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A New Global Tea Model

Specification, Estimation, and Simulation

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Takamasa Akiyama and Pravin K. Trivedi

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The World Bank
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ABSTRACT

This econometric model of the world tea economy represents an advance on previous models for perennial crops in several respects: (i) the use of a conceptual framework based on the vintage production model; (ii) the detailed modelling of the supply side to incorporate new planting decisions in three leading producing countries (this specification makes it possible to distinguish explicitly between the long-run and short-run producer responses to changes in exogenous variables); and (iii) the use of a market-clearing rational expectations approach to modelling the "world price" of tea, which leads to a "forward-looking" price equation for tea. The specification of the supply side is more detailed for the four leading producing and/or exporting countries, viz., India, Sri Lanka, Kenya, and Malawi, since there is some attempt to model long-run decisions, such as new planting, replanting, and uprootings. For the remaining producer countries in the model the specification is simpler. There are sound a priori reasons for expecting that the leading producers/exporters will show substantial divergences in their long-run responses to external stimuli. The empirical results support these a priori expectations in that the long-run response in "newer" producer countries, like Kenya and Malawi seems to be different in kind and magnitude from that in the "older" producing countries such as India and Sri Lanka.

Specification of demand is based on fairly conventional demand equations for tea. Compared with previous models, this paper has greater disaggregation by country or geographical zone. There is also a greater attempt to use the appropriate retail price variable in place of the producer price that is often used in demand equations.

Price determination is based on a simplified linear rational expectations model in which a market clearing price is established in each period. The model consists of a supply and demand relation and an inventory demand equation which closes the model. Inventory demand comprises speculative and transactions components, both of which involve expectations of future prices. The insight provided by the analog model--that price depends upon expectations of future values of exogenous variables--provides the basis for specifying and estimating a "world price" equation which plays an extremely important role in the model. The "world price" is linked to the producer prices and retail prices in individual countries through price linkage equations.

The results of simulation exercises are presented to exhibit the properties and weaknesses of the model. In the estimated model, equilibrium is established very rapidly following an initial shock. This characteristic reflects the market clearing assumption and the absence of lags in price determination. More significantly, the dynamic simulation of the model based on such an assumption portrays the historical behavior of prices reasonably accurately, in the specific sense that the spike-like behavior of the price of tea can be reproduced by the model.

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I. INTRODUCTION

The model of the world tea economy described herein has a number of general features which are shared by other econometric commodity models. The stylized version of an econometric agricultural commodity market model usually contains supply equations for the major producers, demand equations for major consumers and either inventory demand equations or price equations. However, within this general structure there are usually many variations. To give the reader some appreciation of these in the specific case of global econometric tea models the paper begins with a brief overview of the relevant literature.

I.1 An Overview of Published Tea Models

The tea models hitherto estimated and published tend to have the structure of market-clearing commodity models. Some of these models are briefly discussed here and their main characteristics are summarized in Table 1 which is adapted from Ramanujam (1984).

One of the earliest model for tea was developed by Murti (1966). In this model the demand for tea was disaggregated and equations were estimated for eight countries or regions. On the supply side only India and Sri Lanka were considered separately and the rest grouped together. An equation explaining the average price of tea in the London market was specified and estimated. Two price-linkage equations modelling the relationship between the London auction price and the internal price of tea in India and the unit value of imports of tea in the United States were also estimated. Finally, the model included identities for total demand, total supply and stocks.

Table 1: A TABULAR SUMMARY OF SOME TEA MODELS

Model & Year of Publication	Murti 1966	Behrman & Adams 1976	Tyler 1975	UNCTAD/FAO 1978	Cheong-Hoy & Ukpong 1981
1. Type of data period covered or used in estimation method of estimation	Annual 1948-1961 OLS	Annual 1956-1971 OLS	Annual 1958-1971 OLS	Annual 1960-1977 OLS & Cochrane Orcutt Procedure	Annual 1957-1978 OLS & Cochrane Orcutt Procedure
2. Main equations	Supply, Demand & Price	Supply, Demand & Price	Exports, imports, Price & Stocks	Supply, Demand, Stocks Price Linkages	Acreage Response, Yield, Response Supply, Demand, & Price
3. Countries covered in supply	India, Sri Lanka & Rest of World	Developed Countries, Developing Countries Centrally Planned	India, Sri Lanka, Indonesia, Kenya, East Africa & Rest of World	India, Sri Lanka, Kenya, Other Africa, Bangladesh, Argentina, Indonesia, & Rest of World	Total Industrialized Countries, Total Centrally Planned, Total Developing Countries, Asia, India, Sri Lanka, Indonesia, Other Asia, Africa, Kenya, Tanzania, Uganda, Other Africa & Latin America
4. Countries covered	UK, US, Canada, EEC	Same as above	37 Countries	UK, US, India, Other Developing Countries & Eastern Europe	UK, US, Canada, Japan, Australia, Other Industrialized Countries, India, Sri Lanka, Indonesia, Iran, Pakistan, Kenya, Latin America, Other Developing Countries, China, USSR, Other Centrally Planned
5. Price variable employed in					
(a) Supply	London Auction Price for Indian & Ceylon Tea	London Auction Average Price	London Auction Average Price	Average Price of four Auction centers, Colombo, Calcutta, Cochin & Mombasa	London Auction Average Price
(b) Demand	London Auction Average Price	Same as above	Same as above	Same as above	Same as above
6. Market structure	Competitive	Competitive	Competitive	Competitive	Competitive
7. Any other features	Lagged adjustments of supply with adaptive expectation of price	Arbitrary selection of different lags on different supply functions	Price lagged one year in the supply functions	Price determined by equilbrating supply and demand	Fixed gestation period. Supply estimated in two ways: Supply = Acreage & Yield Response; and Supply separately

Adams & Behrman (1976) analyzed the world tea economy in a regional framework. This was one of the seven models they estimated for different commodities with a general specification. They specified three supply and three demand functions for three groups of countries. The price equation was estimated in two ways, in terms of the actual price and the deflated price--both prices were related to stocks and with an assumption of lagged adjustment.

Tyler (1975) designed his world tea model to have all imports and exports determined only by the average London price of tea and a time trend. The equilibrium price of tea for any year was specified as that price which ensures total import demand equals total available exports. The inclusion of a time trend as the only other explanatory variable is clearly a simplification. The trend in exports represents the combined effects of assumed steady trends in the productivity of existing estates and smallholdings and in the extension of acreage. The import trend represents secular influences on the demand side.

FAO and UNCTAD (1979) jointly constructed an econometric model of the world tea economy to analyze the prospective supply/demand balance of tea and the implications of an international buffer stock arrangement and an export quota system. The model consists of eight supply equations, six demand equations, eight price-linkage equations and two inventory equations (one for the supply side and one for the demand side). Total supply is defined as sum of total production and carry-over stocks, while total demand is defined as the sum of world consumption and the demand for inventories. There is no explicit equation for price, which is determined by equilibrating total demand and total supply. Supply is considered to be a function of real price and a time trend. Demand is a function of own price, the price of substitute and a time trend.

Cheong-Hoy and Ukpong (1981) developed an econometric model of the world tea economy for the World Bank. They estimated supply functions for some individual tea producing countries and others were aggregated according to geographical and/or economic regions. The supply functions were somewhat different from the earlier models. The authors attempted to distinguish between long-term effects of investment and short-term price effects on yields. The model included 14 country- or region-specific demand functions. The demand for tea was postulated in per capita terms as a function of the relative price of tea with respect to coffee and per capita GDP. The price equation was estimated with the London auction average price as a function of the proportion of implied stocks to total world tea consumption, the fertilizer price and the price of coffee.

I.2 Distinguishing Features of the Present Model

In this section, some of the important differences between the model estimated in this paper and previous tea models are summarized. Several of these differences also apply to previous models of perennial crops. Broadly speaking, the major differences of conceptual and operational nature between the present model and earlier work is in the specification of the producers' supply decisions and in the specification of the price equation. The treatment of the demand equations is largely conventional.

