An Analysis of the Pass-Through of Exchange Rates in Tropical Forest Product Markets: A Smooth Transition Approach

Selin Guney, Department of Economics, North Carolina State University, Raleigh, NC 27695, USA, sguney@ncsu.edu

Selected Paper prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting, San Francisco, CA, July 26-28

An Analysis of the Pass-Through of Exchange Rates in Tropical Forest Product Markets: A Smooth Transition Approach

Selin Guney

Department of Economics, North Carolina State University, Raleigh, NC 27695, USA

Abstract

This paper assesses exchange rate pass through for forest product prices, namely sawnwood, plywood, lumber spruce and logs prices by incorporating smooth structural changes. The major countries investigated are the USA, Japan (Tokyo), Nigeria (Sapele), Malaysia and Gabon and similar or identical products that are traded are examined. In keeping with Hanninen et al.(2000, 20006), paper examines regime-specific ERPT effects. Results suggest evidence for the convenience of the STAR type models (SETAR and LSTAR) to model deviations from LOP in a nonlinear fashion for tropical forest product markets. Reasonable estimates of the threshold values that may be a representation of transaction costs that are in line with the theoretical arguments in international trade were found. It was also observed that the values of threshold variables vary hugely across different countries and also the impulse responses analysis for each price pairs are also supporting the changing behavior of price ratios in high and low regimes that may be regarded as another justification to use models accounting for structural changes to model LOP and/or ERPT in a nonlinear fashion.

Keywords: Exchange Rate Pass-Through, Smooth Transition Models, Forest Product Market

JEL Classification Codes: **F10, F30, F41, L16**

Introduction

The relationship between exchange rate changes and price adjustments of traded goods across countries—a phenomenon typically referred to as exchange rate pass through—has been investigated in a vast number of academic papers. In efficiently linked international markets, exchange rate shocks and price changes should be perfectly reflected by adjustments that preserve an efficient price equilibrium. Although efficiently linked markets dictate such an equilibrium, more often than not, pass-through effects of exchange rate shocks are found to be imperfect, suggesting undershooting or overshooting in price adjustments.

Trade in tropical forest products is an important source of foreign exchange earnings by many developing countries, particularly those in South Asia and Africa. For example, exports of tropical timber are the second highest source of revenue in Gabon, behind petroleum exports (Terheggen, 2011). Such countries also frequently experience macroeconomic instabilities that may result in volatility in exchange rates. An important aspect of the linkages between primary commodity markets and macroeconomic shocks involves the extent to which commodity prices react to exchange rate changes and to international price shocks. Efficient arbitrage in commodities and in foreign exchange should ensure that, once prices for a homogeneous commodity are expressed in a common currency, shocks should trigger equilibrating adjustments to maintain zero profit conditions.

The focus of interest in linkages of prices and exchange rates has evolved over time. In many cases, a macroeconomic view of pass-through that considers linkages among aggregate price indexes is the focus of attention. In contrast, a micro view, which usually pays attention to the industry or commodity level relationships rather than aggregate ones, is often considered as an important indicator of market performance.

This literature stands on the findings of the phenomenon of Law of One Price (LOP) in the latter case and Purchasing Power Parity (PPP) in the former case. Among the studies that concentrate on the aggregate level relationship and emphasize the importance of macroeconomic conditions are Campa & Goldberg (2005), Choudri and Hakura (2001), Edwards (2006), Gagnon and Ihrig (2004), and Taylor (2000). Examples of the literature focused on micro level relations that examine linkages between import prices and exchange rates at the industry or commodity level include Baldwin (1988), Baldwin and Krugman (1989), Dixit (1989), Dornbusch (1987), and Knetter (1989).

A wide variety of empirical approaches have been applied in evaluations of exchange rate pass through. The simplest approach involves bivariate linear regression (e.g. Uusivuori & Buongiorno, 1991; Vesala, 1992). More recent empirical work has given attention to the time series properties of price and exchange rate data. These studies include Abri and Goodwin (2009), Baharumshah and Habibullah (1995), and Sek and Kapsalyamova (2008). Extensions to a panel context have also been considered (e.g. Hanninen, Toppinen, & Toivonen, 2007). A small number of empirical studies have considered exchange rate pass through in the forest products sector, which is this paper's aim. Among these studies are Baharumshah and Habibullah (1995), Goodwin et al. (2012), and Hanninen et al. (2000, 2006).

In recent years, this literature has mostly evolved to consider models that take into account the structural changes and regime switching behavior. Such behavior is often taken to represent the effects of transaction costs and other frictions as well as government policies which may inhibit price adjustments. Likewise, the presence of such frictions is often considered to be a characteristic that reveals the overall performance of a market—an indicator that is particularly relevant in developing and transition countries. An example is Legrenzi et al. (2004) who study asymmetric adjustment of real exchange rates.
This paper presents an empirical analysis of the effect of exchange rate shocks on import and export prices in the forest industry. In particular, exchange rate pass-through for four important tropical timber commodities are considered: sawnwood (hard and soft), plywood, spruce lumber, and logs (hard and soft). The trading regions considered in the analysis are Tokyo (Japan), Sapele (Nigeria-Africa), Gabon (Africa), Malaysia (Southeast Asia), and the USA.

Literature Review

The question dealing with the validity of Law of One Price (LOP), Purchasing Power Parity (PPP) and Exchange Rate Pass-Through (ERPT) has been extensively investigated in the literature since it has important implications both for economists and traders; as its implication being that no persistent opportunities for spatial arbitrage exist. This may help policymakers to decide on the trade policies to be imposed.

The general conclusion underlying this concept is that prices for homogenous products at different geographical locations should not differ more than transport and transaction costs such as insurance, contract fees etc.

However, one obvious reason why the prices of homogenous products may not be the same is the aforementioned transaction and transport costs and other impediments to trade such as tariffs and quotas and as a result of these nonzero costs, deviations from the LOP could contain significant nonlinearities.

Most recently, following these theoretical arguments several studies have employed nonlinear models to investigate the validity of LOP/PPP and ERPT. Among these are Micheal et al (1994), Obstfeld and A.M. Taylor (1997), A.M. Taylor (2001), O'Connel and Wei (2002).In these studies the nonlinear nature of the adjustment process is generally investigated in terms of a threshold autoregressive (TAR) model of some sort and are cumulating evidence in favor of the threshold-type nonlinearity in deviations from the LOP.

Among the studies that use variants of discrete cointegration models of the sort introduced by Balke and Fomby (1997) are Goodwin and Piggott (2001), Lo and Zivot (2001), Sephton (2003) and Park et al (2007) that have found support for the validity of LOP and threshold effects and mentioned that the path of adjustment to equilibrium depends on the size of the shock introduced into the system.

However, since there exists some reasons to think that the patterns of price adjustment in the markets are smooth rather than discrete even though the economic behavior underlying the adjustments is of a discrete nature (i.e. arbitrage is either profitable or not) (Goodwin et al. 2011) the literature progressed through the usage of smooth transition models instead of discrete models of transition and among the studies taking this approach are Goodwin, Holt and Prestemon (2012) and Enders and Holt (2012).

Beginning from 1980's the ERPT literature mostly involved research investigating the pass-through to the U.S. and progressed from the estimations based on simple OLS models to more advanced models taking into account the non-stationarity, dynamic adjustment processes, asymmetry, simultaneity etc. Among the studies incorporating these issues to exchange rate pass-through estimation are Woo (1984), Hooper and Mann (1989) and Al-Abri and Goodwin (2009).

The dominant approach was to investigate the exchange rate pass through phenomenon at the aggregate level before the rise of imperfect competition and strategic trade theory. These changes led the researches to consider exchange rate pass through concept in the industry level and among the studies taking this approach may be best illustrated by Feenstra (1989) for three different industries; cars, trucks and motorcycles and Pollard and Coughlin (2004) for 30 industries in U.S., Goodwin, Holt and Prestemon (2012) for timber products and Yu (2013) where he investigates how exchange rate pass-through depends on firm heterogeneity in productivity and product differentiation in quality.

Some of the research on ERPT concentrated on the determination of the degree of market power and used the ERPT concept to figure out the market power that a country has and also measure the markups in international markets such as Sumner (1981) that aimed to measure the monopoly behavior for the cigarette industry of U.S. and Bresnahan (1989) that concluded that the exchange rate as being a demand rotator is an important feature of international studies for the measurement of market power (Goldberg and Knetter,1996).

Recent research using the ERPT concept to measure the market power for countries may also be helpful in understanding the effect of trade and other competition policies. Differences observed in market power across industries or countries would also be useful to figure out the significance of the trade and regulatory policies that will be imposed which may be considered as one of the most important factors that facilitates the segmentation of markets and also the competition structure of the countries in question.

In this paper, price dynamics will be investigated by applying a class of nonlinear, time series models that allow for the gradual adjustment among price linkages.

STAR Type Models and Data

Nonlinear smooth transition regression (STR) (Teräsvirta 1994, 1998) models, which can be viewed as a generalization of threshold models with a continuous transition function that allows for smooth changes during the transition period rather than discrete changes, are adopted (Hansen, 1999). STAR models are a general class of state dependent nonlinear time series models where the transition between states is generated endogenously. These models also include other popular nonlinear models such as Threshold Autoregressive (TAR) and Exponential Autoregressive (EAR) models. For more detailed discussions on this property of STAR type models please see Haggan and Ozaki (1981), Tong (1983), Tsay (1989) and Granger and Terasvirta (1993).

This approach has several important advantages. It allows researchers to model structural breaks and regime switching and therefore is useful in evaluating gradual regime switching market linkages that account for nonlinearity. Likewise, asymmetric adjustments of exchange rates play an important role in the exchange rate pass through literature. In particular, the appreciation and depreciation of the exchange rate may have different effects on the exchange rate pass through coefficient. This indicates overshooting and/or undershooting behavior and thus is consistent with incomplete or imperfect pass through.
Finally, the STR methodology has been extended recently to multivariate vector autoregressive and error correction models as well as to panel data. Such extensions are considered in this analysis of timber data by evaluating multivariate models.

The basic STAR model of order p which is used to investigate The LOP may be stated as follows:

$$Y_t = \phi_{10} + \phi_{11} Y_{t-1} + ... + \phi_{1p} Y_{t-p} + (\phi_{20} + \phi_{21} Y_{t-1} + \phi_{2p} Y_{t-p}) G(S_t; \gamma, c)) + \varepsilon_t$$

where Y_t and ε_t are distributed normally with means and variances $N(\mu, \sigma^2)$ and $N(0, \sigma^2)$ respectively.

In this equation $G(S_t; \gamma, c)$ is the 'transition function' that changes smoothly between zero and one depending on a 'transition' variable S_t, and its properties are determined by the values of the speed of adjustment parameter γ >0 and the location parameter c .

In the STAR modeling framework the variable ΔY_t switches between two regimes in a smooth way, implying that the dynamics of the observations ΔY_t may be determined by both regimes, with one regime having more effect in some times and the other regime having more effect in other times. So this type of model actually allows for a continuum of regimes and each regime can be related to a different value of transition function $G(S_t; \gamma, c)$.

In practice, generally and throughout this analysis the transition variable S_t is taken to be some function of the dependent variable Y_t.

The basic unit of analysis Y_t used throughout this study is the natural logarithm of the price ratios; ln (P_{it} / P_{jt}) where P_{it} is the nominal import price in country i for the good in question in period t), P_{jt} is the nominal corresponding export price in country j that are expressed in U.S. dollars and t is a time index such that $t = 1, ..., T$ where $T = 321$.

The transition variable S_t determines the nature of the adjustment or namely the transition process. It is expected that the larger the absolute value of the transition variable the larger the difference in recently observed prices and thus the larger the deviation from a presumed parity condition and potential gains from arbitrage and larger deviations will lead to faster and/or larger market adjustments than smaller ones (Goodwin et al, 2011).

In the literature there are a few choices for the transition function $G(.)$ to be used and one model that has been extensively employed is the Logistic STAR (LSTAR) model where the smooth transition function is a logistic function and may be defined as:

$G(S_t;\gamma,c) = inv(1+\exp(-\gamma(S_t - c))$ where $\gamma > 0$

where S_t is the 'transition' variable and its properties are determined by the values of the speed of adjustment parameter $\gamma > 0$ and the 'location' parameter c .

