S_{t-i}, \gamma, c)$ is selected. At the stage of assessment Terasvirta (1994) proposed the decision that which transition functional form is better for the estimation. From the linearity test results we firstly select the transition variables and then estimate the nonlinear model for Exponential smooth transition regression or Logistic smooth transition regression. The transition funcon $G(S_{t-i}, \gamma, c)$ is selected which is best fitted to the model.

Fourthly, when the transition function is selected, next step is to estimate the parameters for the smooth transition regression models. This model can be estimated by the application of nonlinear least square. The nonlinear least square is equal to quasi maximum likelihood estimates when the error terms are distributed normally. The grid search technique is used to estimate the nonlinear transition function. In grid search method, the value of threshold (c) and the speed of transition (γ) is fixed and select the values of c and γ that minimize the residual sum of square (RSS). These initial values of c and γ are pu.t into the nonlinear least square procedure and estimate the models. This estimation technique gives more precise and accurate results.

A related form of model is used as in Ihrig and Gagnon (2004), Goldberg and Campa (2005), Choudhri and Hakura (2006), and Junior (2008). The firms pricing behavior at aggregate level is taken into account by these functional forms. The estimated model has the following form:

$$\pi_t = \beta_0 + \sum_{i=1}^{n} \beta_{1,i}\, \pi_{t-i} + \sum_{i=0}^{n} \beta_{2,i} \Delta p_{t-i}^{imp} + \sum_{i=0}^{n} \beta_{3,i}\, \Delta y_{t-i} + \sum_{i=0}^{n} \beta_{4,i}\, \Delta e_{t-i} + \left(\beta_0^* + \sum_{i=0}^{n} \beta_{4,i}^* \Delta e_{t-i}\right) G(S_t, \gamma, c) + \varepsilon_t \quad (16)$$

Where π is the rate of inflation, Δy is the change in output growth, Δp^{imp} is the change in the foreign price of imports, $G(S_{t-i}, \gamma, c)$ is the nonlinear function, Δe is the variation in exchange rate and ε is an error term of the model.

Two basic outcomes for exchange rate pass-through are there. In the first outcome of exchange rate pass-through, the transition variable is near the threshold for the ESTR model while for the LSTR model the transition variable is far below the threshold level. Exchange rate pass-through is given just by the linear parameters $\sum_{i=1}^{n} \beta_{4,i}$ in this case. In the second outcome of exchange rate pass-through, the transition variable is far beyond from the threshold for the LSTR model, or far away it for the ESTR model. Here the coefficient is the summation of the linear and nonlinear parts of the model $\sum_{i=1}^{n} \beta_{4,i} + \sum_{i=1}^{n} \beta_{4,i}^{*}$. There is a third possible outcome for the LSTR specification: when the transition variable is equivalent to the threshold exchange rate pass-through is given by $\sum_{i=1}^{n} \beta_{4,i} + \sum_{i=1}^{n} \beta_{4,i}^{*} /2$.

3.4. Hypotheses

On the basis of above model following hypotheses are made:

H_0 : The exchange rate pass through to inflation rate is linear.

H_1: The exchange rate pass through to inflation rate is nonlinear.

If the null hypothesis of the model is accepted, we select the linear model. On the other hand if the null hypothesis of the model is not accepted, we estimate the nonlinear smooth transition regression model.

3.5. Data and Variables Description

The variables that are incorporated in the analysis are inflation rate, import prices, exchange rate, output growth, and real interest rate differential. We have used quarterly data on the above variables for the period that spans 1990:Q1 to 2011:Q4. The data have been taken from International Monetary Fund's (IMF's) International Financial Statitics (IFS) database. All the variables are in log differences.

Inflation rate is the change in the consumer price index. Inflation is a continual increase in the general price level of services and goods in an economy over a period of time. For the making of monetary policy inflation is one of the essential economic indicator. Import prices are the unit value of imports (in US dollars). Nation

Exchange rate is the price of one nation's currency expressed in another nation's currency. The change of the domestic currency per unit of US dollar is the variation in exchange rate. Appreciation of the domestic currency means negative variation and depreciation means positive change. One of the vital determinants of exchange rate pass-through is the output growth. The growth rate of large scale manufacturing production index is used as proxy of quarterly output growth. Real interest rate differential (RIDs) is used as a measure of macroeconomic instability. For Pakistan call money rate and for United States federal funds rate is used to create this variable. To obtain the real interest rates from the nominal interest rates we used the CPI inflation.

4. DATA ANALYSIS AND EMPIRICAL RESULTS

This chapter explains the results of data analysis. Smooth transition regression (STR) model, Logistic STR model and Exponential STR model are applied to satisfy our research objectives. EViews 5 version and Regression Analysis of Time Series (RATS) software are used to analyze the data.

