Exchange Rates and Natural Rubber Prices, the Effect of the Asian Crisis

Kees Burger
Hidde Smit
Ben Vogelvang

Paper prepared for presentation at the Xth EAAE Congress
'Exploring Diversity in the European Agri-Food System',
Zaragoza (Spain), 28-31 August 2002

Exchange rates and natural rubber prices, the effect of the Asian crisis

Kees Burger[1], Hidde Smit[1], Ben Vogelvang[2]

January 9, 2002

Vrije Universiteit
Faculty of Economics and Business Administration
[1]Economic and Social Institute
[2]Department of Econometrics
De Boelelaan 1105
1081 HV Amsterdam
The Netherlands
e-mail: kburger@feweb.vu.nl, hsmit@feweb.vu.nl, evogelvang@feweb.vu.nl

Contents

Abstract

The Asian crisis has provided strong evidence on how exchange rates affect international prices. The more recent depreciation of the Euro currencies has also had substantial effects on the US$ prices in the world market. In this paper we investigate these effects and focus on a commodity strongly represented in the Asian region, natural rubber (NR). The long-run and the short-run influence on the price of NR are first analyzed along the classical Engle-Granger procedure and with the more efficient dynamic generalized least squares (DGLS) estimator introduced by Stock and Watson. Both the long-run and the short-run show influences of production of NR, consumption of rubber and prices of other commodities. Better results, however, are obtained with VAR and VEC models for the entire sample and for subsamples. Confirmation is found for the theoretical model that predicts the effects of both the weighted real exchange rates of important importing countries with regard to the dollar, and the weighted real exchange rates of the NR producing countries. The analysis also shows that traders have changed their behaviour in connection with the Asian crisis, whereas lagged exchange rates were a sufficient source of information before the crisis, contemporaneous effects now dominate.

Keywords: commodity markets, exchange rates, rubber prices.

1 Introduction

Amidst many complaints about presently low international commodity prices, it is not often realized how much these are influenced by the recent and dramatic changes in the real exchange rates of producing and consuming countries. The issue of how exchange rates affect commodity prices is strongly dependent on its actuality. In the early 1970s, Ridler and Yandle (1972) developed the basic model for the evaluation of the impact of the decrease in the US$ exchange rate of that era. In the 1980s the issue became topical again when the same US$ sharply appreciated, leading to analyses as those by Dornbush (1987) and Gilbert (1989, 1991). These papers all focus on the impacts of the changes in the US$, and do not specifically look at changes in currencies of exporting or importing countries. The Asian crisis has provided strong evidence on how exchange rates affect international prices. The more recent depreciation of the Euro currencies has also had substantial effects on the US$ prices in the world market.

In this paper[1] we investigate these effects and focus on a commodity strongly represented in the Asian region, natural rubber (NR). An introduction to this market is given in section 2. A theoretical model on the effect of exchange rate changes on commodity price change is then presented in section 3. In Section 4 the variables which are relevant for the explanation of developments in natural rubber prices are described. We first investigate its link with prices of substitute goods, synthetic rubber in this case, leading to the conclusion that NR prices lead synthetic rubber prices. The theoretical model of section 3 is translated into a simple structural model in section 5 containing the variables reviewed in section 4. The estimation results are shown and discussed in section 6. The long-run equation relates NR prices to supply and demand conditions and exchange rates. The long-run and short-run influence

[1]The authors thank Marius Ooms for his comments on an earlier version of this paper.

on the price of NR are analyzed. This is followed by a more satisfying multivariate analysis by using VAR (VEC) models. We find confirmation for the theoretical model that predicts the effects of exchange rate changes when the analysis follows the line of Johansen's ML approach.

2 The market for natural rubber

2.1 Introduction

This section reviews the natural rubber economy so as to provide a basis for the model specification. Subsequently attention is on consumption, production, prices and the choice of the sample period.

2.2 Consumption of rubber

Rubber is consumed in tyres e.g. passenger car tyres, commercial vehicle tyres and a great variety of other tyres running from bicycle tyres to aeroplane tyres and off-the-road tyres, and in numerous general products e.g. belts, hoses, automotive parts, medical gloves and condoms. These two sets of end-uses are roughly of the same size.

For the analysis of this paper it is important to look at the split between natural rubber (NR) and synthetic rubber (SR). In the 1970s it was believed that NR and SR both had a reasonable share of the market to themselves for technological reasons, while leaving a large share open to substitution for price reasons. Figure 1 shows developments over time starting from a situation just before WWII when SR was invented and further developed.

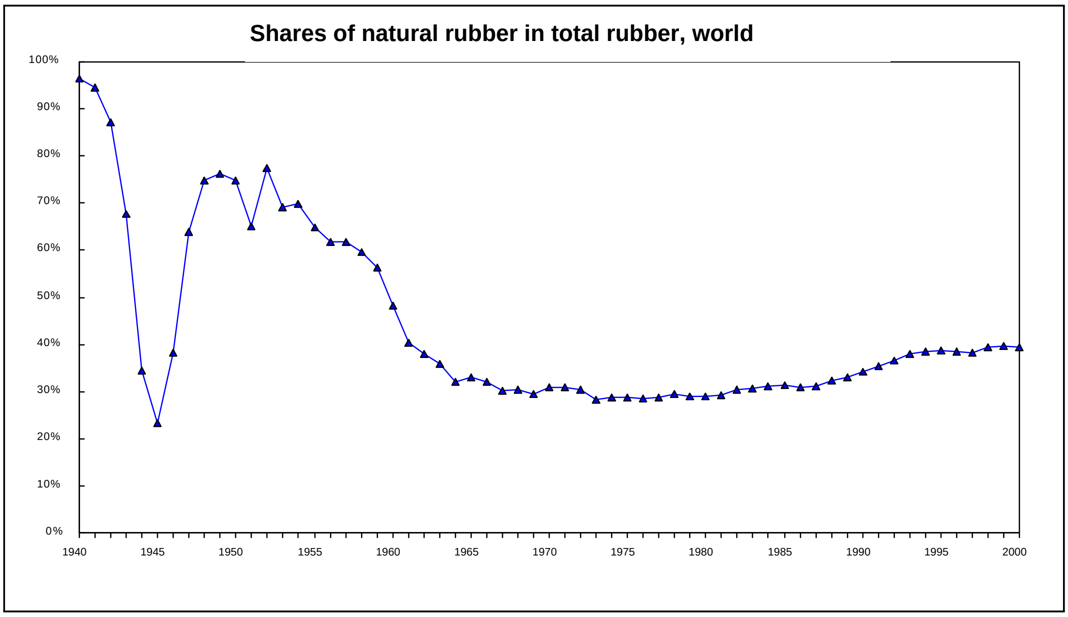

Figure 1: Shares of natural rubber 1940 - 2000

The share of NR decreased dramatically during the war because of unavailability of NR from Southeast Asia. Then SR was further developed technically, allowing it to take over an increasing share of the market, leading to the opinion in some circles in the sixties that NR would be replaced completely. Since the late 1970s the share of NR on a world scale has increased slightly from a trough of less than 30% in the mid 1970s to a peak of around 40% in the 1990s. There are many reasons behind this: NR has some basic characteristics which are difficult to replace by SR; indeed, in the Sowjet Union substitutes were developed, but these have never been of similar quality; this is the major reason for the stable share during the 1970s. Also, the introduction of the radial tire has added to the need for more NR. Another major reason for the increase of the share on a world scale is the geographical distribution of world consumption. The increase is explained by two major factors. First the shift of consumption growth to NR producing countries with a relatively high NR share (e.g. India and Malaysia). And, second, the reduction by over 80% in the former Soviet Union, which applied a share of NR of less than 10% in the late 1980s. For more details see Bennett (1976), Smit (1984), Barlow et al. (1994), Jumpasut (1995), Burger and Smit (1997).

Does this mean that the market has become more competitive and that prices are more strongly related? Smit and Vogelvang (1997) have shown that this is not the case. Technology has advanced and competition is claimed by many to have been replaced by complementarity [see e.g. Schwarz (1998)]. In almost all countries the NR share in the tyre sector is well above that in the general rubber goods sector. For most countries the latter share is declining to zero. Exceptions are e.g. those countries where there is a major dipped good industry based on NR for technical reasons (condoms, surgical gloves). This became very important during the period of the AIDS scare in the late 1980s.

