Vertical Coordination Changes in the Sri Lankan Tea Industry:

Transaction, Management, and Production Costs

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1. INTRODUCTION

Sri Lanka is the world's largest black tea exporter and contributes about 12% of the world black tea production. Up until the 1970s, vertically integrated plantations dominated the growing of green leaf tea and its production into black tea. However, black tea processors who outsource their green leaf tea have tripled their production from 53 million kg in 1980 to 157 million kg in 1998. In contrast, black tea processors who produce from green leaf tea grown in-house have dropped their production from 143 million kg in 1980 to 131 million kg in 1998 (see Table 1). The number of these vertically integrated black tea processors dropped from 429 in 1973 to 117 in 1993, while the number of independent processors who fully outsourced their green leaf tea increased from 63 in 1973 to 184 in 1993 (see Table 2). The green leaf tea bought by processors is grown now almost exclusively by small farmers.

This paper explains the drivers affecting the changing vertical coordination arrangements and in the process makes three important contributions. First, the paper presents a theoretical basis for determining the changes in plantation economies. The decline of vertically integrated plantation production systems in developing countries together with an expansion in the output of small producers has been noted previously for sectors such as the Kenyan tea and coffee industries (Lele and Agrawal, 1989), the Indian rubber industry (Tharian, Haridasan and Sreekumar, 1988), and the Guyana sugar industry (Thomas, 1979). This literature has been a deviant from the studies that focused on explaining the factors leading to the establishment of plantations as a production organization at the time of western colonial expansion (Beckford, 1972; Courtney, 1980; De Silva, 1982; Bandarage, 1982). Studies that analyze the recent changes taking place in plantation economies attribute the changes mainly to state interventions such as small farm support programs, export taxation, land reform, over-valued foreign exchange

regimes, national ownership and management, and parastatal organizations for processing and marketing (Dawood, 1984; Rote, 1986; Barlow and Jayasooriya, 1986; Sajhau and Von Muralt, 1987; Tiffen and Mortimore, 1990; and Hayami, 1994). However, these studies tend to confine their analysis to a qualitative discussion and do not present a theoretical basis for the possible determinants that can be verified empirically. This paper conceptualizes the effects of such determinants and tests their influence using forty years of data for the Sri Lankan tea industry.

Second, the limited number of empirical studies on vertical coordination arrangements for agriculture in developing countries tends to focus on the characteristics of the commodity. Some argue that commodities that pose inherent problems of quality control together with scale economies in production/and or processing will be limited to vertically integrated systems or contract-based systems. In contrast, for commodities with less demanding technical characteristics and lower investment requirements, decentralized, small scale trading and processing operations would be the efficient institutional norm (Binswanger and Rosenweig, 1986; Hayami, 1994; Jaffee and Morton, 1995). This classification of coordination arrangements overlooks many other determinants of how components of a sector are arranged. Transaction, management, and production costs can determine the most efficient coordination arrangement (Demsetz, 1988). This study develops a conceptual framework to consider all of these potential costs.

Third, the changes in coordination arrangements due to transaction and management costs have been emphasized in explaining structural changes for the agricultural sector in developed countries (Boehlje, 1999; Hennessy and Lawrance, 1999; Cozzarin and Westgren, 2000).[1] These studies focus on the role of transaction costs to explain the movement from

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[1] The structure of agriculture has traditionally been examined in terms of changes in the average and distribution of the size in operational units (Kislev and Peterson, 1982, Reining, 1989, Evenson and Huffman, 1997).

independent producers and processors exchanging in a spot market to an industry dominated by either contracts between producers/processors or the vertical integration of these components (Hallberg, 2001; Bohelje, 1999; Hennessy, 1999; Monke *et al,* 1993). Since the movement towards greater vertical integration in agriculture within the developed world has been opposite to the vertical disintegration occurring in the Sri Lankan tea industry, this paper provides an opportunity to test the robustness of models explaining vertical coordination arrangements.

The purpose of this paper is to explain the change in vertical coordination arrangements within the Sri Lankan tea sector from one dominated by vertically integrated plantations to one where independent processors purchase their green leaf tea from independent growers. The conceptual framework is based on work by Demsetz (1988) who argued that the "make" versus "buy" decision or the choice of vertical coordination arrangement in production should be based on the relative size of transaction costs (cost of organizing production through the market), management costs (cost of organizing production within the firm), and technologically determined production costs for these alternative arrangements. The next section describes the conceptual framework. The econometric analysis using data from 1960 to 1998 finds that the changes away from vertically integrated plantations in the Sri Lankan tea sector was due largely to changes in transaction costs associated with the implementation of a pricing formula for green leaf tea and to the change in the relative difference in wage costs for plantation growers versus family farms.