A major difficulty with earlier models of perennial crops is their failure to distinguish clearly between the long-run and the short-run dimensions of the producers' supply decisions. Conventionally, in dealing with the short-run decision the capital stock is taken as given and attention is concentrated on the producers' decision concerning the changes in utilization of

variable inputs (and consequently output) induced by changes in prices. Such an analysis yields a measure of the short-run elasticity of production. To obtain a measure of long-run elasticity, it is necessary to model the response of fixed and quasi-fixed factors to changes in prices. Few global models of perennial crops have attempted this despite the fact that the literature is full of conjectures about the size of the long-run elasticity. The usual approach of specifying an area equation with a distributed lag on prices and of deriving from it both a short-run and a long-run price response has somewhat vague conceptual foundations (Trivedi 1985). In this paper the issue is resolved in the following way:

(i) The conceptual framework is based on the vintage production model (See Trivedi (1985)). Within this framework it is possible to distinguish between actual output, feasible output and potential output in an empirically useful way. Such a framework also explains the components of short-run price response.

(ii) For the major producing countries equations are developed for new plantings and replantings which highlight the role of producer price expectations in the determination of investment decisions. These equations also are potentially valuable for analyzing long-run supply responses. They already incorporate, or given additional data can be made to incorporate, very important local institutional features and incentives that have a key role in determining long-run responses. Moreover, they are consistent with the theoretically more flexible notion of time-variant, long-run supply elasticities.

(iii) For the major producing countries data on new plantings and average age-yield profiles are combined to construct measures of feasible

output which play an important role in the short-run supply equations. Moreover, the measures of feasible output contribute to the ease of interpretation of the supply equations. By contrast, (planted) area equations comprising distributed lags on producer prices are difficult to interpret.

(iv) Both theory and empirical observation suggest that there are important differences between old established producers and newly emerging ones in their supply response to prices. The specification of the tea model exploits this feature at several levels. For example, the new planting and replanting equations and short-run supply equations allow for the differences between countries and, in a few cases, between different types of producers in the same country.

Finally, it is to be noted that the disaggregation by countries is much more extensive than in most previous work.

Coming now to the issue of price determination, a major limitation of previous modelling has been the lack of emphasis on the role of forward-looking variables. The main reason for this lies in the conventional treatment of inventories. In a typical econometric inventory equation the role of expected future prices is not emphasized. It can be shown (see Section V below) that if inventory demand is comprised of a speculative component which depends upon the difference between the expected future price and the spot price and on a transactions component which depends upon expected future demand, and if the market-clearing price is established within each period, this price will depend upon the expected future values of exogenous variables that drive aggregate demand and supply. The derivation of the price equation exploits this feature. The issues involved in estimating such an equation are

discussed below and this discussion makes clear the role of factors such as inflation and exchange rates in commodity price determination. Global commodity modelling has to date not paid adequate attention to these important variables.

Although the treatment of demand for tea is fairly conventional, it needs to be said that previous work in the area has been somewhat cavalier in the choice of the price variable. Often the London auction price has been used in all demand equations whereas a more appropriate variable is the local retail price which would reflect local taxes, margins and the exchange rate. In this model demand for tea is disaggregated to a greater extent than previously. This is desirable because of the important changes in the pattern of consumption that are currently under way. For example, per capita consumption is growing relatively rapidly in India and the Middle East - a factor that has important implications for price behavior.

The rest of the paper is organized as follows. Section II provides an overview of the model and an outline of important features of the data used in estimation. Section III sets out the theoretical specification and the empirical estimates of the supply side. Sections IV, V and VI deal, respectively, with the demand side, price determination and the simulation properties of the model. Section VII concludes. The estimated econometric equations appear in two places, first in the relevant parts of the main body of the paper and again in the Appendix where they have been collected together. Definitions of the variables are also in the Appendix.

II. STRUCTURE OF THE MODEL

The basic structure of the model consists of supply, demand, price and stock blocks. A schematic view of the model is given in Figure 1. The supply block covers production of 15 countries/regions--India, Sri Lanka, Turkey, Bangladesh, Indonesia, Iran, exports of black tea from China, rest of Asia, Kenya, Malawi, Uganda, rest of Africa, USSR, Argentina and rest of Latin America. Of the 15 countries/regions, behavioral equations were estimated for eight regions and the rest were treated as exogenous. The demand block covers demand for 24 countries/regions--United Kingdom, rest of Western Europe, USSR, Eastern Europe, United States, Canada, Australia, New Zealand, South Africa, Pakistan, Saudi Arabia, Arab countries (Abu Dhabi, Bahrain, Oman, Qatar, Dubai, Kuwait and other Arabian states), Iran, Iraq, Syria, Turkey, Afghanistan, North African countries (Algeria, Libya and Tunisia), Egypt, India, Sri Lanka, Indonesia, Chile and rest of world. Of the 24 countries/regions, behavioral equations have been estimated for all except Indonesia, Afghanistan, Iran and Iraq which are treated as exogenous variables. There is one behavioral price equation which determines the world price and 13 price-linkage behavioral equations linking the world price to the major auction prices in producing countries and retail prices in major consuming countries.

All the statistics used are from the various issues of International Tea Council (ITC) publications except for the data on stocks, retail prices, subsidies and other such variables. Efforts have been made to exclude green and other teas from the statistics.

(i) **Production:** Data for each country are from ITC. From the world total, Indonesian smallholders production' in Java and Sumatra, and production in China and Japan has been excluded from the world totals, as

most of this output is of green tea. Exports of black tea from China are treated as part of the world production in the model. This convention allows exclusion of production and consumption of tea in China from the model without causing distortions.

(ii) **Demand:** The statistics used are those of ITC "Tea Imports for Consumption" and "Consumption of Tea in Producing Countries" with few exceptions. For the United Kingdom, "Apparent Consumption" is used. For Pakistan and the United States, net imports of green and other teas are excluded. Morocco is excluded from the model as it mainly imports green tea for consumption.

(iii) **Prices:** The "world" price is a value-share weighted sum of 4 major auctions (Calcutta, Cochin, Colombo and Mombasa) including sales tax, cesses and export duties. Prices used in supply equations are either auction prices excluding sales tax, cesses and export duties or the "world" price adjusted by exchange rates. Prices used in demand equations are retail prices for the United States, United Kingdom, India, Australia and Canada. In those cases where retail price data are not available the "world" price adjusted by exchange rates has been used.

(iv) **Stocks:** "World stocks" used in the price equation is a simple sum of stocks held in United Kingdom, India and Sri Lanka, and denoted by TWS. In the simulation runs of the model, however, the world stocks are calculated as:

$$WK = WK_{-1} + QW - CW$$

where WK = End-of-year World Stocks

QW = World Production

CW = World Consumption

The calculated values of WK for the period 1971-83 showed a correlation coefficient of 0.83 against TWS suggesting that treating TWS as world stocks is not inappropriate. In the ex-post simulation run, an error correction term has been added to adjust the historical discrepancies between WK and TWS. For the ex-ante simulation runs, the discrepancy in 1983, the last year for which data are available, is assumed to persist throughout the period simulated.

III. SUPPLY BEHAVIOR

III.1 General Considerations

This section deals with issues relating to the specification and estimation of relationships which jointly determine the production of tea in the world on an annual basis. The material is divided into three subsections. Sections III.2 to III.4 deal with, respectively: the general issues of specification without emphasis on country-specific detail; the empirical results, on a country basis; and finally the comparison of behavior across countries--at least in respect of certain key parameters. The empirical results are contained in Subsection III.5.

In the case of tea, as also in the case of most tree-crops, when modelling the supply side careful attention has to be paid to four features of the production process: (i) the existence of a biologically-determined gestation lag between planting and obtaining output (ii) the dependence of current production on current as well as on previous levels of inputs; (iii) the existence of significant costs of adjustment in respect of the planting and removal of trees; and (iv) the constraints on planting and removal resulting not only from past decisions but also from the existence of binding non-negativity constraints. 1/ Features (i) - (iv) imply, individually and jointly, that investment behavior of the productive firm cannot be myopic. Features (i) and (ii) imply that the relevant supply theory is intrinsically dynamic. More specifically, if the productivity of trees varies with the age, for given levels of other variable inputs, then the age distribution of the

---

1/ When dealing with aggregate data, feature (iv) may not be as important as it would be in a microeconometric study.

trees becomes important in determining feasible levels of production. The average yield curve for tea shrubs approximates a logistic curve, with the asymptote corresponding to maximum yield obtainable approximately 10 years after planting in the case of the traditional hybrid variety (slightly earlier for vegetatively propagated (VP) clones). There is no significant output in the first four years and yields gradually increase subsequently. Thus, in general, the capital stock should be regarded as heterogeneous with respect to yield. Since the productivity of a tea tree declines very slowly with age (Etherington 1973)--the biologically-productive period can be 90-100 years--to achieve minimum differentiation the stock of trees should be classified into three categories; less than five years old, between five and ten years old and more than ten years old. Furthermore, for countries like India and Sri Lanka which have been growing tea for a long time it would be helpful to disaggregate the last category further into trees less than and more than (say) 60 years old. A further source of heterogeneity in the stock of trees derives from the introduction of VP varieties which have been increasingly adopted since the 1960s. Given these sources of heterogeneity in the capital stock, a major potential misspecification may be avoided by adopting the vintage capital approach to investment and production behavior. This point has been discussed at length in Trivedi (1985). In the next sub-section some of the implications of this approach are spelled out.