The other alternative for the transition function to be used is the Exponential STAR or ESTAR model in which the transition function is defined as:

$G(S_t;\gamma,c) = 1 - \exp[(-\gamma)(Y_{t-d} - c)]^2$

The parameter c can be interpreted as the threshold and γ determines the speed and the smoothness of the transition for both LSTAR and ESTAR models.

It can be observed that if γ is large both transition functions switch between 0 and 1 more quickly compared to the case where γ is small that implies a very slow and smooth switch between regimes and also as $\gamma \to \infty$ both logistic and exponential functions become binary.

Although there exists some similarity between LSTAR and ESTAR models, they actually exhibit different types of transitional behavior. First of all, the logistic function has a single reflection point while the exponential function has two inflection points which can also be observed from the following figure:

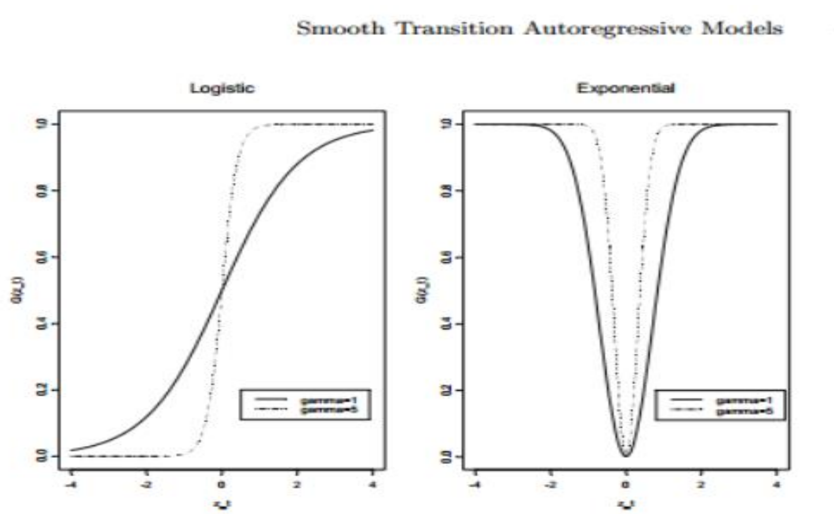


Figure 1.0: Logistic and Exponential Transition Functions

In terms of economic interpretations there are some notable differences between LSTAR and ESTAR models such that LSTAR model is typically related to a couple of regimes (i.e expansive and recessive regimes) with respect to a threshold value and it has the property of being in accordance with an asymmetric business cycle and the variables present a growth with a saturation and associated feedback effects. On the other hand, ESTAR model that includes a symmetric exponential function depicts the sensibility of data to absolute value of transition variable respect to threshold, and then the model lets us to fit in variables with three regimes, a median one and two extremes.

Since the exponential function is symmetric, the ESTAR model switches between two regimes depending on how far away the transition variable S_t is from the threshold C and as a result only the distance between S_t and C matters but not the sign whereas the logistic function is monotonic and the LSTAR model switches between two regimes depending on how much the transition variable S_t is greater or smaller than the threshold C and so both the sign and the distance between S_t and C will be important.

One of the limits of this ESTAR model is that it does not nest as a special case a three-regime self-exciting threshold auto regression (SETAR) which will be explained below since the exponential function approaches the indicator function $I(S_t = c)$ .This property is useful in part because several previous studies of spatial price relationships have successfully employed this model to account for nonlinearities introduced by transaction costs. (see Goodwin and Piggott) (Goodwin et al. 2011).

In contrast to ESTAR models the LSTAR models reduces to a TAR model since the logistic function approaches the indicator function $I(S_t > c)$.

Since the comparison of any nonlinear model will be done with a linear model we will also estimate a linear autoregressive model of order p(AR(p)) and the aforementioned STAR type models will be compared with this model, which may be specified as:

$\Delta Y_t = \Phi 0 + \alpha' X_t + \theta Y_{t-1} + \varepsilon_t$ where $\alpha' = (\phi_1, \phi_2, ...\phi_{p-1})$ and $X_t = (\Delta Y_{t-1}, ..., \Delta Y_{t-p+1})$ or

$Y_t = \mu + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + ... + \phi_p Y_{t-p} + \sigma \varepsilon_t$ where the model parameters σ and $\phi = (\mu, \phi_1, \phi_2, ..., \phi_p)$ are independent of time and stays constant over time.

Threshold Autoregressive Models: TAR and SETAR as an Extension of the Autoregressive Model (AR)

To capture nonlinear dynamics, Threshold Autoregressive (TAR) models which are regarded as an extension of autoregressive models (AR) that have been proposed by Tong (1978). These models allow for variations in the model parameters according to the value of weakly exogenous threshold variable S_t .

The TAR model can be presented as follows:

$Y_t = X_t \phi^{(j)} + \sigma^{(j)} \varepsilon_t$ if $r_{j-1} < S_t < r_j$

where $X_t = (1, Y_{t-1}, Y_{t-2}, ...Y_{t-p})$ is a column vector of variables,

$-\infty = r_0 < r_1 < ..... < r_k = +\infty$ are k non-trivial thresholds dividing the domain of S_t into *k+1* different regimes.

If the threshold variable S_t is assumed to be past values of *Y*, e.g. Y_{t-d} , where *d* stands for the delay parameter, the dynamics of the dependent variable depend on the past values of itself and the TAR model is called self-exciting TAR(SETAR).

Thus, for a given threshold r, the probability of the unobservable regime $S_t = 1$ is given by;

$$P\{[S_t = 1 | \{ S_{t-j} \}_{j=1}^{\infty}, \{Y_{t-j}\}_{j=1}^{\infty}] \} = I \{Y_{t-d} \le r\} = [\begin{matrix} 1 & Y_{t-d} \le r \\ 0 & Y_{t-d} > r \end{matrix}]$$

In TAR type models a regime change is observed when the threshold variable S_t crosses a certain type threshold and the regime switching is assumed to be sudden and discontinuous. However, sometimes it is more reasonable to assume that these regime switches occur gradually and smoothly which lets us to use smooth transition autoregressive models (STAR) that are obtained by replacing the abrupt changes of TAR type models by a smooth transition function.

In this analysis, the emphasis will be based on the comparison of the results of some nonlinear models such as LSTAR and SETAR models which are widely used in the literature of price relationships and the linear counterpart Linear Autoregressive Models (AR).

The data used in the analysis consist of a set of monthly average prices and exchange rates covering the period from October 1982 to June 2009, leading to a total of 321 observations. The monthly series on domestic and foreign prices were obtained from the Commodity Research Bureau (CRB) and the Food and Agricultural Organization (FAO) while the exchange rates were gathered from International Financial Statistics (IFS) published by International Monetary Fund (IMF).

Results

This section provides the empirical results for the test of LOP/ ERPT in accordance with the theory of nonlinear regression for four forest products, namely sawnwood, plywood, lumber spruce and logs by taking into account the structural changes that may be observed over time.

The major countries investigated are the USA, Japan (Tokyo), Nigeria (Sapele), Malaysia and Gabon and similar or identical products that are traded are examined.

The correlation between plywood prices in the USA and plywood prices in Tokyo seems to be low with a positive Pearson coefficient of magnitude 0.23 and the price development in the two markets has a volatile appearance over the period (Figure 1.1).

Unlike Figure 1.1 we can observe tendency of increasing nominal prices in the log market except between years 1995 and 2005. The Pearson correlation coefficients indicate that there is a moderate and positive relationship between soft log prices in USA and logs prices in Sapele and strong positive relationship between soft log prices in USA and Gabon with coefficients of magnitude 0.43,0.76 respectively and a moderate relationship between hard logs prices in USA and logs prices in Gabon with a positive correlation coefficient of 0.65 and slightly lower correlation with coefficient of magnitude 0.64 with Sapele logs prices (Figure 1.2).

In the sawnwood market the correlations between the nominal prices seem to be high and have a tendency to increase before the end of 90's and follow a considerably stable path until 2005 and tends to increase again. The Pearson correlation between hard sawnwood prices in USA and Malaysia is positive and has a magnitude of 0.85 whereas USA soft sawnwood prices and Malaysia sawnwood prices has a correlation coefficient of 0.80 (Figure 1.3).

Strong similarity can be found in price development between the two markets; USA lumberspruce and Malaysia sawnwood before 2000 and show differences after this period. The USA seems to have more volatile prices compared to Malaysia after 2000 and stability of price seems more significant after 2005 for Malaysia. There exists a moderate positive correlation of a magnitude 0.61 between two prices (Figure 1.4).

Also, time series plots of natural logarithms of relative prices are obtained in Figure 1.5 which indicates that there is considerable volatility in price ratios which suggests the potential for significant market interactions.

So overall we may indicate that the figures show a clear relationship between the prices in each market.

When we carefully examine the figures of the aforementioned prices in each market we can gain some important insights about the general economic condition or changes in the data period and its effects on the prices of tropical forest markets. Tropical forest products manufacturing and industries that are related experienced though times during the 1990s in USA: The general economic recession observed in 1989-1991 resulted in a large amount of plant closings and this was a stimulation of a tendency in the 1980s. However, some large firms with private sources of tropical forest products, benefited from the climbing prices. For example, based on a report of S.G. Warburg & Co. Inc., plywood prices increased 67 percent between 1991 and 1993 and these changes in prices can be clearly observed from the Figures 1.1-1.4.

Economic activity in the USA improved significantly during the first half of 2002 which signaled that economic recession was coming to an end beginning in March 2001. Even though we observed decreases in GDP growth during the 2nd quarter of 2003, some elements such as pleasing monetary policy and strong housing sector raised activity as economy moved through the second half of 2003. Low mortgate rates led to the expectation of strength in the housing sector. Wood product demand was at an all-time high in 2003 due to the strong housing construction (FAO/UNECE, 2004).

We can also observe the effects of the mortgage crisis in 2005-2006 in most of the price pairs which led to the deep recession in 2008. Housing prices fell approximately 30% on average from their mid-2006 peak to mid-2009 and remained at approximately that level as of March 2013 (Fred Database-S&P Case Shiller 20-City Home Price Index) and this incident had a huge effect in the prices of most tropical wood products as can be observed in Figures 1.1-1.4.

We can obtain limited information about a causal relationship between variables using the figures and correlation coefficients because of possible different statistical time series properties. Therefore the analysis of aforementioned price relationships is continued by estimating Logarithmic STAR (LSTAR), Self-Exciting Threshold (SETAR) and Linear Autoregressive (AR) regression models.

The first step of the analysis is to assess the statistical properties of the data such as the existence/nonexistence of unit roots and cointegration in price pairs. To this end the Augmented Dickey Fuller (ADF) and Philips Perron (PP) unit root tests are employed.

According to the results of the ADF unit root test in Table 1.3, USA Soft Sawnwood/Malaysia Sawnwood , USA Lumberspruce/Malaysia Sawnwood, USA Plywood/Tokyo Plywood, USA Hard Logs/Sapele Logs and USA Soft Logs/Sapele Logs price pairs have a unit root and are not stationary at 0.05 significance level.

The Phillips–Perron test is a procedure that might be considered as a generalization of ADF test statistic aiming to figure out the stationarity of the variables and test the null hypothesis of a unit root against an alternative of a stationarity by including a non-parametric correction to the t-test statistic. The test is robust with respect to unspecified autocorrelation and heteroscedasticity in the disturbance process of the test equation. The results given in Table 1.4 also confirm the nonstationarity of the USA Hard Sawnwood/Malaysia Sawnwood, USA Plywood/Tokyo Plywood and USA Soft Logs/Sapele Logs price pairs.

Davidson and MacKinnon (2004) report that the Augmented Dickey–Fuller (ADF) test performs better in finite samples than the Phillips–Perron (PP) test, so we continue the analysis with the first differences of the price pairs that are found nonstationary according to the ADF test statistic.

All first differences of the nonstationary price pairs are found to be stationary with a p value of 0.01 and this fact is also supported by Figure 1.6 where the first differences of the price pairs are displayed.

