Ind. Jn. of Agri. Econ.
Vol. 61, No. 4, Oct.-Dec. 2006

Perennial Crop Supply Response Functions: The Case of Indian Rubber, Tea and Coffee

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I

INTRODUCTION

Studying supply response in perennial crops poses additional challenge because of their extended period of output flows, which may range from as low as 2 years to as high as 40 years or more. The present planting decisions of the farmers of perennial crops define their output adjustments in the future. By altering their planting decisions farmers can change their future productive capacity. The productive capacity can be increased either by undergoing new plantings or by uprooting ageing and less productive tree stocks followed by their re-plantation. Technology advancement in terms of varietal improvements and adoption of improved inputs might also lead to higher productive capacity. Similarly by diverting land to alternative uses farmers can reduce their future productive capacity. Hence any adjustment in the productive capacity of a particular plantation crop during a particular year is the net effect of the plantation decisions that modify both the total cultivated area and the age composition of the tree stocks in the past (Kalaitzandonakes and Shonkwiler, 1992). Therefore, in the case of perennial crops the supply response models must explain the planting process (the new plantings), the removal and replacement of plants, age composition of plants and the lag involved between the input and output.

Because of the unavailability of time series data on plantings and removals by age categories most of the studies have analysed supply response relationship based on aggregate (over age group) plantings and removals. However, this approach is limited because it ignores the acreage distribution in various age categories. The earlier work in this category includes French and Bressler (1962), Bateman (1965, 1969), Behrman (1968), Arak (1968, 1969), French and Matthews (1971) and Baritelle and Price (1974). Bateman (1965) and Behrman (1968) were among the first to attempt Nerlove's supply response model on cocoa. Bateman considered adaptive

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The authors gratefully acknowledge the comments offered on the draft of this paper by Ramesh Chand, ICAR National Professor, National Centre for Agricultural Economics and Policy Research, New Delhi. The authors also wish to thank the anonymous referee for the valuable comments and suggestions.

expectations while Behrman used partial adjustment approach to reach a single equation reduced form estimation of cocoa supply response. French and Matthews (1971) tried to estimate a complete model for plantings, removals and variations in yield and output. However, because of data limitation they were not able to estimate the system by simultaneous equations and instead, a single-equation reduced form model was estimated. However, their model suffered from the identification problem.

The later studies tried to cover age distribution effect at least partly if not completely. These studies include, Alston *et al*. (1980), French *et al.* (1985), Akiyama and Trivedi (1987) and Hartley *et al.* (1987). Based on individual structural relationships these studies provided separate estimates of new plantings and removal equations for oranges, cling peaches, tea and rubber, respectively, using age distribution data.[1]

The above-mentioned aggregate acreage as well as individual new plantings/removals equations of supply responses were mostly based on single equation reduced form regressions using OLS technique. However, while the first approach ignored age distribution impacts on new plantings and removals, the second approach requires age distribution data that are not easily available for crops as well as regions. Following these shortcomings, an attempt has been made more recently by Knapp and Konyar (1991) and Kalaitzandonakes and Shonkwiler (1992) to estimate age group dynamics utilising the recent developments in econometrics, namely, state-space approach and Kalman filter.

State-space model is a dynamic system of measurement equations, which relates un-observable (state) variables to observable variables. The Kalman filter generates optimal estimates of the state (un-observable) variables and their variance-covariance matrix. By this method Kalaitzandonakes and Shonkwiler have made an attempt to structurally estimate new planting and replanting investment relationships without detailed data on new plantings and replantings for Florida grapefruit. Similarly, using this technique, Knapp and Konyar estimated parameters of separate new plantings and removals and age group acreage estimates from data on total acreage, production and prices for alfalfa in California. Thus these studies highlighted that within this framework, different dynamic structures of new plantings and re-plantings can be separately considered rather than aggregating them into a reduced form specification.

With regard to studies on supply of commodities under question, studies on rubber include those of Chan (1963) on Malaysia, Olayemi and Olayide (1975) on Nigeria, Uma Devi (1977) and Viju and Prabhakaran (1988) on India and Hartley *et al.* (1987) on Sri Lanka. In the case of tea, the available studies include, Chowdhury and Ram (1978) on India and Akiyama and Trivedi (1987) on major producing countries of tea. On coffee, the studies on supply response include, Arak (1968, 1969) on Sao Paulo, and Parikh (1979) on some Latin American and African countries.

Thus, several studies have provided separate estimates of new plantings and removal equations using different techniques. However, data limitation still remains the major hurdle in studying supply response in perennials. In the present case, no long-term time series was available for new plantings, removals and area under different age groups of bushes in case of coffee. In the case of rubber and tea, however, a time series was available on new plantings and re-plantings. Nonetheless, we cannot derive data on age distribution as well as removals from the given data on new plantings and re-plantings for these two crops also. It was therefore not possible to estimate supply response in terms of planting and removals, which accounts for age distribution effects. Because of the complexity involved with the state space model and due to lack of data on removals we could not estimate state space model. Keeping in mind the above limitations we opted for estimating supply response with aggregate acreage and production data ignoring the age-group dynamics.

1.1 The Model

For perennial crops a distinction has to be made between short run and long run supply functions. In the short run growers can adjust their supply only within their existing productive capacity. They can increase their yield rate by intensive cultivation during a particular year. Increasing area under cultivation however is possible only in the long run. Therefore, in the short run, supply response is estimated by fitting a yield function.[2] The major determinants of yield are the prevailing price in the market and technology, which can shift production upwards in the short run. Age composition of trees and rainfall would be other crucial determinants of yield in the short run.