III.2 Definitions, Assumptions and Basic Concepts

Production possibilities are characterized by a vintage production function $F[K(t,v),L(t,v)]$ where $K(t,v)$ denotes "capital" of vintage v used at time t and $L(t,v)$ denotes "labor" combined with $K(t,v)$. "Capital" means

homogeneous land planted with trees with some specified density and requiring fixed levels of other inputs such as fertilizers and pesticides. 1/ The variable "labor" refers to all non-capital inputs which are used in fixed proportion to labor. Output is produced only by mature vintages and is assumed to be homogeneous. 2/ Total output $Q(t,v)$ is defined by

$$Q(t,v) = \sum_{v} q(t,v) \tag{3.1}$$

where $q(t,v) = F[K(t,v), L(t,v)]$. (3.2)

Average productivity or yield per unit of capital is given by $q(t,v)/K(t,v)$. Assuming constant returns to scale, this can be derived from (3.2),

$$\delta(t,v) \equiv \frac{q(t,v)}{K(t,v)} = F[\frac{L(t,v)}{K(t,v)}]. \tag{3.3}$$

In general $\delta(t,v)$ would depend upon the wage-rental ratio. Two interesting special cases are

$$\delta(t,v) = \delta(t-v) \tag{3.4}$$

and

1/ In practice the issue is complicated by the existence of mixed stands of trees resulting from infilling of existing area. Removal and replacement of aged or damaged trees by younger trees means that a "capital" unit cannot be regarded as homogeneous.

2/ In the case of tea the assumption of homogeneous output is a simplification. $Q(t,v)$ in equation (3.1) should be thought of as measured in units of "standard" quality. If the relative prices of different types of tea vary a lot, aggregation into "standard" units will be difficult.

$$\delta(t,v) = \lambda(t)\delta(t-v). \tag{3.5}$$

In the case of (3.4) productivity depends only on the age of the trees, denoted t-v, and not upon the time at which they were planted. In the case of (3.5) the productivity of trees of age (t-v) changes smoothly with time at a rate determined by the function $\lambda(t)$ which may be given a specific parametric form.

Capital stock of vintage v at the end of period t, denoted K(t,v), obeys the capital depletion equation

$$K(t,v) = K(t-1, v) - U(t,v) \tag{3.6}$$

where U(t,v) denotes uprootings or removals of vintage v capital in period t. By definition,

$$K(t,t) = N(t) \tag{3.7}$$

where N(t) denotes new plantings (or new investment). One may distinguish between additions to the capital stock from new plantings from those which come about from replanting currently uneconomic area under the same crop or under a different crop. Taking account of replantings leads to a modified version of (3.7), viz.

$$K(t,t) = N(t) + R(t) \tag{3.7a}$$

where R(t) denotes replantings. U(t,v), N(t) and R(t) are all non-negative.

Trivedi (1985) presents a model of a competitive firm which chooses levels of U(t,v), N(t), R(t) and L(t,v) to maximize net discounted revenue. The optimization also involves the choice of the subset of mature vintages denoted V, v ε V, which are economic in the sense that they earn non-negative quasi-rents. The remaining vintages are termed 'uneconomic'. The vector {K(t,v)} where v belongs to the set of uneconomic vintages, denoted $\bar{V}$, is termed the 'stock of uneconomic vintages'. If v^* is the marginal vintage, then under certain conditions all vintages older than v^* will be uneconomic. 1/ The total feasible output, $Q^f(t)$, is defined by

$$Q^f(t) = \sum_v \delta(t,v)K(t,v) \qquad , v \underline{\varepsilon} V \cup \bar{V}. \tag{3.8}$$

Total planned output, denoted $Q^p(t)$, is the profit-maximizing level of output which the firm plans to produce given its expectations about the product and input prices expected to prevail in period t. Given (i) the gestation lag for capital to become productive and (ii) the assumption that the adjustment costs associated with new planting, uprooting and replanting are convex, it follows that the scale of these activities is determined jointly by expected future profitability and past investment decisions, see Trivedi (1985). Expected future profitability in turn depends upon expected future net real product prices and net real input prices. For any given time path of all such prices, there will be profit-maximizing levels of all inputs and the associated set of

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1/ A more general possibility is that the subset of uneconomic vintages can belong to any age class. Various possibilities are considered in Trivedi (1985).

economic vintages. These in turn would imply a profit-maximizing level of output which is called planned output, and denoted Q^P_t. That is,

$$Q^P(t) = \sum_v F\left[K^*(t,v),\ L^*(t,v)\right] \quad , \ v \leq V \tag{3.9}$$

where asterisks denote profit-maximizing levels.

Actual production will differ from planned production both because of stochastic supply stocks and because expectations will not be realized on all occasions. Consider the log-linear identity

$$Q(t) = Q(t)\left(\frac{Q(t)}{Q^P(t)}\right) \qquad \Big| \qquad Q(t) = Q^P(t)\left(\frac{Q(t)}{Q^P(t)}\right) \tag{3.10a}$$

and let

$$Q(t)/Q^P(t) = f\left[P(t)/P^e(t)\right]u(t) \qquad \Big| \tag{3.10b}$$

where $u(t)$ is the supply disturbance and $P(t)/P^e(t)$ denotes the relative error of expectation. Then combining (3.10a) and (3.10b) and taking logs we obtain

$$\log Q(t) = \ln\ Q^P(t) + \ln\left[f(P(t)/P^e(t))\right] + \ln u(t) \tag{3.11}$$

from which can be used to derive the long-term and short-run supply elasticities, denoted $\eta^L_{Q,P}$ and $\eta^S_{Q,P}$, respectively. $\eta^S_{Q,P}$ reflects the effect of an unanticipated price change on current output and can be expected to be positive if the suppliers have some margin for adjustment of output, for example as a result of more intensive application of variable inputs, even when the capital stock is completely determined by previous planting decisions. The long-term elasticity, $\eta^L_{Q,P}$, is given by

$$\eta^{L}_{Q,P} = \frac{\partial \ln Q^{P}}{\partial \ln P^{e}} \cdot \frac{\partial \ln P^{e}}{\partial \ln P} + \frac{\partial \ln \left(f(P/P^{e})\right)}{\partial \ln P} .$$