2.3 Production of natural rubber

Natural rubber is produced by tapping rubber trees once a day, a few times a week, throughout the year except for the 'wintering period'. Productivity ranges from a few hundred to a few thousand kilograms per hectare. Trees on average last around 25 to 30 years and cannot be tapped until the age of about 6 years. The major part of production comes from smallholdings, with the share of estates declining. After tapping different processing methods can be followed leading to Ribbed Smoked Sheets, Technically Specified Rubber or Concentrated Latex for dipped goods. After processing the rubber is shipped to the consuming industry. The major natural rubber producing countries are Thailand, Indonesia, Malaysia, India, China, Vietnam, the Philippines and Sri Lanka. Natural rubber is also produced in a number of other Asian countries, Africa and Latin America.

2.4 Natural rubber prices

Most rubber nowadays is sold directly from the processor to the consumer. Part of the rubber is traded on the market. The major markets are in Singapore, Tokyo and Osaka. Developments in NR prices together with SR prices in the USA expressed in US$, are shown in Figure 2.

The research question in this paper is narrowed down to: how are NR prices in the long run and in the short run influenced by exchange rate developments on the supply side and/or on the demand side. Monthly data are used to estimate the effects of exchange rates and other variables on the price of NR. If quarterly or annual data were used it would not be possible to trace a large part of the effect as such would have faded away. A drawback is that monthly data on production and consumption are not very accurate. Since the focus is on NR price formation and because of the quality of the data, monthly supply, demand and stock equations are not estimated. The estimation period is 1975.1 to 1999.12. The data are available through 2001.7, the end of the period (2000.1 - 2001.7) will be used to check the prediction properties of the models. Data for most variables are taken from the Rubber Statistical Bulletin of the International Rubber Study Group.

3 The effect of devaluation on natural rubber prices

Theoretically, the immediate impact of a fall in the currency of a country is to enhance the profitability of exports and to discourage imports. By the same token, domestic sectors that are import competing should benefit, while the effects for the non-tradable sector should be positive as well, namely to the extent that additional (local currency) earnings in the export sectors are spent on domestically produced goods. If the import competing and non-tradable sectors cannot quickly meet the rising demand, a price rise is a natural reaction, which adds to the inflationary effect of the higher price of imported goods.

This standard analysis does not include the effects that exchange rate changes have on the world market prices themselves. Since the three major producers of natural rubber, Thailand, Indonesia and Malaysia were all more or less heavily affected by the currency crisis, we cannot ignore the changes in world market prices that might result from such exchange rate changes.

Effects of exchange rates on world market prices can be expressed in algebraic terms. For our situation let us distinguish an importing country, indexed by m, other world demand indexed by n, supply from an exporting region (r) with exchange xr_r and other supply from outside the region (o). For convenience it is assumed that changes in local demand in the exporting region, or changes in supply in the importing country are not important for the world market prices of commodities concerned. This gives the following equations in a general notation:

Regional supply:

$$\ln(S_r) = \alpha_r + \beta_r \ln(P \cdot xr_r)$$

Other supply

$$\ln(S_o) = \alpha_o + \beta_o \ln(P)$$

Importer's demand

$$\ln(D_m) = \alpha_m - \beta_m \ln(P \cdot xr_m)$$

Other demand

$$\ln(D_n) = \alpha_n - \beta_n \ln(P)$$

Equilibrium

$$D_n + D_m = S_r + S_o.$$

Here, supply is denoted by S, to which a suffix is added for each region, P denotes the world market price in US\$, and xr the exchange rate expressed in local currency per US\$. D is demand also with a suffix.

Changes in any variable affect prices, while maintaining the balance of supply and demand so that

$$d(D_n) + d(D_m) = d(S_r) + d(S_o).$$

where d indicates the change in a variable.

By approximation, this can be written in logarithms and shares:

$$s_n \cdot d\ln(D_n) + s_m \cdot d\ln(D_m) = s_r \cdot d\ln(S_r) + s_o \cdot d\ln(S_o),$$

where s_n and s_m are shares in world demand, and s_o and s_r indicate the shares of the regions in world supply.

The solution for the change in the world market price P, resulting from changes in the exchange rates, is then given by:

$$d\ln(P) = \frac{-s_m\beta_m d\ln(xr_m) - s_r\beta_r d\ln(xr_r)}{s_m\beta_m + s_r\beta_r + s_n\beta_n + s_o\beta_o}.$$

Devaluation amounts to an upward change in exchange rate (local currency/dollar). Look at an example of a 50% devaluation, which implies that only xr_r doubles, as initially happened in SE Asia. Assume that the producer has 80% of the production, and that the supply elasticities are equal to 0.2 and the demand elasticities are equal to 0.05, then:

$$d\ln(P) = -\frac{0.80 \times 0.2 \times \ln(2)}{0.25 \times 0.05 + 0.80 \times 0.2 + 0.75 \times 0.05 + 0.2 \times 0.2} = -0.44,$$

[cf. Burger and Smit (2001)] so that world market prices go down by about 44%. If all elasticities are equal to 0.2 the price change would be −0.28.

The more general version of this result was derived by Ridler and Yandle (1972) who looked at the changes in the US$ compared to other developed countries' currencies. As Gilbert (1991) shows, omission of the producing countries in regressions that aim at explaining how changes in the value of the US$ influences prices of primary commodities, may well overestimate the effects. Implicitly, the same argument of incorrect weights is used to question the use of aggregate indices for the US$ exchange rate.

In our application, we look at the importing and producing countries of one commodity only. This facilitates the finding of appropriate weights for aggregate measures of exchange rates. As the model above implies, the shares in the production or consumption form appropriate weights as long as supply or demand elasticities do not differ much between the countries. Such supply and demand typically depend on local, real prices, and we should therefore, interpret the prices in the above equations as real prices. What matters, therefore, are real, not nominal exchange rate changes, a point also made by Gilbert (1989).

Demand functions for NR can be derived from the supply of the products that use NR. The theoretical model is one of a profit maximizing producer of a good, using NR, SR and metal parts for his product. Derived demand for NR then typically depends on the prices of the product, of NR, SR and metal. Product prices, and the prices of SR and metal should therefore enter into the price equation for NR, besides variables that characterize supply. However, this is only valid if these prices are not themselves dependent on the NR price. This may hold for the price of SR if supply of SR is more controlled than supply of NR. For control means that supply can be adjusted to market demand, and that supply shocks are absent.

For the application below we first investigated the relationships between the prices of NR and SR, concluding that the price of SR follows that of NR, so that the price of SR should not be included in the demand equation. On the other hand, the price of metals was found to be determining the price of NR, and not the other way around. Hence, this price is maintained as explanatory variable. A positive effect of this price could indicate that the two commodities are substitutes, or, what is more likely and more important, that both are affected by the same common cause: a change in the demand for the product containing NR and the metals. One might even go one step further: a change in general industrial activity. Finally, no price of the product containing NR is included: a good proxy for this aggregate price is difficult to find, and goods prices are anyway very stable compared to prices of primary commodities.

Supply functions of NR are usually derived from models that include the vintage composition of the trees that form the basis of this production. For a monthly model, this basis has not much relevance as it changes only very gradually over time in view of its long gestation period and long life cycle. But prices play a role. Farmers can and do adjust the tapping intensity and the application of fertilizer and stimulants in response to price changes.

4 Variables explaining development in natural rubber prices

In this section we elaborate on the explanatory variables. As indicated above, we first report on the nature of the relationship between synthetic rubber prices and those of NR, we then proceed to discuss the quality of the data on physical rubber demand and supply after which we move to monetary factors that have an impact on the prices on natural rubber.

As a substitute good, prices of synthetic rubber should normally enter the demand equation for natural rubber. However, these prices may be endogenous, or, as we shall see below, even determined by the price of natural rubber. In these cases, they no longer serve as explanatory variable and can be left out of the analysis.

Visual investigation of Figure 2 shows a difference in the movements of the price of NR[2] and SR[3]. Peaks in the SR price occur later than those in the NR price. The relatively large short term volatility of the SR price is due to its being an export unit value rather than the price of a single quality as was taken for the NR price.

Factors in the economy, be it rubber related, vehicle related or more general will influence the development of prices. Such influences will become apparent more quickly on a physical market than in export unit values, contracts for which may have been concluded some time before. For that reason too it is reasonable to suggest that the price of natural rubber is the leading price in the market. This is also clear from the graphs.