4.1. Stationarity of Data

We start our analysis with testing the properties of time series. Before we start estimations, the first step involves testing the stationarity of the time series. By stationary series we mean the series with constant mean and variance. Based on non-stationary data, if inappropriately handled, the results are considered to be spurious and cannot be used for policy making. To avoid these types of problems, we need to test the stationarity to each individual time series using Augmented Dickey Fuller (ADF) test. The unit root test results are reported in Table 4.1.

Table 4.1 Results of Unit Root Test

Variables	At Level		At 1st Difference	
	ADF	Prob.	ADF	Prob.
CPI	-1.718	0.4184	-4.520	0.0004
ER	-4.821	0.0001	-7.651	0.0000
Y	-3.758	0.0048	-10.374	0.0000
P^{imp}	-3.845	0.0037	-8.887	0.0000
RID	-3.870	0.0034	-10.628	0.0000

Augmented Dickey Fuller (ADF) test is applied to test the unit root. The series of CPI, ER, Y, P^{imp}, RID are stationary at their 1^{st} difference. The data series are adjusted by taking the logarithmic 1^{st} difference of all the variables in the light of unit root test.

4.2. Testing Linearity against Smooth Transition Regression Model

Modeling procedure for testing linearity against STR model consists of the following steps:

Firstly, residual based test is applied to test the linearity against smooth transition regression (STR) model which is shown in Terasvirta (1996). Initially construct the autoregressive linear model to determine the order p and to obtain the residuals (ε_t). Akaike information criterion (AIC) shows that AR (4) is appropriate model. After the estimation of the linear model, create the residuals from the selected autoregressive model and prepared the following auxiliary equation:

$$\hat{\varepsilon_t} = \alpha_0 + \alpha_1 w_{t-i} + \alpha_2 w_{t-i} s_t + \alpha_3 w_{t-i} (s_t)^2 + \alpha_4 w_{t-i} (s_t)^3$$

Where; w_{t-i} is the vector of explanatory variables (i=1,2,3,4) and s_t denotes the transition variable. The following hypotheses are made

H_0 : α_2, α_3 and α_4 are zero,

H_1 : Atleast one of α_2, α_3 and α_4 is non zero

Lagrange multiplier (LM) statistics is used with Chi-square (χ^2) distribution to test the models. Test the linearity for a number of transition variables and their lags i.e CPI inflation, Exchange rate, output growth, and real interest rate differential to choose the relevant transition variable. All explanatory variables and their lags are considering as transition variable to test the linearity against smooth transition regression model, which are given below:

Table 4.2 Linearity Tests against Smooth Transition Regression model

Variables	Prob	Variables	Prob
π_{t-1}	0.000	Δy_{t-1}	0.052
π_{t-2}	0.116	Δy_{t-2}	0.898
π_{t-3}	0.165	Δy_{t-3}	0.767
π_{t-4}	0.000	Δy_{t-4}	0.074
rid_{t-1}	0.802	Δe_{t-1}	0.708
rid_{t-2}	0.348	Δe_{t-2}	0.092
rid_{t-3}	0.000	Δe_{t-3}	0.304
rid_{t-4}	0.810	Δe_{t-4}	0.898

Note: The numbers are probability-values of Chi-square distribution of the LM test

We select the transition variables that strongly reject the null hypothesis of the linear model. According to above table the potential transition variables are π_{t-1}, rid_{t-3}, Δy_{t-1}, Δe_{t-2} which have nonlinearity in the model. These transition variables are chosen on the basis of lowest p-value for the rejection of the linear model.

4.3. Select the Form of Transition Function

After choosing the transition variables, next step is to select the form of the transition function LSTR or ESTR. From the auxiliary equation we can choose the transition function of the model. Terasvirta (1994) recommended that the following hypotheses are tested to choose the best transition function for the model. The hypotheses are:

$H_0 : \alpha_4 = 0$

$H_1 : \alpha_4 \neq 0$

The test has a LM statistic with a Chsquare (χ^2) distribution. If the null hypothesis is not accepted then the model has the LSTR functional form, otherwise select the ESTR functional form. Table 4.3 reports the LM test results.

Table 4.3 Modl Specification

Transition Variables	p-values	Functional Form
Inflation (π_{t-1})	0.0067	LSTR
Exchange Rate (Δe_{t-2})	0.2833	ESTR
Output Growth (Δy_{t-1})	0.0106	LSTR
RID (rid_{t-3})	0.0002	LSTR

From the above table, ESTR model is more appropriate for the Exchange rate. For this the cause is the size of changes in exchange rate. As said by Junior and Leon-Ledesma (2008), the nonlinear variations in exchange rate are by reason of menu costs because when there is a large shock firms set their prices not in the small shocks. For other transition variables (inflation, output growth, real interest rate differential), LSTR model is more appropriate for the case of Pakistan.

4.4. Smooth Transition Regression Model

Now we have estimated the LSTR and ESTR models using different transition variables. There are two extreme regimes for the pass through coefficients, one is linear part and the other is nonlinear part. A number of misspecification tests are applied to check the quality of estimated LSTR and ESTR models.