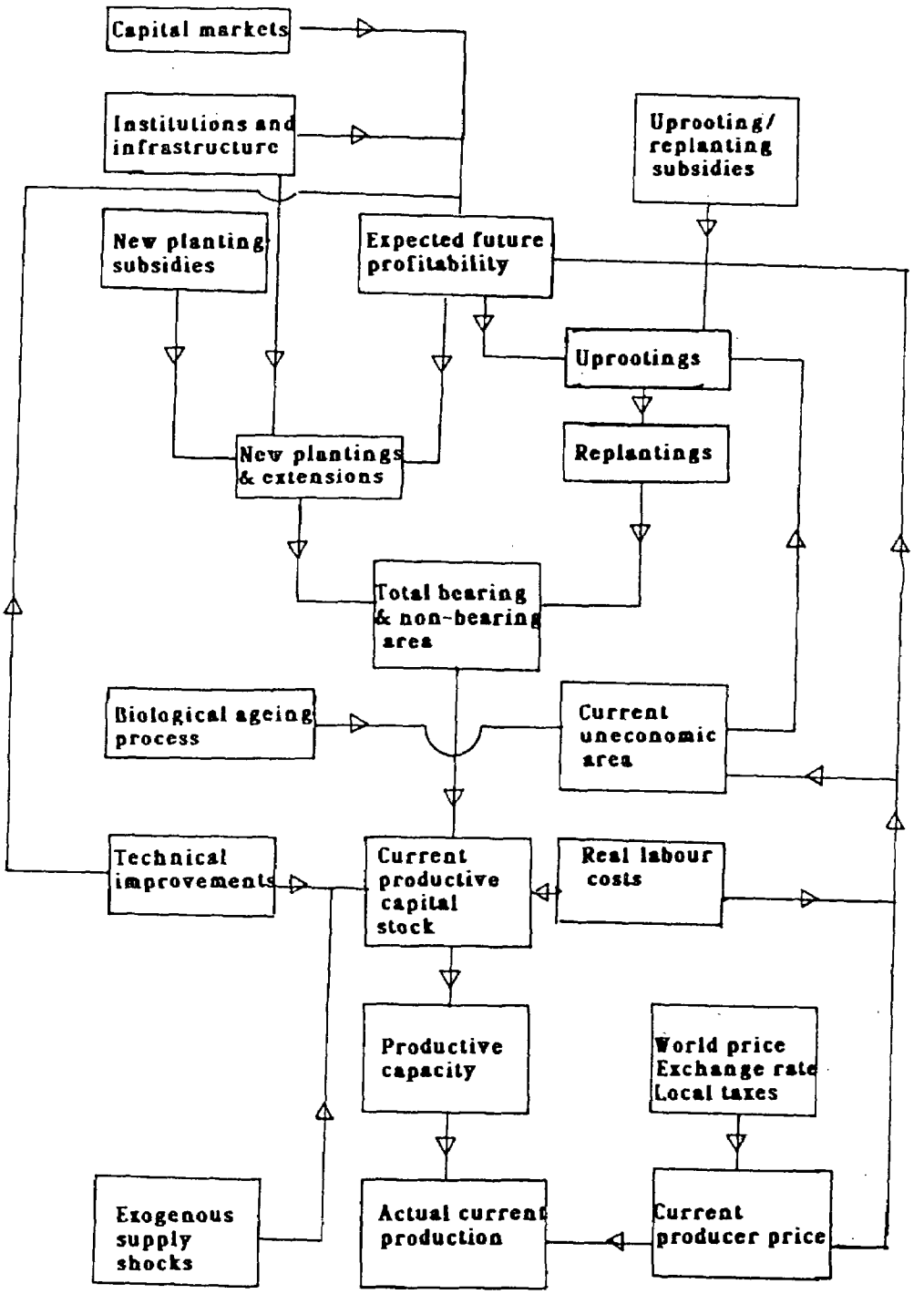
The first derivative on the right-hand side depends, of course, on the sensitivity of new plantings and replantings to variations in price and the second on the elasticity of expectations. If either is negligible, $\eta^{L}_{Q,P}$ and $\eta^{S}_{Q,P}$ will be close.

Equation (3.11) is the generic form of the supply equation used in this paper. The exact variant used in any equation explaining the supply response of any country will depend upon the way in which an equation for Q^{P} is specified and on the assumption made about P^{e}.

Figure 1 which follows gives a schematic representation of the links between the production process and related decisions. It should be read in conjunction with the notes that follow the diagram.

Given the immediately preceding general outline and Figure 1, the immediate task now is to develop estimating equations for the main endogenous variables that appear on the supply side of the model. There will be some differences in the specifications used for different countries, since it is wished to incorporate both the institutional differences within a country and differences in constraints which apply to different countries.

Figure 1: A SCHEMATIC REPRESENTATION OF PRODUCTION PROCESS AND DECISIONS IN A PRICE-TAKING PRODUCING COUNTRY



Notes:

Figure 1 is designed to explain the principle linkages between variables that appear in the supply side of the model. For the main producing and exporting countries, viz., India, Sri Lanka, Kenya and Malawi, these are (i) new plantings, (ii) uprootings, (iii) replantings, (iv) the current feasible level of production and (v) the actual level of production. Where data limitations are an operating constraint, or where the producing country is not 'large' in the relevant sense, only some of these equations have been fitted. The schematic representation of Figure 1 should be followed from the top and centre. Exogenous or pre-determined variables are arranged on the extreme left and right and linked to the important endogenous variables in the centre. Several of these including, for example, the variable 'currently unprofitable bearing area' are not directly observed and the model does not have equations corresponding to them. Nevertheless, for expository reasons they have been included in the diagram. The symbol (L) represents either a simple or a distributed lag.

III.3 Specification of New Plantings and Replantings

The task of specifying suitable models for explaining new plantings is complicated both by the diverse economic environments to which the model is intended to apply and by inter-country differences in data availability. The available data permit estimation of new planting equations for India, Sri Lanka, Kenya and Malawi. 1/ The first two are long established producers which have experienced little or no growth for a considerable period whereas the last two, especially Kenya, have shown a steady growth in production since the early 1960s. Production in Sri Lanka stagnated in the mid-1960s and has since declined.

Production in India has continued to rise but not anywhere near as fast as in Kenya. Furthermore, most of the growth in new plantings in Kenya has occurred amongst the smallholders, 2/ who are probably subject to different economic constraints from the older and more established estate plantations in the same country. In general, it could be expected that the constraints on expansion would be rather different for new emerging producers than for the long established ones. Given these differences, a flexible model to explain new plantings is needed.

The model which seems suitable for India and Sri Lanka is an error correction model (ECM) which is known to be consistent with decision equations

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1/ The data from India distinguish between 'extensions' which represents increases in area and 'replacements' which represents new planting on virgin land. In the case of Kenya and Malawi the available data refer to the net change in the planted area; no separate figures for new plantings and uprootings are available.

2/ See Schluter (1982).

derived from dynamic optimization in the presence of convex adjustment costs.1/ Specifically,

$$N(t) - N(t-1) = \alpha_1\left(N^*(t) - N(t-1)\right) + \alpha_2\left(N(t-1) - N^*(t-1)\right)$$

$$N(t) = \alpha_1 \Delta N^*(t) + (\alpha_1 - \alpha_2)N^*(t-1) + (1-\alpha_1 + \alpha_2)N(t-1). \qquad (3.12)$$

A priori it is expected that $1>\alpha_1>0$, $\alpha_2<0$ provided $N(t)$ is always positive. The fact that $N(t)$ can be zero whenever a corner solution is optimal is a problem. $N^*(t)$ denotes the desired level of new plantings in period t. The objective of new plantings is to obtain some desired level of capacity output in period t+G where G is the gestation lag. Denote this level by $Q^p(t+G)$ and assume that it has been calculated conditionally on expectations about future profitability. If no new planting were undertaken between period t and period t+G, the feasible level of production would depend upon the current feasible production level, $Q^f(t)$, and on the additional production from currently planted but immature vintages. The profitable level of production would be at most equal to $Q^f(t)$, and the profitable level anticipated at t would depend upon expected future prices. Denote this level by $\hat{Q}^p(t)$. Specify that if $Q^p(t+G) > \hat{Q}^p(t)$, then

$$N^*(t) = \beta[Q^p(t+G) - \hat{Q}^p(t)], \qquad \beta>0 \qquad (3.13)$$

which means that the rate of new plantings is an increasing function of the expected shortfall in profitably-usable capacity. Once again, the presumption

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1/ See Nickell (1985).

that $N^{*}(t)$ is non-negative is troublesome, since the expected shortfall in capacity can be negative. If the shortfall is negative there may be an incentive for uprooting or replanting of unprofitable trees.

Let $Q^{P}(t+G)$ be linear in two sets of variables Z_1 and Z_2 which are determinants of expected future profitability and which will be specified later, and let $\hat{Q}^{P}(t)$ be linear in Z_1; 1/ that is,

$$Q^{P}(t+G) = f_1 Z_1(t) + g_1 Z_2(t) \tag{3.14}$$

$$\hat{Q}^{P}(t) = f_2 Z_1(t) \tag{3.15}$$

where f_1, f_2 and g_1 are vectors of parameters. Combining (3.12) ~ (3.15) leads to,

$$\begin{aligned} N(t) = {} & \alpha_1[\beta(f_1-f_2)\,(Z_1(t) - Z_1(t-1)) + \beta g_1(Z_2(t) - Z_2(t-1))] \\ & + (\alpha_1-\alpha_2)\,\beta[(f_1-f_2)\,Z_1(t-1) + g_1 Z_2(t-1)] \\ & + (1-\alpha_1+\alpha_2)\,N(t-1). \end{aligned} \tag{3.16}$$

which is the type of equation estimated for Sri Lanka.

1/ Slightly greater generality can be achieved by allowing $\hat{Q}^{P}$ and Q^{P} to depend upon, respectively, Z_1 and Z_2 and Z_1 and Z_3. That is, Z_1 is the common subset of variables and Z_2 and Z_3 are specific to $\hat{Q}^{P}$ and Q^{P}, respectively.

