SURVEY OF LITERATURE

A brief review of the earlier research work, relevant to the present study, is provided in this Chapter. Published literature pertaining to natural rubber on output growth and instability, supply response, price behaviour and demand are very limited. Therefore, we seek to survey some of the related literature in the broad areas of this study, namely,

1. Growth and instability in agricultural production
2. Supply response of perennials
3. Spectral analysis and its application
4. Demand for rubber.

2.1. GROWTH AND INSTABILITY IN AGRICULTURAL PRODUCTION

Growth and instability which explains the sources of change and variability in production is an important area of interest for research workers and several empirical studies have been done in this area. However, published literature on growth and instability in perennial crops are scanty, especially, with respect to rubber. Therefore, the review covers the major field crops so as to gain an understanding of the theoretical developments, empirical applications and their results.

Foote et al. (1952) examined the relative importance of yield and acreage changes in U.S.A. corn production
variability. The results were obtained by determining the average year-to-year changes in yield and acreage as a percentage of average yield and acreage, respectively, over a sample period 1919-1948 and then summing the two. The average annual changes in yield and acreage were then expressed as a percentage of this sum. The results pointed out that about 90 per cent of the variation in corn production could be attributed to yield variability. Average year-to-year changes in yield were 15 per cent of average yield, whereas acreage variability was merely 3 per cent of average acreage.

The method used by Foote et al. (1952) failed to equate strictly changes that take place in acreage and yield with changes in production. Therefore, an alternative approach on which multiplicative identity was expressed as an additive one in terms of natural logarithms was proposed by Sackrin (1957). The sum of the coefficients on acreage and yield obtained when production was regressed on these variables was exactly one, so that this decomposition accounted for all the changes in output.

Minhas and Vaidyanathan (1965) used the decomposition model to examine the sources of changes in crop production in India from 1951-54 to 1958-61. Their study indicated that out of total increase in output approximately 45 per cent was
attributed to area growth, 46 per cent to increase in yield, 8 per cent to changes in cropping pattern, and only one per cent to interaction term between yield and cropping pattern. Further, they also studied the regional pattern of sources of growth in production and it was found that in Punjab, Rajasthan, Assam and West Bengal, the contribution of area was substantially higher (above national average). Whereas in erstwhile Madras, Kerala, Madhya Pradesh, Bihar and Orissa the contribution of yields was higher than the national average. In Punjab, Madras, Gujarat, Maharashtra, Andhra Pradesh and West Bengal the contribution of cropping pattern changes was the highest.

Kaul (1966) conducted a study in Punjab and found that changes in area and yield were the major sources of growth in output in most of the districts during the period of the fifties and sixties. Districts having more irrigated area, showed higher contribution of yield to increase in food grain production.

Later in 1966, Minhas expanded his earlier four component model to seven component model by introducing interaction terms. Both the models were used to analyse the sources of increased production from 1951-54 to 1958-61 in Punjab. He noticed that the contribution of all interaction terms
together increased slightly, but the results at state level were not much different in both the models.

Parikh (1966) examined the sources of output growth in different states of India using Minhas and Vaidyanathan model. His study revealed that changes in cropping pattern contributed more than 45 per cent to growth in agricultural production in Madhya Pradesh, Madras, Mysore, Rajasthan and Uttar Pradesh. In Bihar, Kerala, West Bengal and Madhya Pradesh, area growth contributed, more than 55 per cent to the total output growth, while in Bihar and Madras, growth in productivity played an important role in increasing production.

Sen (1967) observed that in India, during the period 1900-1924 and 1950-1966, growth as well as instability were high in production, in comparison to the period 1924-51. Severe droughts and inefficient use of irrigation were the main sources of production instability during 1950-1966, whereas cultivation of crops on marginal land and frequent droughts were responsible for production instability during 1800-1924.

With the help of decomposition of additive identify technique, Rourke (1970) studied the sources of variability in world coffee production. His results showed that Brazil directly contributed 86 per cent to the total variability in
World coffee production and other countries accounted for another 12 per cent of the total variability. Further, he inferred that changes in productive capacity and in yield from existing capacity caused variability in production. However, decomposition of variance lacked the subjective explanation of fluctuations in Brazil coffee production.

Misra (1971) analysed the contribution of different components of growth in output for two different phases covering the period 1949-52 to 1956-59 and 1959-62 to 1966-69 in different districts in Gujarat. The study revealed that in majority of the districts in both the time periods yield contributed more to the growth of output. The contribution of yield increased from 49 to 90 per cent in the second period, over the first period for the state as a whole, whereas contribution of area decreased from 38.55 to -1.71 per cent in the second period. In the majority of the districts, the contribution of cropping pattern was not comparatively higher, but there was little change in the cropping pattern.

Based on a study in 1973, Konwar and Lokrey concluded that in India, the restraints of crop output growth due to area expansion were greater than the restraints on the yield induced increase in output. They observed that the contribution of area growth to total growth in output
decreased from 45 per cent (in fifties) to 24 per cent (in sixties), whereas contribution of other factors increased from 55 to 76 per cent during the same period in India.

Narula and Sagar (1973) argued that Minhas and Vaidhyanathan (1965) model yields biased estimates since we are giving current area weight to yield, and base yield weight to area, but area and yield are changing over time. In this method yield effect is over estimated and area effect is under estimated. They suggested that averages of current year and base year should be used as weights for area and yield components. The results obtained by this new method can be used for over time and over space comparison.