4.4.1. Transition Variable: Inflation

We select the first lag of inflation as a transition variable (see table 4.2), it strongly reject the null hypothesis of linear model, and after the estimation of the nonlinear smooth transition regression model there is no additional nonlinearity. The rejection of null hypothesis is based on the lowest p-value and the first lag of inflation is selected. For the case of Pakistan LSTR model is more suitable model (see Table 4.4).

We now estimate logistic smooth transition regression model with first lag of inflation as a transition variable. Following table report the estimation results.

Table 4.5 Results of LSTR model with Inflation as a transition variable

		$\boldsymbol{\pi_{t-1}}$	
Threshold (c) Speed of transition (γ)		8.619 (0.00) 4.723 (0.03)	
Linear Part		**Non-linear Part**	
Constant	-0.672 (0.319)	Constant	5.170 (0.000)
Δy_t	0.024 (0.359)	Δy_t	-0.613 (0.005)
Δe_t	0.126 (0.027)	Δe_t	0.278 (0.008)
Δp_t^{imp}	0.013 (0.595)	Δp_t^{imp}	0.104 (0.002)
Δy_{t-1}	0.027 (0.296)	Δy_{t-1}	-0.082 (0.133)
Δe_{t-1}	-0.083 (0.134)	Δe_{t-1}	-0.236 (0.029)
π_{t-1}	1.120 (0.000)	π_{t-1}	-0.614 (0.000)
AIC	3.485	AIC	2.325
Adjusted R^2	0.895	Adjusted R^2	0.923
S.E of regression	1.33	S.E of regression	1.142

Note: The values in the parenthesis are the p-value

In contrast to the linear model the AIC is lower, adjusted R^2 is higher, and the S.E of regression is lesser in te non-linear part. These results reinforce that for Pakistan the exchange rate pass-through response is nonlinear to the inflation rate. Detailed results of LSTR model with Inflation are presented in table A1 and A2 in Appendix A.

Table 4.6 Sum of the Exchange Rate Coefficients – Inflation

Transition Function	Inflation (π_{t-1})
$G(S_{t-i}, \gamma, c) = 0$	0.043
$G(S_{t-i}, \gamma, c) = ½$	0.064
$G(S_{t-i}, \gamma, c) = 1$	0.085

For Pakistan the threshold inflation (annual rate) is 8.6%, the smoothness parameter and threshold is significant in our results. Regarding speed of transition (γ), our results indicate a relatively moderate value which is a proof of smooth transition between the two inflation regimes. Inflation rate is significant in both the parts. The summation of the nonlinear coefficients of exchange rate is positive, so there is a positive linkage between inflation and exchange rate pass-through. In this sense, higher will be the exchange rate pass-through, when inflation increases above the threshold. The response of prices to rise and fall of exchange rate depends positively on inflation. Our findings agree with the Junior and Leon-Ledesma (2008) who used the STR model and found lower pass-through in response of low inflation and the nonlinear exchange rate pass-through regarding inflation and also showing a positive association along with inflation and pass-through. Cheikh (2012) found 8 out of 12 EA countries that showing the same results. Likewise, Shintani et al. (2009) found the similar domino effect for United States. Table 4.5 shows the exchange rate coefficients summation of the transition variable inflation (π_{t-1}) , when the transition function $G(S_{t-i}, \gamma, c)$ = 0, 1, and ½. For Pakistan the response to the inflation is weak on behalf of exchange rate pass-through, as the summation of the nonlinear exchange rate coefficients is 0.085. However, empirical evidence shows that inflation is non-linear and we cannot reject LSTR type nonlinearities in the data.

4.4.2. Transition Variable: Output Growth

In this section we raise the issue of whether the business cycles have effect nonlinearly the exchange rate pass-through. The empirical evidence on this issue suggests a positive link with output growth and exchange rate. Intuitively, when the economy is flourishing in those period firms wanted to increase the cost which is imminent from the exchange rate. In this sense exchange rate pass-through would be above in phase of boom subsequently in period of recession. When the value of output growth exceeds the threshold, then this is the prosperity period. Whereas, when the value of output growth is below the threshold, these are periods of economic slowdown.

According to Werlang and Goldfajn (2000), output growth is one of the important determinant of exchange rate pass-through. Naturally, when the economy is improving rapidly, it is more convenient for firms to pass through changes in cost. Whereas, the sales of the firms are already decreasing when there is a recession in economy. We analyze the level in the direction of exchange rate pass-through may be nonlinear to output growth. Our findings show that the first lag of output growth is the potential transition variable (see Table 4.7). This is chosen on the basis of lowest p-value for the rejection of null hypothesis. In addition LSTR model is more appropriate as compared to ESTR (see Table 4.8).

We now estimate logistic smooth transition regression model with first lag of output growth as a transition variable. Following table report the estimation results.