To get more insight in the time-series properties of the prices, a preparatory analysis of the data has been performed, like unit-root tests, causality tests etc.[4].

[2] P_t^{NR} : the natural rubber (NR) price, which is a market price for a particular grade: Ribbed Smoked Sheet, number 1 (RSS1), Singapore, converted into US$.

[3] The synthetic rubber (SR) price is the export-unit value of Styrene Butadiene Rubber.

[4] All computations have been done using EViews 3.1 and later 4.0. The results of all these computations and estimation results in following sections have not been included in the paper to keep its length within bounds.

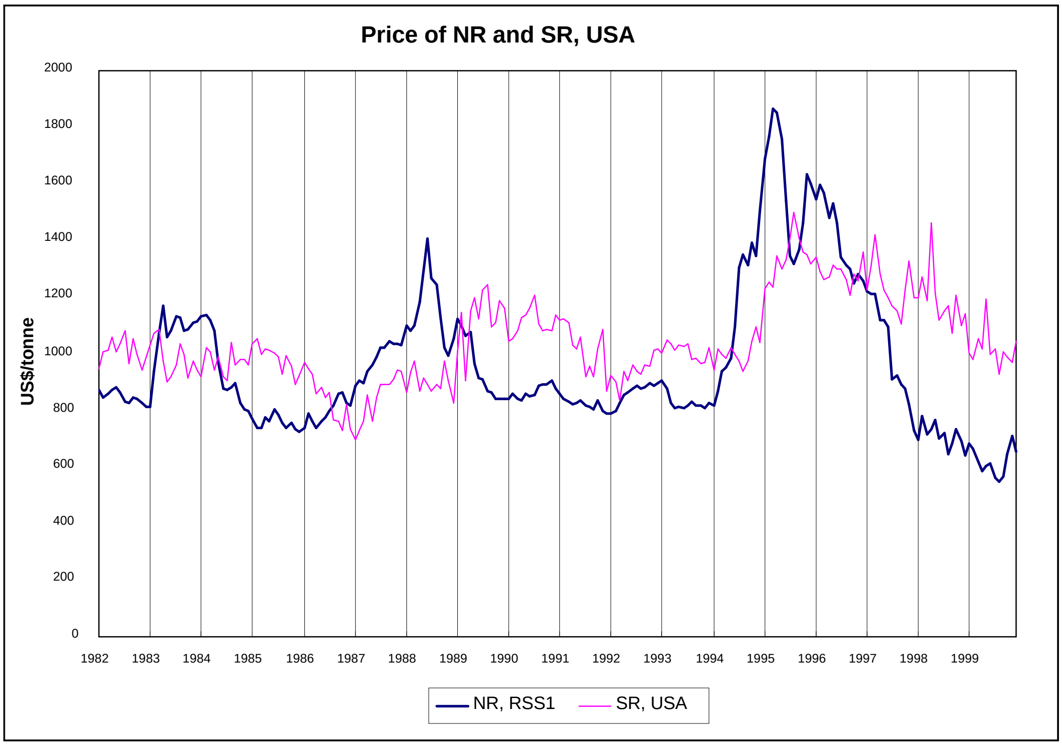

Figure 2: Development of NR and SR prices 1982 - 1999

ADF-tests have shown that all variables are integrated of the first order. Then the causality between the two prices is considered. Granger causality tests have been applied to check if any of the prices is the leading price. The tests have been computed by using 3 lags according to the Akaike Information criterium (AIC) when estimating an unrestricted VAR for these variables. Granger causality between the price of natural rubber and the synthetic rubber prices does exist with natural rubber prices leading synthetic rubber prices, and becomes stronger in more recent years; see Table 1.

	1982 - 2000		1990 - 2000	
H_0	$F-statistic$	$p-value$	$F-statistic$	$p-value$
$P_t^{NR} \nRightarrow P_t^{SR}$	3.467	0.017	4.522	0.007
$P_t^{SR} \nRightarrow P_t^{NR}$	1.240	0.296	0.490	0.691

Table 1: Granger causality between prices of NR and SR

Because of the results of the Granger causality tests, cross-correlations between the price of natural rubber and the prices of synthetic rubber have been computed to get more insight in the dynamics of the relations between these prices. The coefficients indicate that SR prices do not lead NR-prices. The coefficients are small and mostly not significantly different from zero after about 7 months lags. The values indicate that the price of natural rubber is leading, up to on an average of about seven months in advance. Any contemporaneous effect appears not to be present, which may be caused by the time required for delivery as mentioned above. All results show that

NR-prices influence SR-prices with a lag of about seven months. Because of this causality, the price of SR cannot be included as explanatory variable in the analysis.

4.1 The physical rubber side

The fundamentals of price determination naturally include factors that bear upon demand and supply. The standard demand-supply framework confronts producers (and their marginal costs) with consumers (and their marginal costs). Actual price discovery, however, is not between those two groups, nor fed by information on marginal costs. Monthly price determination on the NR world market is made between buyers (mostly NR consuming tyre manufacturers) and sellers (mostly stockholders). On the consumer side, these agents come quite close to what theory expects them to be. On the producer side, traders intermediate and their considerations and information should play a role in the price setting process. Thus, while buying agents may be well-informed about their employer's marginal costs considerations, selling agents only indirectly take the marginal costs of production into account. The information at their disposal cannot include exact data on total production in the recent months, nor data on consumption, but is based on guesses and rumours about physical supply and demand and stocks, fed by data on imports and exports in a more distant past, and by day-to-day information on their own company, and on actual prices of the commodity, other commodities, exchange rates and the like. Thus, physical changes in the market can hardly be believed to have a strong immediate impact on the prices, while price information might stand in for the missing information on the physical changes. If all traders would trade in the same market, all information could - in principle - be combined in the price discovery mechanism. This is not so in the rubber market: most trade (some 70%) is done in bilateral deals between large suppliers (producers or traders) and consumers. Only a small part is actually traded through the market and contributes to the establishment of prices. Hence, traders that help establishing the market price cannot be fully informed about supply-demand condition, even when taken together. Eventually, shortages or surpluses will be felt by all of them, and translated into negotiated prices, but on any single day or even month, they can have but an imperfect view of these conditions. This explains why price and exchange rate information has such a strong role to play. Even the price history of the commodity itself is believed to contain substantial information, as witnessed by the popularity of charting methods.

Hence, the current month's production - if at all known - can hardly play a role, as this production cannot physically reach the consumers. Current production is expected to play a role only in as far as some indication is required for the stockholders about what future replenishment of their stocks is to be expected. Lagged production may play both roles: providing information on future availability on the market and making natural rubber physically available. Other obvious considerations regarding the prices are those of the NR consumers and those of the stockholders. Changes in private stocks partly take place for seasonal reasons, as production and consumption do not match per month. Larger opening stocks have a depressing influence on the prices. In spite of the large seasonal fluctuations in supply and demand, prices do not show this cyclical pattern. This may be incorporated in the price equation by deseasonalising the influence of consumption and production. Thus, stockholders appear to play their role well of accommodating these short-term fluctuations.

Demand pressure is included in the model through total consumption of rubber, without distinguishing different types. Above it has been concluded that there is no scope for the inclusion of the price of the 'competing' synthetic rubber. Supply is represented by world natural rubber production.

It is important for the interpretation of the variables for production and consumption to pay attention to the way data are collected. Starting with production, monthly figures for natural rubber production are not directly collected in producing countries. The basic identity is used: production equals net exports plus domestic consumption plus change in stocks. Mostly, quite accurate monthly statistics are available for net exports. Reasonably accurate estimates are made of domestic consumption, which e.g. in Thailand, the largest producer of natural rubber, plays a minor role. Finally, estimates are made of stocks, a difficult job. Stocks held by farmers and smaller dealers can not be estimated. Some estimates based of 'survey data' may be obtained for stocks held by the largest traders. Therefore, production data of natural rubber are heavily based on export data, to which some 'trends' and 'assumptions' are added. When natural rubber prices are explained in an equation using natural rubber production as explanatory variable, this explanatory variable therefore indirectly includes demand elements when the production data are derived in the way described above

A similar story can be told for consumption of rubber, be it natural or synthetic. A consuming country normally has no estimates on consumption of rubber by the industry. In most cases consumption is derived as net imports plus domestic production, neglecting stocks. This may lead to difficulties in assessing the levels of coefficients. When e.g. natural rubber prices increase, the rise in net imports may exceed, for speculative reasons, the rise in consumption, which by itself may even decline because of a shift to competing synthetic rubber. This leads to a mixed relationship between prices and consumption, derived on the basis of net imports. Added to this must be another word of caution: import statistics for many countries are not very accurate.