As usual in error correction models, the right-hand side variables appear in first difference and also in (lagged) level form. Note also that if corresponding elements of vectors f_1 and f_2 have the same sign a priori, the coefficients of levels as well as the first differences of Z_1 are ambiguous in sign. Those of $(Z_2(t) - Z_2(t-1))$ and $Z_2(t-1)$, however, are not. The broad concept of variables which influence expected future profitability subsumes a variety of specific factors and can accommodate a number of ways in which those specific variables can be introduced into the equation. Two determinants of expected profitability are the expected real price of the product received by the producer and the expected real unit cost of production. The first will be positively related to both the desired level of future production and to the profitable level of production from the existing capital stock. That is, an increase in future expected product price will raise desired capacity output and thereby stimulate new plantings, but it may also make the existing capital more profitable and cause previously unprofitable capital to become profitable and hence lead to postponement of uprootings and replantings. Thus the net effect on the level of new plantings may be unclear. If the existing capital stock is large relative to the level of new plantings, the negative effect may well dominate. In the same way an increase in the unit real cost of production will depress both the required future capacity and the level of output from the existing capital stock. This could lead to scrapping of existing capacity to such an extent that the net effect may well be to stimulate new plantings.

There are some factors, subsumed under Z_2, which will affect $Q^P(t+G)$ but not $\hat{Q}^P(t)$. Examples are new planting subsidies and embodied technological progress, both of which will reduce the marginal cost of new planting and hence stimulate it.

Some empirical short-cuts may be necessary if the data on real unit cost of production are not available. One possibility is to assume that the unobservable variable $\hat{Q}^p(t)$ is proportional to $\hat{Q}^f(t)$--e.g., $\hat{Q}^p(t)$ is k times $\hat{Q}^f(t)$. The latter denotes estimated feasible output which could be measured using (3.8), given $\delta(t,v)$, although in general this would lead to a measurement error. If this assumption is employed, the estimating equation will have the following form:

$$N(t) = \alpha_1\beta[f_1(Z_1(t) - Z_1(t-1)) + g_1(Z_2(t) - Z_2(t-1))$$

$$+ (\alpha_1-\alpha_2)\beta[f_1Z_1(t-1) + g_1Z_2(t-1)]$$

$$- \alpha_1\beta k(\hat{Q}^f(t) - \hat{Q}^f(t-1)) - (\alpha_1-\alpha_2)k\hat{Q}^f(t-1)$$

$$+ (1-\alpha_1+\alpha_2)N_{t-1}. \qquad (3.17)$$

(This is the type of equation used for India for which no data are available on cost of production.) If $\alpha_1>\alpha_2$, both $\hat{Q}^f(t)$ and $\Delta\hat{Q}^f(t)$ will enter the equation with a negative sign. The use of $\hat{Q}^f$ in place of Q^f (3.17), however, will involve a misspecification error (due to the use of the proportionality assumption) whenever the scrapping of capacity moves in a highly variable fashion.

Before proceeding to another variant of the new planting equation it is worth noting that equation (3.17) incorporates a complex dependence between the existing capital stock and new plantings. This is captured directly via the proxy for the $\hat{Q}^p$ variable in (3.17); in (3.16) it is captured indirectly

via variables which influence the rate of discarding of old capacity. However, since the magnitude of the unprofitable productive capacity is not directly observable, it seems desirable to include variables which would capture the effects of both physical and economic obsolescence. Equation (3.16) does not adequately capture the first and equation (3.17) does not adequately capture the second.

Consider now the variants of the new planting equation which have been used for Kenya. In this case the specification for the smallholders is different from the rest. Since the new plantings of smallholders in Kenya shows a strong trend-type behavior, the ECM specification developed above needs to be modified. An ECM model for the rate of growth of new plantings expressed as a proportion of existing smallholder area, denoted r(t), seems more appropriate (see below for the rationale)

$$r(t) - r(t-1) = \gamma_1\left(r^*(t)-r(t-1)\right) + \gamma_2\left(r(t-1)-r^*(t-1)\right)$$

or

$$r(t) = \gamma_1\left(r^*(t)-r^*(t-1)\right) + (\gamma_1-\gamma_2)\, r^*(t-1) + (1-\gamma_1+\gamma_2)r(t-1) \qquad (3.18)$$

where a priori $\gamma_1>0$, $\gamma_2<0$ and $r(t) = N(t)/A(t-1)$, with $A(t-1)$ being the total area under smallholder production at t-1. $r^*(t)$ denotes the desired rate of expansion; its precise specification is not needed at this juncture. Given the strong trend in smallholders' new plantings the choice of r(t) has the merit that it ensures the model has the property of trend neutrality. This would not be so if N(t) was chosen to be the dependent variable. If the previous

specification for N(t) were adopted, wherein $N^*(t)$ incorporated a trend component, the standard partial adjustment model would imply that once N(t) and $N^*(t)$ begin to diverge the discrepancy would never be made up. In contrast the model of (3.18) applies the partial adjustment principle only to the deviations from the trend growth rate. See Pagan (1985) for a discussion of higher-order error correction models.

Note that this specification implies a different type of costs-of-adjustment specification from the one which implicitly underlies (3.16). In the present case, costs of adjustment arise from growth of new plantings exceeding or falling short of the optimal rate $r^*(t)$, whereas in the former case they arise from N(t) being different from $N^*(t)$. This latter specification seems appropriate in certain cases such as for Kenya smallholders.

Theoretical analysis shows that planned uprootings and replantings are interrelated decisions not only in the sense that uprooting (U) precedes replanting (R) but also in the more substantial sense that they are jointly determined--i.e., a sequence of planned $\{R(t)\}$ implies a corresponding sequence of $\{U(t)\}$. On the other hand, actual $\{R(t)\}$ is likely to be closely related to previous actual levels of uprootings. For this reason the preferred strategy would be to develop a behavioral model for {U(t)} and relate {R(t)} to {U(t)} through a simple distributed lag model. Unfortunately, however, data on both U(t) and R(t) are available only for Sri Lanka. For India, data are available only for R(t). For relatively new tea producers such as Kenya and Malawi, for which only the data on net new plantings are available, uprootings and replantings are not thought to be important.

An estimating equation for either U(t) or R(t) can be derived from a vector error correction model (VECM) as follows:

$$\begin{bmatrix} \Delta U(t) \\ \Delta R(t) \end{bmatrix} = \begin{bmatrix} \mu_{11} & \mu_{12} \\ \mu_{21} & \mu_{22} \end{bmatrix} \begin{bmatrix} U^*(t)-U(t-1) \\ R^*(t)-R(t-1) \end{bmatrix} + \begin{bmatrix} \nu_{11} & \nu_{12} \\ \nu_{21} & \nu_{22} \end{bmatrix} \begin{bmatrix} U(t-1)-U^*(t-1) \\ R(t-1)-R^*(t-1) \end{bmatrix} \quad (3.19)$$

where U^* and R^* denote, respectively, the desired rate of uprooting and replanting. Planned uprooting followed by replanting depends upon the stock of uneconomic capital and on the expected future profitability of production. As before, these variables are subsumed in the vector Z(t) and it is assumed that $U^*(t)$ and $R^*(t)$ are both linear in Z(t), i.e., $U^*(t) = h_1'Z(t)$ and $R^*(t) = h_2'Z(t)$. Substituting these into (3.19) and expanding, the following equation for $U^*(t)$ is obtained:

$$U(t) = [\mu_{11}h_1' + \mu_{12}h_2'] (Z(t) - Z(t-1)) +$$

$$[\mu_{11}h_1' + \mu_{12}h_2' - \nu_{11}h_1' - \nu_{12}h_2'] Z(t-1)$$

$$+ (1-\nu_{11} - \mu_{11}) U(t-1) + (\nu_{12} - \mu_{12}) R(t-1). \quad (3.20)$$

A similar equation can be obtained for R(t) if desired. The main difference between this and the scalar ECM is the appearance of R(t-1) in the equation with an ambiguous coefficient. The expected future profitability variables subsumed in Z appear in the level form and as rates of changes. If the off-diagonal terms in the μ- and ν- matrices are not too large, and if μ_{11} and ν_{11} are positive, the coefficients of Z(t) and $\Delta Z(t)$ have their signs determined by the signs of the corresponding elements of h_1' and h_2' which (it is expected)

share the same sign. For example, an increase in the expected future price or in the uprooting-replanting subsidy will affect U(t) and R(t) in the same direction.