In the long run, however, farmers can expand/contract their holdings or change their composition by replanting ageing trees. Every year the producer of a perennial crop is presumed to have in mind a desired amount of area to be allocated to the specific crop he wants to grow. The possible determinants of desired area could be expected long run profitability[3] of the perennial crop under question; the expected profitability of the competing crops; the risk factor involved and some other factors associated with plantation of the crop like, land surface, weather conditions, etc. Thus, the desired changes in bearing area under a perennial crop in a particular year may be specified as:

$$BA^*_{it} - BA_{it-1} = f\,(RP_{it}^e, RP_{jt}^e, Y_{it}^e, Y_{jt}^e, S_t^e, R_t, L_{t-1}, v_t) \qquad \text{….(1)}$$

Where BA^*_{it} = the desired bearing area of the i-th perennial crop in year t,
BA_{it-1} = the actual bearing area of the i-th perennial crop in year t-1,
RP_{it}^e = the expected real price of the i-th perennial crop,
RP_{jt}^e = the expected real price of j-th (alternate/competing) crops,
Y_{it}^e = the expected yield of the i-th perennial crop,
Y_{jt}^e = the expected yield of the j-th (alternate/competing) crops,
S_t^e = the variable to account for changes in perceived risk,
R_t = Rainfall index,

L_{t-1} = the lagged dependent variable,
v_t = the disturbance term.

In the case of perennial crops farmers cannot achieve their desired bearing area within a short span (say one-year) because of the gestation period involved. It would require ‘k’ years to adjust the actual bearing area to reach to the level of desired area where ‘k’ is the gestation period. So, operationally BA^*_{it} may be replaced by BA^*_{it+k} in equation (1).

$$BA^*_{it+k} - BA_{it-1} = f\,(RP_{it}^e, RP_{jt}^e, Y_{it}^e, Y_{jt}^e, S_t^e, R_t, L_{t-1}, v_t) \qquad \text{....(2)}$$

The term on the left-hand side in the above equation becomes desired new plantings in year ‘t’ after taking into account removals during the gestation period and the young area, which will also reach the bearing stage during the gestation period. Symbolically,

$$NPA^*_t = BA_{t+k} - BA_{t-1} + R_{Kt} - N_{t-1} \qquad \text{....(3)}$$

Where NPA^*_t = the desired planting in year ‘t’,
R_{Kt} = the expected removals during the next ‘k’ years including year ‘t’,
N_{t-1} = the young area (under non-bearing stage) in year ‘t-1’.

Because of measurement error and input restrictions, the actual new plantings (NPA_t) may deviate from the desired new plantings (NPA^*_t). Following French and Matthews (1971), the relationship between actual plantings and desired plantings may be specified in the partial adjustment form

$$NPA_t - \beta\, NPA_{t-1} = \alpha\,(NPA^*_t - \beta\, NPA_{t-1}) + u_t \qquad \text{....(4)}$$

Simplifying the above equation

$$NPA_t = \alpha\, NPA^*_t + \beta\,(1-\alpha)\, NPA_{t-1} + u_t \qquad \text{....(5)}$$

Where, $0 \leq \alpha \leq 1$ is the coefficient of adjustment and, $0 \leq \beta \leq 1$ is the residual effect of some unattained disturbance. It is possible that unfulfilled desired plantings in the past periods could influence current actual plantings, thus affecting the disturbance structure (French *et al.*, 1985). In the long run the coefficient of adjustment will take its unit value, i.e., $\alpha = 1$. By combining equations (2), (3) and (5) the new plantings function may be expressed as

$$NPA_{it} = f\,(RP_{it}^e, RP_{jt}^e, Y_{it}^e, Y_{jt}^e, S_t^e, L_{t-1}, R_t, v_t) \qquad \text{....(6)}$$

While allocating area to new plantations the farmers' decision is conditioned by their expectations on price and yield risks. The squared deviations of expected values from the actual values were taken as an observation on risk. Thus the price risk was measured as $SP_t = (RP_{it} - RP_{it}^e)^2$ and yield risk as $SY_t = (Y_{it} - Y_{it}^e)^2$.

However, the variables on price and yield as defined above are in expectation form and so are unobservable. These unobservable variables must be derived from their actual past observations. Different alternatives available are adaptive expectations, rational expectations and moving average. In the present analysis we have used the moving average method for choosing the level of average, which produces the best fit and have the appropriate economic interpretation.[4]

II

DATA

The data required for this analysis have been collected from various published sources like *Database on Coffee* published by Market Intelligence Unit, Coffee Board; *Indian Rubber Statistics* published by Statistics and Planning Department, Rubber Board; and *Tea Digest* and *Tea Statistics* published by Statistics Branch, Tea Board; Ministry of Commerce, Government of India. Besides these three major sources, we also used various publications of the Directorate of Economics and Statistics, viz., *Area and Production of Principal Crops in India; Agricultural Prices in India; Agricultural Statistics at a Glance* etc.