As specified, LSTAR and SETAR models are nonlinear in parameters so nonlinear estimation methods are called for these models including the first differences of the aforementioned price pairs.

Optimal lag lengths for each of the specified models are chosen by the AIC criterion and same lag length is assumed for each regimes.

Finally, the choice between the mentioned models is done through careful examination of the each model's AIC and MAPE criterions.

The first model proposed was the AR (p) model and this model will be the base model to compare the other models to since a fundamental building block of any non-linear time series model is a typical linear model, here a typical linear autoregressive model.

As an improvement to the AR model, we then applied a SETAR (2; 2, 2) model with threshold delay $\delta = 1$ and an LSTAR model with threshold delay $\delta = 1$ again. For an automatic comparison, we may fit different linear and nonlinear models and directly compare measures of their fit. In this analysis the mentioned nonlinear models are estimated and compared with the linear counterpart in terms of their fit measures specifically AIC and MAPE criterions. The results of these comparisons between the models are presented in Table 1.5.

Following Hansen (1997) to make sure that the results are not affected by the possible outliers that may be observed in the data and the model is well identified, the trim value for the grid search for the estimation of the models was chosen as 0.15, meaning the range for the grid search was chosen as to include the 15th and 85th percentiles.

In principle, we do not expect to have large values of the delay parameter d as we do not expect the deviations from LOP to be sticky; throughout this analysis the delay parameter is chosen to be 2, which sets this study apart from some other literature in this area in which the delay parameter d is estimated according to the best fit model but not restricted to unity as has been done in some other previous studies.

From the comparison of all aforementioned models, the SETAR model seems to fit all price pairs best according to AIC criterion whereas the results of the MAPE criterion seems to favor LSTAR model in most price pairs such as USA Soft Sawnwood / Malaysia Sawnwood, USA Plywood /Tokyo Plywood, USA Soft Logs /Gabon Logs and support SETAR model in USA Soft Logs /Sapele Logs, USA Hard Logs /Gabon Logs and USA Lumberspruce/ Malaysia Sawnwood price pairs. According to the MAPE criterion, USA Hard Sawnwood /Malaysia Sawnwood and USA Hard Log /Sapele Logs price pairs are best represented by the linear model.

When there is a contradiction between AIC and MAPE result, models are estimated according to both criteria and evaluated in terms of the significance of the estimated parameters. The best fit models are discussed here. More detailed diagnostics are extracted from these best fit models and are given in Tables 1.6-1.13.

According to Tables 1.8, 1.9, 1.12, and 1.13, it seems that most of the high and low regime coefficients are statistically significant for the USA Lumberspruce /Malaysia Sawnwood, USA Plywood / Tokyo Plywood, USA Hard Logs / Gabon Logs and USA Soft Logs / Gabon Logs price pairs respectively for the SETAR models. The values of the threshold variables are 0.02128, -0.01935, 0.08986 and -0.32. Persistence from the deviations from LOP that are characterized by nonlinear adjustments depends on whether the exchange rate passes these threshold values—possibly representing the transaction costs—allows us to identify two regimes, high and low. The high regime (second one) is identified as the one in which the increase in lagged percentage change in prices are higher than 0.02128, 0.01935, 0.08986 and -0.32 in absolute terms respectively. Arbitrage is profitable and the process is mean reverting whereas the low (first) regime occurs when the deviations from the LOP are smaller than the threshold values calculated. Arbitrage is not profitable and LOP will not hold as the exchange rates are not likely to move back to equilibrium level.

Table 1.8 shows that for USA Lumberspruce /Malaysia Sawnwood price pair analysis, the low regime includes 72.01% of observations whereas the second high regime includes 27.99%. Results shown in Table 1.9 indicate that in the plywood trade markets between USA and Tokyo, the low regime includes 32.7% of total observations and occurs mainly in the first part of the data sample while the proportion of the data in the high regime (second one) is at about 67.3%. On the other hand, according to Table 1.12, in the logs market between USA (Hard) and Gabon, the low regime includes 92.16% of total observations and the second regime involves only 7.84% part of the data. Table 1.13 shows a similar type of relationship as Table 1.10 in terms of the inclusion of data points in the high and low regime and indicates that for USA Soft Logs / Gabon Logs, the proportion of points in low regime is 10.03% while the high regime includes most of the data points with a 89.97% level. For the USA Soft Logs / Sapele Logs price, the estimated threshold value is 0.0531 and the proportion of points in low regime is 93.71% and the second high regime includes the 6.29% of the data (as can be seen from Table 1.11). As implied earlier, the low regime may indicate a situation of no trade or may imply that there exist some important barriers to trade such as tariffs and quotas, whereas the high regime may correspond to the case of trade.

As we know, the more far away the prices are from each other, the larger the deviation from a presumed parity condition and potential gains from arbitrage, thus the reason for differences in prices is the transaction costs. According to Table 1.6, if the two possible best models—SETAR and Linear—are compared, the SETAR model seems to fit better in terms of significance of the coefficients for USA Hard Sawnwood / Malaysia Sawnwood price pair; therefore, a SETAR model is assumed for this price pair.

When the same analysis is done for USA Hard Logs / Sapele Logs price pair, the difference between SETAR and Linear models follows the same path wherein the SETAR model is superior to linear model in terms of the significance of estimated parameters (Table 1.10).

According to Table 1.7, the comparison between the LSTAR and SETAR models for price pair of USA Soft Sawnwood / Malaysia Sawnwood favors the usage of SETAR model as the appropriate model since it includes more significant coefficients. Overall, compared to the other models, the SETAR specification mostly accommodates potentially different market adjustments that approximately follow departures from spatial price parity.

It is expected that the larger the value of the transition variable, the larger the difference in recently observed prices will be; thus, the larger is the deviation from the assumed parity conditions mentioned here, and larger are the potential gains from arbitrage. In this manner, the values of the threshold coefficients provide important insights about the arbitrage opportunities for each country in question; the bigger the coefficient, the more possibility to gain from arbitrage.

The overall results show that nonlinearity and structural change are important features of these markets; price parity relationships implied by the economic theory are generally supported by the estimated models, and the figures of the price pairs presented also supports this conclusion.

The next step in the analysis was to use the out-of-sample forecasting from the aforementioned best fit models and compare the forecasting performance of these models; in addition, using the impulse response functions, the dynamics of these models are investigated further.

The forecasting approach taken here for SETAR and LSTAR models is to evaluate the forecasts for each regime separately in order to see if the nonlinear model can be used to obtain forecasts in a particular regime (see Clements & Smith (1999); van Dijk &Terasvirta (2000); and Tiao & Tsay (1994) for applications of this approach to SETAR models) as there is a possibility that the forecastibility of the time series may be different in different regimes according to the values of the transition variable.

The bootstrap method is chosen to obtain forecasts as they are found more preferable to the naive methods of forecasting and may effectively be used to obtain the confidence intervals using the realizations from bootstrap methods (Clements & Smith, 1997) as empirical forecasts do not always let us to assess the forecasting quality of the STAR type models. So, an estimated SETAR model is used to generate an artificial time series and then forecasts are obtained from these time series using AR (2) model.

It is observed that for most of the price pairs, switching between regimes is not frequent; this fact suggests that the forest market is not jumping back and forth between regimes on a monthly basis, but rather tends to remain in a regime for a long period of time.

Reasonable estimates of the threshold values that may be a representation of transaction costs were found that are in line with the theoretical arguments in international trade. Threshold values obtained show variation across countries and this heterogeneity observed in transaction costs for the same or similar sectors such as using the dollar as our reference currency the estimated threshold values change from %1 to %32 in this analysis may be partly due to the country-specific effects as some countries exhibit relatively higher thresholds for a given sector (Juvenal &Taylor, 2008).

To figure out whether the shocks introduced into this system will have any significant impulse response effects and to assess the time path of these variables, the bootstrap method with 1,000 replications for SETAR and LSTAR models were used. Also, only positive shocks were taken into account in this analysis.

Figures 1.7-1.14 exhibit the graphs of impulse responses for the SETAR models for USA Lumberspruce-Malaysia Sawnwood, USA Plywood-Tokyo Plywood, USA Hard Logs-Sapele Logs, USA Soft Logs-Sapele Logs, USA Hard Logs-Gabon Logs, USA Soft Logs-Gabon Logs, USA Soft Sawnwood /Malaysia Sawnwood, USA Hard Sawnwood /Malaysia Sawnwood price pairs respectively. In the low (first) regime (Figure 1.7), a shock introduced into the system initially increases USA Lumberspruce-Malaysia Sawnwood price in an increasing rate, but after two periods, the relative price tends to increase at a decreasing rate; thereafter, it converges to its long run equilibrium level at about 40 periods. In the high (second) regime (Figure 1.7), a huge increase of the USA Lumberspruce-Malaysia Sawnwood price is observed in the first 3 periods, and the price ratio immediately turns to its equilibrium level.

For USA Plywood-Tokyo Plywood price ratio (Figure 1.8), some important differences between high and low regime characteristics are observed: a shock introduced into the system will only lead to a slight increase in price ratio in low regime, and it tends to converge to the equilibrium level at about 16 periods, whereas this same shock results in a huge price increase in the initial periods of high regime and a quick turn to equilibrium level in 5 periods only.

The USA Hard Logs-Sapele Logs price pair (Figure 1.9) seems to follow a different path in low and high regimes. A shock introduced into the system leads to an increase in the price ratio in the first 2 periods in the low regime whereas an opposite response is observed in the high regime where the price ratio immediately decreases in the first 2 periods. Thereafter, the price ratio tends to increase and reaches its equilibrium level in about 9 periods in the low regime; however, the high regime needs about 38 periods for this ratio to come to equilibrium level.

USA Soft Logs-Sapele Logs pair also exhibits different behavior in low and high regime (Figure 1.10). In the low regime, it takes a long time for the price pair to recover to its long run equilibrium level and still seems not to catch that level even after 50 periods. In the high regime, after a shock given into the system, the price pair immediately returns to its pre-shock level.

In Figure 1.11, USA Hard Logs-Gabon Logs price ratio tends to exhibit an opposite behavior in the first initial 2 periods after a shock. In the low regime, this shock results in a slight increase in price ratio whereas price ratio decreases in the high regime as a result of a shock. Thereafter, in both regimes it starts to increase towards converging to its long-run equilibrium level. The amount of time needed for the convergence is about two times (30 periods) that of the high regime (15 periods) in the low one.

For USA Soft Logs-Gabon Logs price ratio (Figure 1.12), the response to a shock into the system seems to be completely different from the other in the low and high regimes. In the low regime, the price ratio responds to a shock in a way that leads to a decrease in the initial periods and thereafter continues to decrease further reaching to equilibrium level at about 40 periods. In the high regime, a sharp increase is observed in the initial period that increases continue gradually until the long-run equilibrium is achieved after 15 periods. In Figure 1.13, a similar path for the SETAR model of USA Soft Sawnwood/Malaysia Sawnwood price ratio in the low and high regimes is observed. The price ratio decreases slightly after a shock and immediately reaches to its long run equilibrium level in a few periods. The SETAR model estimated for USA Hard Sawnwood / Malaysia Sawnwood ratio in Figure 1.14 indicates that after a shock, a short period of time is needed for the price pair to come to its long run equilibrium level which is less than 2 months in both regimes.

Here the impulse responses were compared at a mutual level of shock to be able to get clear view of how the basics of the models would vary across regimes. It is also possible to compare the shocks that differed in terms of their sizes in high and low regimes, but this is not preferred here in order to avoid the problem of amplifying the differences in impulse responses.

1.7. Conclusion

This paper attempted to examine the price dynamics of forest products from Africa, Southeast Asia and Japan to the United States using some linear and non-linear regression approaches taking into account the structural changes. Considerable volatility in price ratios were observed, which suggests the potential for significant market interactions between the USA, Africa, Japan and Southeast Asia. The analysis of aforementioned market interactions and price pairs was employed by estimating Logarithmic STAR (LSTAR), Self- Exciting Threshold Autoregressive (SETAR) and Linear Autoregressive (AR) regression models. Optimal lag length for each of the specified models is chosen by applying the AIC criterion. Finally, the choice between the mentioned models are done through careful examination of the each models' AIC and MAPE criterions.