Table 4.9 Results of LSTR model with Output Growth as a transition variable

		Δy_{t-1}	
Threshold (c) Speed of transition (γ)		4.816 (0.00) 6.719 (0.07)	
Linear Part		**Non-linear Part**	
Constant	-0.064 (0.893)	Constant	0.801 (0.592)
Δy_t	-0.025 (0.216)	Δy_t	0.070 (0.307)
Δe_t	0.055 (0.143)	Δe_t	-0.013 (0.964)
Δp_t^{imp}	0.076 (0.000)	Δp_t^{imp}	-0.185 (0.008)
Δy_{t-1}	0.020 (0.520)	Δy_{t-1}	0.054 (0.209)
Δe_{t-1}	-0.140 (0.009)	Δe_{t-1}	0.175 (0.713)
π_{t-1}	1.314 (0.000)	π_{t-1}	-0.518 (0.173)
Δp_{t-2}^{imp}	-0.043 (0.000)	Δp_{t-2}^{imp}	0.014 (0.861)
Δy_{t-2}	0.046 (0.031)	Δy_{t-2}	-0.056 (0.354)
Δe_{t-2}	0.137 (0.002)	Δe_{t-2}	0.394 (0.219)
π_{t-2}	-0.407 (0.000)	π_{t-2}	0.596 (0.142)
AIC	10.417	AIC	10.254
Adjusted R^2	0.917	Adjusted R^2	0.921
S.E of regression	1.184	S.E of regression	1.157

Note: The values in the parenthesis are the p-values

In contrast to the linear model the AIC is lower, adjusted R^2 is higher, and the S.E of regression is lesser in the non-linear part. These results reinforce that for Pakistan the exchange rate pass-through response is nonlinear to the output growth. Detailed results of LSTR model with output growth are presented in table B1 and B2 in Appendix B.

Table 4.10 Sum of the Exchange Rate Coefficients – Output Growth

Transition Function	**Output Growth** (Δy_{t-1})
$G(S_{t-i}, \gamma, c) = 0$	0.052
$G(S_{t-i}, \gamma, c) = ½$	0.330
$G(S_{t-i}, \gamma, c) = 1$	0.608

The above table shows the exchange rate coefficients summation of the transition variable output growth (Δy_{t-1}). The nonlinear exchange rate coefficients summation is 0.608, means the response of pass-through is positive, signifying that the exchange rate pass-through effect is very strong so in the period when economy is overheated means over the threshold then exchange rate pass-through is augmented. Firms motivated to increase the cost which is imminent from the exchange rate. The response of smoothness parameter for Pakistan is weak, as the speed of transition (γ) is slow. Therefore the movement between the regimes is smooth and results are significant. When output growth is above some threshold the exchange rate transmission to CPI inflation is significantly greater. The threshold values of output growth here are significant. Junior and Leon-Ledesma (2008) and Cheikh (2012) also observed positive relationship between pass-through and economic activity as is observed in this study.

4.4.3. Transition Variable: Real Interest Rate Differentials (RIDs)

According to Junior and Leon-Ledesma (2008), monetary policy credibility affects the degree of exchange rate pass-through. In this theoretical model (section 3.1) we talked about the macroeconomic stability. Low inflation environment and high credibility level would refer to a general macroeconomic stability. In period when the economy is stable and inflation is low, exchange rate pass-through would be anticipated to decrease and vise-versa. In our research we use real interest rate differentials as an indicator of macroeconomic instability. When RIDs increases, exchange rate pass-through would increases as well.

Table 4.2 shows the linearity tests against STR model and found the third lag of RIDs as a transition variable to capture the nonlinearity. The LSTR model is more fitting model for Pakistan instead of ESTR (see Table 4.11).We now estimate logistic smooth transition regression

model with third lag of RIDs as a transition variable. Following Table 4.12 report the estimation results.

Table 4.13 Results of LSTR model with RIDs as a transition variable

		rid_{t-3}	
Threshold (c) Speed of transition (γ)		1.221 (0.00) `17.778 (0.54)	
Linear Part		**Non-linear Part**	
Constant	1.293 (0.051)	Constant	-0.981 (0.278)
Δy_t	-0.066 (0.024)	Δy_t	0.054 (0.213)
Δe_t	0.040 (0.348)	Δe_t	-0.059 (0.468)
Δp_t^{imp}	0.084 (0.000)	Δp_t^{imp}	-0.133 (0.000)
Δy_{t-1}	0.029 (0.301)	Δy_{t-1}	-0.083 (0.097)
Δe_{t-1}	0.089 (0.063)	Δe_{t-1}	0.125 (0.128)
π_{t-1}	0.815 (0.000)	π_{t-1}	0.247 (0.006)
AIC	3.485	AIC	2.302
Adjusted R^2	0.895	Adjusted R^2	0.916
S.E of regression	1.33	S.E of regression	1.205

Note: The values in the parenthesis are the p-values

In comparison to the linear model the AIC is lower, adjusted R^2 is higher, and the S.E of regression is lesser in the non-linear part. These results reinforce that for Pakistan the exchange rate pass-through response is nonlinear to the RIDs. Detailed results of LSTR model with RIDs are presented in table C1 and C2 in Appendix C.