III

RESULTS AND DISCUSSION

Before discussing the results of empirical estimation, an overview of the main variables is presented in Figures 1 to 3. All the variables, viz., area, yield and price of own and alternate crops registered an increasing trend for all the three crops during the study period. Apparently, the slope of area as well as yield of rubber was steeper than the other two crops indicating that area and yield of rubber increased at a faster rate compared to coffee and tea. Similarly, price of own crop increased at a much faster rate compared to the price of substitute crop in all the cases. It was pointed out in Section 1.1 that the theoretical variables on price and yield (as also risk factor) were in expectation form and so were unobservable. These unobservable variables are derived from their actual past observations. For illustration, Annexure Table presents an example of the actual and expected variables (in terms of six years moving average) for the rubber crop as used in the present case in building up supply response function.

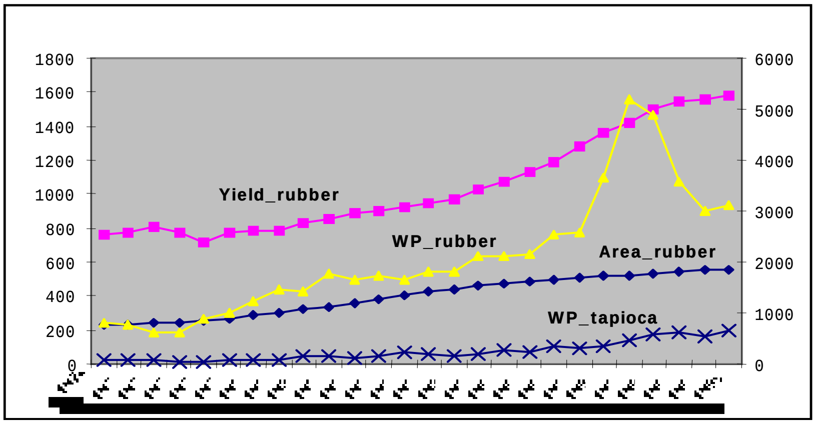

Figure 1: Area, Yield and Price Variables (Rubber)

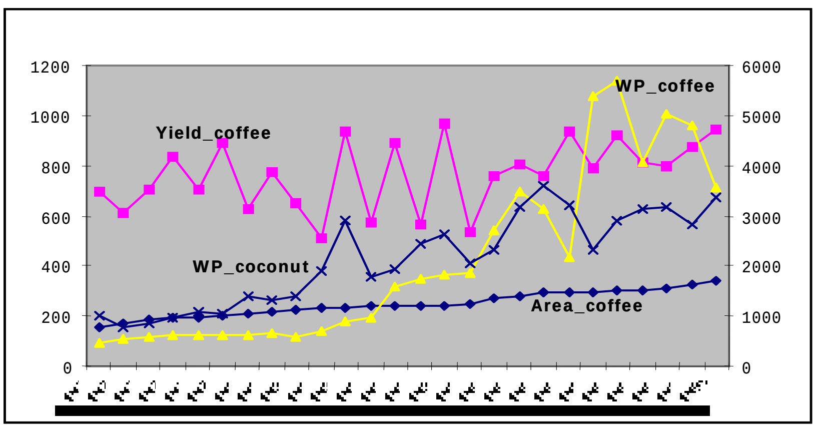

Figure 2: Area, Yield and Price Variables (Coffee)

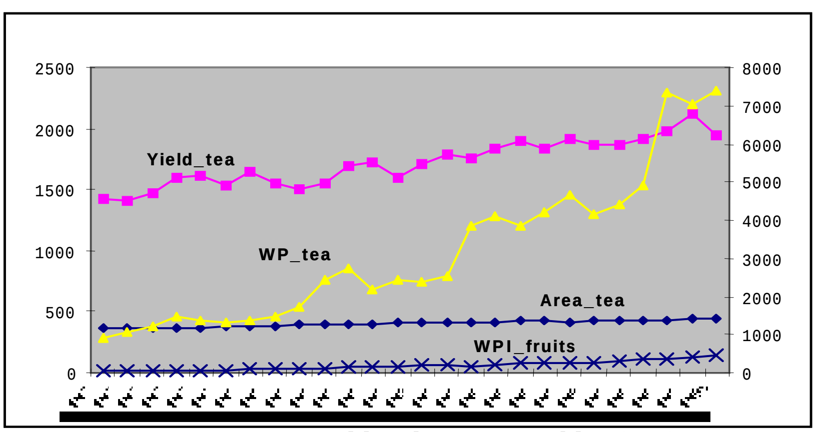

Figure 3: Area, Yield and Price Variables (Tea)

The results of supply response should be seen in the light of distinct policy changes which occurred in the international and domestic commodity markets during the decades of 1980s and 1990s. Despite varied experiences of perennial crops across countries and policy initiatives to achieve comparative stability of prices, due to difficulties in setting the price range for intervention and scarcity of funds in keeping prices within the specified range (Gilbert, 1996), all the post-colonial International Commodity Agreements (ICA) collapsed with remote chances of revival. The International Coffee Agreement had not been renewed since October 1989. The latest victim was the International Natural Rubber Agreement (INRA), which was terminated on October 13, 1999 (Lekshmi and George, 2003).