2. THEORETICAL MODEL

The relative net benefits of alternative vertical coordination arrangements are cast in terms of the make versus buy decision for tea processors. The "make" decision results in

vertically integrated plantations having both green leaf tea production and black tea processing are under same decision making unit. The "buy" decision involves vertically independent farms producing green leaf tea and selling to mainly independent black tea processors. We develop a model of the green leaf tea market in Sri Lanka that can illustrate the influence of transaction, management and production costs on the make versus buy decision. The framework extends the Blair and Kesserman (1987) model, who focus on the possibility of introducing formula pricing in an intermediate product market showing the indifference between "make" versus "buy" decisions, by introducing post-negotiated incentives leading to opportunistic behavior by one party when the other party has transaction specific investments. The model generates refutable hypotheses related to the influence of government intervention in the pricing of green leaf tea that reduced the possibility of hold up.

Profit for a representative green leaf producer per period is Π_G:

$$\Pi_G = P_x X_G - (C_{vx}(X_G, P_{ZG}) + \alpha)X_G - I_G \qquad (1)$$

where P_x is the price per kilo of green leaf tea for the representative green leaf producer, X_G is the amount of green leaf tea produced, $C_{vx}(X_G, P_{zG})$ is the short run average variable cost function that is convex in X_G, P_{zG} is the input price vector, α is an additive exogenous shift parameter that decreases with increases in management efficiency, and I_G is the amortized investment cost of establishing a green leaf tea farm. A representative green leaf tea producer maximizes equation (1) through the choice of green leaf tea production (X_G). Solving the resulting first order condition in terms of X_G, generates the individual output supply function X^*_G that is a function of green leaf price, input price, and technology. Given the optimal supply for a representative green leaf producer and the number of green leaf producers (N^G) maximized total profit of green leaf tea production sector ($\overline{\Pi}_G$) is;

$$\overline{\Pi}_G = N^G [P_x X_G^* - [C_{vx}(X_G^*, P_{zG}) + \alpha]X_G^* - I_G] \tag{2}$$

Profits for a representative green leaf tea processor per period, Π_P, can be summarized as;

$$\Pi_P = P_Q Q(X_P) - P_x X_P - C_{VQ}(Q(X_P), P_{ZP})Q(X_P) - I_P \tag{3}$$

where P_Q is the price per kilo of black tea (Q) received, $Q(X_P)$ is the concave transformation function converting green leaf tea to black tea, X_P is the amount of green leaf tea procured, $C_{VQ}(Q(X_P), P_{ZP})$ is the short run average variable cost of black tea processing, P_{ZP} is a vector of input prices, and I_P is the amortized investment cost of establishing a processing facility. A representative processor maximizes profit (3) through the choice of the amount of green leaf purchased. Solving the resulting first order condition in terms of X results in the processor's input (green leaf) demand function (X^*_P) which depends on the prices of black tea, green leaf, and other processing input prices. The aggregate profits ($\overline{\Pi}_P$) for processors where N^P is the total number of processors is

$$\overline{\Pi}_P = N^P [P_Q Q(X_P^*) - P_x X_P^* - C_{VQ}(Q(X_P^*), P_{zP})Q(X_P^*) - I_P] \tag{4}$$

The profits for growers and processors and hence the joint profits depend on the supply and demand functions of green leaf. The green leaf tea price (P^*) that maximizes the joint profit ($\overline{\Pi}_G + \overline{\Pi}_P$) is achieved in a competitive market equilibrium. Any green leaf price that deviates from P^* would change each party's profit and reduce joint profits. The model could derive the green leaf price that achieves this maximum joint profit with a given set of exogenous variables ($\alpha, P_{ZP}, P_Q, P_{zG}$).

Suppose a social planner carries out both green leaf production and processing activities in such a way as to maximize the joint profits from both stages. In other words, the social planner runs the two activities as a vertically integrated operation (denoted by subscript I for the integrated operation). The profits of the social planner, Π_I, would be;

$$\Pi_I = P_Q Q(X) - [C_{VX}(X, P_{zG}) + \alpha)]X - I_G - [C_{VQ}(Q(X), P_{ZP})]Q(X) - I_P \qquad (5)$$

Since production is integrated, the subscript for green leaf tea production ($_G$) and green leaf processing ($_P$) is irrelevant as is the green leaf tea price (P_x). Assume that input prices for both green leaf production and black tea processing are fixed. The joint profit now becomes a function of size of green leaf production along with the exogenous parameters of P_Q, and α. The optimal green leaf tea production (X^*) that maximizes equation (5) is found by solving the following.

$$\frac{\partial \Pi_I}{\partial X} = P_Q \frac{\partial Q(X)}{\partial X} - \frac{\partial C_{vx}(X)}{\partial X} X - C_{vx}(X) - \alpha - \frac{\partial C_{VQ}(Q)}{\partial Q} Q(X) - C_{VQ}(Q) \frac{\partial Q(X)}{\partial X} = 0 \qquad (6)$$

The implicit function theorem states that when the equation (6) holds there exists a function; $X^* = X^*(P_Q, \alpha)$ relating the exogenous variables to optimal green leaf procurement (X^*). Solving for the inverse of the optimal level of industry or individual green leaf demand function derived through (3), the equation $X^* = X^*(P_Q, \alpha)$ could be substituted to determine the joint profit maximizing green leaf price relationship with the above exogenous parameters as shown in (7).

$$P_x^* = P_x^*(P_Q, \alpha) \qquad (7)$$

If independent green leaf producers and processors adhere to this price function, their joint profit will be maximized as in a vertically integrated production situation. If so, parties would be

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indifferent to vertical coordination arrangements. However, the possibility of hold up threats with the arms length transactions might prevent the parties achieving P^*.