The findings suggest that from this comparison, the SETAR model seems to fit the data best for most price pairs according to AIC and MAPE criteria with the lowest values. When this result was combined with the comparisons of significance of estimated parameters from various proposed models in case of a contradiction between the results suggested by AIC and MAPE criterions, it was concluded that compared to the other models, SETAR specification accommodates potentially different market adjustments that approximately follow departures from spatial price parity; thus, the SETAR model is thought to better represent this market compared to the other model specifications.

The overall results show that nonlinearity and structural change are important features of these markets; price parity relationships implied by the economic theory are generally supported by the estimated models and the figures of the price pairs used also supports this conclusion. Results suggest evidence for the convenience of the STAR type models (SETAR and LSTAR) to model deviations from LOP in a nonlinear fashion for tropical forest product markets. Reasonable estimates of the threshold values that may be a representation of transaction costs that are in line with the theoretical arguments in international trade were found. It was also observed that the values of threshold variables vary hugely across different countries. The value of the threshold variable is changing between 1% and 32%, which suggests huge differences in potential arbitrage opportunities for countries examined.

For instance, in the soft logs market, the threshold value of the SETAR model is 0.0531 between the USA and Sapele whereas this coefficient is calculated as 0.32 between the USA and Gabon. This fact suggests that the difference in recently observed prices is larger for Gabon, and larger deviations from the parity conditions in Gabon compared to Sapele are observed. Also, a bigger threshold value exposes the fact that Gabon has larger potential gains from arbitrage and will face a faster adjustment process compared to Sapele, which does not have persistent opportunities for spatial arbitrage. These differences in threshold values may result from region-specific effects for Gabon and Sapele; in general, such effects may be related to country or continent-specific effects (Tables 1.11 and 1.13).

The threshold values dividing the regimes into low and high also provideinformation about countries' trade situations. Taking the same example, in Sapele, if the increase in lagged percentage change in prices of soft log is higher than 5%, the country will be considered in high regime which may indicate the situation of trade and will have potential gains from arbitrage. However, this fact will be valid only for the 6.29% in the data whereas this fact is true for Gabon whenever the lagged percentage change in prices is higher than 32% and the trade situation is observed for the 89.97% of the data points (Tables 1.11 and 1.13).

The results for the hard sawnwood, soft sawnwood and lumber spruce prices in the USA and Malaysia do not show much difference in terms of the values of the threshold variables, opportunities for spatial arbitrage, or the portion of data points in low and high regimes. The threshold values change between 2% and 3%, not suggesting notable differences between these two countries in terms of deviations from parity conditions defined (Tables 1.6, 1.7 and 1.18).

In the hard log markets between the USA, Gabon and Sapele, the estimated threshold values are 0.08 and 0.03 respectively indicate that if the increase in lagged percentage change in prices of hard logs is higher than 8% and 3%, the countries will be considered in high regime which may indicate the situation of trade and will have potential gains from arbitrage. However, this fact will be valid only for the 92.16 % in the data for Gabon, whereas this fact is true for Sapele for the 10.06% of the data points (Tables 1.10 and 1.12).

Finally, the impulse response analysis for each price pair also supports the changing behavior of price ratios in high and low regimes to a unit shock into the system for almost all price pairs, which may be seen as an another justification to use models taking into account the structural changes to model LOP and ERPT in a nonlinear fashion.

REFERENCES

Al-Abri, A., & Goodwin, B. (2009). Re-examining the Exchange Rate Pass-Through into Import Prices Using Non-linear Estimation Techniques: Threshold Cointegration. International Review of Economics & Finance, 18(1), 142-161.

Baharumshah, A., & Habibullah, M. (1995). The efficiency of the Spot Foreign Exchange Market: Evidence from the Malaysian Currency Market. Third Malaysian Econometric Conference.

Baldwin, R. (1988). Hysteresis in Import Prices: The Beachhead Effect. The American Economic Review, 78(4), 773-785.

Baldwin, R. & Krugman P.(1989).Persistent Trade Effects of Large Exchange Rate Shocks. The Quarterly Journal of Economics,104 (4), 635-654.

Balke, N., & Fomby, T. (1997). Threshold Cointegration. International Economic Review, 38(3), 627-645.

Bresnahan, T.F. (1989).Empirical Studies of Industries with Market Power. Handbook of Industrial Organization.1011-1057, doi: 10.1016 /s1573- 448 (89)02005-4>.

Campa, J., & Goldberg, L. (2005). Exchange Rate Pass Through into Import Prices. Review of Economics and Statistics, 87(4), 679-690.

Choudhri, E., & Hakura, D. (2001). Exchange Rate Pass-through to Domestic Prices: Does the Inflationary Environment Matter? (IMF Working Paper, No.194). Retrieved from http://www.iese.edu/research/pdfs/DI-0475-E.pdf

Clements, M. P. & J.P. Smith (1997), "The Performance of Alternative Forecasting Methods for SETAR Models", International Journal of Forecasting, 13, 463-75.

Clements, M. P. & J.P. Smith (1999), "A Monte Carlo Study of the Forecasting Performance of Empirical SETAR Models", Journal of Applied Econometrics, 14, 123-41.

Dixit, A. (1989). Hysteresis, importe penetration, and exchange rate passthrough. Quarterly Journal of Economics,14, 205–228.

Dornbusch, R. (1987). Exchange Rates and Prices. American Economic Review, 77, 93-106.

Edwards, S. (2006). The Relationship Between Exchange Rates and Inflation Targeting Revisited, NBER Working Paper No. 12163.

Enders, W., & Matthew, T. (2012). Sharp Breaks or Smooth Shifts? An Investigation of the Evolution of Commodity Prices. American Journal of Agricultural Economics, 94(3), 659-673. doi:10.1093/ajae/aar162.

Feenstra, R. C. (1989). Symmetric pass-through of tariffs and exchange rates under imperfect competition: An empirical test. Journal of International Economics 27 (1-2), 25–45.

Gagnon, J.E., & Ihrig J. (2004). Monetary Policy and Exchange Rate Pass-Through. International Journal of Finance & Economics, 9(4):315-38.

Goldberg, P., & Knetter, M. (1997). Goods prices and exchange rates: What have we learned? Journal of Economic Literature, 35(3), 1243-1277.

Goodwin, B., & Piggott, N. (2001).Spatial Market Integration in the Presence of Threshold Effects. American Journal of Agricultural Economics, 83, 302–317.

Goodwin, B., Matthew, T., & Prestemon, J. (2011). North American Oriented Strand Board Markets, Arbitrage Activity and Market Price Dynamics: A Smooth Transition Approach. American Journal of Agricultural Economics, 93, 993-1014.

Goodwin, B., Matthew, T., & Prestemon, J. (2012).Nonlinear Exchange Rate Pass Through in Timber Products: The Case of Oriented Strand Board in Canada and the United States. Munich Personal RePec Archive, No. 40834.

Granger, C., & Teräsvirta, T. (1993). Modeling Nonlinear Economic Relationships. USA: Oxford University Press.

Haggan, V., & Ozaki, T. (1981). Modeling Nonlinear Random Vibrations Using an Amplitude-Dependent Autoregressive Time Series Model. Biometrika, 68(1), 189-196.

Hänninen, R., Craig, S., & Toppinen, A. (1999). Long-run Price Effects of Exchange Rate Changes in Finnish Pulp and Paper Exports. Applied Economics, 31(8), 947-956.

Hänninen, R., Craig, S., & Toppinen, A. (2000). EMU and Forest Products Pricing in Europe. Western Agricultural Economics Association Annual Meetings, Vancouver, British Columbia.

Hänninen, R., Toppinen, A. & Toivonen, R. (2007).Transmission of Price Changes in Sawnwood and Sawlog Markets of the Old and New EU Member Countries. European Journal of Forest Research, 126(1), 111-120.

Hansen, B.E. (1997). Inference in TAR Models. Studies in Nonlinear Dynamics and Econometrics, 2, 1-14.

Juvenal, L. & Taylor, M.P. (2008). Threshold Adjustment of Deviations from the Law of One Price. Studies in Nonlinear Dynamics & Econometrics, 12(3).

Hooper, P., & Mann, C. (1989). 'Exchange rate pass-through in the 1980s: the case of U.S. imports of manufactures. Brookings Papers on Economic Activity, (1), 297-337.

Knetter, M. M. (1989).Price Discrimination by U.S. and German Exporters. American Economic Review, 79(1), 198-210.

Lo, M. C., & Zivot, E. (2001).Threshold Cointegration and Nonlinear Adjustment to the Law of One Price. Macroeconomic Dynamics, 5 (4), 533–576.

Micheal,P., & Nobay ,R. (1994).Purchasing Power Parity yet Again: Evidence from Spatially Separated Markets. Journal of International Money and Finance, 13 (6), 637-657.

Obstfeld,M., & Taylord A.M.(1997).Nonlinear Aspects of Goods-Market Arbitrage and Adjustment: Heckscher's Commodity Points Revisited. Journal of the Japanese and International Economies, 11 (4), 441 -79.

O'Connell, P.G.J., & Wei S. (2002).The Bigger They Are, the Harder They Fall'': Retail Price Differences across U.S. Cities. Journal of International Economics, 56 (1), 21–53.

Park, H., Mjelde J., & Bessler D. A. (2007). Time-Varying Threshold Cointegration and the Law of One Price. Applied Economics, 39 (9), 1091–1105.

Pollard, P. & C. Coughlin.(2004), Size matters: asymmetric exchange rate passthrough at the industry level", Federal Reserve Bank of St. Louis, Working Papers,29.

Sek, S. K. & Kapsalyamova, Z.(2008). Exchange rate pass-through and volatility: Impacts on domestic prices in four Asian countries. MPRA Papers. http://mpra.ub.uni-muenchen.de/id/eprint/11130

Sephton, P. S. (2003). Spatial Market Arbitrage and Threshold Cointegration. American Journal of Agricultural Economics, 85 (4), 1041–1046.

Sumner, D. A. (1981).Measurement of Monopoly Behavior: An Application to the Cigarette Industry. Journal of Political Economy, 89 (5), 1010 -1019.

Taylor, A.M. (2001).Potential Pitfalls for the Purchasing-Power-Parity Puzzle? Sampling and Specification Biases in Mean-Reversion Tests of the Law of One Price. Econometrica, 69(2), 473-498.

Taylor, J. (2000).Low Inflation, Pass-Through, and the Pricing Power of Firms. European Economic Review, 44(7), 1389-408.

Teräsvirta, T. (1994).Specification, Estimation, and Evaluation of Smooth Transition Autoregressive Models. Journal of the American Statistical Association, 89(425), 208–218.

Teräsvirta, T. (1998). Modelling Economic Relationships with Smooth Transition Regression. In Handbook of Applied Economic Statistics (pp. 507-522). New York: Marcel Dekker.

Terheggen, A. (2011). The Tropical Timber Industry in Gabon: A Forward Linkages Approach to Industrialisation. MMCP Discussion Paper, 10.

Tiao, G.C. & Tsay R.S.(1994).Some Advances in Nonlinear and Adaptive Modeling in Time Series. Journal of

Forecasting, 13, 109-140.

Tsay, R. (1989).Testing and Modeling Threshold Autoregressive Process. Journal of the American Statistical Association, 84 (405), 231-240.

Tong, H. 1978. On a threshold model. Pattern Recognition and Signal Processing, ed. C. H. Chen, Kluwer: Amsterdam.

Tong, H. (1983). Nonlinear Time Series Analysis. In: Lovric, Miodrag (Editor), (2010).

Uusivuori, J., & Buongiorno, J.(1991).Pass Through of Exchange Rates on Prices of Forest Product Exports from the United States to Europe and Japan. Forest Science, 37 (3), 931-948.

van Dijk D., Teräsvirta T. & Franses, P.H.(2000). Smooth Transition Autoregressive Models — A Survey of Recent Developments. Econometric Reviews,21(1), 1-47.

Vesala, J. (1992). Incomplete Exchange Rate Pass Through and Hysteresis in Trade: A Survey of Recent Theories and Empirical Study of Export Pricing of Finnish Paper Manufactures. Bank of Finland Discussion Papers, 29(72).76 p.