Table 4.14 of the Exchange Rate Coefficients – Real Interest Rate Differentials

Transition Function	**RIDs** (rid_{t-3})
$G(S_{t-i}, \gamma, c) = 0$	0.129
$G(S_{t-i}, \gamma, c) = ½$	0.162
$G(S_{t-i}, \gamma, c) = 1$	0.195

There is a positive connection among RIDs and exchange rate pass-through because the summation of the coefficients of exchange rate is positive can be seen in table 4.9. The RIDs

effect is strong on exchange rate pass-through, since the nonlinear coefficients summation on exchange rate is 0.195 hence the role of credibility is important. When the economy faces confidence crises and macroeconomic instability subsequently exchange rate pass-through will be higher. The threshold value of RIDs is 1.2%. The response of smoothness parameter for Pakistan is very strong, as the speed of transition (γ) is fast. The loss of confidence crise and increase in macroeconomic instability would cause a higher responsiveness of inflation to exchange rate changes. The results recommend the stability of economy consequences on the exchange rate pass-through is considerable. The changes in exchange rate is not taken by the firms under the bad economic situations hence higher would be the exchange rate pass-through. Conversely under good economic situations exchange rate pass-through would be lower.

4.4.4. Transition Variable: Exchange Rate

Nonlinearities can be arising by the variation in the size of exchange rate which depends on the movement of the exchange rate is small or large. Following the linearity test against STR model shown in 4.2 table. Nonlinear STR model is applied and found the second lag of exchange rate as a transition variable for Pakistan to capture the nonlinearities. An ESTR specification is more appropriate as compare to LSTR (see Table 4.15), The reason for this is the magnitude of variation in exchange rate. Junior and Leon-Ledesma (2008) narrated that, the nonlinear alteration in exchange rate is by reason of menu costs because when there are large shocks firms set their prices not in the small shocks. The nonlinear ESTR model is good to estimate the nonlinearities as compare to the linear model.

We now estimate exponential smooth transition regression model with second lag of exchange rate as a transition variable. Following Table 4.16 reports the estimation results.

Table 4.17 Results of ESTR model with Exchange Rate as a transition variable

		Δe_{t-2}	
Threshold (c) Speed of transition (γ)		0.753 (0.087) 0.218 (0.002)	
Linear Part		**Non-linear Part**	
Constant	4.224 (0.006)	Constant	-4.243 (0.008)
Δy_t	-0.113 (0.038)	Δy_t	0.103 (0.096)
Δe_t	-0.503 (0.000)	Δe_t	-0.528 (0.000)
Δp_t^{imp}	0.088 (0.047)	Δp_t^{imp}	0.002 (0.963)
Δy_{t-1}	0.151 (0.046)	Δy_{t-1}	-0.144 (0.081)
Δe_{t-1}	0.663 (0.000)	Δe_{t-1}	0.642 (0.000)
π_{t-1}	0.271 (0.179)	π_{t-1}	0.699 (0.000)
Δp_{t-1}^{imp}	0.082 (0.227)	Δp_{t-1}^{imp}	-0.121 (0.095)
Δy_{t-2}	-0.073 (0.208)	Δy_{t-2}	0.108 (0.096)
AIC	6.339	AIC	6.088
Adjusted R^2	0.911	Adjusted R^2	0.918
S.E of regression	1.242	S.E of regression	1.185

Note: The values in the parenthesis are the p-values

In comparison to the linear model the AIC is lower, adjusted R^2 is higher, and the S.E of regression is lesser in the non-linear part. These results reinforce that for Pakistan the response of exchange rate pass-through is nonlinear to the exchange rate. Detailed results of ESTR model with exchange rate are presented in table D1 and D2 in Appendix D.

Table 4.18 Sum of the Exchange Rate Coefficients – Exchange Rate

Transition Function	(Δe_{t-2}) **Exchange Rate**
$G(S_{t-i}, \gamma, c) = 0$	0.160
$G(S_{t-i}, \gamma, c) = ½$	0.217
$G(S_{t-i}, \gamma, c) = 1$	0.274

Exchange rate pass-through behavior regarding the scale of amendment in exchange rate is nonlinear for Pakistan. The summation of the coefficients of exchange rate is positive (see 4.11

table). The size of variation in the pass-through and exchange rate has positive relationship, as the summation of the nonlinear coefficients of exchange rate is 0.274. When the exchange rate changes are large the response of inflation is higher conversely, when there are little modification in exchange rate the inflation rate is less, this is due to the existence of menu cost. When the modification in the exchange rate is little, the firms do hesitate to change prices for the reason that the cost to change the prices is too high. Alternatively, if changes in exchange rate is on upper side the firms must desire to adjust the price as by not changing prices its financial effect will be very high on the firms. This comparison reflects the positive relation among impact of currency changes for Pakistan on pass-through of exchange rate. Junior and Leon-Ledesma (2008) and Cheikh (2012) also found a positive and nonlinear response of changes in between pass-through and exchange rate for 2 out of 6 countries and 9 out of 12 Euro Area countries respectively. The speed of transition for Pakistan is slow; in this sense the effect of transition from one place to another place is smooth for Pakistan.