2.A. Green Leaf Tea Prices and Transaction Costs

Suppose green leaf tea producers and processors are independent and their arms length transaction adheres to the joint profit maximizing green leaf price (P^*) as derived in the equation (7). The return to the investment of a representative green leaf farmer is total revenue (P^*X_G) minus total variable costs ($C_{vx}(X_G) X_G$). The opportunity cost of investing in a tea garden is the salvage value of that asset (S). Net revenue minus salvage value is known as the quasi-rent of the asset or the returns that the investor will be deprived of by quitting production (Klein, Crawford and Alchian, 1978).

The threat of hold up exists if the return from the next best alternative trading arrangement is lower than the returns from the best trading arrangement (Klein, Crawford and Alchian, 1978). Suppose the next best alternative buyer is another processor (denoted as processor B). Assume the price of green leaf is the joint profit maximizing price of P^* but that the producer incurs a per kilo cost of $T(D)$ associated with perishability-related expenses, which increase with the distance (D) to haul to the next alternative processor. Therefore, quasi rent from next best alternative to the green leaf producer would be $[P_x^*-T(D)-C_{vx}(X_G)]X_G -S$.

Specialized quasi rent is the difference between quasi rents from the best trading arrangement and next best trading arrangement (Klein, Crawford and Alchian, 1978). Thus, the specialized quasi rent (SQR) for a representative green leaf tea producer is;

$$SQR = [(P^* - C_{vx}(X_G))X_G - S] - [(P^* - T(D) - C_{vx}(X_G))X_G - S] \qquad (8)$$

The *SQR* is reduced to $T(D)X_G$ and thus solely dependent on $T(D)$[2]. The best trading partner (processor *A*) might try to extract the *SQR* knowing that this portion of quasi rent is available to the other party only through him. Thus, the specialized quasi rent for a green leaf producer is vulnerable to hold up threats by the best trading partner. It is possible that processor *A* might act opportunistically and misrepresent information relevant to the joint profit maximizing price (P^*) and offer prices, *P* (green leaf prices other than P^*), lower than P^* such that $P>P^*-T(D)$. Once the investment is committed to planting tea (with substantial sunk cost), the green leaf producer's best choice is to sell tea at this price, $P \geq P^* - T(D)$ rather than sell to processor *B* provided that $T(D) \geq 0$ and $P \geq C_{vx}$. There may be extreme situations when $T(D)$ is prohibitively large due to the lack of transportation facilities and the perishability of green leaf tea allowing *P* to be pushed to its limit such that $P = C_{vx}$. Green leaf prices lower than P^* can lead to long run losses on the grower's investment and eventual exit from the industry. The threat of hold up prevents mutually beneficial exchange opportunities for both parties. The "buy" decisions with prices less than P^* lead to lower joint profits, and lower levels of green leaf production, relative to the "make" decisions in which hold up threats are absent. Thus, it is possible that "make" decisions were encouraged and "buy" decisions were discouraged due to the possibility of hold up problem in the period of arms length transactions in the Sri Lankan green leaf market.

The existence of a hold up problem hinges on the size of switching costs or the difficulty of diverting the investment in green leaf production to alternative uses. The cost of establishing green leaf tea fields is the largest among the perennial crops, yet the revenue from tea is

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[2] The relative size of *T(D)* could be assessed by how sparsely the independent processors are distributed. In 1972, the regional classes (based on elevation) had following number of independent processors; High grown (area 1653 square mile and 1 independent processor), Mid grown (area 2326 square miles and 22 independent processors), Low grown (area 2384 square miles and 33 independent processors). The other related factor is cost of transportation and availability of transportation facilities. A survey on tea small holders in 1994 found that only 12% had their own vehicles to transport green leaf to the processors (see Herath, 2001 p. 212).

comparable to other perennial crops in Sri Lanka (see Table 3). Prior to field establishment of tea plants about two years of soil-rehabilitation is recommended (Handbook of Tea, 1986). In addition, there are specific field related investments, such as shade trees, drains, and terraces, which are not useful in the production of any other crops. Tea takes approximately seven years from its initial field establishment to reach a harvestable age and this is the second longest waiting period to reach the harvestable age among the perennial crops (see Table 3). As a result, production related sunk costs are larger for green leaf tea production than other perennials.