Woo, W.T. (1984).Exchange Rates and the Prices of Nonfood, Nonfuel Products. Brookings Papers on Economic Activity, 15 (2), 511-530.

Zhi, Y. (2013). Exchange Rate Pass-through, Firm Heterogeneity and Product Quality: A Theoretical Analysis. Globalization and Monetary Policy Institute Working Paper, No. 141.

TABLES AND FIGURES

Table 1.1: Summary Statistics for prices of 321 observations from 1982 to 2009

Variable	Mean	Std Dev	Minimum	Maximum
plywood_tokyo	82891.68	13000.29	62659.19	125233.59
plywood_usa	249.9446000	80.3386335	129.7500000	517.6000000
logs_sapele	17394.73	19307.52	107.0439370	68512.52
logsh_usa	198.0830530	74.4807032	76.4100000	520.8100000
logss_usa	145.3788162	44.6346703	55.8700000	259.9700000
logs_gabon	107579.53	45053.29	42985.82	166617.14
sawnwood_malaysia	1531.15	522.7685327	655.5502800	2147.00
sawnwoodh_usa	554.2112150	203.4422575	169.6300000	940.9700000
sawnwoods_usa	251.8463551	70.0104034	121.1700000	372.6000000
lumberspruce_usa	252.5919315	78.6286909	130.2500000	466.7500000

*Prices in Countries' Home Currency (Yen for Tokyo,Naira (NGN) for Sapele, CFA Frang for Gabon, and Ringgit(MYR) for Malaysia)

Table 1. 2: Pearson Correlation Coefficients

Price Pairs	Pearson Correlation Coefficient
USA Hard Sawnwood-Malaysia Sawnwood	0.84677
USA Soft Sawnwood-Malaysia Sawnwood	0.79695
USA LumberspruceMalaysiaSawnwood	0.60848
USA Plywood-Tokyo Plywood	0.23324
USA Hard Logs-Sapele Logs	0.64165
USA Soft Logs-Sapele Logs	0.42933
USA Hard Logs-Gabon Logs	0.64482
USA Soft Logs-Gabon Logs	0.75728

Table 1.3: Augmented Dickey Fuller (ADF) Unit Root Tests

Price Pairs	ADF Test statistic	p Value(ADF)
USA Hard Sawnwood/Malaysia Sawnwood	-3.5071	0.04232
USA Soft Sawnwood/Malaysia Sawnwood	-3.0911	0.1164
USA Lumberspruce/Malaysia Sawnwood	-2.8318	0.2257
USA Plywood/Tokyo Plywood	-2.7843	0.2458
USA Hard Logs/Sapele Logs	-3.3584	0.06157
USA Soft Logs/Sapele Logs	-1.6022	0.7442
USA Hard Logs/Gabon Logs	-3.7646	0.02113
USA Soft Logs/Gabon Logs	-3.8593	0.0164

Table 1.4: Philips Perron (PP) Unit Root Tests

Price Pairs	Philips- Perron Test statistic	p Value(PP)
USA Soft Logs /Sapele Logs		
USA Hard Sawnwood/Malaysia Sawnwood	-21.0141	0.05514
USA Soft Sawnwood/Malaysia Sawnwood	-36.7174	0.01
USA Lumberspruce/Malaysia Sawnwood	-23.2142	0.03528
USA Plywood/Tokyo Plywood	-20.819	0.05807
USA Hard Logs/Sapele Logs	-22.4924	0.041
USA Soft Logs/Sapele Logs	-8.4204	0.6384
USA Hard Logs/Gabon Logs	-26.3631	0.01811
USA Soft Logs/Gabon Logs	-28.1974	0.01128

Table 1.5: Model Selection Through AIC and MAPE Criterion

Price Pairs	AIC	MAPE
USA Hard Sawnwood /Malaysia Sawnwood		
Linear	-2205.299	1.898770
SETAR	-2205.979	2.059094
LSTAR	-2202.447	2.106865
USA Soft Sawnwood /Malaysia Sawnwood		
Linear	-2232.192	1.989909
SETAR	-2236.514	1.968964
LSTAR	-2229.575	1.698884
USA Lumberspruce /Malaysia Sawnwood		
Linear	-2232.192	1.989909
SETAR	-2236.514	1.698884
LSTAR	-2229.575	1.968964
USA Plywood /Tokyo Plywood		
Linear	-1921.869	1.419646
SETAR	-1926.929	1.567863
LSTAR	-1923.027	1.371151
USA Hard Log /Sapele Logs		
Linear	-2242.767	1.893787
SETAR	-2247.684	2.259924
LSTAR	-2240.168	2.490861

USA Soft Logs/Sapele Logs		
Linear	-2164.346	1.555727
SETAR	-2165.463	1.463125
LSTAR	-2160.627	1.597272
USA Hard Logs /Gabon Logs		
Linear	-2223.264	0.7206582
SETAR	-2232.986	0.6724562
LSTAR	-2226.748	0.6836987
USA Soft Logs /Gabon Logs		
Linear	-2166.729	0.9876545
SETAR	-2168.721	0.9847713
LSTAR	-2166.364	0.9689818

Table 1.6: Results of SETAR and LINEAR Model for USA Hard Sawnwood/Malaysia Sawnwood

SETAR Model USA Hard Sawnwood / Malaysia Sawnwood

	Estimate	Std. Error	t value	Pr(>|t|)	
const L	0.00011419	0.00145718	0.0784	0.93759	
phiL.1	0.39588796	0.06242987	6.3413	7.925e-10	***
phiL.2	-0.19945091	0.07783983	-2.5623	0.01086	*
const H	-0.00467992	0.00737505	-0.6346	0.52618	
phiH.1	0.02846533	0.12022222	0.2368	0.81299	
phiH.2	0.12792115	0.14918820	0.8574	0.39185	

Signif. codes: 0‘***’0.001 ‘**’0.01‘*’0.05 ‘.’ 0.1 ‘’ 1

Threshold Value: 0.02234

Proportion of points in low regime: 88.36%

High regime: 11.64%

Table 1.6 Continued

LINEAR Model USA Hard Sawnwood / Malaysia Sawnwood

	Estimate	Std. Error	t value	Pr(>|t|)	
const	0.00072208	0.00134493	0.5369	0.59172	
phi.1	0.31740038	0.05590563	5.6774	3.106e-08	***
phi.2	-0.10757305	0.05567077	-1.9323	0.05422	.

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 1.7: Results of SETAR and LSTAR Model for USA Soft Sawnwood / Malaysia Sawnwood

SETAR Model USA Soft Sawnwood / Malaysia Sawnwood

	Estimate	Std. Error	t value	Pr(>|t|)	
const L	-0.00082066	0.00180568	-0.4545	0.649790	
phiL.1	-0.40518047	0.05708916	-7.0973	8.511e-12	***
phiL.2	-0.18113770	0.06889214	-2.6293	0.008977	**
const H	0.01258988	0.01532206	0.8217	0.411881	
phiH.1	0.27716631	0.20644155	1.3426	0.180375	
phiH.2	-0.02320355	0.24418191	-0.0950	0.924355	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Threshold Value: 0.03805, Proportion of points in low regime: 90.88% High regime: 9.12%

Table 1.7 Continued

LSTAR Model for USA Soft Sawnwood / Malaysia Sawnwood

	Estimate	Std. Error	t value	Pr(>|z|)	
const1	-0.0032847	0.0050323	-0.6527	0.5139328	
phi1.1	-0.3945301	0.0641829	-6.1470	7.898e-10	***
phi1.2	-0.2567382	0.1332510	-1.9267	0.0540138	.
const2	0.0381427	0.0358503	1.0639	0.2873543	
phi2.1	0.3516665	0.2682524	1.3110	0.1898734	
phi2.2	-0.0880541	0.3538342	-0.2489	0.8034716	
gamma	100.0000042	122.7659230	0.8146	0.4153252	
th	0.0399837	0.0120122	3.3286	0.0008729	***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table 1.8: Results of SETAR Model for USA Lumberspruce / Malaysia Sawnwood

USA Lumberspruce / Malaysia Sawnwood

Estimate Std. Error t value Pr(>|t|)

const L -0.0104045 0.0070763 -1.4703 0.14247

phiL.1 1.1084454 0.0567769 19.5228 < 2.2e-16 ***

phiL.2 -0.1492092 0.0590933 -2.5250 0.01206 *

const H -0.1907494 0.0389309 -4.8997 1.538e-06 ***

phiH.1 0.7955181 0.1734814 4.5856 6.539e-06 ***

phiH.2 -1.1611432 0.2904010 -3.9984 7.950e-05 ***

Threshold Value: 0.02128

Proportion of points in low regime: 72.01% High regime: 27.99%

Table 1.9: Results of (SETAR) and LSTAR Model for USA Plywood / Tokyo Plywood

SETAR Model USA Plywood / Tokyo Plywood

Estimate Std. Error t value Pr(>|t|)

const L -0.0154493 0.0079973 -1.9318 0.05428 .

phiL.1 0.1801807 0.0948336 1.9000 0.05835 .

phiL.2 -0.2406931 0.1201924 -2.0026 0.04608 *

const H 0.0087918 0.0040011 2.1973 0.02873 *

phiH.1 0.1431608 0.0679231 2.1077 0.03585 *

phiH.2 -0.3911983 0.0985733 -3.9686 8.964e-05 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Threshold Value: -0.01935

Proportion of points in low regime: 32.7% High regime: 67.3%

LSTAR Model USA Plywood / Tokyo Plywood

Estimate Std. Error t value Pr(>|t|)

Estimate Std. Error t value Pr(>|z|)

const.L -0.0784164 0.1074672 -0.7297 0.4656

phiL.1 0.0022688 0.1827971 0.0124 0.9901

phiL.2 -0.6218819 0.5661739 -1.0984 0.2720

const.H 0.1065268 0.1313212 0.8112 0.4173

phiH.1 0.2127073 0.2387743 0.8908 0.3730

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Threshold Value: -0.03751

Table 1.10: Results of SETAR and LINEAR Model for USA Hard Logs / Sapele Logs

SETAR Model USA Hard Logs/Sapele Logs

	Estimate	Std. Error	t value	Pr(>|t|)	
const L	-0.02724382	0.01310393	-2.0791	0.03842	*
phiL.1	-0.25110485	0.18129771	-1.3850	0.16702	
phiL.2	-0.30627741	0.21942791	-1.3958	0.16376	
const H	-0.00054344	0.00179857	-0.3021	0.76274	
phiH.1	0.27839503	0.05788211	4.8097	2.35e-06	***
phiH.2	0.15702840	0.07078693	2.2183	0.02725	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Threshold Value: -0.03362

Proportion of points in low regime: 10.06% High regime: 89.94%

LINEAR Model for USA Hard Log /Sapele Logs

	Estimate	Std. Error	t value	Pr(>|t|)	
const	5.1992e-05	1.6784e-03	0.0310	0.97531	
phi.1	2.3597e-01	5.5923e-02	4.2196	3.205e-05	***
phi.2	1.0673e-01	5.5890e-02	1.9096	0.05709	.