Sondhi and Singh (1975) examined the sources of increased crop output in India from 1960-61 to 1970-71. The entire time period was divided into pre-green revolution period and post-green revolution period and Minhas and Vaidyanathan (1965) model was applied in both the periods and results were compared. They observed that in all the states, the yield was contributing more than 50 per cent to output growth, followed by changes in area and cropping pattern having very less effect on output growth. In Uttar Pradesh, Bihar and Punjab, the effect of yield has decreased during the second time period, while in other states, it has increased. Interestingly, in Maharashtra, the changes in area, yield and
cropping pattern were having negative effect on output growth. Increase in area under food grain crops was higher than increase in the area under non-food grain crops, thus, widening the area imbalances between food grain and non-food grain crops.

Dharam Narain (1977) observed that in India, overall the real gain in productivity resulting from locational shifts was rather small, thus, reflecting on the limited play of market forces in bringing about interregional specialization in the production of crops.

A study conducted by Sagar (1977) showed that in Rajasthan, about 64 per cent of the total growth in aggregated farm output from 1956 to 1974 was due to increase in the level of yield. Major part of productivity (in value terms) growth was shared by bajra, wheat and oilseed crops.

Das (1978) examined the extent of instability in crop production during the green revolution period in eastern India. He observed that in Orissa and West Bengal, though the average periodicity of decline was the same but the rate of decline decreased during the green revolution period. In Assam and Bihar, production instability increased after the introduction of high yielding varieties.

Barker et al. (1981) studied the effect of new technology on production instability and they found no evidence to
support the contention that the adoption of modern technology led to greater production stability. On the contrary, they found a tendency for the absolute variability to increase even though relative variability may in some cases remain unchanged or even decline. This was supported with the fact that the production stabilizing components of technology such as plant and land amelioration are almost invariably accompanied by destabilizing components of technology and on balance absolute variability in yield tends to increase. In order to minimize the inherent instability associated with new technology, he emphasized on increasing the investment in maintenance research.

In a study, Ray (1981) found that in India during the green revolution period, although there has been an increase in crop production but its rate of growth has declined as a result of unfavourable weather conditions and slow growth rates of area and yield. A subsequent study by him (Ray, 1983b) revealed that a major share of output growth could be attributed to growth in area and yield. However, during the seventies for all crops (aggregated output) contribution of area growth has decreased, whereas contribution of crop pattern to output growth has increased substantially.

Mehra (1981) analysed the instability in Indian agriculture in the context of new technology. The analysis
was carried out by dividing the time period into pre-green revolution period and post-green revolution period, and making the comparison between the two periods. The results indicated that out of the 18 crops examined, the standard deviation of the production rose in 15 crops and the coefficient of variation of production rose in 12 crops. A comparatively higher yield variability showed that it was a dominant source of production variability. The standard deviation for non-food grain (aggregated) crops has decreased. Further, it was stated that because a comparatively larger area under wheat, rice, potato and sugarcane was irrigated, these crops showed less increase in yield variability in the second period. Similarly, states having larger area under irrigation showed smaller increase or decrease in variability in production.

Hazell (1982) decomposed the changed variance in post-green revolution period over pre-green revolution period. Total variance of production was measured as sum of production variances of individual crops within states and the sum of all inter crop and interstate covariances. The variance of total cereal production for all India increased by 342 per cent between the two periods. Of the total increase only 6 per cent was attributed directly to increased variance of individual crop yield measured at state level.
The lion's share (62 per cent) of this increased variances between crops within the states and in different states. Further, it was found that yield covariances and area and yield covariances were the dominant sources of this increased production covariances. He also considered that production instability is an inevitable consequence of rapid agricultural growth and there is little that can be done about it.

Rayner et al. (1982) examined the yield instability in sugar crops and cereals in the European Economic Community over the period 1957-58 to 1978-79. It was reported that sugar yield had high variance in Belgium and France, while on the other hand, Belgium and Holland marked high yield variability in cereals. Italy was having rather stable yields of sugar and cereal crops. Among the cereals, maize yield variability was higher. The authors viewed that there was little scope for achieving short-term stability of markets at the national level through intra community trade, because in both sugar and cereal crops, yield covariances were positive and significant in the majority of cases.

Wohlken and Hoh (1982) reported that German Federal Republic has achieved higher level of yield with reduced yield instability in cereal crops. Differences in yield and returns on individual types of cereal crops and risk were
responsible for changed structure of cereal production during 1950-1980 in the country.

Ray (1983a) performed a decade-wise decomposition analysis and indicated that instability in production round to be low during 1950s. However, for each successive decade that followed, instability generally showed a tendency to increase. The yield fluctuations and synchronised movements in the year-to-year changes in area, and yield indices were the predominant sources of production instability. The later component strengthened over the decades, whereas the former appeared to be declining over the decades.

In a subsequent study, Hazell (1984) compared the sources of increased variability in cereal production in India and U.S.A. He observed that covariance between crops and states were contributing a very large proportion of increased variability in both the countries. In U.S.A. changes in yield covariability and mean yield were predominant sources, contributing 141 per cent and 48 per cent, respectively to the total increased variance of cereal production. But in India, changes in yield covariability and area and yield covariability represented 31 per cent and 27 per cent respectively of the total increased cereal production variability.
Reddy and Hiremath (1984) in a similar study, examined the effect of high yielding varieties on production instability in Karnataka state. It was found that changes in production variance of individual crops had influenced total cereal production, through changes in yield covariance between districts and crops, rather than through district yield variability at farm level.