The lock in nature of the farmer's investment and large switching cost are an important reason why green leaf producers prefer contractual arrangements to a spot market (Masten, 1991; Grosh, 1994; Delgado, 1999). The existence of relationship specific investment and the large transactional frictions associated with bargaining and reaching an agreement on price in an unregulated green leaf tea market would favor vertical integration as the coordination mechanism. However, these transaction costs were altered by the following green leaf tea pricing formula implemented in 1968 (all the components are measured in the units of Rupees/kg);

$$\text{Price of green leaf} = \frac{\text{Black tea price} - \{\text{cost of processing} + \text{processor' s profit}\}}{4.5}$$

The denominator of 4.5 is the weight of green leaf required to make a unit weight of black tea (Report of the Committee on Tea Small Holdings Sector, 1980 p.17). Black tea price is determined in the Colombo auction and the black tea processor is a price taker. The above formula ensured profits to processors but did not necessarily provide profits for green leaf tea producers. It was modified in 1978 to include a guaranteed minimum price but inflation in Sri Lanka since 1978 negated the effectiveness of the minimum price as the consumer price index

almost tripled from 1975 to 1984. Hence, minimum prices were proportionately increased with the inflation level. Finally, in 1984, the guaranteed minimum price was eliminated by the "Reasonable Pricing Formula" which split the black tea price with 25% going to the processor and 75% to the green leaf supplier. In 1985, the shares changed to 30% and 70% and in 1987 to 32% and 68%. This formula price for green leaf tea remains in effect.

The price intervention imposes at least a lower bound on the range of green leaf prices between C_{vx} and P^*. Without having actual green leaf prices before and after the price intervention, one cannot definitely claim whether the green leaf price after price intervention stays in the neighborhood of P^*. Yet, this assertion can be empirically tested. If the price intervention forces green leaf tea prices to deviate substantially away from P^*, vertically independent production would not go up. This is because if the price intervention results in green leaf tea prices to exceed P^* substantially, black tea processors would resort to producing their own green leaf, given management cost and production cost stays unchanged. On the other hand if the price intervention makes green leaf tea prices to fall substantially short of P^*, green leaf producers eventually shy away from green leaf production. In either case, vertically independent production is unlikely to go up. The following two hypotheses are developed to test these assertions.

> ***Hypothesis 1***: *The share of black tea production and green leaf output from a vertically independent sector relative to a vertically integrated sector increased with the extent of government intervention in the pricing of green leaf tea which reduced the potential for hold up threats.*

Hypothesis 2: *If both the vertically independent sector and integrated sector respond to black tea prices identically, ceteris paribus, there should not be any systematic relationship between black tea prices and the share of black tea production by either sector. However, in the presence of hold up threats, ceteris paribus, the supply response to black tea prices by the vertically integrated sector would be larger than that for the vertically independent sector.*

2.B. Production Costs and the "Make" vs. "Buy" Decision

In the theoretical model, the short-run average variable cost function of green leaf production is assumed to be same for independent producers (equation 1) and vertically integrated producers (equation 5). However, differences in these cost functions could result in differences in the purchase price of green leaf tea by independent processors or the internal transfer price of green leaf tea by vertically integrated processors. Suppliers of an input may be able to produce at a lower cost than vertically integrated units due to economies of size and learning associated with providing the input for a number of purchasers in the market.

Size economies are not present in the production of green leaf tea which remains a labor intensive activity. Mendis (1992) and Roberts (1989) showed that Sri Lankan tea production exhibits constant returns to scale technology while Ramachandran (1963), Etherington (1971), Casperze (1975), Fernando (1981), and De Silva (1982) also rejected scale economies in the growing of green leaf and the subsequent cost advantage associated with larger production units. Over 72% of the cost of green leaf production is labor related (Herath, 2001) and both vertically integrated plantations and small farms continue to use the same labor intensive production

technology to grow and harvest green leaf tea. Thus, relative wage rates are the major factor affecting the difference in the cost of producing green leaf tea.

Wage rates have increased in the vertically integrated sector due to a unionized labor force relative to the opportunity cost of labor for the independent growers who tend to rely on family workers.   The political importance of the plantation labor force, which is ethnically based labor union *cum* political party, have been increased with the constitutional changes took place in 1978 (see Herath, 2001).   The changes towards market procurement of green leaf tea ("buy" decision) and avoiding in-house production ("make" decision) can be viewed as an attempt to reap the cost advantages of green leaf tea production from vertically independent small farms. The hypothesis about the association between the changes in relative opportunity costs of labor and the changes in vertical coordination arrangements of black tea production is as follows:

> **Hypothesis 3**: *Changes in relative production costs as driven by the opportunity cost of labor decreased the share of green leaf grown by vertically integrated processors as compared to the share of green leaf purchased by independent processors.*

2.C. Management Costs and the "Make" vs. "Buy" Decision

Management costs are the costs of organizing resources within firm and are represented by " in (1) and (5). The management efficiency parameter (") is assumed to be same for independent producers (equation 1) and vertically integrated producers (equation 5). Management costs may be higher within vertically integrated units due to the presence of agency and influence costs and the reduction of competitive pressures. Bringing what was formerly a market transaction in-house increases the size of an organization, which often results in

additional hierarchical levels. As firms get bigger, with additional hierarchical levels and greater distances between superiors and subordinates, agency costs likely increase. On the other hand, Williamson (1985) argues that markets promote high-powered incentives and restrain bureaucratic distortions more effectively than internal organizations.