At the domestic front Coffee Board was in full control of purchasing, processing and exporting coffee through domestic and export auctions. In 1992-93, Coffee Board initiated a liberalisation process. An Internal Sales Quota (ISQ) was introduced that allowed growers to sell 30 per cent of their output to the domestic market. Free Sales Quota (FSQ) subsequently replaced the ISQ in 1993-94 allowing growers to sell 50 per cent of their output in the domestic or external market. By 1996 the Coffee Board’s involvement in marketing ended completely and coffee growers and exporters were free to trade the crop as they chose (Krivonos, 2004). In the case of rubber cultivation, the development of the high-yielding variety (HYV) planting material RRII 105 in the 1970s and its official release by the Rubber Board in 1980 for unrestricted planting and a comparatively higher adoption of the new variety by the dominant small holding sector have significantly transformed the viability of rubber cultivation. A relatively higher realised and potential level of yield of the clone and incentives for the adoption of the clone contained in the integrated rubber plantation development scheme since 1980 resulted in a vertical shift in the yield profile of the crop (Lekshmi and George, 2003).

With the removal of marketing controls there is no regular procurement by the government in the case of coffee, rubber and tea. However, in the event of unexpected fall in domestic prices, State Trading Corporation (STC) or the Commodity Boards procure some amount from the growers, albeit these interventions are only a temporary phenomenon. With this brief outline of the recent policy changes in the perennial crops, the results of supply response are presented in the following paragraphs.

Short Run

As pointed out earlier variations in output in the short run are explained by the variations in yield. We estimated yield function for rubber, coffee and tea with respect to one year lagged real price, deviation of actual rainfall from the normal level, trend factor representing technology and one-year lagged yield. The random disturbance term accounts for variation in yield due to age composition of trees and other miscellaneous factors. The results are presented in Table 1.

TABLE 1. SHORT RUN SUPPLY RESPONSE FUNCTIONS (1974-99)
(DEPENDENT VARIABLE = LOG YIELD)

(1)	Constant (2)	Log Real Wholesale Price (-1) (3)	Log Rainfall (4)	Time Trend (5)	Log Yield (-1) (6)	R^{-2} (7)	D-W (8)
Rubber							
(i)	6.03	0.10*				0.99	1.94#
	(17.8)	(2.7)					
(ii)	6.05	0.09**	-0.03			0.99	1.82#
	(16.7)	(2.2)	(-0.9)				
(iii)	5.72	0.10*	-0.03	0.05*		0.99	2.16#
	(21.8)	(2.8)	(-1.0)	(5.9)			
(iv)	-0.47	0.07***	-0.02		1.04*	0.98	1.65
	(-2.1)	(1.8)	(-0.3)		(33.6)		
(v)	-0.57	0.09***	-0.06		1.05*	0.98	1.95#
	(-1.8)	(1.9)	(-0.9)		(25.8)		
Coffee							
(i)	6.05	0.24*				0.44	2.09#
	(37.8)	(3.6)					
(ii)	5.23	0.21*	0.18**			0.49	2.08#
	(11.4)	(3.1)	(2.0)				
(iii)	5.28	0.19***	0.17***	0.001		0.47	2.08#
	(10.5)	(1.9)	(1.9)	(0.3)			
(iv)	8.21	0.32*	0.21***		-0.51*	0.45	1.71
	(6.6)	(3.5)	(2.0)		(-3.1)		
(v)	9.46	0.27**	0.24**		-0.71*	0.48	2.06#
	(8.7)	(2.4)	(2.6)		(-5.2)		
Tea							
(i)	7.12	0.15*				0.91	2.31#
	(41.6)	(3.2)					
(ii)	6.09	0.14*	0.14*			0.91	2.07#
	(18.8)	(3.6)	(3.7)				
(iii)	5.83	0.14*	0.13**	0.01*		0.93	1.68#
	(15.9)	(3.5)	(2.6)	(10.0)			
(iv)	-0.53	0.10**	0.24*		0.79*	0.92	1.78
	(-1.0)	(2.5)	(4.7)		(13.4)		
(v)	-0.65	0.06	0.22*		0.84*	0.89	1.96#
	(-1.6)	(1.5)	(3.7)		(16.1)		

Notes: (i) Figures in parentheses are respective 't' values. (ii) *, **, *** indicate the level of significance at 1, 5 and 10 per cent level, respectively. (iii) # indicates that the equation is corrected for auto-correlation. (iv) The rainfall variable for rubber is annual rainfall for the Kerala meteorological division. For coffee the rainfall variable is weighted average rainfall of South Interior Karnataka and Kerala (meteorological divisions) during the months of March, April and May (weights being production of coffee). For tea, the rainfall variable is weighted average annual rainfall of Assam and Meghalaya, Sub-Himalayan West Bengal, and Tamil Nadu and Pondicherry meteorological divisions (weights being production of tea).

The results indicate that rubber growers positively respond to the price incentives. The coefficient of real price of rubber was significant with elasticity equal to 0.10.[5] The earlier estimates of price elasticity of yield of rubber by Uma Devi (1977) and Viju and Prabhakaran (1988) were 0.19 and 0.04, respectively. Trend variable was also significant with positive sign indicating 5 per cent annual growth rate in yield rate of rubber, which is a clear indication of technological improvement in the production of rubber also mentioned above as adoption of improved clone in the 1980s. Significant lagged dependent variable with elasticity equal to one indicates that the impact of higher use of inputs on productivity rather than being immediate was disbursed over a period of two years or even more. The rainfall variable remained insignificant. The possible reason might be mis-specification of the rainfall variable as the rainfall used was annual rainfall for the Kerala meterological sub-division. However, the actual rainfall for the state remained above the desired amount of rainfall for rubber[6] during the study period.