The findings of Walker (1984) revealed that interdistrict production covariance were contributing more than 92 per cent to total increased production variance in sorghum and pearl millet production in SAT India. The change in yield covariance turned out to be single largest source of these increased interdistrict production covariance. Furthermore, adoption of hybrids and changes in rainfall covariances increased the yield covariances in both the crops. However, irrigation increased the yield covariance in sorghum, whereas it led to reduced interregional pearl millet yield covariance.

In another comprehensive study, Hazell (1985) observed that the increase in yield variances and a simultaneous loss in offsetting pattern of variation in yields between crops and regions, were the overwhelming sources of the increase in world cereal production variability. He explained that this might be, because of the fact, that adoption of new
technology has increased the modern input use across the crops and regions. The input use has become more variable and synchronized in response to sharp increase in the variability of world cereal and oil prices since the early 1970s. An analysis done by Wan et al. (1985) indicated that the introduction of modern cultivars has been associated with larger spatial correlation of yield across the wheat producing regions of N.S.W. in Australia and with the increase in variability as measured by the coefficient of variation and moving average of regional yields. They considered that none of these effects would seem to be of such magnitude as to cause concern.

Achoth et al. (1986) analysed the growth and stability in natural rubber production using variance decomposition technique. They observed that the growth in rubber production in the country was by and large area led. In all the three states namely Kerala, Tamil Nadu and Karnataka much of the increase in production was due to changes in area rather than changes in productivity. The variability in production between two periods during 1972-73 to 1982-83 over 1962-63 to 1971-72 revealed that a greater amount of stability was introduced into rubber production in the country as a whole and particularly in Kerala. Changes in mean yield and changes in mean area, and the interaction
between the two, were the major contributing factors for stability.

Pal and Sirohi (1988) examined the growth and instability in the production of five commercial crops, namely sugarcane, groundnut, cotton, jute and potato using Hazell’s decomposition model. The findings showed that the intensity of shortfall in yield had increased over time. Groundnut was the worst affected crop. Instability was more prominent in disaggregated production at the state level and even much higher at the farm level. They suggested that concerted efforts should be made to safeguard the farmers from the risk of instability. Yield stabilising policies in groundnut, cotton and potato would bring about greater impact on production stability.

Webster and Williams (1988) analysed the data for 16 wheat growers and 18 barley growers in South-East England for changes in variability of production and yield between the periods 1964-74 and 1975-84. It was indicated that 16 percent of the increase in variability of wheat production was due to changes in yield variances and covariances. The increase in variability of barley production was not statistically significant.

In another study, Pal and Sirohi (1989) analysed the sources of instability in crop production and yield in
different states in India between two periods 1950-65 and 1966-1984. The findings revealed that yield variance contributed largely to variance of production in pulses and oilseeds and the same had increased over time. After adoption of HYV's, the absolute variance increased on account of increased sensitivity of HYV's to inputs and weather, especially rainfall. The intensive use of irrigation led to comparatively stable production of food grains.

2.2. SUPPLY RESPONSE OF PERENNIAL CROPS

Literature on crop supply response is concentrated mainly on the supply of annuals. Nerlove (1958) in his epoch making study put forth the dynamic supply model based on the concept of adaptive expectation. He argued that expectations are non-static, and are not single valued, rather a distributed lag of past values of a variable. He enunciated the adaptive expectation model, wherein producers revised their notion of what is 'normal' based on the differential between what actually happened and what they considered as 'normal' previously. With the help of this model Nerlove succeeded to a large measure, in explaining the behaviour of farmers in United States. Borrowing the structural framework of Nerlove, a large number of supply response studies have been conducted in India and elsewhere during the past three decades. However, the special problems associated with
formulating supply models for perennial crops received little attention till the sixties.

It was perhaps Chan (1962), who made a systematic attempt first to analyse the supply response of perennial crop. She investigated the supply behaviour of rubber estates in Malaysia for the period 1948-59, using regression analysis to explain production response by prices variously defined, e.g., current, lagged, 3-year moving average, with and without export taxes. The effect on output of current prices represented harvesting decisions and of lagged prices, planting decisions.

The real breakthrough in perennial crops supply methodology came in a study by French and Bressler (1962), who developed supply response for lemons in terms of new plantings and removal relationships. They found that the acreage of new lemon trees planted in each year depended on the expected long run profitability as measured by the average net returns for five years; and the tree removals depended upon expected current (short-run) profitability, proportion of bearing trees (25 years of age in 't') and the proportion of areas removed for urban expansion.

Bateman (1965) used Nerlove’s lagged adjustment model to study the relationship between the planting and prices and also between planting and output, in case of Ghanian cocoa
for the period 1946-62. This in fact received a boost for studies on perennial crop supply response studies. Bateman in his study expressed new plantings of cocoa as a function of mean value of discounted future prices of cocoa and coffee (alternative crop) that the farmers expected to prevail. He assumed that the producers actual expectations and output in the year 't' was considered to be the result of acreage planted in the previous year.

He used the quantity harvested as a function of price of cocoa lagged 8 years ($P_{t-8}$) and lagged 12 years ($P_{t-12}$) and the prices of coffee with similar lags along with rainfall and humidity. The results of the study revealed that the producer prices affected the output in the long run by influencing the planting decisions and they did not influence the short run decisions regarding maintenance, harvesting and marketing. Only climatic factors were found to influence the short run decisions.