Now consider the determinants of $U^*(t)$ and $R^*(t)$. As in the case of $N^*(t)$ the ultimate objective of uprooting and replanting is to eliminate the gap $\left(Q^P(t+G) - \hat{Q}^P(t)\right)$. Therefore, variables which enter the U(t) and R(t) equations should be the same as those in the N(t) equation, with the qualification that the subsidy variable in the former case would be specific to uprooting and replanting. Furthermore, to eliminate the unobserved variable $\hat{Q}^P(t)$ will require approximations as is the case in the N(t) equation. (See discussion immediately preceding equation (3.17).)

III.4 The Supply Equation

III.4.1 The Basic Specification

The supply equation for the model is based on (3.11). However, more detailed discussion needs to be provided about the calculation of $Q^p(t)$ and the choice of a suitable functional form. Both these steps involve important simplifications and approximations. Details vary considerably even for the three major producers--India, Sri Lanka and Kenya. For the remaining countries the specification of the model is rather crude.

First, it is assumed that actual and potential output are related by the following equation:

$$Q(t) = A'\left(Q^p(t)\right)\left(P(t)/P^e(t)\right)^{\theta}u(t) \qquad (3.21)$$

where A' is an unknown scale factor and θ is the unknown elasticity of Q with respect to P. If $P^e(t)$ in (3.21) is the same $P^e(t)$ that determines $Q^p(t)$, then $P^e(t) = P(t)$ would imply equality of $Q(t)$ and $Q^p(t)$ apart from the scale factor A' and the supply shock $u(t)$. Since neither $Q^p(t)$ nor $P^e(t)$ are directly observable, additional assumptions are required to reduce (3.21) to a suitable form for estimation. Begin with the identity

$$Q^p(t) = Q^f(t)Q^p(t)/Q^f(t). \qquad (3.22)$$

Let $Q^f(t)$ denote <u>measured</u> feasible output calculated under the assumption of a given (not necessarily profit-maximising) age-yield profile and assume that

$$\text{(i)} \qquad Q^f(t) = k_1\left(\hat{Q}^f(t)\right)^{\varepsilon}, \qquad k_1,\ \varepsilon>0 \qquad (3.23)$$

and

$$\text{(ii)} \qquad \frac{Q^p(t)}{Q^f(t)} = k_2 \prod_{i=0}^{m} P(t-i)^{\beta_i}, \quad \beta_i \geq 0. \tag{3.24}$$

The difference between Q^f and $\hat{Q}^f$ arises from the possible error in calculating $\hat{Q}^f$ from an "average" age-yield profile. The justification for (3.24) is that the profit-maximising level of output is an increasing function of the producer price whereas $Q^f(t)$ is definitionally determined, given past decisions. Furthermore, lags are introduced in (3.24) to take account of the dependence of <u>current</u> yield on <u>past</u> inputs such as fertilizers. Whereas it is expected that the unknown value of m would be a small integer such as 1 or 2, the issue is empirical.

Combining (3.21) ~ (3.24) and taking logs we obtain the basic supply equation:

$$\ln Q(t) = \ln(A' k_1 k_2) + \varepsilon \ln \hat{Q}^f(t) + (\beta_0 + \theta) \ln P(t)$$

$$- \theta \ln P^e(t) + \sum_{i=1}^{m} \beta_i \ln P(t-i). \tag{3.25}$$

To convert this equation to a form suitable for estimation the following steps are necessary: (a) either make specific assumptions about the relation between $\hat{Q}^f(t)$ and observable variables such as past new plantings or precalculate $\hat{Q}^f(t)$; (b) make a specific assumption about how expectations are formed; and (c) fix the value of m. With respect to (a) the premise approach on takes will depend on the data constraints; with respect to (b) it is assumed that $\ln P^e$ is a linear function of past values of P which is, strictly speaking, inconsistent with the approach elsewhere in the paper

and, finally, with respect to (c) an empirical approach is taken and m is fixed at 1, 2 or 3. 1/

III.4.2 Alternative Specifications for $\hat{Q}^f(t)$

Since it is desired to take into consideration the differences in the average productivity of capital (trees) of different ages and the effects of disembodied technological change on the age-specific yields, a distinction is made between known total productive capacity (feasible output) existing at some arbitrary origin, denoted Q(0), and the subsequent additions to that capacity arising from new planting and replanting in subsequent periods. Let $Q^{of}(t)$ denote the former and $Q^{nf}(t)$ the latter; then

$$\hat{Q}^f(t) = Q^{of}(t) + Q^{nf}(t) . \tag{3.26}$$

Assume that old capacity Q(0) is changing at an unknown proportionate rate λ_2, which reflects the joint effects of disembodied technological change and of the reduction in productivity due to aging;

$$Q^{of}(t) = e^{\lambda_2 t}Q(0). \tag{3.27}$$

Given data on total newly planted and replanted areas from t=1 onwards, and given the normalized age-yield profile $\bar{\delta}(t-v)$ known up to a proportionality constant $\beta(0)$ (i.e. $\beta(0)\bar{\delta}(t,v)$ gives the productivity in physical units of capital of age (t-v) in period 0), it is possible to construct an index of the productive capacity contributed by additions to the planted area since time 0. Denote this by $\beta(0)\sum_{t-v=1}^{t}\bar{\delta}(t-v)N^+(t-v)$ where $N^+(t-v)$ is the cumulated sum of new

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1/ A consequence of this approach is that coefficients of P(t-1), P(t-2),... P(t-m) could be ambiguous in sign. Empirically, it is found that these coefficients are usually positive when statistically significant.

plantings and replantings of age (t-v) at time t. 1/ $\beta(0)$ is the productivity of mature vintages in period 0. Finally, assume that $\bar{\delta}(t-v)$ is also subject to disembodied technical change at a constant proportionate rate λ_1 (>0 if productivity is increasing). That is,

$$Q^{nt}(t) = \beta(0)e^{\lambda_1 t}\left[\sum \bar{\delta}(t-v)N^{+}(t-v)\right]. \tag{3.28}$$

Combining (3.25) ~ (3.28) yields Variant 1 of the "vintage" supply function.

$$\ln Q(t) = \ln A + \ln \left[\beta(0)e^{\lambda_1 t}\left[\sum \bar{\delta}(t-v)N^{+}(t-v) + e^{\lambda_2 t}Q(0)\right]\right]$$

$$+ (\beta_0+\theta)\ln P(t) - \theta \ln P^{e}(t) + \sum_{i=1}^{m} \beta_i \ln P(t-i) + u(t) \tag{3.29}$$

which is nonlinear in the unknown parameters $(A,\beta(0), \lambda_1, \lambda_2, \theta)$. The expression inside the square bracket is analogous to the shift term representing the heterogeneous stock of capital. The remaining terms are analogous to the price variable of the textbook supply function. Given data on N^{+}, $\bar{\delta}(t-v)$, $Q(0)$ and an appropriate proxy for $P^{e}(t)$, (3.29) can be estimated by nonlinear least squares. Data permit such estimation for two major producers, India and Sri Lanka, whose age-yield profiles appear to have changed through time. Though straight-forward in principle, the estimation of (3.29) in practice poses difficult problems of identifiability, as will be seen in Section III.5.

1/ There could be an important aggregation problem here if different kinds of trees are planted at different times.

III.4.3 A Special Case of (3.29)

If (a) $Q(0) = 0$ and (b) the age-yield profile is approximately constant such that $\lambda_1 \equiv 0$, (3.29) simplifies to the log-linear equation which is Variant 2 of the vintage supply function:

$$\ln Q(t) = \ln A + \ln [\Sigma \bar{\delta}(t-v)N^{+}(t-v)] + (\beta+\theta) \ln P(t) - \theta \ln P^{e}(t) + \Sigma\beta_i \ln P(t-i) + u(t). \quad (3.30)$$

In certain cases (e.g., Kenya estates) it was necessary to allow for changing yields through time. It was possible to construct with Kenyan data three time series corresponding to planted area in three age-classes--less than 5 years old, between 5 and 10 years and more than 10 years old. Using data on normalized yields (=1 in the age-class 'older than 10 years'), a weighted area measure, denoted WAREA, was constructed. Then, variant 3 of the vintage supply function which may be thought of as the 'yield equation', was specified as follows:

$$\frac{Q(t)}{WAREA(t)} = Ae^{\lambda_1 t}[P(t)/P^{e}(t)]^{\theta}u(t). \quad (3.31)$$

(Note that this assumes that all age-groups share equi-proportionally in the increase in yield.)