All demand and supply variables based on the statistics discussed above show a strong upward trend. The graphs of the supply and demand variables indicate seasonality in supply of NR and in demand for rubber in the EU, in Japan and in the world as a whole, whereas it is hardly present in the data for the demand in the USA. The seasonal variables have been seasonally adjusted (multiplicative). In the model we experimented with total world consumption of natural plus synthetic rubber as explanatory variable and compared its performance with a more accurately measured alternative: the same consumption but now limited to USA, Japan and the EU; this is the variable C_t^{T3} which counts for 50% of the total rubber consumption. While the latter was retained in the results that we present, the differences are only minor as the correlation between the two series is no less than 0.94.

4.2 The monetary side

As shown in the model for the effects of exchange rate changes, prices in the world market cannot be determined in a confrontation of demand and supply only. Prices, and therefore price transmission mechanism matter. In particular the exchange rates of dominant consumers and producers play a role. Included in the model are the weighted average exchange rate of seven important natural rubber importing countries with market based exchange rates vis-à-vis the US$ $\left(E_t^I\right)$ [5], to represent the demand side, and a weighted mean of the real exchange rates of the three major natural rubber producing countries $\left(E_t^Q\right)$ [6] to capture the important changes on the supply side. The graph of the exchange rate E_t^I is in Figure 3. Figure 4 shows the dramatic changes in the currencies $\left(E_t^Q\right)$ of the NR producing countries since mid 1997.

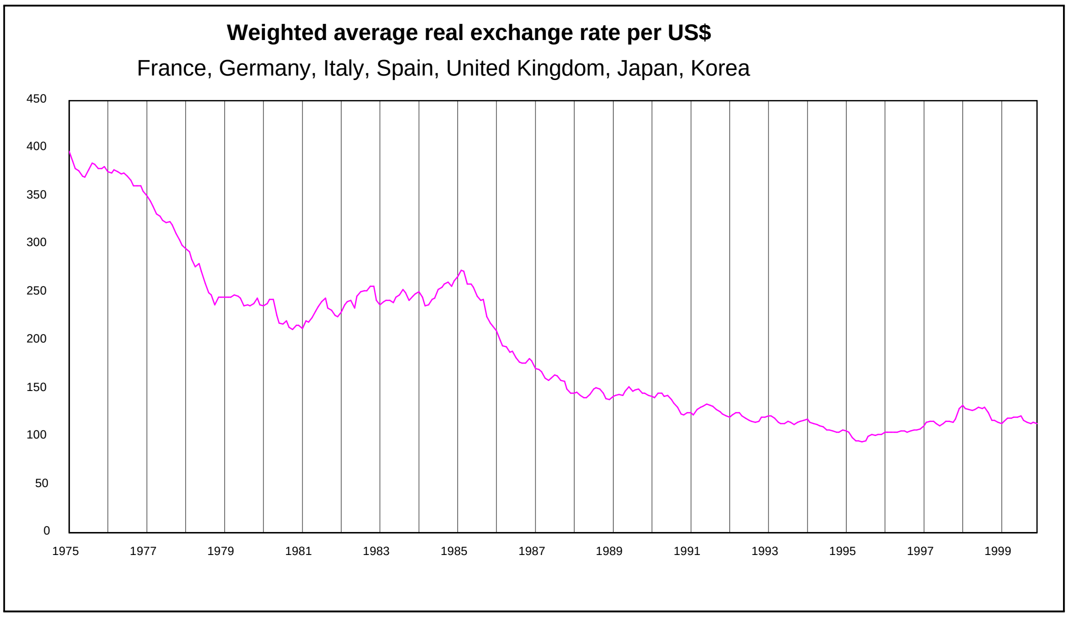

Figure 3: Developments in E_t^I, 1975 - 1999

Their influence may even go beyond their role as transmitter of the world market prices to domestic users. Particularly on the demand side, there can be speculative demand for currencies and commodities alike, so that changes in the outlook for natural rubber can induce people to switch funds from currencies to NR or vice versa. As major futures markets for natural rubber are located in Japan, where restrictions on currency trade was in place some time in the past, yen-dollar speculators could use the NR market to cover their currency interest. A similar dual role is played by another price variable included in the model the price index for minerals, ores and metals $\left(P_t^{MOM}\right)$. This variable represents the (US$) price of commodities in demand by the same industry that uses natural rubber. In this way higher prices reflect high levels of industrial activity. But demand for metals and minerals is also an alternative for natural rubber for speculators, and some arbitrage between the various commodities is likely to occur (cf. Frankel, 1984). Data on the price index for minerals, ores and metals are taken from UNCTAD's Monthly Commodity Statistics.

As mentioned above, the price of synthetic rubber is not included, as this price follows the price of NR. We checked whether P_t^{MOM} was also following, rather than leading P_t^{NR}. Figure 5 shows the evolution of the two prices over time, and Table 2

[5]The weights in E_t^I are based on each share in the common import of the countries in question.
[6]The weights in E_t^Q are based on each share in their common production.

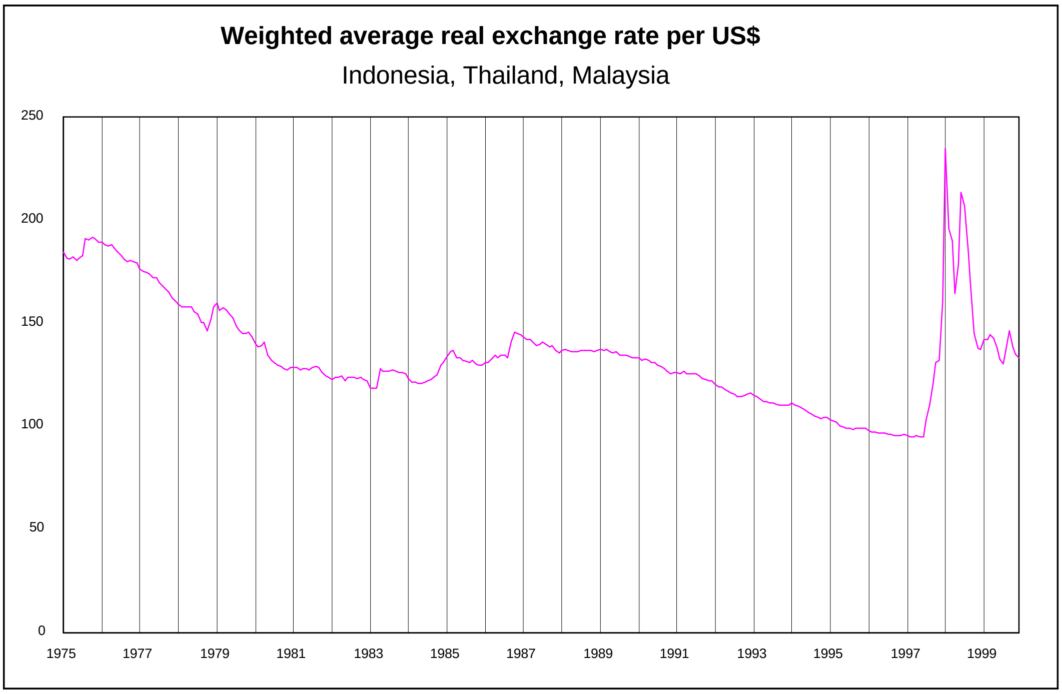

Figure 4: Developments in E_t^Q, 1975 - 1999

shows the results of a test on Granger causality of either price.
Figure 5 shows that this price index follows a pattern, which strongly resembles that of the price of NR.

H_0	$F - statistic$	$p - value$
$P_t^{NR} \nRightarrow P_t^{MOM}$	1.066	0.364
$P_t^{MOM} \nRightarrow P_t^{NR}$	6.945	0.000

Table 2: Granger causality between prices of NR and minerals, ores and metals

The tests clearly reject the null hypothesis that NR prices lead P_t^{MOM}, but permit the conclusion that P_t^{MOM} leads P_t^{NR}.

5 A simple structural model

We consider the following model, with all the variables in logarithms.