Stern (1965), using data for 1953-60, studied supply response for natural rubber in Malaysia. He used current price deflated by agricultural workers' wages, the ratio of inventories to sales and a time trend to explain estate production. For small holders, responsiveness was calculated by using deflated current rubber and rice prices and a time trend. The results indicated that prices had no effect on
estate supply, but small holders responded positively to increase in prices. However, the elasticity obtained was small and only 0.20.

Behraman (1968) estimated models for each of the eight cocoa producing countries, Ghana, Nigeria, Ivory Coast, Camaroon, Brazil, Ecuador, Dominican Republic and Venezuela. His model was based on a planting equation relating actual to desired stock of trees. Behraman assumed that the desired area in cocoa trees in time 't' was a function of the producers real price expectations held at time 't'.

Arak (1969) focused her interest on the determination of changes in the tree stock. It was basically a stock-adjustment model, relating the actual new plantings to the desired stock of trees. The model was used by her to analyse the Brazilian coffee production had wide application to tree crops. The parameters of the model were estimated by the Quandt Goldfield algorithm. Further, she calculated the short-run and long run price elasticities.

Maitha (1968) used an econometric model to analyse the supply response of Kenyan coffee. The response of producers to price and other economic variables were estimated for Kenya and compared with those of Brazilian and Colombian coffee. He concluded that Kenyan farmers with smaller holdings were relatively more responsive to price incentives.
as compared to those having larger holdings both in the long run and short run. He averred that for perennial crops like coffee, productivity is a more accurate measure of supply response.

Rajagopalan and Meenakshi Sundaram (1969) formulated a model to explain the production behaviour of the Indian tea industry. They examined the effect of lagged area, yield, price and time trend on the production of tea. They used two models, one with all the above variables and another excluding lagged area. The coefficient of price was found to be insignificant while the trend variable was highly significant.

Tweeten and Quance (1969) related the stock of productive assets as a function of relative prices, lagged productive assets and time. The price elasticity of productive assets was 0.23 for the period 1921-66, 0.60 during 1921-41 and 0.48 during 1948-61. The adjustment coefficient for productive assets was \( (1 - 0.835) = 0.065 \). Further, he also examined the irreversible supply response by splitting the price variable.

Nair (1970) used acreage response model to estimate the price response of cashew and coconut in Kerala state. Cashew showed a negative area response to price, however in the case
of coconut, price had a significant influence on the acreage under coconut.

Turnovsky (1970) in his study on the formation of price expectation, averred that the most widely used expectations hypothesis are the extrapolative and adaptive hypothesis. Further, he suggested that any predictive scheme to be rational, the actual price change should be regressed on the same variable generating the expectations and the magnitude of the coefficient examined.

French and Mathews (1971) developed a most detailed model based on the rational behaviour of farmers. The two basic relationships concern the adequacy of the existing tree stock in producing the desired output and the adjustment of new plantings towards the desired stock of trees. The remaining equations in the model included: (i) the acreage removed each year; (ii) the transformation of unobservable expectations variables to observable variables; and (iii) variations in yield. This provided a framework for estimating the differential rates of supply expansion and contraction of perennial crops and brought out explicitly the nature of the variables and the gestation lag involved in influencing the supply response.

Rajagopal et al. (1971) applied the acreage models and three production models so as to estimate the parameters of
output response with respect to tea in India. They observed that output response models would be more relevant than acreage models. Price lagged by one period was found to be highly significant in explaining variation in output over time.

Wolffram (1971) criticised the basis for partitioning the price variable, adopted by Tweeten and Quance (1969) on the grounds that it was mathematically incorrect. He suggested an alternative method which splits the price, based on the computation of first difference of the observations. The increases were summed up in formulating the increasing price variable, and it assumed constant values during falling prices. The decreasing price variable was similarly constructed. Based on this suggestion, Tweeten and Quance (1971) conceded that their method was in error.

Oni (1972) estimated the supply response of West Nigerian cocoa farmers. A comparison of results obtained from cross sectional data in all the cases, had given price coefficients more significant than those obtained from time series data. The responses for different provinces ranged between 2.37 to 4.37 in case of cross section data, whereas in case of time series data it ranged between 0.75 to 1.73. This divergence according to him was mainly due to the uncertainty and expectation problem, farmers' credit and liquidity position.
He expressed the view that the use of estimates derived from

time series data to make policy decisions had limitations

since the current response of the farmers might deviate

substantially from the historical time series analysis.

Wickens and Greenfield (1973) derived a supply function

for coffee based on the formal optimising model similar to

the investment model developed by Jorgenson (1965). The

model consisted of three basic structural relationships

reflecting the supply behaviour in both the short and long

run. The supply response function was derived as the reduced

from solution of the three-equation system. The three

structural relationships consisted of (i) the vintage

production function, which reflects the constraint of

potential output supply; (ii) the investment function, which

reflects the long gestation lag in perennial crop potential

supply; and (3) the harvesting function, which reflects

short-run harvesting decisions.

Baritelle and Price (1974) estimated the supply response

function, relating yearly planting to past prices, using

polynomial distributed lag model. He observed first an

increasing response and then a declining response to past

prices over time.

Using the data for the period 1948-70, Saylor (1974)

examined the supply response of coffee in the state of Sao
Paulo, Brazil. The price variable used was a weighted average of past three years price, with declining weights. The Nerlovian distributed lag function was used with the inclusion of zero-one dummy variable. Further, the response to increasing and decreasing price were studied, by splitting the price variable, based on the method suggested by Wolffram (1971).