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 1. 11: Results of SETAR Model for USA Soft Logs / Sapele Logs

SETAR Model USA Soft Logs/Sapele Logs

	Estimate	Std. Error	t value	Pr(>|t|)	
const L	-0.0017740	0.0019813	-0.8954	0.371268	
phiL.1	-0.2142053	0.0591686	-3.6203	0.000343	***
phiL.2	-0.0827050	0.0704995	-1.1731	0.241633	
const H	0.0258441	0.0244691	1.0562	0.291694	
phiH.1	-0.5988918	0.1678859	-3.5673	0.000417	***
phiH.2	-0.2900146	0.2959269	-0.9800	0.327830	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Threshold Value: 0.0531

Proportion of points in low regime: 93.71% High regime:6.29%

Table 1.12: Results of SETAR Model for USA Hard Logs / Gabon Logs

SETAR Model USA Hard Logs/Gabon Logs

Estimate Std. Error t value Pr(>|t|)

const L -0.0041124 0.0029150 -1.4108 0.1592910

phiL.1 1.1462939 0.0579367 19.7853 < 2.2e-16 ***

phiL.2 -0.2114007 0.0594169 -3.5579 0.0004313 ***

const H 0.0092989 0.0151864 0.6123 0.5407697

phiH.1 1.6919841 0.1224753 13.8149 < 2.2e-16 ***

phiH.2 -0.7983158 0.1313636 -6.0771 3.529e-09 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Threshold Value: 0.08986

Proportion of points in low regime: 92.16% High regime: 7.84%

Table 1.13: Results of SETAR and LSTAR Model for USA Soft Logs / Gabon Logs

SETAR Model USA Soft Logs/Gabon Logs

Estimate Std. Error t value Pr(>|t|)

const L -0.292254 0.096356 -3.0330 0.002622 **

phiL.1 0.791375 0.140481 5.6333 3.921e-08 ***

phiL.2 -0.630986 0.275696 -2.2887 0.022759 *

const H -0.013010 0.005625 -2.3129 0.021375 *

phiH.1 0.684174 0.058855 11.6247 < 2.2e-16 ***

phiH.2 0.248641 0.060175 4.1320 4.615e-05 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Threshold Value: -0.32

Proportion of points in low regime: 10.03% High regime: 89.97%

LSTAR Model for USA Soft Logs/Gabon Logs

Estimate Std. Error t value Pr(>|z|)

const.L -0.75950 NA NA NA

phiL.1 1.11718 NA NA NA

phiL.2 -2.11207 NA NA NA

const.H 0.74023 NA NA NA

phiH.1 -0.44472 NA NA NA

phiH.2 2.27111 NA NA NA

gamma 18.76923 NA NA NA

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

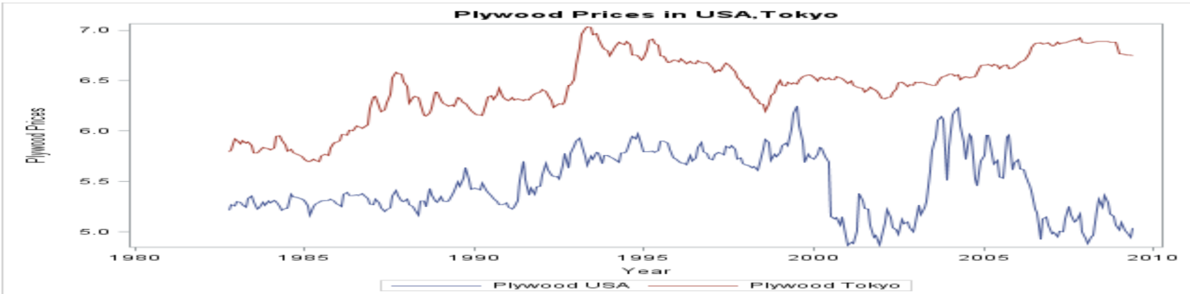


Figure 1.1: Nominal Plywood Prices in USA and Tokyo, 1982:10-2009:6 (Logarithmic Form)

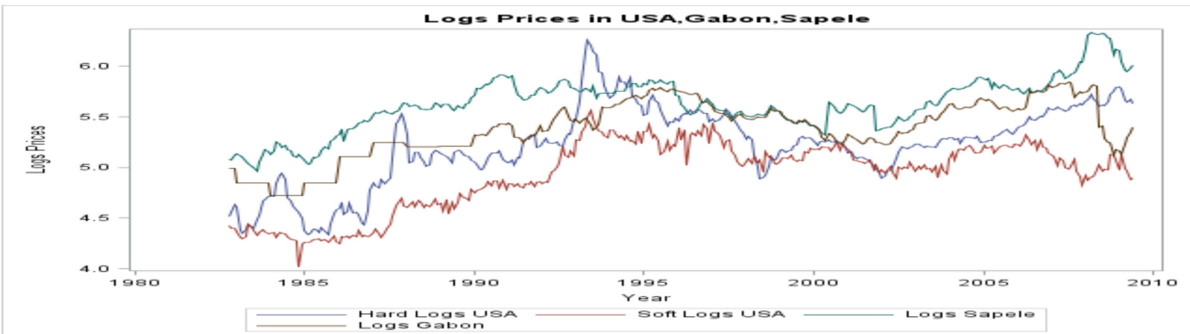


Figure 1.2: Nominal Logs Prices in USA, Gabon and Sapele, 1982:10-2009:6 (Logarithmic Form)

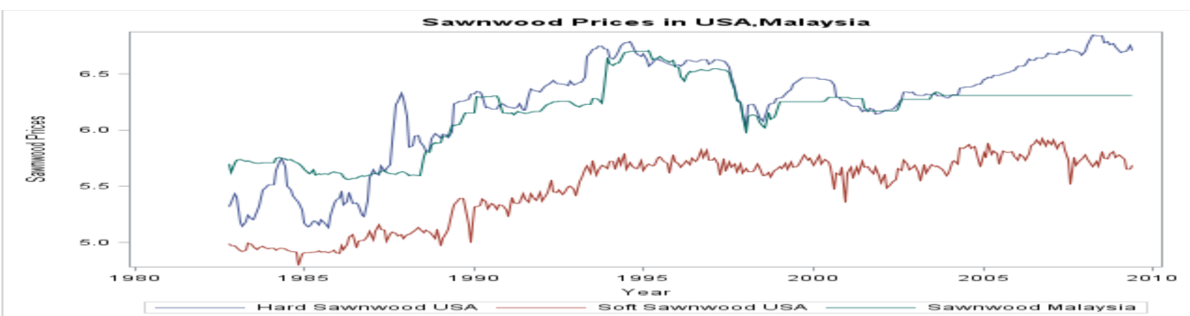


Figure 1.3: Nominal Sawnwood Prices in USA and Malaysia, 1982:10-2009:6 (Logarithmic Form)

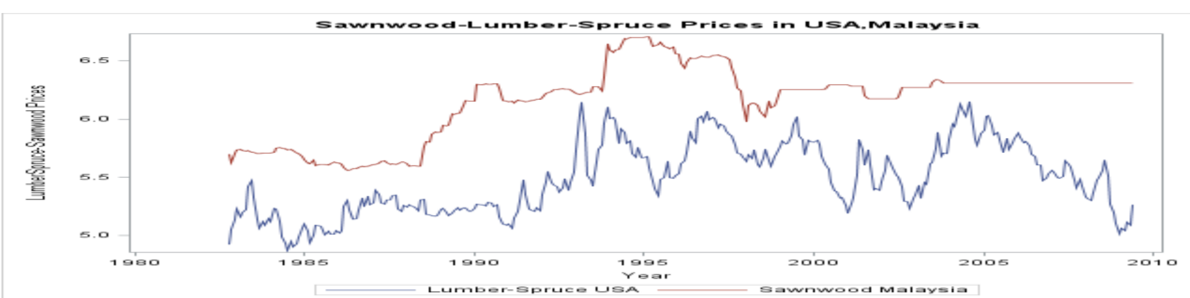


Figure 1.4: Nominal Lumberspruce-Sawnwood Prices in USA and Malaysia, 1982:10-2009:6 (Logarithmic Form)

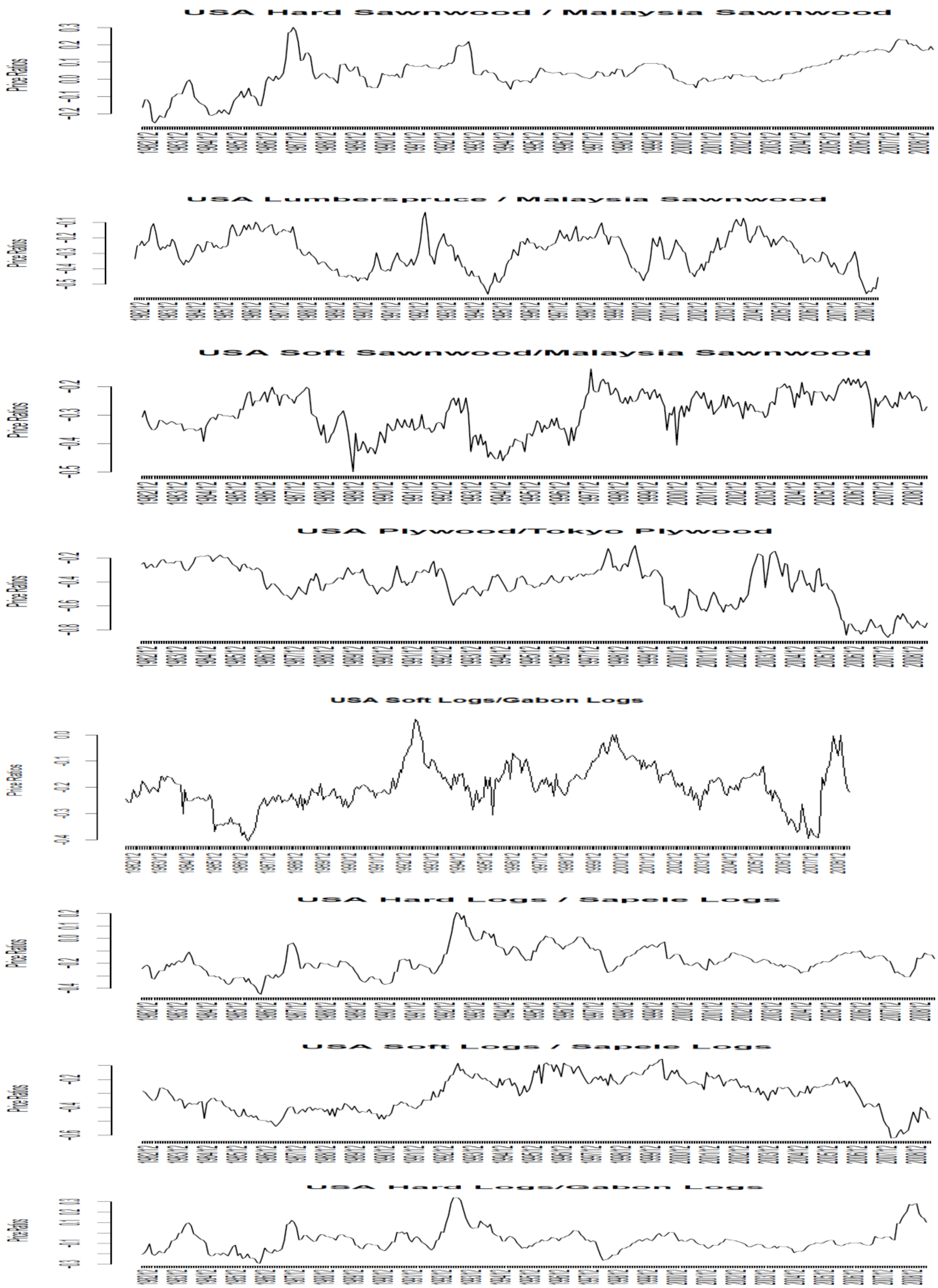


Figure 1.5: Time Series plots of Natural Logarithms of Relative Prices 1982:10-2009-6