As in the case of rubber, yield of coffee was regressed on one-year lagged real price of coffee, actual rainfall, trend and one year lagged yield of coffee to estimate the short run supply function of coffee. It is evident from Table 1 that the price of coffee had a significant influence on yield rate in the short run. The price elasticity turned out to be around 0.25 indicating a 10 per cent hike in real wholesale price of coffee leads to around two and a half per cent increase in its yield rate. The insignificant trend factor indicates that in coffee, technological breakthrough has not occurred and thereby no major productivity shift has taken place during the period under study. This gives an explanation of higher area expansion for rubber compared to coffee during this period. The lagged dependent variable was significant with a negative sign indicating that high yield in coffee was not followed consecutively. This is because of the presence of biennial cycle in coffee (Parikh, 1979, Wickens and Greenfield, 1973). The biennial cycle has been attributed to the strain suffered by the tree due to a heavy crop with the result that the next year's crop is a light one (Rourke, 1970). The coefficient of rainfall was significant with a positive sign. It highlights the predominance of rainfall in coffee yield especially that of blossom showers during the months of February, March and April.

The short run supply response in the case of tea is similar to that of rubber. In the wake of higher price expectations the growers generally resort to longer rounds of plucking, i.e., plucking below the mother leaf thus raising the productivity of tea in the short run. This is evident from the results of short run supply response, which shows that with higher prices in the market the growers try to take advantage by undertaking intensive plucking of tea (Table 1). The price elasticity of yield was estimated to be 0.14, which is roughly half of the elasticity estimate (0.32) arrived at earlier by Chowdhury and Ram (1978). The trend factor indicates 1.0 per cent per annum growth rate in the yield of tea. The rainfall turned out as highly significant variable with average elasticity of 0.18 with positive sign indicating higher rainfall leads to higher productivity of tea. The lagged dependent variable was significant with a positive sign, indicating lag in the use of inputs and their realisation in terms of higher output.

Long Run

The long run supply response function of rubber as elaborated above was estimated with the expectations derived through 6 years moving average. For alternative crops, we tried various combinations, viz., tapioca, coconut, pepper and cashew nut. However, tapioca turned out to be the best fit both in terms of expected price and expected yield rate. Other alternative crops were insignificant. Therefore, the results of other alternative crops are not reported. As an alternative, we have used ratio of price (yield) of rubber to its competing crops as another option in building supply response relationship. The other variables used were rainfall deviation and price and yield risk factors. The results are shown in Table 2.

TABLE 2. LONG RUN SUPPLY RESPONSE FUNCTIONS FOR NATURAL RUBBER (1974-99)

Dependent Variable = Log (New Planted Area / Tapped Area of Rubber)									
Independent Variables (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	-3.67 (-2.7)	-3.38 (-2.3)	-3.37 (-2.2)	6.22 (0.8)	8.51 (0.7)	19.1 (1.4)	-3.44 (-3.8)	-6.24 (-2.1)	18.6 (1.4)
Log Real Wholesale Price of Rubber (6 Years MA)	2.42* (4.1)	2.29* (3.7)	2.30* (3.6)	1.61** (2.1)	1.84** (2.6)	1.39*** (1.9)			
Log Real Wholesale Price of Tapioca (6 Years MA)	-2.25* (-5.4)	-2.27* (-5.3)	-2.28* (-5.1)	-1.31 (-1.6)	-1.78* (-2.8)	-1.54** (-2.5)			
Log Rainfall Deviation from the Normal Level		-0.15 (-0.7)	-0.16 (-0.7)	-0.04 (-0.2)	-0.11 (-0.5)	0.07 (0.3)	-0.13 (-0.6)	-0.11 (-0.6)	0.08 (0.4)
Log Price Risk Factor			-0.002 (-0.2)	0.003 (0.3)					
Log Yield Risk Factor						0.04*** (1.7)			0.03*** (1.8)
Log Yield of Rubber (6 Years MA)				-1.16 (-1.3)					
Log Yield of Tapioca (6 Years MA)					-1.09 (-0.9)	-2.08 (-1.6)			-2.05 (-1.7)
Log Ratio of (6 Years MA) WP of Rubber and Tapioca							2.32* (5.8)	1.77* (3.0)	1.50** (2.6)
Log Ratio of (6 Years MA) Yield of Rubber and Tapioca								-1.38 (-1.1)	
R^{-2}	0.90	0.90	0.90	0.90	0.90	0.91	0.89	0.91	0.92
D-W	2.09	2.03	2.04	2.06	2.17	1.84	2.01	1.93	1.85

Notes: (i) Figures in parentheses are respective ‘t’ values. (ii) *, **, *** indicate the level of significance at 1, 5 and 10 per cent levels respectively. (iii) All the equations are corrected for auto-correlation. (iv) The rainfall variable is annual rainfall for the Kerala meteorological division.

It is evident from the table that higher expected price of rubber worked as an incentive for the growers to allocate more area to this crop. Similarly as anticipated, lower expected price of tapioca (the competing crop) also led to higher plantation of rubber. However, expected yield of rubber did not show any significant association with rubber plantation which means that price rather than yield rise led to area expansion of rubber during the decades of 1980s and 1990s. The average own price elasticity of rubber and cross price elasticity with respect to tapioca price turned out around 2.0. In the other two studies referred to earlier, the estimates for own price elasticity ranged between 0.18 to 1.04 (Uma Devi, 1977) and 0.76 (Viju and Prabhakaran, 1988). Thus, the significant own price elasticity of new plantings indicates that rubber producers in general respond to profit incentives. This was further supported by the variable on yield risk that was significant with a positive sign indicating that given the price hike, farmers undertake risk on yield to plant new area under rubber.