Let demand be given by

$$C^{NW} = \alpha_0 + \alpha_1 C^{T3} + \alpha_2 P^{MOM} - \alpha_3 P^{NR} - \alpha_4 E^I$$

and supply by

$$Q^{NW} = \beta_0 + \beta_3 P^{NR} + \beta_4 E^Q$$

then the equilibrium price would be

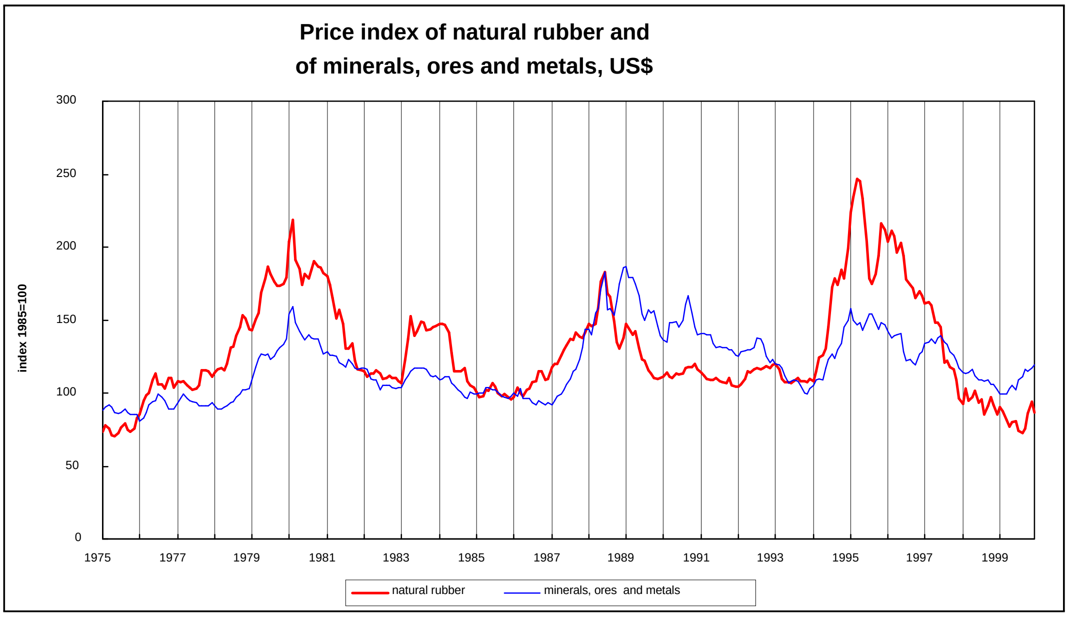

Figure 5: Developments in P_t^{NR} and P_t^{MOM}, 1975 - 1999

$$P^{NR} = \frac{\alpha_0 + \alpha_1 C^{T3} + \alpha_2 P^{MOM} - \alpha_4 E^{SDR} - \beta_0 - \beta_4 E^Q}{\alpha_3 + \beta_3}$$

Here C^{NW} is world consumption of NR, C^{T3} the consumption of all types of rubber in the three major consuming regions, P^{MOM} the price index of minerals ores and metals in current US\$, P^{NR} the price of natural rubber in current US\$s per ton, E^I the weighted exchange rate for some importing countries per US\$. Q^{NW} is world production and E^Q is the weighted exchange rate index of the three major producing countries in terms of real local currencies per US\$. P^{NR} should be co-integrated with the RHS variables and the equation establishes the long-run path for the co-integrated variables. In the short run, deviations from this path occur, due to innovations that cause temporary shocks.

In the long-run equation, both C^{T3} and P^{MOM} give information about the situation on the demand side. Information on the supply side is more difficult to assess: the (real) exchange rates indicate how prices are transmitted to local producers.

A priori, with price elasticities of demand (α_3 and α_4) equal to about 0.1 and elasticities of supply (β_3 and β_4) equal to 0.2, we should expect that E^I has an estimated coefficient of around 1/3 and E^Q of about 2/3. If the pass-through of exchange rate changes is not perfect, the α_4 may typically be less than α_3, and β_4 be less than β_3. In this case, the coefficients for the exchange rates are less than the 1/3 and 2/3 suggested earlier.

The reduced form estimation to which the above equation gives rise did not do a good job in terms of explanatory power, especially because no variables were included to characterize supply conditions other than the real exchange rate. For this reason, the long-run equation was reformulated so as to include Q^{NW} as one of the explanatory variables. By itself, this should make the E^Q redundant, as the equation now becomes

$$P^{NR} = \left(\alpha_0 + \alpha_1 C^{T3} + \alpha_2 P^{MOM} - \alpha_4 E^I - Q^{NW}\right) / \alpha_3$$

For the estimated parameter of E^I the implication would be that this must be close to unity (if pass-through is complete and E^I an adequate variable). If, in this relationship, E^Q would still get a significant sign, this can be taken as evidence that the exchange rate changes have an effect different from what the model suggest. The parameter value of Q^{NW} should be fairly large.

6 Estimation and prediction of long-term and short-term developments in natural rubber prices

6.1 Introduction

The process of obtaining a good explanation of P_t^{NR} has been most interesting. The period 1975.1 - 1999.12 has been used as estimation period. Since starting the analysis in late 2000, additional data have become available. This latter part of the available data, 2000.1 - 2001.7, has been used to assess the predictive properties of the models. Below, first the results of a structural analysis for the entire estimation period is described. The estimated long-run and short-run model were concluded not to be satisfactory. Consequently, the estimation period has been divided in a period before and after 1997.7, the month that the Asia crisis started. In section 6.3 vector autoregressive (VAR) models have been estimated. The analysis of the two sub periods clearly results in different models describing P_t^{NR}. In the first period cointegration is not found and an unrestricted VAR model explains P_t^{NR} rather well. In the second period cointegration has been found and a VECM yields good estimation and simulation results. An alternative model is a VAR model for the entire period with a dummy variable for the two regimes which is presented first. This model explains P_t^{NR} rather well too, in both the sub periods.

6.2 Structural analysis of the sample period 1975.1 - 1999.12

The analysis of the long-run and short-run influence of the variables described above on the price of natural rubber was commenced with the classical Engle-Granger procedure [Engle and Granger (1987)]. Weak evidence of cointegration was found. The null-hypothesis of a unit root in the OLS residuals of the static equation is not rejected at the 5% level (ADF: -3.866). The coefficients of the long-run equation were not as expected, based on the considerations given in the previous section. Both Q_t^{NW} and E_t^Q have to be specified for getting somewhat acceptable results. The variable E_t^I could not be included because it got the wrong sign. Equation (1) shows the results.

$$P_t^{NR} = 8.139 - 0.682 Q_t^{NW} + 0.408 C_t^{T3} + 0.766 P_t^{MOM} - 0.707 E_t^Q + e_t \qquad (1)$$

In addition, the dynamic generalized least squares estimator (DGLS), as introduced by Saikkonen (1991) and Stock and Watson (1993), was used to see whether more efficient estimates of the long-run parameters could be obtained, but that was not the case. A short-run error-correction model (ecm), not reproduced here, was also estimated. The error-correction term had a t-value of -2.500, which hardly supports the hypothesis of cointegration of the variables. The period after 1997.7 shows a world with clearly different exchange rates and we checked therefore whether the coefficients of the exchange rate variable on the supply side had changed in this process. Recursive estimates of the parameters of ∇E_t^Q and ∇E_{t-1}^Q were computed. These interesting plots are shown in Figure 6. Until the currency crisis, the estimated effects of the

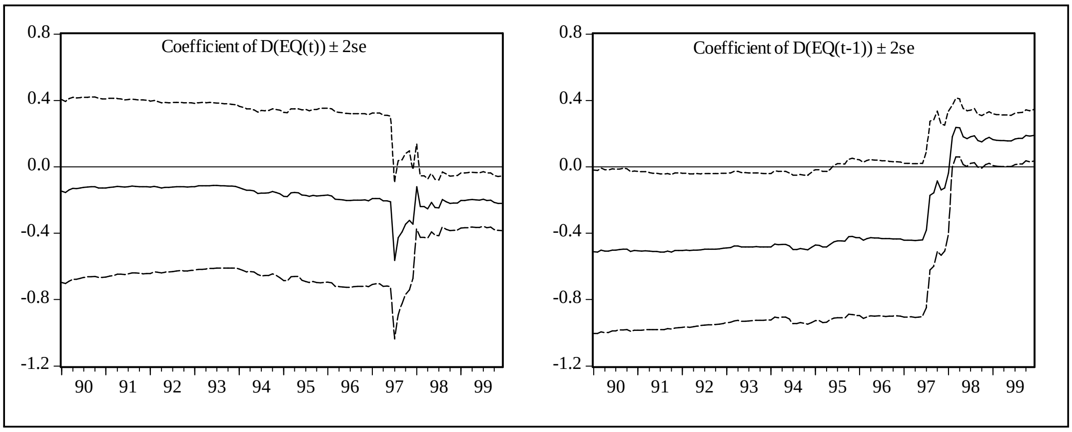

Figure 6: Recursive estimates of the parameters of ∇E_t^Q and ∇E_{t-1}^Q

contemporaneous exchange rates was insignificant and small (but negative), while the effect of the lagged exchange rate was relatively large and nearly significant. After the outbreak of the crisis, the contemporaneous effect has gained enormously in significance, but without much change in size, while the lagged effect has become positive, though again only mildly significant. Applying the Chow-breakpoint test, the null-hypothesis of no structural break in the model since July 1997 is clearly rejected with an F-statistic of 2.896 (0.004).