Ghoshal (1975) analysed the supply response of rubber in Liberia using different models including the one of output explained by current price, mature acreage and a trend variable and a Nerlovian model. He opined that the elasticity may be low due to two different reasons: a) technical conditions, due to the producers inability to increase production in the short run and b) producers are not maximizers. He examined the latter hypothesis and concluded that Liberian producers do respond significantly to lagged prices and the elasticities ranged between 0.12 and 1.71 for various grades.

Rao and Carman (1975) hypothesised profit expectation as a function of expected gross revenue, where price was a deflated four year moving average. They attempted to incorporate technological change in apple production in acreage response models. This was done primarily through the
impact of technological change on producers' yield expectations.

Uma Devi (1977) studied the output supply and acreage response with respect to natural rubber in India for different time periods ranging between 1948-49 and 1974-75. The estimates were made using Fisherian and Nerlovian types of price expectation models. The two methods yielded contrasting results. The estimated coefficients were negative in case of Fisherian price expectation function, whereas it was positive in Nerlovian specification. Therefore, for policy use, the Nerlovian specification was considered to be more reliable. Accordingly, it was concluded that producers were influenced by the past six years price in their planting decisions, and they responded positively to price.

Chowdhary and Ram (1978) examined the supply response of Indian tea for the period 1953-1973. Surprisingly, they got negative price coefficient for area model. The reasons they attributed to this were geographical limitation, weather inclemency and lack of adequate capital. However, they got significant and positive coefficient for rainfall and significant negative coefficient for non-bearing area in case of yield model.
Douling (1979) based his model on Wickens and Greenfield to estimate supply response of rubber in Thailand during 1951-75. His reduced form was almost identical to Wickens and Greenfield but derived by different approach. He obtained a significant and positive response for prices. The short-run elasticities ranged between 0.09 and 0.027; and long-run elasticities from 1.21 to 2.64.

Alston (1980) in his study of supply response of Australian orange growing industry, observed that expected profitability of growing oranges significantly influenced planting. An important feature of this study was that the price was not hypothesised to influence yield, on the grounds that growers tend to standardise cultural practices.

Tan (1984) employing Wickens and Greenfield (1973) model estimated the supply responses of major rubber producing countries of the world during 1956 to 1978. The model consisted of three basic structural relationships reflecting the supply behaviour in both the short-run and long-run. The supply response function estimated was derived as the reduced form solution of the three equation system. Consequently both the short and long-run supply elasticities were derived from the estimated coefficients of the nonlinear reduced form equation. The elasticities were computed over three different lengths of time periods namely, short, medium and
long-run. She obtained significant positive responses for all the countries, except for Brazil in the short-run. The long-run elasticity for India was as high as 37.3776. On the whole the supply elasticities were found to increase as the lagged periods increased, except for Africa, Brazil and small holder production in Malaysia.

Suleiman (1980) based his supply response model on the theory of adjustment cost where the production function incorporates the investment rather than the price expectation model. He used this model in estimations covering estates and small holders in Malaysia 1950-80. In this study the output supply and input demand functions were derived from the production function. Besides this, the investment flow concept was incorporated in the analysis to reflect the dynamics of production process. The estimated supply response was inelastic especially with respect to small holdings. The short run elasticities were 0.0153 and 0.0903 for estates and small holdings, respectively; and the long run elasticities were 0.400 and 0.013 for estates and small holdings respectively.

Hartley et al. (1987) employed a modified version of Wickens and Greenfield (1973) formulation, which estimated the output response directly from the explicit age yield relationship and the actual age distribution of the tree
stock in each year, for the period 1944-78 in case of Sri Lankan rubber. They opined that the Wickens Greenfield model which focus on new investment was inappropriate to the study of mature industry, like Sri Lanka wherein the scope for extension cultivation was limited, and the responses to prices and other factors depend upon the uprooting and replanting of existing stands. Their results indicated: a) significant and positive long run response of replanting to variations in expected normal prices (elasticity = 1.7); b) small, negative and significant response to current prices; and c) significant positive response to subsidies designed to encourage replacement of older stands with high-yielding varieties.

Viju Ipe and Prabhakaran (1988) analysed the supply response of natural rubber in India for a period 1953-54 to 1983-84 using Nerlovian expectation model. The study considered yield response, new plantings and changes in stock of trees. The elasticities with respect to expected rubber price and change in the expected yield were 0.760 and 0.1047 respectively. The authors concluded that increased prices, yield of rubber, fall in the productivity of coconut and subsidy scheme for planting rubber were the important factors contributing for acceleration of area under rubber.
Barah and Chiranjeevi (1991) estimated the supply responses for Indian tea using Nerlovian expectation model. The results revealed that both area as well as yield responded significantly to expected prices. Yield per hectare revealed higher response to expected prices and risk due to prices, as compared to 'total area'. Risk due to prices had a relatively small but a positive impact on yield per hectare, and had negative impact on 'total area' or 'area newly planted', which indicated a less than favourable overall impact. They suggested that stability of prices would become a crucial factor for maintaining stable growth of tea production.

2.3. SPECTRAL ANALYSIS AND ITS APPLICATION

Econometricians presently have access to a number of powerful methods for analysing time series, namely spectral analysis, stepwise regression procedure, and exponentially weighted moving averages. The first of these methods, which finds a place in this study, was initially applied in the physical sciences to detect faint cyclical patterns buried in predominantly random data. Its most well known application in economics has been with stock market price behaviour. This method is also being used to commodity prices not only to discern price cycles but also to achieve a more uniform explanation of regular and irregular price behaviour.
Spectral method can also test the correlation between fluctuations in prices and their corresponding determinants. Tests between prices, supply, demand and speculation can be formulated in a manner similar to correlation analysis. Spectral methods, however, in addition to supplying a statistic similar to the correlation coefficient, simultaneously determine the nature of lead-lag between corresponding series (Labys and Granger, 1973).