The alternate variable in terms of price ratio of rubber and tapioca also turned out significant with average elasticity of 1.86. However, the variable on yield ratio remained insignificant supporting our above contention that rise in price rather than yield worked as a profit incentive for the area expansion of rubber. Lastly, the variable on rainfall remained insignificant with the possible reason as indicated above in the case of yield function. Thus, we can conclude from the above results that higher relative price of rubber has led to rubber cultivation more profitable venture and thereby tremendous increase in its area during the eighties and nineties.

For the long run supply function for coffee, new-planted area as a proportion of bearing area was regressed on 4 years moving average real price and yield of coffee (Table 3). The other variables being real price of alternate crop (coconut, cardamom and pepper), rainfall deviation from the normal level and the risk factor for price and yield as defined above. As was expected, the real price of coffee turned out significant with a positive sign. It was pointed out (in the previous section) that a number of policy reforms took place in coffee during the mid nineties. The removal of bindings on the growers' sale to the Coffee Board enabled the domestic producers to obtain higher net prices for their sale. This assertion is substantiated by the significant and positive own price elasticity both in the case of short run as well as in the long run.

The real price of coconut (the competing crop) was significant with a negative sign. The own and competing crops' price elasticity were measured as 2.6 and –3.1, respectively. New plantings in coffee would take place if the expected price of coffee increases or the expected price of coconut decreases. The price of other competing crops namely cardamom and pepper remained insignificant. A continuous fall in price of coconut led to a shift in area from coconut to coffee, which also explains why coconut was observed as significant alternate crop to coffee.

However, changing the price and yield variables into ratio terms, i.e., ratio of price and yield of coffee to its competing crops, namely, coconut, cardamom and pepper showed better results. In this case we observed both price and yield ratios were significant with a positive sign not only for coconut but also for cardamom and pepper. This implies that as the price or yield of coffee rises more than its competing crops, its area will undergo expansion. The rainfall variable was highly significant indicating any deviation of annual rainfall from its normal level will have a negative effect on the new plantings in coffee. Finally the risk factors, both price as well as yield, did not turn out to be significant.

TABLE 3: LONG RUN SUPPLY RESPONSE FUNCTIONS FOR COFFEE (1974-99)

DEPENDENT VARIABLE = LOG (NEW PLANTED AREA / BEARING AREA OF COFFEE)									
Independent Variables (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	36.5 (2.7)	37.9 (2.4)	41.5 (2.7)	86.9 (3.5)	44.6 (3.9)	40.2 (1.5)	7.73 (1.5)	-4.86 (-3.4)	-8.72 (-5.2)
Log Real Wholesale Price of Coffee (4 Years MA)	2.30** (2.7)	2.24** (2.5)	2.47** (2.7)	3.65* (3.0)	2.69* (3.7)	2.46 (1.5)			
Log Real Wholesale Price of Coconut (4 Years MA)				-3.13** (-2.4)					
Log Real Wholesale Price of Cardamom (4 Years MA)					1.73 (1.3)				
Log Real Wholesale Price of Pepper (4 Years MA)						-0.31 (-0.3)			
Log Rainfall Deviation from the Normal Level	-2.60* (-3.0)	-2.46** (-2.3)	-2.80* (-3.0)	-2.74** (-2.9)	-1.87*** (-2.1)	-2.58** (-2.8)	-1.69 (-1.4)	-3.21* (-2.7)	-1.70*** (-2.1)
Log Price Risk Factor		-0.16 (-0.3)							
Log Yield Risk Factor			0.22 (0.6)						
Log Yield of Coffee (4 Years MA)	-6.91* (-3.2)	-7.11* (-3.0)	-7.73* (-3.2)	-6.10** (-2.8)	-9.36* (-3.8)	-7.23** (-2.9)			
Log Yield of Coconut (4 Years MA)				-5.85** (-2.3)					
Log Yield of Cardamom (4 Years MA)					-0.17 (-0.2)				
Log Yield of Pepper (4 Years MA)						-0.19 (-0.1)			
Log Ratio of MA WP of Coffee and Coconut							1.37*** (2.1)		
Log Ratio of MA WP of Coffee and Cardamom								1.77** (2.4)	
Log Ratio of MA WP of Coffee and Pepper									1.88*** (1.8)
Log Ratio of MA Yield of Coffee and Coconut							5.45** (2.2)		
Log Ratio of MA Yield of Coffee and Cardamom								2.15** (2.5)	
Log Ratio of MA Yield of Coffee and Pepper									5.71* (3.0)
R^{-2}	0.45	0.40	0.41	0.58	0.52	0.33	0.39	0.31	0.32
D-W	1.62	1.67	1.39	2.04	1.78	1.68	1.82	2.86	2.18

Notes: (i) Figures in parentheses are respective 't' values. (ii) *, **, *** indicate the level of significance at 1, 5 and 10 per cent levels respectively. (iii) All the equations are corrected for auto-correlation. (iv) The rainfall variable is weighted average annual rainfall of South Interior Karnataka and Kerala meteorological divisions (weights being production of coffee).