For the remaining countries the quality and quantity of data do not permit estimation of anything much more than simple variants of (3.25), usually based on the assumption that $\hat{Q}^{f}(t)$ is a function of a linear or quadratic time trend. This specification will be referred to a Variant 4 of the basic specification. It makes essentially no use of any data of a vintage nature.

III.5 Empirical Results

III.5.1. Computation of the Index of Feasible Production

To calculate $Q^f(t)$ as defined in (3.26) ~ (3.29) involves the unknown parameters $\beta(0)$, λ_1 and λ_2.The first task is to construct an index of the productive capacity added by new plantings and replantings, denoted $\Sigma\bar{\delta}(t-v)$ $N^+(t-v)$. The coefficients in the sequence $\bar{\delta}(t-v)$denote the proportion of peak yield obtainable at different ages prior to full maturity. This profile will, of course, vary between countries and over time. Available information concerning the base period, derived from World Bank project reports, is summarized in Table 2. It is assumed that in those countries such as India, Kenya and Malawi where the yields are rising 1/ the increase is spread over all age groups. The base period profile is taken to be the same in India and Sri Lanka.

In India and in Sri Lanka, the rate of new planting and replanting as a proportion of total planted area has varied considerably over the last 20 years. The range of variation is from 0.8 to 1.8 percent in India and from 0.9 to 1.4 percent in Sri Lanka. (The latter figure should be treated with caution because of uncertainties about the planted area.) In contrast, the annual average growth rate of planted area for Kenya smallholders has been at nearly 17 per cent over the period 1963-83; though the rate has declined to around 4 per cent in the last five years.

1/ Such information as is available fails to distinguish between the productivity of new VP varieties and the older hybrids.

Table 2: BASE PERIOD AGE-YIELD PROFILES

	0	1	2	3	4	5	6	7	8
India 1952-(a)	0	0	.074	.299	.449	.599	.749	.899	1
-(b)	0	0	70	281	422	563	704	845	939
Sri Lanka -(a)	0	0	.074	.299	.449	.599	.749	.899	1
1956 -(b)	0	0	76	303	455	608	760	912	1014
Kenya* -(a)				.199	.399	.399	.798	.899	.899
-(b)	0	0	0	206	412	412	824	928	928

(a): Proportion of peak output at different ages prior to full maturity.
(b): Yield in Kg/hectare at different ages.
*: Applies to smallholders only.

III.5.2 New Planting and Replanting Equations

In both India and Sri Lanka new planting and replanting are subsidized. Information about the subsidies in India remains very sketchy and it is hoped that the estimated new planting and replanting equations cam be revised at a later date when more detailed and accurate information has been obtained. There are indications that such respecification and reestimation is required. In the case of Sri Lanka, uprooting and replanting subsidies are more important relative to the new planting subsidies. However, there are a number of subsidy schemes in existence and they have changed considerably over the years, so the computation of total value of subsidies is a somewhat involved matter.

In Kenya it is important to distinguish between the behavior of smallholders, who account for nearly two-thirds of the area but only one-third of the production, and that of the estates which have been producing tea for several decades. (Etherington 1973; Schluter 1982; Lamb and Muller 1982). Net new plantings have therefore been disaggregated into smallholder and estates

categories. The former (but not the latter) shows a strong trend-like behavior which cannot be readily understood without reference to the historical and institutional factors. These have been studied by Etherington (1973) and by Lamb and Muller (1982). The former author has stressed the stimulative effects of the removal of legal restrictions on the cultivation of tea by smallholders at a time when tea was an alternative cash crop; the latter have detailed the important role played by the Kenya Tea Development Authority (KTDA) in the provision of extension services and a network of factories which provided the necessary infrastructure and increased the profitability of tea production to the smallholder. The specification used here, therefore, pays attention to these factors. 1/

A measure of this role is KTDA development expenditure (including the expenditures on nurseries, tea stumps, field and factory development) per hectare of smallholder-planted tea area. This variable has a role similar to but not identical with that of subsidies in other countries.

For Kenya smallholders the model used for replanting is equation (3.18). To complete it a specification of $r^*(t)$ is needed. Specify $r^*(t)$ to be linear and increasing in (i) real per hectare investment expenditure by the KTDA, denoted E(t), and (ii) the real producer price PR(t). That is, $r^*(t) = a_1E(t) + a_2PR(t) + a_0$, and

$$r(t) = \gamma_1[a_1(E(t) - E(t-1)) + a_2(PR(t) - PR(t-1))]$$

1/ From an analytical viewpoint such factors are akin to subsidies which increase the net producer price and hence the actual and expected profitability.

$$+ (\gamma_1-\gamma_2)\,[a_1E(t-1) + a_2PR(t-1)]$$

$$+ (1-\gamma_1+\gamma_2)r(t-1) + (\gamma_1-\gamma_2)a_0. \qquad (3.32)$$

The main justification for this specification is that the Kenya smallholders probably did not face an area constraint in this period and that the critical limitation arose from access to planting material, credit facilities, factories for processing tea leaves and expertise in the marketing of the leaf. To the extent that the KTDA provided these facilities, it made it easier for the smallholder to take up growing tea. It is postulated that by maintaining a constant real rate of development expenditure 1/ per hectare the KTDA would enable more smallholders to undertake tea production and to maintain a steady growth in new plantings. Of course, this assumption is reasonable only as long as the availability of suitable land is not a binding constraint. Eventually, such a constraint will become binding and this would imply a different kind of adjustment cost function.

Consider now the net new plantings of Kenya estates. In absolute terms new planting activity of the estates is small compared with that of the Kenya smallholders. It is also highly variable. The main difference between the behavior of the estates and smallholders in the specification is that it is hypothesized the former to be active at the intensive margin and the latter at the extensive margin. Specifically, any improvement in expected profitability, arising from (say) an increase in the real price of tea, causes more

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1/ Actual real rate of expenditure per hectare (KEXPPH) declined after 1969 but stabilized after 1980.

smallholders to enter tea production, whereas it causes estates to increase production at the intensive margin by greater use of yield-increasing agricultural practices. (The yield-price relationship has been discussed elsewhere.) A general model of production and demand for inputs clearly does not rule out the possibility that a firm may respond to higher product prices by raising its production through more intensive utilization of variable inputs. Given sufficiently high adjustment costs of fixed inputs this may be an optimal response. 1/ The empirical fact that in the case of the estates in Kenya yields per hectare have increased in a spectacular fashion, while the area under production has increased rather slowly, suggests that the hypothesis proposed is reasonable. To obtain the estimating equation, a variant of (3.12) has been combined with the following specification of new plantings $N^*(t)$,

$$N^*(t) = c_0 + c_1 YLD(t) \qquad (3.33)$$

$c_1<0$. Note that YLD(t) is an endogenous variable. This leads to an equation in which new plantings depend upon the yield and the change in yield as well as lagged values of new plantings.

In the case of Malawi a similar equation has been used but it has also been assumed that the yield is a function of past real producer prices and a time trend. The justification for specifying the Malawi equation in the same way as for Kenya estates is that the estates in Malawi account for a

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1/ Although no concrete data is available, land prices in Kenya have been increasing at a rate much faster than the general consumer price index in recent years.

predominant part of total output 1/ and, it is assumed, most of the rather small absolute amount of new plantings.

The estimated equations for India (extensions and replantings), Sri Lanka (new plantings, uprootings and replantings), Kenya smallholders (rate of growth of area planted), Kenya estates (net change in planted area) and Malawi (net increase in planted area) are given in Table 3. For Sri Lanka actual R(t) is specified as a finite distributed lag on current and lagged values of U(t); thus,

$$R(t) = \sum_{i=0}^{m} w_i U(t-i) \qquad (3.34)$$

where $\Sigma w_i = 1$ if all uprootings are followed by replanting.

For India the specification of the replanting equation is similar to (3.20), no account having been taken of the interdependence between U(t) and R(t) as no data on uprootings are available.

The discussion of these results focusses on the role of (a) subsidies; (b) future profitability factors as they operate through expected future real producer prices; and (c) other factors.

In general terms, the econometric results are consistent with the error correction models described in Section III. Some equations, such as the Indian new planting equation, display certain econometrically unsatisfactory features, such as heteroscedastic residuals, which will be the subject of a more thorough investigation when additional data on subsidies have been

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1/ On July 1, 1981 the estates accounted for 16,181 hectares out of a total area of 18,190 and 14,129 hectares of the estate area comprised trees more than 10 years old.