The relative difference in management costs in the vertically integrated and independent systems in the Sri Lankan tea industry substantially changed with the nationalization of plantations in the mid 1970s. With the nationalization and land reform policies in 1972 and 1975, state acquired 377,000 acres of privately owned tea lands which represented about 63% of the total tea area of the country. The acquired lands were larger than 50 acres in size and so were mostly vertically integrated operations. About 96% of these state-owned tea lands were assigned to two state corporations for management; State Plantation Corporation and Peoples Estate Development Board. The two state corporations, which were devoid of any market incentives in any of its operations, ended up in a bureaucratic gridlock and by 1992, management of these two entities were transferred to private management companies.

There were several spheres of management of vertically integrated operations that went wrong under the state ownership and management. First, the incentives for managers that had existed under the private ownership, such as profit-sharing bonuses and the prospect of climbing higher in the estate management were absent under the nationalized-management (Rote, 1986 p.215). Government salary scales were applied to the managers in the state corporations and these salaries were less than the manager's remuneration under private ownership (Rote, 1986). In addition, the salaries and other remuneration of the managers/bureaucrats were independent of the profits or losses of the tea farms they managed (Bandaranaike, 1993). Critics have noted the various management failures during the period of state ownership in running the vertically

integrated large tea farms, such as land and soil management practices, tea bush maintenance (Tea Master Plan, 1978), adequate fertilizer application (Sinnathamby and Deveraj, 1987), and replanting (Peiris, 1984; Sinnathamby, 1993).

Between 1978 and 1992, black tea production in these two corporations declined by 19% and there were five years with negative profit margins (Herath, 2001). The average cost of producing black tea for privately-owned, large tea farms for the five-year period before state ownership (1972-76) was 3.00 (1952 constant Rs/kg) and doubled to 5.86 in the 1986-91 period during the state ownership. In the re-privatization process in 1992, 52 large tea farms were identified as non-viable or uneconomical to continue because they had losses in each of the previous 5 years and the yield of tea was below 1000 kg per hectare (World Bank 1997). These 52 large tea farms covered about 47,640 acres or about 13% of the total tea land acquired with the land reform laws of 1972 and 1975. While the management costs of vertically integrated sector seems to have increased under the state ownership and management, there were no specific changes took place in the vertically independent small holders or black tea processors that led to an increase in their relative management costs. All else equal, increase in management costs of vertically integrated production system during the period of state ownership relative to the management cost of vertically independent sector would lead to an increase in the competitiveness of independent units.

> **Hypothesis 4**: *An increase in management costs of vertically integrated system during the period of state ownership from 1975 to 1992 relative to the management costs in vertically independent system increased the share of black tea production from vertically independent units during this period.*

3. EMPIRICAL MODEL

3.A. Dependent Variable

The changes in vertical coordination arrangements within the Sri Lankan tea industry are proxied by the ratio of black tea produced from market-procured green leaf (vertically independent production) to total black tea production. The amount of black tea processed from market-procured green leaf and self-grown green leaf is available from 1980 to 1998 (see Table 1). This measure is estimated for the period of 1960 to 1979 on the basis of the amount of black tea processed at the regional levels which are categorized according to elevation. The main suppliers of market-procured green leaf are small tea farmers and they are based largely in the Low Grown elevation class. There is a significant correlation between black tea production from market-procured green leaf and black tea production in the Low Grown region for the period of 1980 to 1998 (Pearson correlation coefficient of 0.998). The share of black tea processed from bought green leaf is estimated as a function of black tea produced in the Low Grown region using the available data and resulted in the following regression equation (t-values in parentheses):

Black Tea from Bought Green Leaf = -17.01 + 1.146 (*Low Grown Black tea Production)*
$\qquad\qquad\qquad\quad$ (-4.68)$\quad$(31.74) $\qquad\qquad\qquad$ Adj R^2 = 0.982

The dependent variable is estimated for the period of 1960 to 1979 using the above equation.

3.B. Independent Variables

The theoretical model generated four hypotheses related to the relative costs of vertical integration versus independent units or the make versus buy decision. Each hypothesis can be tested with the following explanatory variables.

Dummy variables for different time periods are introduced to capture the effects of green leaf tea price interventions in allaying the hold up problems and expanding the share of black tea production in the vertically independent sector (Hypothesis 1). During the period from 1960 to 1968, there was no intervention in the green leaf market. From 1969 to 1978, there was a formula for sharing black tea price, which did not guarantee a minimum price for the growers. A minimum price was granted in 1978 but it did not account for the inflationary pressure so the minimum price was adjusted upward occasionally. The Reasonable Price Formula was put into effect in 1984, which specified a sharing rule of the auction prices for black tea between the growers and the processors.