For the long run response for tea, we used moving average prices from 3 to 8 years as tea plants start yielding from the third year onwards and it might take up to 8 years to reach regular plucking field stage (Sarma, 1996). Though there was hardly any competing crop for tea, we tried real prices of crops such as rubber, coffee, coconut, pepper and arecanut, but none of these turned out to be significant variable. Given the fact that pineapple and some other fruit crops have been replanted in place of tea in some parts of the country, we got better results with price of fruits as an alternative crop to tea. Thus we regressed new-planted area under tea as a proportion to bearing area on expected price and yield of tea, expected price of fruits as alternate crop,[7] a rainfall variable, the risk factor on price and yield and price ratio of tea and fruits (Table 4).

TABLE 4. LONG RUN SUPPLY RESPONSE FUNCTIONS FOR TEA (1974-99)

DEPENDENT VARIABLE = LOG (NEW PLANTED AREA / BEARING AREA OF TEA)								
Independent Variables (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)[@]	(9)[@]
Constant	-5.29 (-2.7)	-6.83 (-4.0)	-6.67 (-2.6)	-6.03 (-2.0)	-8.43 (-4.0)	-10.68 (-2.1)	-6.91 (-4.1)	18.47 (0.8)
Log Real WP of Tea (6 Years MA)	2.51** (2.6)	2.05* (3.0)	2.04* (2.9)	2.13** (2.5)			2.94* (4.2)	
Log Real WP Index of Fruits (5 Years MA)	-1.36*** (-2.0)	-0.69 (-1.3)	-0.67 (-1.1)	-0.79 (-1.2)			-1.17** (-2.2)	
Dummy_1996	0.88* (4.6)	0.89* (5.8)	0.89* (5.6)	0.90* (5.3)	0.82* (5.4)	0.82* (5.1)		
Log Rainfall Deviation from the Normal Level		-0.46** (-2.1)	-0.46*** (-2.0)	-0.51*** (-1.8)	-0.45*** (-2.0)	-0.42*** (-1.8)	-0.28*** (-1.8)	-0.30*** (-1.7)
Log Price Risk Factor		-0.02*** (-1.9)	-0.02*** (-1.8)			-0.02 (-1.2)	-0.03* (-3.1)	-0.03** (-2.7)
Log Yield Risk Factor				-0.002 (-0.1)				
Log Yield of Tea (5 Years MA)			-0.03 (-0.1)	-0.10 (-0.3)		0.30 (0.6)		
Log Yield of Tea (6 Years MA)								-3.86 (-1.3)
Log Ratio of (6-5 Years MA) WP of Tea and Fruits					1.37*** (1.8)	1.45*** (1.8)		2.32* (3.1)
R^{-2}	0.51	0.67	0.65	0.58	0.52	0.51	0.71	0.50
D-W	1.92	1.82	1.82	1.65	1.73	1.74	2.09	1.94

Notes: (i) Figures in parentheses are respective 't' values. (ii) *, **, *** indicate level of significance at 1, 5 and 10 per cent levels respectively. (iii) All the equations are corrected for auto-correlation. (iv) @ indicate that in the above regressions the year 1996-97 as being abnormal year in plantings has been dropped. (v) The rainfall variable is weighted average annual rainfall of Assam and Meghalaya, Sub-Himalayan West-Bengal, and Tamil Nadu and Pondicherry meteorological divisions (weights being production of tea).

A cursory reading of the results shown in table reveals that all the variables had the right sign. In the case of real price of tea it was the 6 years moving average price, which showed the best fit. This variable was significant with price elasticity around 2.3. In an earlier study Chowdhury and Ram (1978) observed negative but insignificant price elasticity for extension, replacement, replanting and for the total new planted area (Table 5). The dummy variable was significant with a positive sign, which indicates break in the new-planted area in 1996-97. The real price of fruits with 5 years moving average turned out significant when the rainfall variable was not included among the independent variables. However, when we dropped the year 1996-97 from our database the results indicated higher price elasticity of tea with respect to its own price, equal to 2.94 and also the price of fruits became a significant variable with a negative sign. Price elasticity of fruits turned out to be –1.17, which implies that any increase in the real prices of fruits would lead to more than proportionate decline in the area allocated to tea. The alternate price variable in terms of ratio of price of tea and fruits was also significant with a positive sign indicating higher plantation of tea as the price of tea rises compared to the price of fruits.

TABLE 5. SUPPLY ELASTICITY WITH RESPECT TO PRICE UNDER VARIOUS STUDIES

(1)	Various studies (2)	Short run (3)	Long run (4)
Rubber	Uma Devi (1977)	0.19	0.18 - 1.04
	Viju and Prabhakaran (1988)	0.04	0.76
	Our Study	0.07 – 0.10	1.39 – 2.42
Tea	Chowdhury and Ram (1978)	0.32	Insignificant
	Our Study	0.10 – 0.15	2.04 – 2.94
Coffee	Our Study	0.19 – 0.32	2.24 – 3.65

From the rainfall variable one notices that both excessive as well as below normal rainfall leads to reduction in area allocated to tea. It implies that the desired amount of rainfall was essential and beneficial for the tea crop in the long run. The risk factors both in terms of price as well as yield turned out insignificant indicating risk avoiding behaviour of the tea growers.

V

CONCLUSIONS

With the given limitation of lack of availability of data on age distribution of trees of the selected crops (namely, rubber, coffee and tea) the study was undertaken to estimate their perennial supply response functions, ignoring the age dynamics. Although single equation OLS was used for the estimation, the study overcomes some of the missing links in the earlier works. This study uses the possible competing crops for the estimation of supply response. Besides, one of the most important variable ignored by almost all earlier studies, i.e., the effect of rainfall on the supply response of tree crops has been captured very well in the present study. This study also analyses the behaviour of the growers towards the risk factor.