This evidence of a structural break can be explained by the role that exchange rates play in most of the trade that was done. Until the dramatic changes of 1997, traders did not need to look at the exchange rates. Their behaviour was smooth, and trendwise. Some implicit considerations for exchange rates movements might have been included in longer-term contracts but even then without much fuss. Only the currency rates of the most recent months had some impact, if any. But as of July 1997, traders were squarely faced by enormous changes in exchange rates, and the currency terms of the contracts suddenly became all important. Taking last month exchange rates would be completely wrong, and immediate adjustments in the US$ price were made when dealing with exporters from devaluating countries. Yet, the supply was not as immediate and some lags in shipments are inevitable. Hence some forecasting is unavoidable, but also very difficult in these months. This may explain the overshooting of the effects of immediate exchange rates, which is compensated in the following month. The structural change in the model that is suggested by the Chow-test, thus amounts to the inclusion of exchange rates in the price negotiations among traders.

Finally the ecm has been re-estimated with a dummy variable for ∇E_{t-1}^Q and an ARCH(3) process for the disturbance term yielding more efficient estimates. The detected ARCH(3) effect indicates the existence of 3 months cycles in the market and likely reflects the popularity of 3-month forward selling and hedges. The dummy variable is zero before 1997.7 and equal to one for the last part of the sample period. The simulations for P_t^{NR} with and without the error correction are given in Figure 7. Although still not very good, the model without the error correction term in Figure 7(b) gives better results.

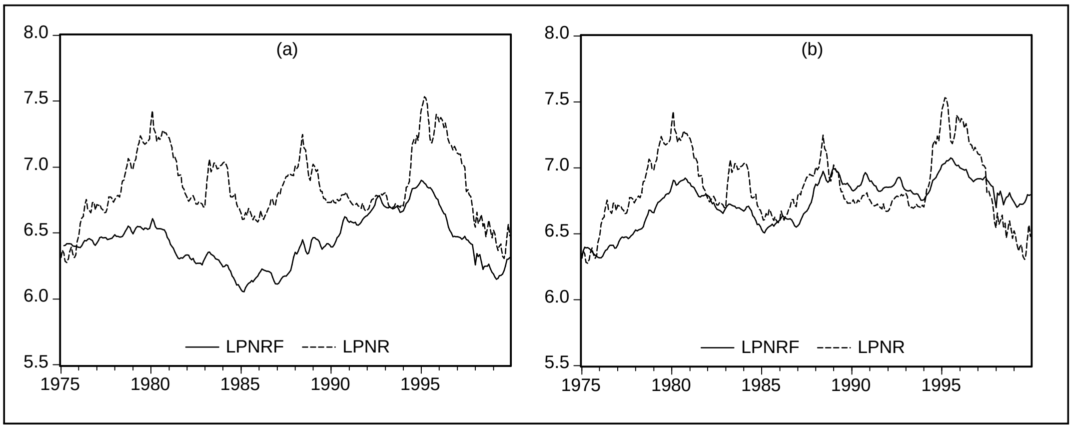

Figure 7: Simulation of the structural model with error correction (a), and without (b) for the estimation period 1975.1 - 1999.12

The models do not simulate P_t^{NR} well and the figures endorse the conclusion that a long-run relationship between these variables does not exist. This means that only a short-run dynamic model can be estimated, one model with a dummy variable or two models for the two sub periods. In any case, the structural analysis does not yield a satisfactory model for the short run. A different way of modelling, by estimating a vector-autoregressive (VAR) or vector-error correction model (VEC) model, is described in the following sections.

6.3 A VAR model for the period 1975.1 - 1997.7

A different approach compared to estimating dynamic short-run structural models is to estimate vector autoregressive models. These models show the complete interdependence between the variables in the short run. VAR or structural VAR and VEC studies which can be found in the literature. Examples are Anderson, Hofman and Rasche (1998) concerning the US economy, Gottschalk and Zandweghe (2001) on the German economy, Jang and Ogaki (2001) on shocks from the US monetary policy on the dollar/yen exchange rate, and Adolfson (2001) with export price responses to exogenous exchange rate movements. As the structural approach did not succeed in adequately explaining P_t^{NR}, the VAR and VEC methods have been applied to see whether better results could be obtained.

It is possible to distinguish between endogenous and exogenous variables in a VAR specification. The general form of a VAR(p) process is:

$$\mathbf{y}_t = \mathbf{A}_1\mathbf{y}_{t-1} + \mathbf{A}_2\mathbf{y}_{t-2} + \cdots + \mathbf{A}_p\mathbf{y}_{t-p} + \mathbf{B}\mathbf{x}_t + \mathbf{u}_t, \text{ with } \mathbf{u}_t \sim N(\mathbf{0}, \mathbf{\Omega})$$

with $\mathbf{y}_t$ a vector of k endogenous and $\mathbf{x}_t$ a vector with d exogenous variables. $\mathbf{A}_i$ (with $i = 1, \cdots p$) are $k \times k$ matrices and $\mathbf{B}$ is a $k \times d$ matrix of parameters. For our analysis a VAR model has been specified with the variables P_t^{NR}, Q_t^{NW} and C_t^{T3} as endogenous variables, whereas the exchange rates and P_t^{MOM} are considered exogenous. The existence of a long-run relationship can be investigated by using the maximum likelihood methodology of Johansen. For a VAR a number of criteria for the choice of the lag length can be computed. The criteria provided by EViews (Final prediction error, Akaike information criterion, Schwarz information criterion, Hannan-Quinn information criterion) do not give identical results. They vary between 2 and 8 lags for the first period. Therefore the absence of residual autocorrelation has been used as criterium for the lag length.

An estimated VAR(9) model is the smallest model that has no significant residual autocorrelation at the 5% level (VAR residual serial correlation LM tests have been computed for this purpose) and clearly simulates the endogenous variables much better than the misspecified model of the previous section. The LR-test indicates still the existence of cointegration and the estimated long-run parameters have the correct sign, but the residuals of the cointegration relation obviously behave with a trend which contradicts the existence of an equilibrium relationship among the variables. Figure 8 shows two things: the simulation across the estimation period 1975.1 - 1997.7 and the predictions given the values of the exogenous variables for the period 1997.8 - 2001.7.