Two time dummy variables are introduced to differentiate the three periods of government involvement in the green leaf market; *Price Inter I* is set equal to one for the period of 1969 to 1984 and equal to zero otherwise. *Price Inter II* is equal to one for the period 1985 to 1998 and zero otherwise. It is hypothesized that during the period of unabated hold up threats, the share of black tea production by the vertically independent sector would be smallest. In contrast, the pricing intervention is expected to increase the amount of black tea processed with purchased green leaf. The reduction in the hold up potential is hypothesized to be greatest during the period of Reasonable Price Formula (1985 to 1998). The hypothesized positive coefficient for *PriceInter II* is expected to be larger than that for *PriceInter I*.

Higher black tea prices should increase green leaf production for both the "buy" decisions (vertically independent growers) and the "make" decisions (vertically integrated growers). However, an increase in "buy" decisions is dependent on the share received by the green leaf producer for his green leaf, yet this is not relevant to the "make" decision. This share for the green leaf tea producers is influenced by the potential for hold up problems. Thus response by

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the vertically independent sector could be constrained by the potential for hold-up. If independent green leaf growers do face the threat of hold-up, it is hypothesized that the own-price response of the vertically integrated sector is larger than that for the vertically independent sector (Hypothesis 2). Thus, all else equal, the ratio of black tea production by the vertically independent sector from total black tea production should be negatively related with the black tea prices. A three-year lag of black tea price (*Price*) is used to capture the effect of black tea prices on the relative production shares. The average Colombo auction black tea price (constant 1952 Rs/kg) was obtained from the annual report of Central Bank of Sri Lanka. These prices ranged from a low in 1966 of Rs/kg 2.62 to a high of 11.63 in 1984 with an average of 4.83 Rs/kg.

The opportunity cost of labor for the vertically integrated sector is taken as the plantation sector daily (real) wage rate while that of vertically independent sector is assumed to be the industrial sector daily (real) wage rate. These wage rates were collected from the annual reports of the Sri Lankan Central Bank. The ratio between industrial sector wages and plantation sector wages (*WR*) is the proxy variable representing the change in the opportunity cost of labor between vertically independent integrated sectors. All else equal, as the relative labor cost of vertically integrated sector increases black tea production in vertically independent sector would be relatively more profitable (Hypothesis 3). The average of the wage rate ratio is 1.3 but it has dropped from a high of 1.85 in 1971 to a low of 0.91 in 1997.

A dummy variable (*State*) is introduced to capture the effects of distorted incentives and larger management costs associated with state ownership in the vertically integrated sector. In contrast, the management costs of the vertically independent sector are assumed to remain unchanged or to not increase as much as for the plantations. Thus, it is hypothesized that under the period of state ownership, the share of black tea production by the vertically independent

sector is higher than the rest of the period (Hypothesis 4). The period from 1976 to 1992 vertically integrated production system was under state ownership and management, thus for this period *State* is set equal to 1 and equal to 0 when plantations were under private management from 1960 to 1975 and 1993 to 1998.

3.C. Econometric Model

The regression model relating the share of total tea production produced by independent processors to the five explanatory variables defined in the previous section is estimated through the following Box-Cox transformation;

$$Y^{(\lambda)} = \gamma_0 + \gamma_1 WR^{(\lambda)} + \gamma_2 Price^{(\lambda)} + \gamma_3 State + \gamma_4 PriceInterI + \gamma_5 PriceInterII + U$$

where λ is the Box-Cox parameter, γ are the regression coefficients, and U is the error term. The transformation enables the estimation of functional form parameters that best fit the data (Davidson and MacKinnon, 1993). The problem of the covariance matrix of the γ coefficients conditional on the value of λ in the maximum likelihood estimation is resolved through re-scaling the data set by dividing each variable by its geometric mean as suggested by Spitzer (1984). Such a re-scaling leaves the Box- Cox parameter (λ) unaffected but the γ coefficients are no longer interpreted as the partial derivatives of the associated independent variable with respect to the dependent variable but rather as point elasticities estimated at the geometric mean.

4. RESULTS

The estimated model explains the variability in the changes of vertical coordination arrangements well. The adjusted R^2 is 0.96 and the *F*-value is significant at the 1% level. The Durbin-Watson statistic is 2.004 so that the null hypothesis of positive or negative first order

autocorrelation in the error term is rejected (Gujarati, 1995). The signs of all estimated coefficients are consistent with the theory and all the estimated coefficients are statistically significant at the 95% or higher confidence level with the exception of *State* dummy (Table 4).