5. CONCLUSIONS

In this research work, the role of non-linear exchange rate pass through into inflation for Pakistan is investigated. Quarterly data has been used for time between 1990 and 2011 .Parsimonious markup model of import prices is presented where it is assumed that macroeconomic environment changes can cause the occurrence of nonlinearities. This study focused not only on exchange rate pass through with respect to exchange rate shocks, but also on testing some significant transition variables so that we can find out some realizable nonlinearities that could manipulate exchange rate pass through. Variables included in our analysis are inflation rate, import prices, exchange rate, output growth, and real interest rate differential. The analysis started with testing the properties of time series, checking the stationarity of data in addition to determining order of integration.

Firstly, linear portion of the AR(p) model was estimated for the time series given to determine the order p by specifying the AR (p) model's lag length and obtaining the residuals (ε_t). Akaike information criterion (AIC) test statistic showed that AR (4) is appropriate model. Secondly, testing in residuals of AR (4) model, the null of linearity against the STR nonlinearity alternative and selecting the transition variables strongly rejected the baseline linear model's null of linearity. In Pakistan, π_{t-1}, rid_{t-3},Δy_{t-1}, Δe_{t-2} are found potential transition variables which supported the nonlinearity in the model. Next step is to take decision between the transition function (LSTR or ESTR). After testing the hypothesis, ESTR model is found more appropriate for the Exchange rate and for other transition variables (inflation, output growth, and real interest rate differential), LSTR model is more suitable for the case of Pakistan. When the transition function is selected, next step is to estimate the parameters of STR-models. STR-model is estimated by the application of nonlinear least square.

Results for Pakistan show that, there is nonlinear exchange rate pass through into inflation. Existence of nonlinearities with respect to inflation, output growth, magnitude of changes in exchange rate and measure of macroeconomic instability are observed.

Strong evidence is found that exchange rate pass through respond nonlinearly with respect to inflation. Between inflation and exchange rate pass through a positive relationship was observed since the sum of nonlinear exchange rate coefficients is 0.085. It can be deducted that when inflation increases more than threshold, exchange rate pass through also increases. Regarding magnitude of changes in exchange rate, a higher reaction of pass through for large changes in exchange rate is observed than relatively for small ones. The sum of the nonlinear exchange rate coefficients is 0.274, a positive relationship is therefore observed between pass through and magnitude of changes in exchange rate. However, output growth, where the economy of Pakistan is overheated means above the threshold, exchange rate pass through is higher since expected sum of nonlinear exchange rate terms is 0.608 signifying that the effect on exchange rate pass through is very strong. A positive relationship between RIDs and exchange rate pass through has been found. The effect of RIDs on exchange rate pass- through is strong, as sum of the nonlinear exchange rate coefficients is 0.195, recommending a central role of credibility. Exchange rate pass through seems to increase, when there is a macroeconomic instability in Pakistan. For lower exchange rate pass through, there is a need to implement better economic policies, to keep inflation rate low and to bring macroeconomic stability in Pakistan.

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APPENDIX -A: Results of LSTR model with transition variable: Inflation

Table A1: Linear Regression

Linear Regression - Estimation by Least Squares

Dependent Variable INF

Quarterly Data From 1990:02 To 2011:04

R-Bar^2	0.8955057
Standard Error of Estimate	1.3300655843
Sum of Squared Residuals	141.52595669
Log Likelihood	-144.6137
Durbin-Watson Statistic	1.2466

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.589869126	0.523946432	1.12582	0.26360800
2. Y	-0.036542855	0.025941400	-1.40867	0.16280780
3. ER	0.005933274	0.045909778	0.12924	0.89749394
4. IMP	0.077062291	0.016277537	4.73427	0.00000936
5. Y{1}	0.020237420	0.025407116	0.79653	0.42808404
6. ER{1}	-0.042473065	0.049057513	-0.86578	0.38919929
7. INF{1}	0.873418671	0.043887669	19.90123	0.00000000