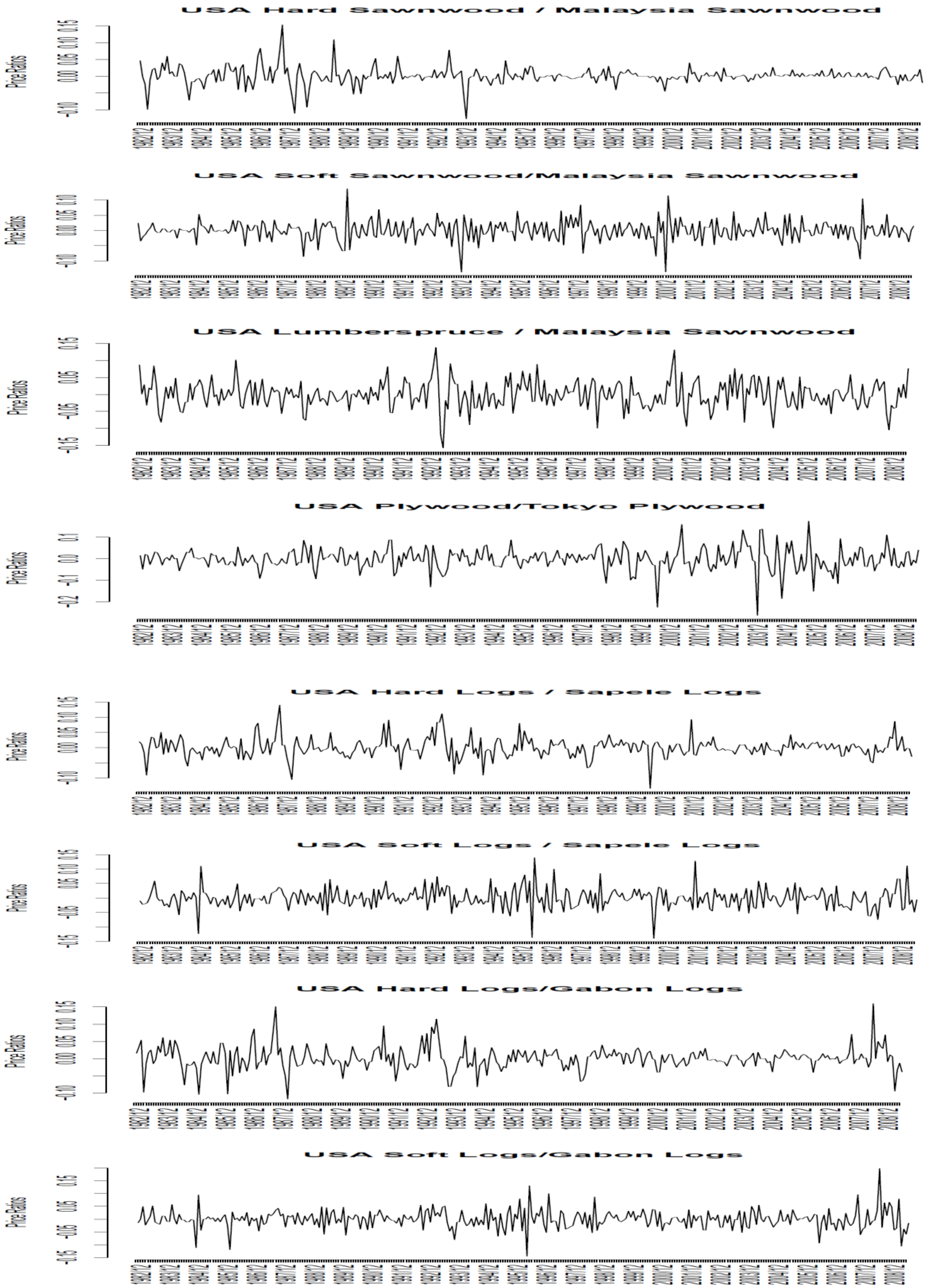
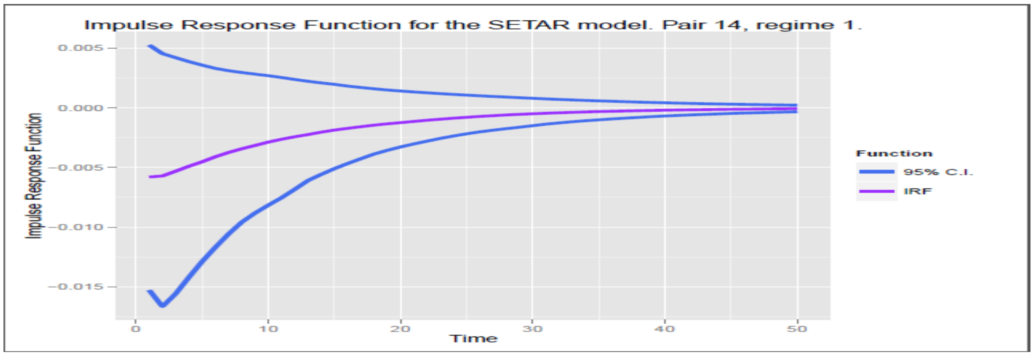


Figure 1.6: Time Series Plots of First Differences of Relative Prices 1982:10-2009-6



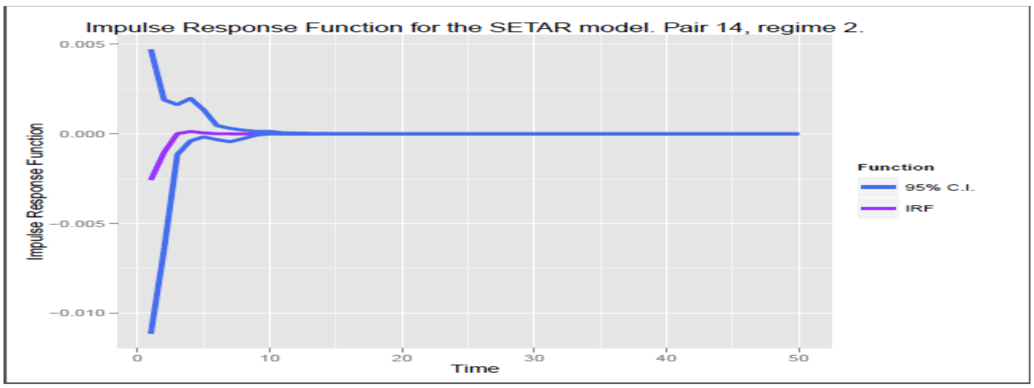
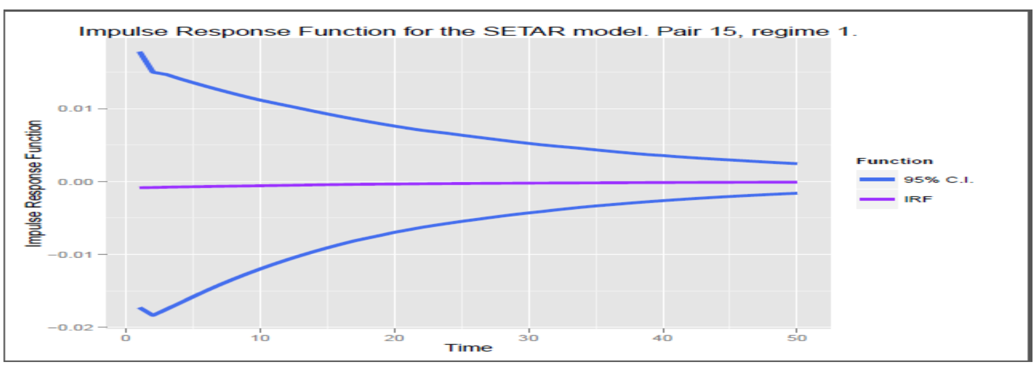


Figure 1.7: Impulse Response Function for USA Lumberspruce-Malaysia Sawnwood



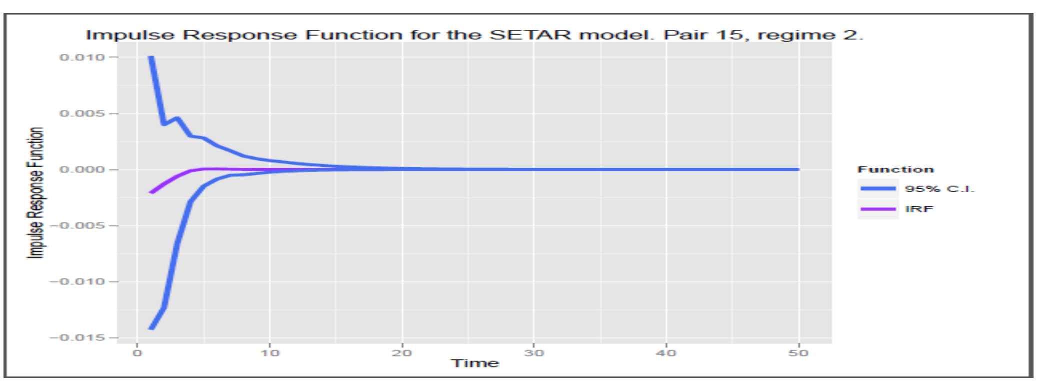
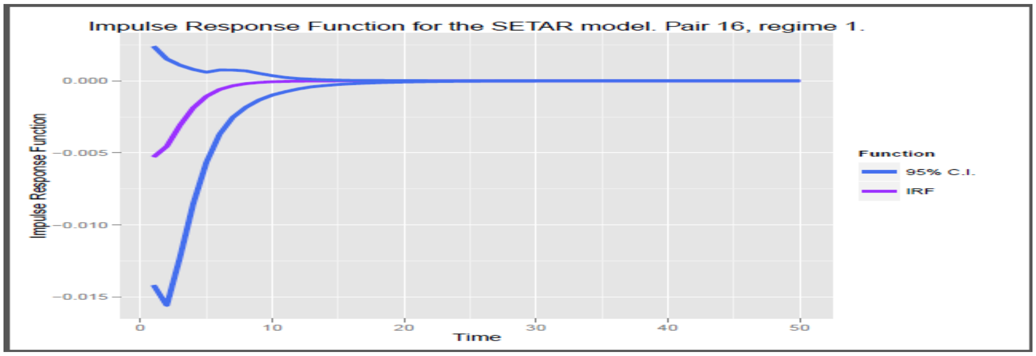


Figure 1.8: Impulse Response Function for USA Plywood-Tokyo Plywood



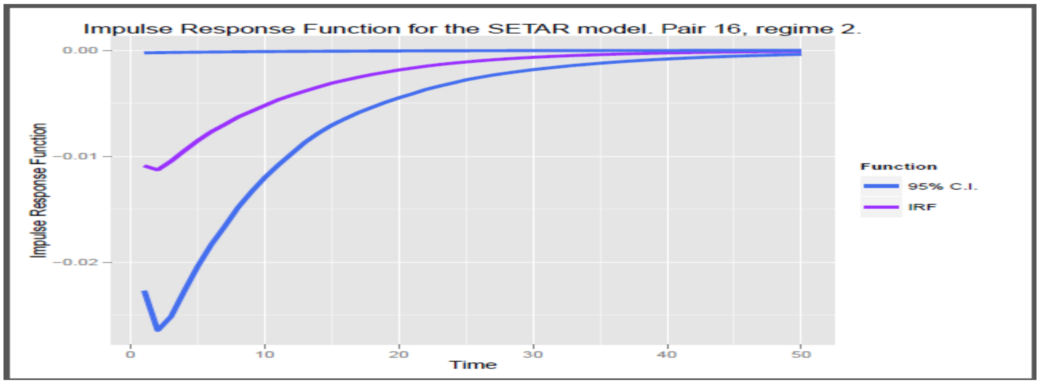
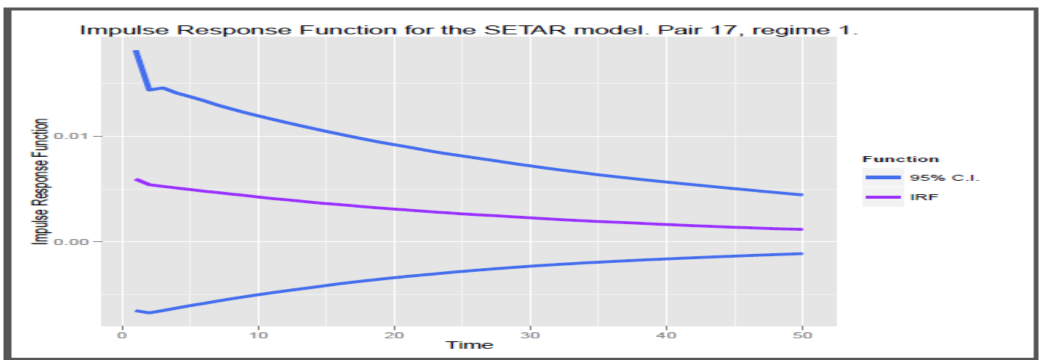