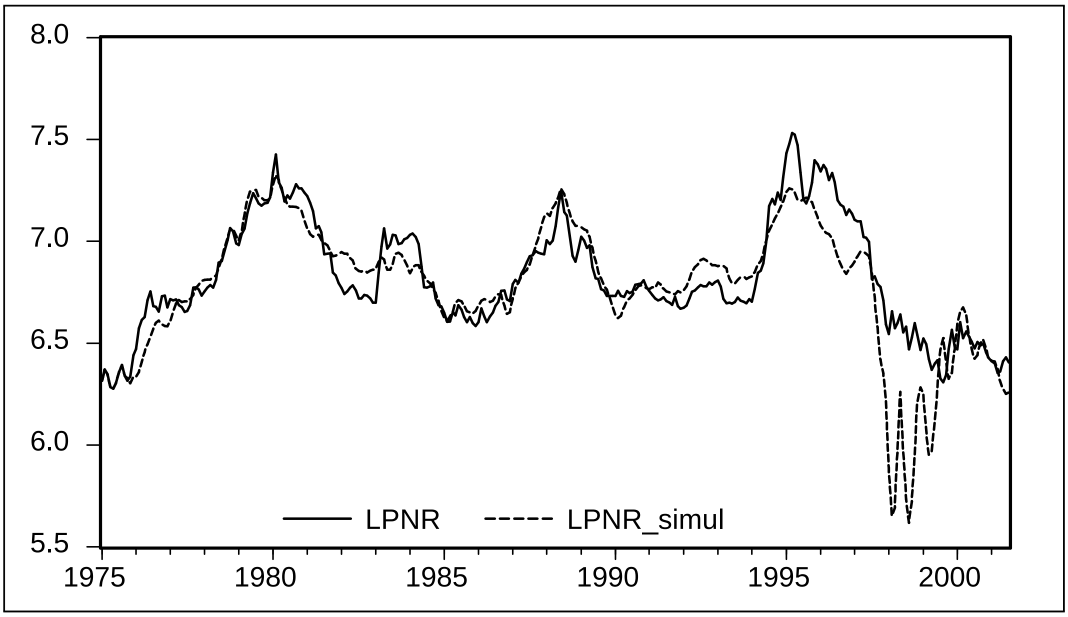

Figure 8: Simulated natural rubber prices from a VAR(9); 1975.1 - 1997.7 and predictions for 1997.8 - 2001.7

The price P_t^{NR} is simulated much better by the VAR model than the structural model from the previous section. It is clear the model cannot predict P_t^{NR} during the Asian crisis. It is interesting to see that the simulated prices 'return' to the observed prices at the end of the sample period.

A second simulation has been done to see the effect of E_t^Q on P_t^{NR} in the period after 1997.7 without an Asian crisis. For this purpose E_t^Q is set equal to its value in 1997.7 for the last period, whereas the other exogenous variables still have their real values. The effect is shown in Figure 9.

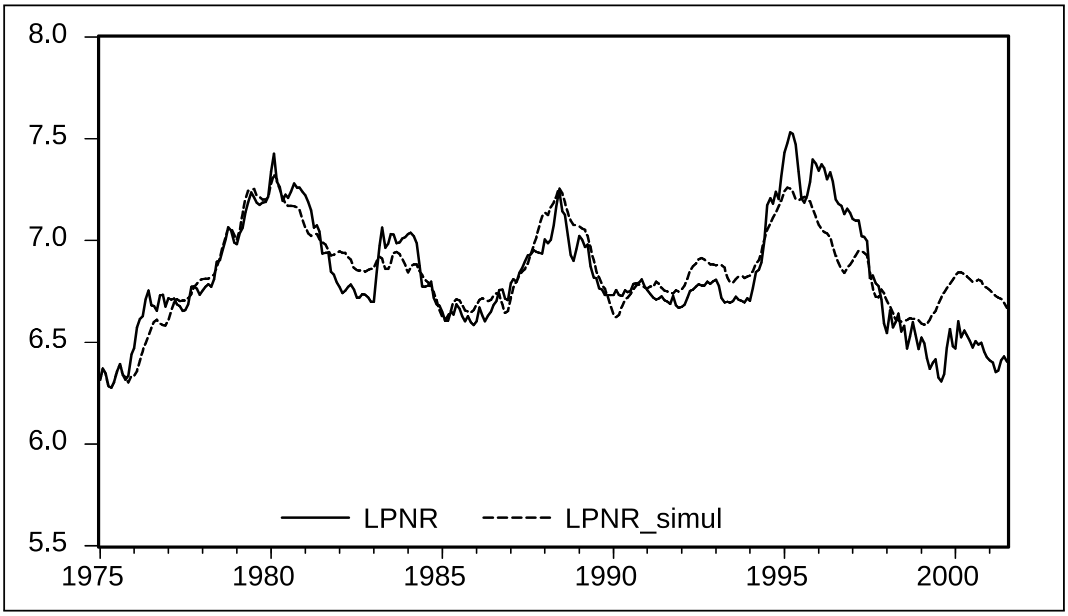

Figure 9: Simulated natural rubber prices till 1997.7 and predictions with E^Q held constant in the period 1997.7 - 2001.7

The simulated prices are clearly higher compared with the real and previous simulated prices. If E^I is also kept constant after 1997.7 then the simulated prices are very close to those from Figure 9, the mean is even identical. An idea about the difference can be obtained by comparing the mean of P^{NR} and its simulated values for the period 2000.1 - 2001.7, as Figure 8 shows that the simulated prices have 'returned' to the observed prices. The mean of the simulated prices is 36.6% higher than the observed prices in this period, whereas the constant value of E^Q is 29.6% lower than the mean of the observed E_t^Q in those 18 months. This result is rather close to the outcome from the theoretical model in section 3.

6.4 A VAR model for the complete sample with a regime-switch dummy

Because of the structural break that has been observed, a dummy variable has been included for the exchange rate variable E_t^Q, equal to zero before 1997.7 and equal to one for the last part of the sample period. The LR-test does not clearly reject a cointegrating relationship, but the trend in the residuals of the cointegrating equation is still present. Therefore it is better to look at the results of an unrestricted VAR model with the dummy variable. The lag length criteria suggest a lag of 5 periods, but an estimated VAR(5) has autocorrelated residuals. This is also true for a VAR(9). The 'smallest' model without significant autocorrelation at the 5% level is a VAR(12). So it takes some time before changes in the variables have been completely assimilated by P_t^{NR}. The inclusion of the dummy variable in the model clearly takes care of the changed influence of E_t^Q. The simulations for the crisis period starting from 1999.7 are very good, while predictions for the period 2000.1 - 2001.7 are rather close to the observed prices, but systematically a little on the low side. These results are shown in Figure 10.

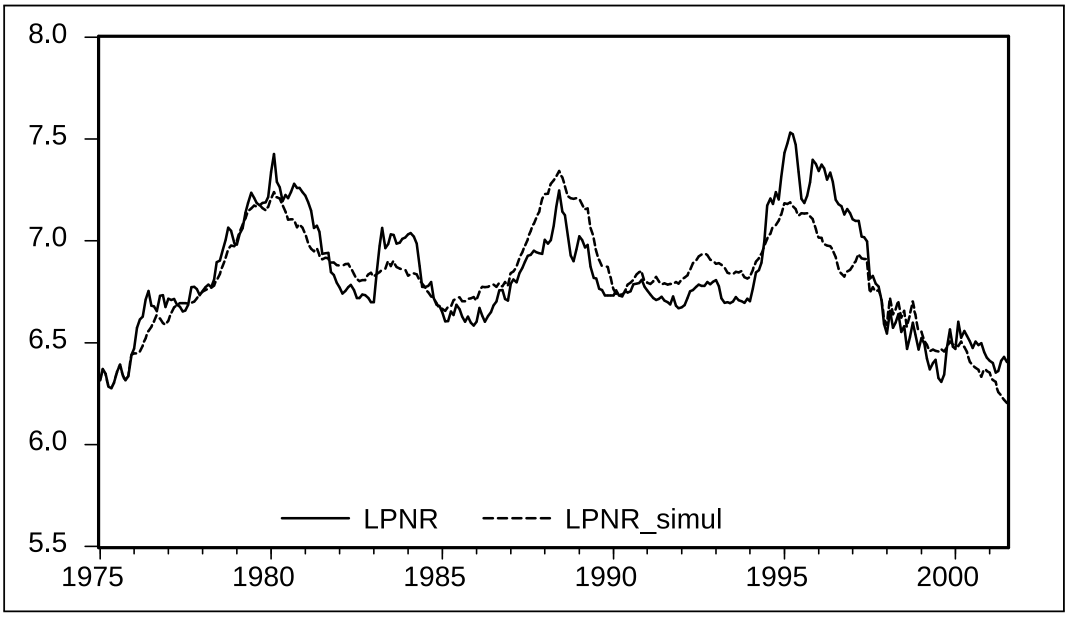

Figure 10: Simulated natural rubber prices from a VAR(12); 1975.1 - 1999.12, with a dummy for the 2nd period; predictions for 2000.1 - 2001.7

This model has as restriction that the disturbance variances are equal in both regimes. A plot of the residuals hardly shows any difference between the sub periods, supporting the idea that this restriction does not cause a problem.