The application of spectral method in the field of econometrics received a fillip with the work of Granger and Hatanaka (1964), who effectively put together, in a comprehensive manner, the relevant theoretical information and empirical procedures required to understand the use of this technique. Further contributions by Jenkins and Watts (1969), Fishman (1969), Malinvaud (1970) and Dhrymes (1970) have made the applications of the technique to economic problems easier.

Spectral techniques are used in various contexts in its empirical applications in economic time series. Granger (1966) employing this technique tested the hypothesis of existence of typical spectral shape for an economic variable. Several instances are found in the investigation of business cycles in the economy using spectral technique. Adelman (1965), Harkness (1966), Howrey (1968), Burley (1969), Bonomo
and Tanner (1972), Stern (1972), Van Ewijk (1982) and others used spectral technique to test the existence of various business cycles in the economy with the help of estimated power spectrum for a number of macroeconomic variables.

Spectral and Cross spectral analysis was used to investigate the behaviour of long and short term interest rates and their relationships by Faund (1966), Granger and Rees (1968), Bonomo and Schotta (1969) and Cargill and Meyer (1972).

Hannan (1964), Nerlove (1964, 1965) and Grether and Nerlove (1970) used spectral techniques to verify the consequences and effectiveness of various seasonal adjustment procedures.

Another area where spectral methods are used is the estimation of distributed lag models. Hamon and Hannan (1963) suggested a method for estimating linear regression using spectra and cross spectra which was later modified by Hannan (1965).

Fishman (1969) illustrated and outlined the application of spectral analysis in the estimation of distributed lag models.

Spectral analysis has also been commonly used in studies concerned with behaviour of stock market prices. Granger and Morgenstern (1963), Godfrey et al. (1964), Granger (1988),
Cargill and Rausser (1972) used spectral technique to test the random walk hypothesis in stock prices. In the Indian context, Kulkarni (1978) employed spectral analysis for testing the random walk behaviour of stock prices of Bombay, Calcutta and Madras stock exchanges. It was concluded that random walk hypothesis has weakened in case of share price behaviour in India since they possessed seasonality component and not trend or even cycles. For Indian share prices, the spectral analysis revealed a similar 4 week cycles for all the stock exchanges.

Spectral method is also employed in the study of price behaviour of agricultural commodities traded in the futures market. The application of spectral technique to study the behaviour of commodity prices, quantities and their inter-relationship as well as its application to market efficiency, is of relatively recent origin. Application of spectral methods to study rubber market are rather rare.

Larson (1967) examined the relationship between cash and future price movements for eggs using 11 years period ending 1966. The hypothesis of previously assumed 12 months seasonal and 30 months cyclical pattern was tested by spectral methods. The results did not prove this hypothesis, but revealed only a trace of 12 months seasonal price pattern.
Aggrey-Hensah and Tuckwell (1969) applying spectral and cross-spectral analysis for weekly supply and price series studied the price behaviour of Sydney Wholesale Banana Market. The analysis revealed many interesting features. The existence of pronounced seasonal component and a two week lag structure between supply and prices were revealed from this analysis. Both supply and price series exhibited an evolving seasonal pattern with the amplitude of the seasonal component generally declining with time, particularly in case of price series. The coherence diagram showed negative slope implying strong association in the long term period and little association in the short term period. The gain values indicating quantities regressed on prices were declining with increase in lags (higher frequency). This implied that supply was not responsive for short term variations in prices. However, the gain values were reasonably high in the range of \((0, \pi/26)\) indicating that supplies in the long run were influenced by the average level of prices received over some period in the past. The power spectrum was estimated using 728 weekly observations considering 130 lags.

Rausser and Cargill (1970) using autospectral analysis investigated the hypothesised 30 months cycle of broiler industry in United States. The results cast doubt on the hypothesised existence of cycles longer than the seasonal.
Only for broiler and chicks, cycles of roughly 30 months were revealed. Cross spectral methods indicated little relationship among each set of series after trend removal except at the seasonal components. Further, there was no meaningful lead or lag pattern except at the seasonal components. They also studied the impact of vertical integration considering two sub-periods separately using complex demodulation of 12 months cycle (seasonals) with cross spectral methods. The results indicated that the seasonal variability had declined over the period.

Weiss (1970) analysed the world cocoa prices applying spectral methods. He hypothesised the existence of three different cycles associated with factors such as (i) 14 to 24 years due to the inherent lag from the time of planting to effective bearing of the trees; (ii) 13 to 24 months due to lag in investment, marketing and pricing decisions of chocolate industry and consequent consumption response; and (iii) seasonal based on succession of crop and intercrop periods. The results indicated the existence of periodic cycles of lengths of 14 years as well as 22 months attributable to lag in production response and consumption response to price changes, respectively in addition to seasonal components.
Parikh (1971) analysed the short term price fluctuations in world coffee prices. The results did not provide any evidence for the hypothesised 24 months cycle in coffee prices caused by tree yields. However, a strong periodic component of 5 months was noticed in Brazilian and Colombian coffee prices and a two months cycle in African Ambraz coffee. The coherence obtained from cross spectra showed that the long run and short run components of various price series moved together, and the hypothesis of no lead or lag was rejected by empirical analysis. The analysis also suggested that the spectra remained insensitive to various trend elimination procedures as all stationary times series of a given variable produced a spectral peak at the same period.