State intervention in the pricing of green leaf tea was expected to increase the share of black tea produced with purchased with green leaf tea (*Y*) because the determined prices would reduce the hold up problems between vertically independent green leaf growers and black tea processors. The mean values of *Y* are higher for both the pricing intervention regimes relative to the base period without price intervention and the differences are statistically significant at 95% confidence level. More importantly, the mean value of *Y* (0.369) was higher during the regime of the reasonable pricing formula (*PriceInterII*) relative to the mean value of *Y* (0.067) during the regime of government determined prices (*PriceInterI*). Therefore, the theoretical proposition about the impact of pricing intervention in expanding the equilibrium output in the vertically independent sector is consistent with the data. During the first price intervention regime of 1969 to 1984 (*PriceInterI*), the government arbitrarily determined the green leaf price which were not directly linked to black tea prices. In contrast, the reasonable price formula in place from 1985 to 1998 (*PriceInterII*) determined the price any green leaf grower would receive on the basis of reasonable returns to the growers and the conversion factor of green leaf into black tea. Thus, the pricing intervention reduced the transaction costs for independent arrangements and the effect was greater under the formula pricing regime.

The negative sign for the coefficient on black tea price (Price) is consistent with hypothesis 2 and is statistically significant at the 95% confidence level. It was argued that if the supply responses to black tea price are the same for the vertically integrated and independent sectors, *ceteris paribus*, there should not be any systematic relationship between the share of

black tea production by either sector with black tea price (since *Y* is a ratio, it stays constant if both sectors respond identically). While an increase in black tea price would increase the amount of tea grown and produced by plantations, the threat of holdup means the increase in profitability associated with an output price increase may not be translated to all parties in an arms length transaction. Thus, negative relationship found between the share of black tea produced from independent processors with purchased green leaf and the price of black tea is consistent with the hypothesis.

The coefficient of the ratio of relative opportunity cost of labor for independent (small) farms and vertically integrated plantations (WR) is consistent with expectations and significant at the 99% confidence level. Hypothesis 3 argued that, all else equal the "make" versus "buy" decision depends on the production cost differences associated with growing the green leaf in-house and buying it from independent growers. Labor remains the major expense for green leaf production regardless of farm size as there are no economies of size in production. The influence of unionization has increased the wage cost of labor on plantations relative to the cost of family labor used by most independent growers. Thus, the "buy" decision has become less expensive relative to the "make" decision. The returns for independent processors have increased relative to plantations since the cost of purchased green leaf tea is less than the internal transfer price for green leaf in vertically integrated units. Thus, the decrease in relative production costs of green leaf is an important economic force associated with the changes in vertical coordination arrangements.

The coefficient for the dummy variable *State* is not significant yet has the expected sign. The mean value of *Y* was expected to be larger during state ownership of vertically integrated plantations from 1976 to 1992 relative to the period of private ownership from 1960 to 1975 and

from 1992 to 1998. It was argued that, all else equal, state ownership of vertically integrated plantations would increase management costs relative to the independent sector due to the influence of agency and influence costs (Hypothesis 4). Resulting increase in management costs associated with state ownership of vertically integrated units did result in more of the total tea output being produced from independent units but the effect is statistically insignificant.

5. CONCLUSIONS

This paper provided a unifying conceptual framework to characterize the factors affecting vertical coordination arrangements. Unlike the changes within agriculture in developed countries, the Sri Lankan tea sector has changed from one dominated by vertically integrated plantations to one where independent processors of black tea purchased their input (green leaf tea) from small, independent growers. The shift can be explained by changes in transaction and production costs that have altered the relative benefits of the make versus buy decision for green leaf. State intervention into the price for green leaf tea has significantly reduced the threat of hold up due to the perishability of green leaf and the large, sunk investment costs to the farmer associated with establishment of a tea garden. Not only have the returns to independent green leaf production been raised and stabilized, the costs of growing have not increased relative to the production of green leaf on plantations. The technology for green leaf continues to be labor intensive regardless of the size of operation. Union pressures have forced wage rates up for workers on plantations relative to the expenses for the family labor used by most independent growers. The result is a shift in the profitability toward separated growing of green leaf and its processing into black leaf tea and away from vertically integrated plantations. Structural changes from plantation production systems that have been reported in many Asian and African countries

could also be explained by this framework in which the agents in the sector respond to underlying changes in technological parameters and institutional regimes.

In explaining structural changes in agriculture, the role played by institutional regimes and other forces governing exchange arrangements have not been fully explored nor understood (Masten, 1991). In order to harness market mechanisms in facilitating agriculture development, a deeper understanding of the workings of institutional regimes are important. This paper illuminates how transactional friction could be alleviated by changes in institutional regimes but they could also serve to increase transaction costs. This paper also demonstrates that technologically determined production costs and management costs also play significant roles in determining the optimal vertical coordination arrangement for production.