Figure 1.9: Impulse Response Function for USA Hard Logs-Sapele Logs



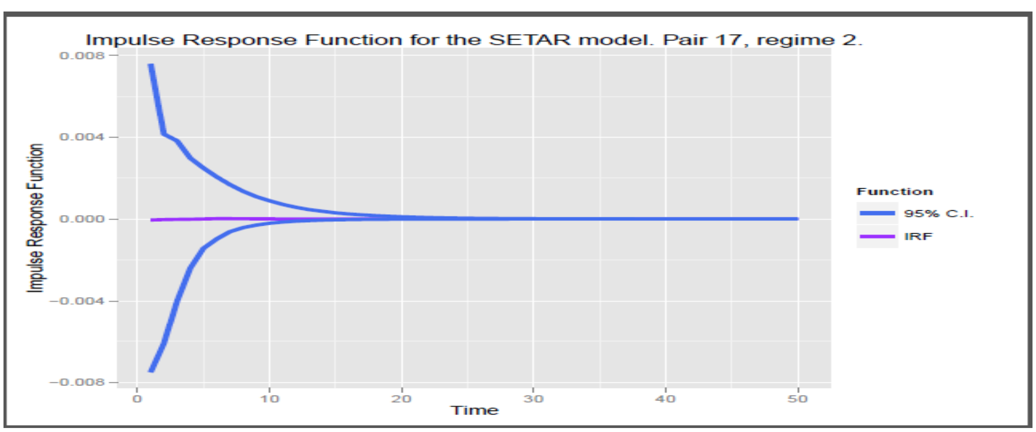
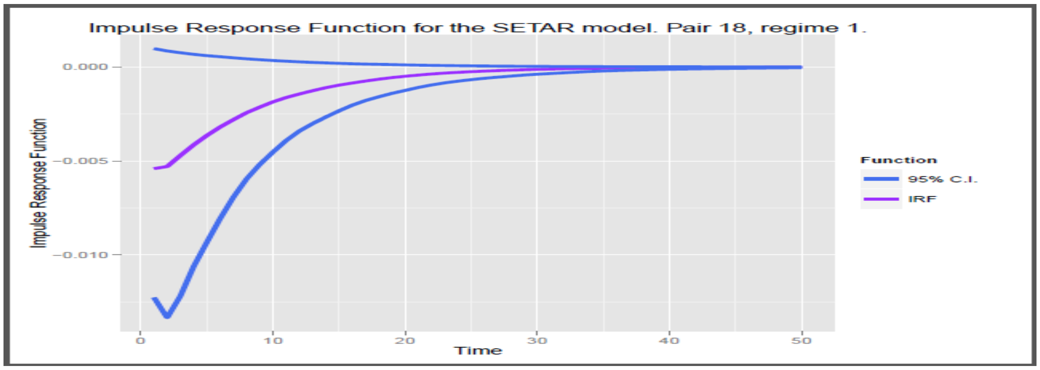


Figure 1.10: Impulse Response Function for USA Soft Logs-Sapele Logs



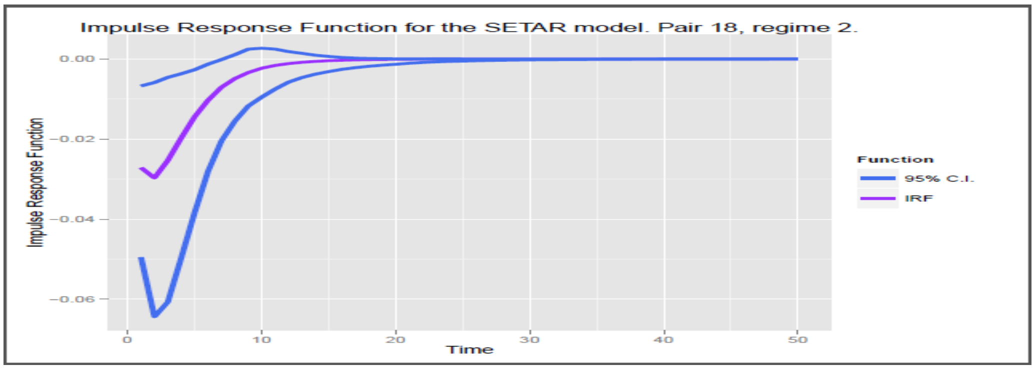
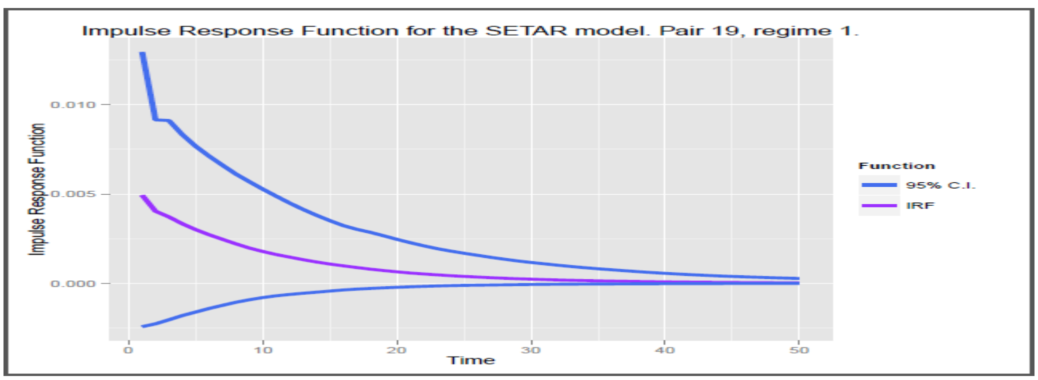


Figure 1.11: Impulse Response Function for USA Hard Logs-Gabon Logs



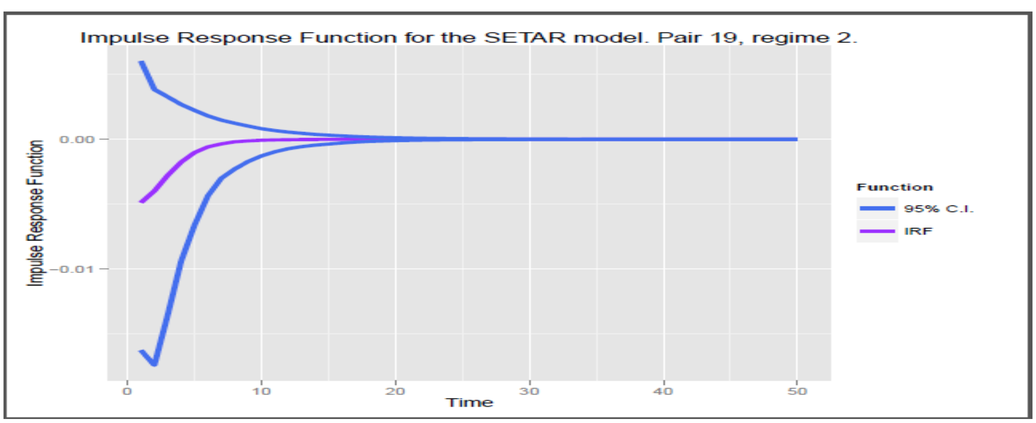
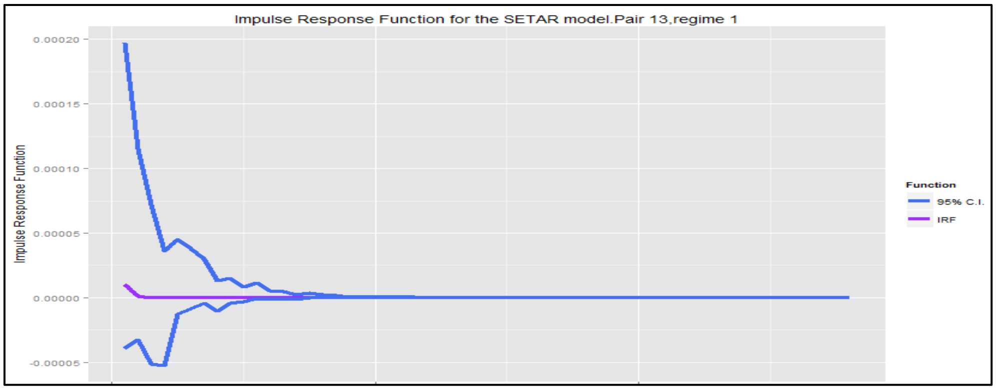


Figure 1.12: Impulse Response Function for USA Soft Logs-Gabon Logs



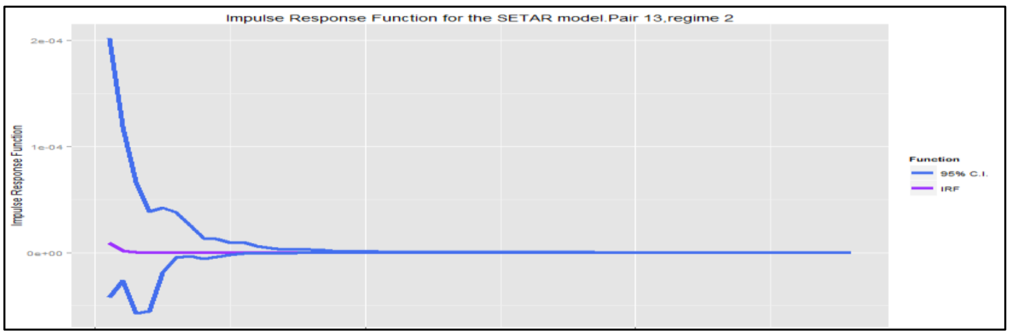
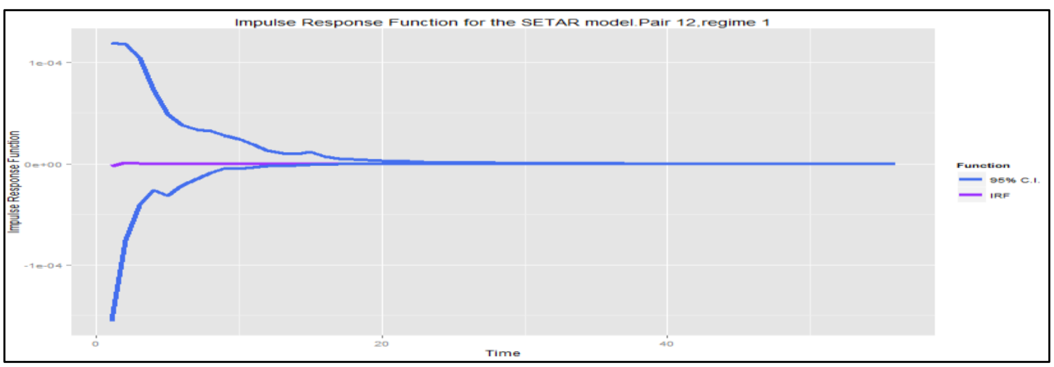


Figure 1.13: Impulse Response Function for SETAR model of USA Soft Sawnwood /Malaysia Sawnwood



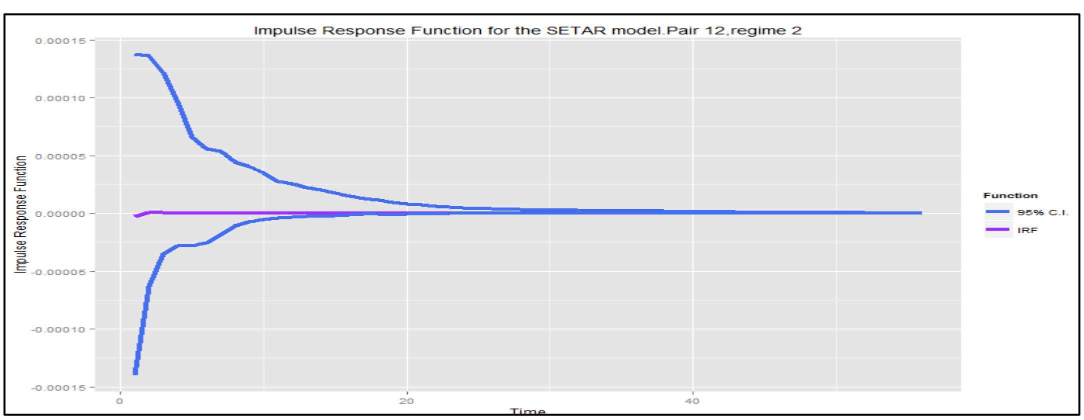


Figure 1.14: Impulse Response Function for SETAR Model of USA Hard Sawnwood / Malaysia Sawnwood