The random behaviour in commodity prices was investigated by Cargill and Rausser (1972) for the daily closing future contracts of live beef cattle, copper, corn, oats, frozen pork, rye, soybean and wheat. They employed three different methods in time domain namely, autocorrelation function, spectral density function and integrated periodogram analysis. The results of these tests differed in their conclusions. The spectrum showed flatness and almost all the estimates were within the 95 per cent interval around the theoretical value of white noise (equal to 0.05). But the
results of integrated periodogram showed non-randomness in 43 out of 167 contracts. Ultimately it was concluded that the results clearly invalidated the simple random walk as a general explanation of future price behaviour.

Hunt (1974) in his study on short run price movements in Sydney Wool futures market using spectral analysis established evidence of systematic short run price movements. The spectra obtained for daily prices showed the existence of weekly cycles for the futures prices. The traders' reaction to market uncertainty was suggested as the rationale of futures price periodicity. The presence of continued and significant weekly cycles led him to reject the random walk hypothesis, implying that the market was inefficient at least in the short run.

Kulshrestha and Wilson (1974) employed spectral technique to study the cattle and hog cycles in order to aid in stabilization policies in Canadian agriculture. The results showed the presence of serious seasonal fluctuations in both cattle and hog output. The removal of seasonality by using time variant linear filter was attempted. The study indicated 40 months cycle in case of hog output. For cattle a 60 month cycle was noticed when monthly data were considered. The analysis using annual data for slaughter
cattle exhibited a 10 year cycle which remained unchanged with the change in truncation points.

Barksdale et al. (1975) applied cross spectral analysis to study the lead-lag relationship between beef prices at four different market levels. The results of the analysis indicated that prices at the feeder, live animal and wholesale levels moved together without any time lag and that retail beef prices lagged prices at other three levels by about three weeks. Therefore, it was concluded that beef prices were not established at retail level. Analysis of timing relationship between price and quantity of beef at slaughter level suggested that price and quantity were perfectly out-of-phase over the lower frequencies, with no time delay. Thus, the long term decrease in quantity were matched by corresponding increase in price. Over the higher frequencies, changes in prices led changes in quantity by about 9 months. This was attributed to fixity of supply of beef over the short run.

The study by Kanbur and Morris (1975) was perhaps the only application of spectral methods to study rubber market. They examined the price behaviour and relationships among the important world markets for natural rubber using spectral and cross spectral analysis. The results revealed the presence of 30 months cycles. The coherence values between London and
Colombo prices suggested that low frequency components moved together more than the higher frequency components. The authors attributed for such a relationship because of the bilateral agreements that existed between Sri Lanka and East European countries and China. The phase shift between London and Kaula Lampur series revealed that Kaula Lampur lagged by the order of two weeks for a wide range of cycle frequency. This was not true with respect to London and Colombo prices. They concluded that spectral approach has its inbuilt advantages for quantitative analysis of rubber prices when compared to other statistical methods.

Cross spectral approach was employed by Griffith (1975) in order to study the pricing efficiency in the New South Wales pig meat market by examining the nature and relationship between movements of ten pig and pork prices series differentiated by type of pig at auction, wholesale and retail levels. The results indicated a mixed results. In general, it was revealed that in the long run, there was strong correlation between the various pairings examined. However, in the short run prices were not well related throughout the market and in some cases there was no association at all. He concluded that there was justification for the view that the pig market in New South Wales was not performing efficiently in view of lack of
relationship between price pairings in the short run. The role of imperfect information was noted as a major contribution for observed short run price independence.

Griffith (1977) in his later study examined the pig production cycle using monthly observations of Australian pig slaughtering, pig meat production and homebush pork prices from 1968 to 1975. Results indicated the evidence of strong annual cycles in prices series and weak evidence of annual cycles in production and slaughtering series.

Gelb (1979) hypothesised a model for coffee market oscillations, which included demand, investment, capital survival and supply equations. The distinctive feature of the study was that prediction of cycles by the model was compared with the real world data, thus establishing the validity of the model. Cross spectral analysis was performed on price cycles and quantity cycles, but there was no evidence of quantity cycle coinciding with price cycle frequencies. He concluded that coffee price cycles do not influence quantity cycles.

Griffith and Meike (1979) studied the price behaviour and substitution patterns between 14 major fats and oils in United States employing spectral and cross spectral methods. They observed strong interdependence of prices of fats and oils of similar characteristics and end use at least in the
low frequencies which was particularly for the edible oils. The prices of particular fats and oils reacted in different degrees to price changes in other fats and oils in various frequencies. Further, the reactions between the same two oil prices varied over time.

Chambers and Woolverten (1982) investigated the intertemporal relationship between cash and futures price changes using the techniques of spectral and cross spectral analysis. The spectral density functions of wheat cash and futures prices were similar and so were those of corn cash and futures prices. However, soybean cash and futures prices were not so. The same relationship was true for coherence also. They also observed that there was no evidence of linear relationship between cash and futures price changes at the high angular frequencies suggesting that the short term price movements are not closely related.

Becker (1985) conducted a study in order to verify whether regional markets for pigs for slaughter in the GFR are characterised by temporal imperfections in market transparency. Cross spectral analysis was applied to eleven regional markets for pigs for slaughter to examine the intertemporal market relationships. The results of the analysis indicated that as temporal market information between markets became more incomplete the shorter became the
period of adjustment. The absence of any lead-lag structure between the price series implied that there was no evidence of causality in the sense that one time series causes another.