The short run supply functions show that the growers very well respond to the price incentives. As the price rises in the short run, growers indulge in intensive cultivation to take benefit of price incentives. The trend variable shows that technological breakthrough has occurred the most in the case of rubber giving possible explanation of its area expansion much more than that of other two crops. The lagged dependent variable of yield was significant in rubber and tea indicating lag in inputs used (like fertilisers, pesticides etc.) and realisation of its effect on productivity. In the case of coffee, a biennial cycle was observed in yield indicating that a heavy crop is followed by light crop in the next year.

In the long run it was observed that in all the three crops, own expected price had positive effect on the planted area, whereas the expected price of competing crops led to a decline in the area planted. It was price rather than yield, which played as an incentive for the area expansion in the case of all the three crops. Mostly the growers were observed to be risk averters rather than risk takers. Finally, except rubber, rainfall was observed to be the most important variable explaining yield as well as new plantation of these tree crops.

Received July 2004. *Revision accepted November 2006.*

NOTES

1. The age distribution data used by these studies were mostly survey based.

2. Yield = Total production/Total bearing area.

3. Measured in terms of expected price and yield.

4. This method was preferred to others given the assertion that distributed lag models with shorter lags which have been successful in developing countries cannot be expected to perform well for tree crops (Parikh, 1971).

5.The price of rubber used is RSS4 rubber (the name of the variety) at Kottayam market deflated by wholesale price index of all commodities.

6. The observed rainfall for Kerala-meterological sub-division had remained above 2157 mm for the period 1977-78 to 1999-2000 whereas the ideal requirement of rainfall for rubber is 2000 mm. The rainfall deviation specifically in the rubber grown area might have been a better indicator for the rainfall variable. However, data on rainfall was available only at the Kerala state level and there was no source for rainfall at the crop level.

7. The new-planted area of tea had a structural break during 1996-97. The change in area under tea indicates that the new plantings rose from 3.2 thousand hectares in 1995-96 to 8.1 thousand hectares in 1996-97, which came down to 5.1 thousand hectares in 1997-98. Replacements and extensions in area in northern and eastern parts of the country mostly accounted for this expansion in area during 1996-97. In an attempt to capture this sudden break we tried dummy variable with value one in 1996-97 and zero otherwise. In another set of equations we dropped the year 1996-97 from the database. Results of both sets of regressions are presented in the table.

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ANNEXURE TABLE

THE EMPIRICAL MEASUREMENTS OF THE THEORETICAL VARIABLES FOR THE CASE OF RUBBER

(1)	Whole-sale price of rubber (2)	6Years MA of WP of rubber (3)	Whole-sale price of tapioca (4)	6Years MA of WP of tapioca (5)	Yield of rubber (6)	6Years MA of yield rubber (7)	Yield of tapioca (8)	6 Years MA of yield tapioca (9)	Risk factor in price of rubber* (10)	Risk factor in yield of rubber† (11)
1969	520		33		616					
1970	464		41		653		14870			
1971	426		46		678		17020			
1972	453		47		725		17550			
1973	482		62		756		17450			
1974	810	526	63	49	762	698	16300	16638	80751	4053
1975	784	570	61	53	772	724	16930	16687	45867	2272
1976	615	595	84	61	806	750	16520	16962	400	3155
1977	628	629	51	61	770	765	15890	16773	0	23
1978	883	700	57	63	711	763	16710	16633	33367	2687
1979	1006	788	91	68	771	765	16610	16493	47669	32
1980	1242	860	89	72	788	770	18280	16823	146179	336
1981	1460	972	88	77	779	771	16380	16732	237819	67
1982	1440	1110	135	85	830	775	17690	16927	109010	3043
1983	1752	1297	147	101	857	789	18450	17353	206873	4579
1984	1655	1426	105	109	886	819	18560	17662	52517	4556
1985	1732	1547	164	121	898	840	17700	17843	34287	3403
1986	1660	1617	224	144	926	863	18170	17825	1892	4011
1987	1791	1672	174	158	944	890	20210	18463	14240	2898
1988	1815	1734	143	160	974	914	19410	18750	6534	3580
1989	2131	1797	198	168	1029	943	20500	19092	111333	7425
1990	2129	1876	265	195	1076	975	21030	19503	63840	10302
1991	2141	1945	249	209	1130	1013	23250	20428	38612	13650
1992	2550	2093	327	226	1191	1057	22150	21092	209001	17867
1993	2569	2223	308	248	1285	1114	24530	21812	120062	29184
1994	3638	2526	365	285	1362	1179	24420	22647	1235803	33550
1995	5204	3039	459	329	1422	1244	23583	23161	4689390	31565
1996	4901	3501	559	378	1503	1316	22112	23341	1961400	35156
1997	3580	3740	619	440	1549	1385	25282	23680	25707	26787
1998	2994	3814	543	476	1563	1447		23985	672947	13379
1999	3099	3903	636	530	1576	1496		23849	645880	6427

Source: Indian Rubber Statistics, Statistics and Planning Department, Rubber Board, Ministry of Commerce, Government of India.

Note: * Price Risk = $(WP_{it} - WP_{it}^{e})^2$, † Yield risk = $(Y_{it} - Y_{it}^{e})^2$.