Table A2: Nonlinear Regression

Nonlinear Least Squares - Estimation by BFGS Restricted

Dependent Variable INF

Quarterly Data From 1990:01 To 2011:04

R-Bar^2 0.9229568

Standard Error of Estimate 1.1420731432

Sum of Squared Residuals 92.607505581

Log Likelihood -126.1648

Durbin-Watson Statistic 1.2865

Variable	Coeff	Std Error	T-Stat	Signif
1. A0	-0.672015485	0.670659945	-1.00202	0.31973620
2. A1	0.023839083	0.025844102	0.92242	0.35943422
3. A2	0.126323732	0.055953207	-2.25767	0.02704286
4. A3	0.012676466	0.023723100	0.53435	0.59476791
5. A4	0.026905526	0.025544742	1.05327	0.29578835
6. A5	-0.083224786	0.054923065	1.51530	0.13413665
7. A6	1.120177307	0.107051389	10.46392	0.00000000
8. B0	5.107440651	1.363636098	3.74546	0.00036307
9. B1	-0.162738741	0.056428489	-2.88398	0.00519439
10. B2	0.278468618	0.103016773	2.70314	0.00858823
11. B3	0.104304883	0.033393881	3.12347	0.00258698
12. B4	-0.081549780	0.053627791	-1.52066	0.13278570
13. B5	-0.235975135	0.105798391	-2.23042	0.02888110
14. B6	-0.614225600	0.122577586	-5.01091	0.00000382
15. ALPHA	8.619429335	0.842143883	10.23510	0.00000000
16. GAMMA	4.722746936	0.327240150	2.20861	0.03043090

APPENDIX -B Results of LSTR model with transition variable: Output Growth

Table B1: Linear Regression

Linear Regression - Estimation by Least Squares

Dependent Variable INF

Quarterly Data From 1990:03 To 2011:04

R-Bar^2 0.9179409

Standard Error of Estimate 1.1838859507

Sum of Squared Residuals 105.11894581

Log Likelihood -130.6608

Durbin-Watson Statistic 1.8909

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.322481849	0.555046655	0.58100	0.56298269
2. Y	-0.017093995	0.024211703	-0.70602	0.48236186
3. ER	0.052147618	0.046382477	1.12430	0.26447317
4. IMP	0.062860449	0.017133116	3.66894	0.00045307
5. Y{1}	0.018038089	0.024286400	0.74272	0.45996891
6. ER{1}	-0.120266817	0.070233430	-1.71239	0.09095727
7. INF{1}	1.266482309	0.110465961	11.46491	0.00000000
8. IMP{2}	-0.046329055	0.015495983	-2.98975	0.00377455
9. Y{2}	0.011429998	0.023377088	0.48894	0.62631082
10. ER{2}	0.086861281	0.049085557	1.76959	0.08086032
11. INF{2}	-0.346663604	0.106646177	-3.25060	0.00172590

Table B2: Nonlinear Regression

Nonlinear Least Squares - Estimation by BFGS Restricted

Dependent Variable INF

Quarterly Data From 1990:01 To 2011:04

R-Bar^2 0.9216542

Standard Error of Estimate 1.1567893504

Sum of Squared Residuals 82.966019280

Log Likelihood -120.4843

Durbin-Watson Statistic 1.6747

Variable	Coeff	Std Error	T-Stat	Signif
1. A0	-0.06424532	0.47671067	-0.13477	0.89323191
2. A1	-0.02518168	0.02016555	-1.24875	0.21645197
3. A2	0.05491870	0.03705473	1.48210	0.14337955
4. A3	0.07593721	0.01474024	5.15169	0.00000284
5. A4	0.02007269	0.03100047	0.64750	0.51970112
6. A5	-0.14047923	0.05278350	-2.66142	0.00989567
7. A6	1.31363142	0.09277961	14.15862	0.00000000
8. A7	-0.04273268	0.01155675	-3.69764	0.00046331
9. A8	0.04637837	0.02105549	2.20267	0.03134422
10. A9	0.13714315	0.04170047	3.28877	0.00166118
11. A10	-0.40678187	0.09426267	-4.31541	0.00005833
12. B0	0.80112267	1.48699963	0.53875	0.59198785
13. B1	0.07032705	0.06832774	1.02926	0.30735587
14. B2	-0.01317935	0.28879726	-0.04564	0.96374760
15. B3	-0.18497434	0.06814144	-2.71456	0.00858383
16. B4	0.05452984	0.04292489	1.27035	0.20870492
17. B5	0.17453413	0.47338750	0.36869	0.71361340
18. B6	-0.51768569	0.37588912	-1.37723	0.17339328
19. B7	0.01374360	0.07830403	0.17552	0.86124627

20. B8	-0.05612975	0.06013986	-0.93332	0.35427523
21. B9	0.39422825	0.31797799	-1.23980	0.21972250
22. B10	0.59600224	0.40086416	1.48679	0.14213741
23. ALPHA	4.81641401	1.50117763	7.00218	0.00000000
24. GAMMA	6.71952938	0.39414577	1.82554	0.07273641

APPENDIX -C: Results of LSTR model with transition variable: Real Interest Rate Differentials (RIDs)

Table C1: Linear Regression

Linear Regression - Estimation by Least Squares

Dependent Variable INF

Quarterly Data From 1990:02 To 2011:04

R-Bar^2	0.8955057
Standard Error of Estimate	1.3300655843
Sum of Squared Residuals	141.52595669
Log Likelihood	-144.6137
Durbin-Watson Statistic	1.2466