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Table 1. Black Tea Production from "make" & "buy" green leaf tea (million kg)

	From vertically integrated green leaf (make: vertical links of (1) in Figure 1)					From market-procured green leaf (buy: vertical links of (2), (3) and (4) in Figure 1)					Total (10+11)
Year	JEDB[#]	SLSPC[*]	RPC[♣]	Other State Agencies	Total	JEDB	SLSPC	RPC	Total	Independent Processors	
1	2	3	4	5	6	7	8	9	10	11	12
1980	70.4	64.43	0	7.9	142.73	7.00	13.45	0	20.45	32.20	52.65
1981	78.6	65.07	0	9.2	152.87	7.00	15.33	0	22.33	36.70	59.03
1982	64.8	57.88	0	7.4	130.08	5.10	12.12	0	17.22	35.50	52.72
1983	60.2	52.94	0	7.8	120.94	4.70	11.76	0	16.46	38.70	55.16
1984	74.1	58.25	0	8.5	140.85	5.30	14.45	0	19.75	48.40	68.15
1985	72.3	59.72	0	8	140.02	5.40	13.38	0	18.78	54.80	73.58
1986	69.1	58.42	0	8	135.52	4.70	12.49	0	17.19	57.60	74.79
1987	67.6	55.58	0	8.6	131.78	4.90	12.12	0	17.02	66.30	83.32
1988	69	57.05	0	9.3	135.35	5.40	12.45	0	17.85	73.90	91.75
1989	64.3	51.35	0	7.8	123.45	5.10	12.05	0	17.15	68.90	86.05
1990	67.2	52.18	0	8.1	127.48	5.00	14.44	0	19.44	85.90	105.34
1991	65.7	53.3	0	8.1	127.10	5.20	14.00	0	19.20	92.10	111.30
1992	2.5	3.2	80.2	2.3	88.20	0.30	0.000	16.15	16.45	77.70	94.15
1993	3.4	3	108.98	6.7	122.08	0.30	0.001	25.3	25.60	86.40	112.00
1994	3.8	3.25	112.97	9	129.02	0.30	0.006	24.72	25.03	90.90	115.93
1995	3.9	0.003	107.82	9.9	121.62	0.26	0.00	25.84	26.10	94.00	120.10
1996	3.9	3.7	106.69	10.8	125.09	0.23	0.13	26.46	26.82	111.30	138.12
1997	3.9	4.2	117.38	10.8	136.28	0.20	0.60	28.52	29.32	111.30	140.62
1998	3.7	4.2	111.87	11.6	131.37	0.18	1.21	31.78	33.17	124.00	157.17

Source: Plantation Sector Statistical Pocket Book 1999; Columns 2,3,4,7,8, and 9 from
Table 5.23 (p.139), and column 5 and 11 from Table 2.5 (p.24).
[#]JEDB (Janatha Estates Development Board), [*]SLSPC (Sri Lanka State Plantation Corporation),
[♣]RPC (Regional Plantation Companies)

Table 2. Number of black tea processors and their green leaf out sourcing

% of outsourced green leaf from the total green leaf procurement	Number of black tea processors		
	1973	1993	%Δ
0	429	117	-73
<50%	177	135	-23
>50%	147	151	+3
100%	63	184	+192

Source: Report of the Presidential Commission on the tea industry and trade 1995 p.80

Table 3. Estimated Cost of Developing and Bringing into Bearing Tea and some Alternative Crops in Sri Lanka (nominal prices in 1968)

Crop	Cost (Rs per Acre)	Annual Revenue (Rs/Acre)	Ready to Harvest At Years	Economic Life Span (Years)
Tea	4000-6000	326	6-7	40-50
Coconut	1,000	277	6-8	60-70
Oil Palm	1,500	482	NA	NA
Coffee	1,800	500	3	15
Cocoa	2,000	NA	4	20
Cinnamon	995	NA	NA	NA
Cardamom	810	NA	NA	NA
Pepper	2040	NA	4	15
Cloves	1520	NA	NA	NA
Nutmeg and Mace	1800	NA	NA	NA

Source: IBRD, Review of World Tea Economy, 1970 (Annex I, Table 18 & 19)
Tilakaratna, 1984 (Table 4, p.221)

Notes: Coffee, Cocoa, Pepper, Cloves cost up to 5th year including establishment
Cinnamon, Cardamom costs up to 3rd year including establishment
Nutmeg and Mace costs up to 6th year including establishment

Table 4. Maximum Likelihood Estimates of the Factors Affecting the Vertical Coordination Changes

Variable	Estimated Coefficient	Asymptotic T-Ratio	p-Value	Consistent with Expected Sign
Constant	-0.148	-4.369	0.000	Not Applicable
WR	-0.917	-10.80	0.000	Yes
Price	-0.144	-2.361	0.018	Yes
State	0.0145	0.4141	0.679	Yes
Price Inter I	0.067	1.987	0.047	Yes
Price Inter II	0.369	7.886	0.000	Yes

Adj R^2= 0.96, Model F value =195.2[**], Log of the Likelihood Function = 46.29
Box-Cox Parameter (λ) = -0.06, Durbin-Watson statistics = 2.0044,
The likelihood ratio test for functional forms of linear ($\lambda=1$) rejected and logarithmic ($\lambda=0$) not rejected