2.4. DEMAND FOR RUBBER

A vast number of empirical studies are available on the estimation of demand for various commodities, especially for consumer goods both single equation demand models as well as simultaneous equation methods. However, in the present case the review is confined to rubber demand functions only.

Cheong (1972) observed that natural rubber demand was generally insensitive to price changes, but sensitive to changes in aggregate economic activities. The price-demand coefficients estimated for various countries were small and did not have the expected negative sign. The elasticity of substitution between natural and synthetic rubber obtained was approximately -0.3 for the developed countries indicating that a 10 per cent increase in NR : SR price ratio would result in a three per cent decrease in the NR : SR usage ratio. The estimates obtained for other countries included cross elasticities of -0.15 for the world, -0.35 USA, -0.62 UK, -0.13 France and -0.08 for Japan. However, he obtained a high elasticity of demand with respect to industrial activity and economic growth. The demand elasticity for
natural rubber with respect to industrial products were 0.998 and 1.325 for USA and Canada respectively.

Grilli et al. (1978) studied the factors influencing rubber demand in the world market and found that population and index of industrial production were the two major factors explaining the rubber consumption. They also studied the consumption pattern of natural rubber in terms of product groups and found that the single most important group of end use for natural rubber was tyres and related products which accounted for 70 per cent of natural rubber consumption in US, 55 per cent in the EEC and below 50 per cent in Japan. Of this, truck/bus tyres constituted the largest single outlet for natural rubber. These tyres generally required a higher content of natural rubber because characteristics such as high wear and tear, cracking resistance and low heat build up were needed. Natural rubber content in tyres generally ranged from 100 per cent for giant tyres, to about 65 per cent for large tyres and 17-25 per cent for smaller tyres.

NCAER (1980) made a comprehensive study on rubber demand in India for all types of rubber, natural, synthetic and reclaimed rubber for the period 1980-81 through 1989-90. Using regression technique the future demand for rubber was assessed. The demand estimates were based on identified micro and macro variables supposed to influence the
consumption of rubber. The micro variables considered were the production of all types of tyres and tubes and other rubber products like storage batteries, conveyor and transmission beltings, rubber sole footwear, various types of hoses, railway and automobile fittings, ebonite water proof fabrics, contraceptives etc. The macro variable considered was index of industrial production (IIP). Separate regression estimates were made using micro and macro variables respectively. The overall demand was then split into its constituents namely natural, SBR and PBR, butyl and reclaimed rubber. They arrived at a final estimate of 3,33,164 tons for 1984-85 and 5,27,450 tonnes for 1989-90.

Smit (1982) estimated the world rubber demand using regression method. Separate estimates were used for non-tyre sector and tyre sector. Separate equations were fitted for the major rubber consuming countries like Germany, U K, Italy, France, U S, Canada, Japan and Brazil. Other countries were considered together. He used simple multiple linear equations with consumption of non-tyre rubber as dependent variable and income as the primary independent variable. However, dummy variables were included in the different functions to capture the outliers. Income was found to have a significant effect on the rubber consumption
for all the countries and the response was relatively higher in case of U K and Italy.

An aggregate function considering all other countries also revealed similar results.

Similarly, Smith (1982) estimated the demand for rubber in the tyre sector. The estimates were done country wise for both passenger car tyres and commercial vehicle tyres. The quantity of rubber consumed was obtained by multiplying the estimated tyres by the respective rubber weight contained in different tyres. The results revealed that the total demand for rubber in the non-tyre sector would vary between 84.50 lakh and 156.06 lakh tonnes by 2000 A.D. in the world (excluding Asian centrally planned economy).

Similarly the demand for rubber by the tyre sector worked out to about 141.86 lakh tonnes by 2000 A.D.

Philip (1984) reviewed the Indian rubber industry and projected the demand for polymer based on the average annual growth rate of 8 per cent. Accordingly, the projected demand for all types of polymers (natural and synthetic rubbers) amounted to 9,26,970 tonnes in the year 2000 A.D. and of which the share of natural rubber estimated was 5,56,187 tonnes.

Tan (1984) derived an aggregate input demand function for the world rubber economy based on the assumption that rubber
goods are produced under cost minimization conditions in a perfectly competitive market. The demand equations were estimated separately for each country in log-linear form using Almon Polynomial lags for lagged relative prices. Other variables included were output of tyres, output of tubes, industrial production index and trend variable to proxy technological changes. The estimated input demand for rubber with respect to relative prices were low especially in the short-run which ranged between -0.0102 in case of West Germany to -0.4370 in case of Canada. The estimated price elasticity of natural rubber demand for India was -0.2664.

Sekhar (1988) in his study on natural rubber supply in India sponsored by the All India Rubber Industries Association and Tyre manufacturers Association indicated that heavy reliance on imports have to be inevitable for India to meet her growing rubber demand. As regards supply, he estimated an achievable level of 4,80,000 tonnes in 2000 A.D. Against this, the projected demand ranged between 6,19,000 and 7,16,000 tonnes indicating the possibility of a wide gap to occur between the demand and supply by 2000 A.D. He emphasised the vital need nationally, to change the natural rubber production industry within supply targets for 2000 A.D. at long-term stable and remunerative prices. He
also stressed on a similar policy with respect to synthetic rubber production.