6.5 A VEC model for the period 1997.7 - 1999.12

An alternative for the VAR model for the complete estimation period with the dummy variable is to analyse the second period separately. Interesting differences have been found. In the second period which has been characterized by volatile behaviour of the economy, cointegration is found between the variables P_t^{NR}, Q_t^{NW}, C_t^{T3} by using Johansen's cointegration tests (with 1 lag). The estimated long-run equation is:

$$P_t^{NR} = -27.039 - 4.953Q_t^{NW} + 1.646C_t^{T3} + e_t.$$

These estimated coefficients are less than could be expected from section 5.

A VEC(1) model with some exclusion restriction on the parameters has been estimated for the short run. This means that changes are very rapidly captured by P_t^{NR}, which is an important difference with the first period. In Figure 11 the model simulations are given. For the sake of easy comparison with the result of the VAR model with the regime-dummy, Figure 10 has been reproduced in Figure 11b for the period 1997.8 - 2001.7. It is easy to see that the VEC(1) model simulates the observations better than the VAR model.

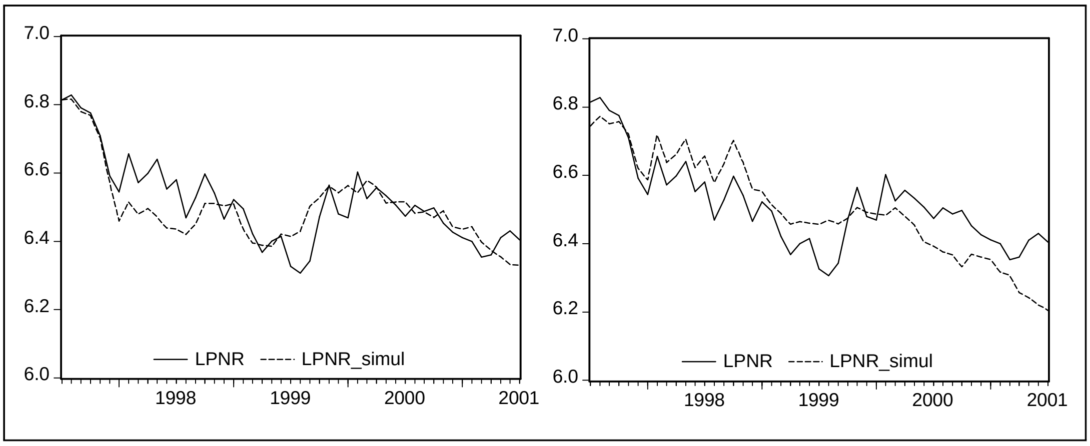

Figure 11: Simulated natural rubber prices from a VEC(1) (a) compared with the VAR result (b) for the period 1997.7 - 1999.12 and predictions for 2000.1 - 2001.7

7 Conclusions

This paper assesses the role exchange rates play in price formation on world commodity markets, in this case represented by the natural rubber market. The basics of the market and the variables are described in section 2. A theoretical model shows the effect of exchange rate changes on prices incorporating market shares (section 3). Exchange rate changes should have an inverse effect on prices. A preparatory statistical analysis leads to the conclusion that natural rubber (NR) prices lead synthetic rubber (SR) prices by several months (section 4). SR prices are therefore not included in explaining NR prices. A structural model for the effect on the price of NR of exchange rates in producing countries and/or consuming countries is formulated in section 5 and estimated in section 6. Also included are variables representing production and consumption.

First it is tried to estimate a long-run equation and a short-run equation. Estimation of the long-run parameters is done by using Stock and Watson's DGLS estimator, after which a corresponding error-correction model was estimated for the short run. No acceptable results were obtained. Subsequently VAR models were applied, clearly showing a structural break in mid-1997. Applying a regime switch dummy for the period after the break strongly improves the estimation results while simulations over the sample period and up to 2001.7 give good results. Even better results for the second period are obtained by applying a VEC model.

It is shown that natural rubber prices were heavily affected by the Asian crisis. This comes as no surprise given that a large majority of rubber is produced in Thailand, Indonesia and Malaysia. The estimated effect on the US$-denoted world market prices was substantial: real exchange rates of the three major producers have gone up by some 40%, after initially being even higher. The effects were calculated with a model, including the combined exchange rate of the three major producers, the weighted real exchange rate of seven major non-US$ importing countries to account for effects on the demand side, the price of minerals ores and metals to capture the level of industrial activity and speculative funds and the monthly supply of NR and the monthly demand for all types of rubber to account for volume effects. Simulation results both for the sample period as well as the post-sample period are very good. World market prices respond to exchange rate changes on the supply side as well as on the importing side. There is strong evidence for co-movement of rubber prices with that of minerals, ores and metals.

References

Adolfson, M. (2001), 'Export price responses to exogenous exchange rate movements', *Economic Letters*, 71, 91-96.

Anderson, R.G., D. Hoffman and R.H. Rasche (1998), 'A Vector Error Correction Forecasting Model of the U.S. Economy', *Federal Reserve Bank of St. Louis*, Working Paper 98-008A.

Barlow, C., S. Jayasuriya and C. Suan Tan (1994), *The world rubber industry*, Routledge, London, England.

Bennett, D.A. (1976), 'Changes in Markets for Synthetic Rubber and Its Raw Materials,' *Proceedings of the ECMRA Conference Madrid*; processed.

Burger, K. and H.P. Smit (1997), *The natural rubber market - Review, analysis, policies and outlook* -, Woodhead, London, England.

Burger, K. and H.P. Smit (2001), 'International Market Responses to the Asian Crisis for Rubber, Cocoa and Coffee', in Gérard F. and F. Ruf: *Agriculture in Crisis: People, Commodities and Natural Resources in Indonesia*, Curzon Press, Richmond, United Kingdom.

Dornbush, R. (1987), 'Exchange rates and prices', *American Economic Review*, 77, pp. 93-101

Engle, R.F. and C.W.J. Granger (1987), 'Cointegration and Error Correction: Representation, Estimation and Testing,' *Econometrica*, 55, 251-276.

Frankel, Jeffrey A. (1984), 'Commodity Prices and Money: Lessons from International Finance', *American Journal of Agricultural Economics*, Vol. 66, pp. 560-566.

Gilbert, C.L. (1989), 'The impact of exchange rates and developing country debt on commodity prices', *Economic Journal*, 99, 773-784.

Gilbert, C.L. (1991), 'The response of primary commodity prices to exchange rate changes', in L. Phlips ed.: *Commodity Futures and Financial Markets*, Dordrecht: Kluwer.

Gottschalk, J. and W. van Zandweghe (2001), 'Do Bivariate SVAR Models with Long-Run Identifying Restrictions Yield Reliable Results? The Case of Germany', *Kiel Institute of World Economics*, Working Paper 1069.

Herrmann, R., K. Burger and H.P. Smit (1993) *International commodity policy: a quantitative analysis*. London: Routledge

Jang, K. and M. Ogaki (2001), 'The Effects of Monetary Policy Shocks on Exchange Rates: A Structural Vector Error Correction Model Approach', *Ohio State University, Department of Economics,* Working Paper 01-02.

Jumpasut, P. (1995), 'Synthetic rubber prices', *Proceedings of the International Rubber Forum*, International Rubber Study Group, Tokyo, Japan, pp. 159-173.

Ridler, D. and C.A. Yandle (1972) 'A simplified Method for Analyzing the Effects of Exchange Rate Changes on Exports of a Primary Commodity' *IMF Staff Papers*, 19, pp. 550-578.

Saikkonen, P. (1991), 'Asymptotically Efficient Estimation of Cointegrating Regressions', *Econometric Theory,* 7, 1-21.

Schwarz, D. (1998), 'Trends in natural rubber usage for tyres', *Proceedings of the International Rubber Forum*, International Rubber Study Group, Bali, Indonesia (forthcoming).

Smit, H.P. (1984), *Forecasts for the world rubber economy to the year 2000*, Macmillan.

Smit, H.P. and E. Vogelvang (1997), 'Estimation and forecasting evaluations of different models for a changing relationship between the price of natural and synthetic rubber', unpublished manuscript, *Vrije Universiteit Amsterdam.*

Stock, J.H. and M.W. Watson (1993), 'A simple estimator of Cointegrating Vectors in Higher Order Integrated Systems,' *Econometrica*, 61, 783-820.