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.589869126	0.523946432	1.12582	0.26360800
2. Y	-0.036542855	0.025941400	-1.40867	0.16280780
3. ER	0.005933274	0.045909778	0.12924	0.89749394
4. IMP	0.077062291	0.016277537	4.73427	0.00000936
5. Y{1}	0.020237420	0.025407116	0.79653	0.42808404
6. ER{1}	-0.042473065	0.049057513	-0.86578	0.38919929
7. INF{1}	0.873418671	0.043887669	19.90123	0.00000000

Table C2: Nonlinear Regression

Nonlinear Least Squares - Estimation by BFGS Restricted

Dependent Variable INF

Quarterly Data From 1990:01 To 2011:04

R-Bar^2 0.9158021

Standard Error of Estimate 1.2054213952

Sum of Squared Residuals 100.25981106

Log Likelihood -127.6271

Durbin-Watson Statistic 1.4277

Variable	Coeff	Std Error	T-Stat	Signif
1. A0	1.29333570	0.65210793	1.98332	0.05131342
2. A1	-0.06603242	0.02855143	-2.31275	0.02372432
3. A2	0.04042988	0.04280582	0.94449	0.34821247
4. A3	0.08358014	0.01375671	6.07559	0.00000006
5. A4	0.02867629	0.02755817	1.04057	0.30170616
6. A5	0.08879153	0.04693854	-1.89166	0.06273440
7. A6	0.81458187	0.04749487	17.15095	0.00000000
8. B0	-0.98083466	0.89793849	-1.09232	0.27849247
9. B1	0.05360949	0.04267470	1.25624	0.21326723
10. B2	-0.05877414	0.08047102	-0.73038	0.46763277
11. B3	-0.13352095	0.03692277	-3.61622	0.00056439
12. B4	-0.08290218	0.04931736	-1.68099	0.09728580
13. B5	0.12541591	0.08130335	1.54257	0.12750984
14. B6	0.24679765	0.08709943	2.83352	0.00603203
15. ALPHA	1.22138269	0.12139388	10.0613	0.00000000
16. GAMMA	17.77828479	28.84791061	0.61628	0.53974005

APPENDIX -D: Results of ESTR model with transition variable: Exchange Rate

Table D1: Linear Regression

Linear Regression - Estimation by Least Squares

Dependent Variable INF

Quarterly Data From 1990:03 To 2011:04

R-Bar^2	0.8958331
Standard Error of Estimate	1.3338633310
Sum of Squared Residuals	136.99773672
Log Likelihood	-142.0502
Durbin-Watson Statistic	1.4305

Variable	Coeff	Std Error	T-Stat	Signif
1. Constant	0.416783647	0.544847448	0.76495	0.44663667
2. Y	-0.041269537	0.027071358	-1.52447	0.13148769
3. ER	0.015175635	0.046512179	0.3262	0.74510348
4. IMP	0.093793182	0.020725670	4.52546	0.00002158
5. Y{1}	0.023927285	0.026889474	0.88984	0.37632445
6. ER{1}	-0.045387639	0.049489092	-0.91712	0.36194128
7. INF{1}	0.898044721	0.046748122	19.21028	0.00000000
8. IMP{1}	-0.029319674	0.021438445	-1.36762	0.17540925
9. Y{2}	0.010058567	0.024695652	0.40730	0.68491694

Table D2: Nonlinear Regression

Nonlinear Least Squares - Estimation by BFGS Restricted

Dependent Variable INF

R-Bar^2 0.9177859

Standard Error of Estimate 1.1850037338

Sum of Squared Residuals 92.679434035

Log Likelihood -125.2451

Durbin-Watson Statistic 1.5055

Variable	Coeff	Std Error	T-Stat	Signif
1. A0	4.224392227	1.490897109	2.83346	0.00610229
2. A1	-0.112940318	0.053416785	-2.11432	0.03826941
3. A2	-0.503353048	0.126894294	3.96671	0.00018205
4. A3	0.088415091	0.043775108	2.01976	0.04747177
5. A4	0.150749618	0.074009222	2.03690	0.04567410
6. A5	0.663453456	0.177530737	-3.73712	0.00039105
7. A6	0.271235533	0.199967427	1.35640	0.17959440
8. A7	0.081636268	0.066941877	1.21951	0.22699105
9. A8	-0.073489216	0.057762449	-1.27227	0.20774278
10. B0	-4.243433191	1.555100685	-2.72872	0.00814066
11. B1	0.103223765	0.061053429	1.69071	0.09560967
12. B2	-0.527944411	0.136492583	-3.86793	0.00025371
13. B3	0.002263710	0.049122559	0.04608	0.96338333
14. B4	-0.144090511	0.081336962	-1.77153	0.08108967
15. B5	0.641579913	0.182916272	3.50751	0.00081921
16. B6	0.698716069	0.200474591	3.48531	0.00087868
17. B7	-0.121217032	0.071537254	-1.69446	0.09489200
18. B8	0.107936093	0.063895659	1.68926	0.09588974
19. ALPHA	0.752742014	0.433255344	1.73741	0.08697949
20. GAMMA	0.218044210	0.066884180	3.26003	0.00176355