Table 3: ESTIMATED EQUATIONS FOR SUPPLY BLOCK *

INDIA SUPPLY EQUATION

LN QIND = 1.1942 + LN [1.0 exp (.0099t) TPRODI + exp (.0099t) 283500]
(12.35) (10.00) (10.00)

+ 0.0383 LN PRI (-1) + .0903 LN [PR1(-1)/PREI[-4)]
(0.85) (2.32)

R-SQUARED(CORR.): 0.9851 SEE: 0.0241 DW: 2.11

PERIOD OF FIT: 1959 1983

F(3,21) = 532.25

SRI LANKA SUPPLY EQUATION

LN QSL = 1.00 + LN[0.8 exp (0.0095t) TPRODSL + exp (-0.02105t).230420]
(0.97) (5.45)

- 0.4861 LN QSL(-1) + 0.5060 LN QSL(-2)
(4.91) (5.08)

+ 0.0346 LN RATPC(-1) -0.1405 LEDM
(1.45) (5.08)

R-SQUARED(CORR.): 0.9162 SEE: 0.0644 DW: 2.40

PERIOD OF FIT: 1965 1983

F(5,13) = 40.65

KENYA SMALLHOLDERS PRODUCTION

0280: QKSHL = 4.5995 + 0.7314 QKSEL + 0.1708 PRIKTDARL + 0.2278 PRIKTDARL(-1)
(7.0572)(18.2242) (1.2894) (1.7189)

R-SQUARED(CORR.): 0.968 SEE: 0.93797E-01 DW: 1.92

PERIOD OF FIT: 1971 1983

F(3, 9): 120.756

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* See Glossary of Variables for definition of variable names.

continued...

...continued

SRI LANKA - NEW PLANTINGS

0299: SRINEWP = -811.3419 - 0.3108 SRINEWP(-1) + 33626.1953 PRESREV
(-2.2003)(-1.3598) (3.8431)

+ 23842.2539 COPSLCHR(-1) + 15003.5449 PRES(-1)
(2.2507) (1.8374)

+ 8665.0684 COPSLR(-2) + 534.5070 PRCHS
(1.8878) (1.6844)

R-SQUARED(CORR.): 0.725 SEE: 195.41 DW: 2.39

PERIOD OF FIT: 1966 1982

F(6, 10): 8.023

SRI LANKA - UPROOTINGS

0301: SRIUP = -1589.8682 + 0.5055 SRIUP(-1) + 3851.3064 PRES(-1)
(-0.8483) (1.0557) (0.2245)

- 0.9836 SRIREPL(-1) + 179.9945 RSSLREAL(-1)
(-1.6552) (3.1637)

+ 37472.8594 PRESREV + 118.8185 RSSLREALCH
(1.3144) (3.8879)

R-SQUARED(CORR.): 0.816 SEE: 314.93 DW: 1.88

PERIOD OF FIT: 1967 1982

F(6, 9): 12.053

SRI LANKA REPLANTINGS

0302: SRIREPL = -118.9512 + 0.4716 SRIUP + 0.2110 SRIUPMA
(-1.7587) (7.9319) (7.4639)

R-SQUARED(CORR.): 0.968 SEE: 145.56 DW: 2.04

PERIOD OF FIT: 1958 1982

F(2, 22): 368.433

continued...

...continued

INDIA - EXTENSIONS

0303: AIEXT = 9889.8164 + 0.4085 AIEXT(-1) + 13240.4561 PREI(-1)
(2.1743) (2.0153) (2.0144)

+ 2624.8997 PREIREV + 614.6401 TR51
(0.2445) (2.2529)

- 0.0472 TPRODCI(-2) - 0.0492 TPRODCICH(-1)
(-2.2338) (-1.2400)

R-SQUARED(CORR.): 0.538 SEE: 462.11 DW: 1.57

PERIOD OF FIT: 1959 1982

F(6, 17): 5.463

INDIA - REPLANTINGS

0304: AIREPL = 294.6120 + 0.6393 AIREPL(-1) - 0.0001 TPRODCI(-2)
(0.5272) (3.7826) (-0.1852)

+ 2252.3240 PREI(-1) - 1817.5537 PREIREV
(1.0344) (-0.4508)

R-SQUARED(CORR.): 0.752 SEE: 185.17 DW: 1.77

PERIOD OF FIT: 1959 1982

F(4, 19): 18.397

KENYA - SMALLHOLDER REPLANTINGS

0305: KSHNPRT = -0.1127 + 0.7487 PRK(-1) + 0.2009 KEXPPHD
(-1.3569) (1.3074) (2.4076)

+ 0.2077 KEXPPH(-1) + 0.5052 KSHNPRT(-1) + 0.0379 PRKD
(2.9789) (3.3228) (0.7936)

R-SQUARED(CORR.): 0.894 SEE: 0.29772E-01 DW: 1.85

PERIOD OF FIT: 1966 1982

F(5, 11): 27.943

continued...

...continued

MALAWI - YIELD

0306:

YLDMAL = - 0.6515 + 26.6545 PRIMALR(-1) + 0.3365 PRIMALRD + 0.4504 SQTR61
(-1.8836) (1.4423) (1.8637) (7.7225)

R-SQUARED(CORR.): 0.861 SEE: 0.10629 DW: 2.03

PERIOD OF FIT: 1969 1982

F(3, 10): 27.832

MALAWI WEIGHTED AREA

0307:

ZMALAW = 6776.2852 + 322.1262 TR51
(61.2830) (72.2880)

R-SQUARED(CORR.): 0.999 SEE: 53.510 DW: 1.45

RHO(1): 0.593

PERIOD OF FIT: 1965 1983

F(1, 16): 20841.455

KENYA - ESTATES WEIGHTED AREA

0310:

ZKEAW = 7384.9956 + 3668.4729 SQTR61
(8.6687) (18.0140)

R-SQUARED(CORR.): 0.967 SEE: 293.98 DW: 2.30

PERIOD OF FIT: 1972 1983

F(1, 10): 324.511

KENYA - ESTATES YIELD

0311:

YLDKES = - 2.9655 + 6.2409 PRK + 6.5530 PRK(-1) + 8.2313 PRK(-2)
(-3.2975) (2.1918) (2.3573) (2.8528)

+ 0.7958 SQTR61
(5.6774)

R-SQUARED(CORR.): 0.754 SEE: 0.15353 DW: 1.72

PERIOD OF FIT: 1972 1982

F(4, 6): 8.655

continued...

...continued

USSR - PRODUCTION

0519:
LN QUSSR = 6.2296 + 1.6151 LN TR51
(15.5242 (13.2194)

R-SQUARED(CORR.): 0.987 SEE: 0.35147E-01 DW: 1.33

RHO(1): 0.690

PERIOD OF FIT: 1970 1984

F(1, 12): 979.561

BANGLADESH - PRODUCTION

0523:
QBANL = 6.5752 + 1.3801 TR51L - 0.2721 DM84 + 0.1746 WPRICEDFL
(12.5706 (10.3322) (-3.5705) (1.8032)

R-SQUARED(CORR.): 0.898 SEE: 0.57627E-01 DW: 2.04

PERIOD OF FIT: 1972 1984

F(3, 9): 36.304

REST OF ASIA - PRODUCTION

0559:
QOASP = - 23208.6016 + 706.8953 TR51 + 55595.7383 WPRICEDF
(-11.1823) (25.8332) (3.9448)

+ 105251.8438 WPRICEDF(-1) + 131339.1250 WPRICEDF(-2)
(7.8039) (9.2639)

+ 133857.5781 WPRICEDF(-3) + 112807.2109 WPRICEDF(-4)
(9.6506) (9.7135)

+ 68188.0156 WPRICEDF(-5)
(9.6833)

R-SQUARED(CORR.): 0.987 SEE: 246.15 DW: 1.71

PERIOD OF FIT: 1972 1984

F(3, 9): 293.332

continued...

...continued

INDONESIA - PRODUCTION

0501:

QINDOL = 9.6311 - 0.1343 DUMINDO + 0.1645 PRIINDOL(-1) + 0.0611 TRINDO
(86.7219) (-4.8481) (4.5895) (37.5920)

R-SQUARED(CORR.): 0.992 SEE: 0.24642E-01 DW: 2.38

PERIOD OF FIT: 1968 1984

F(3, 13): 675.156

CHINA - BLACK TEA EXPORTS

0326:

XBTCHT = - 36592.8594 + 307333.4375 WPRICEDF + 4061.9905 TRCH
(-2.9041) (0.7501) (8.8841)

R-SQUARED(CORR.): 0.876 SEE: 5396.0 DW: 1.83

PERIOD OF FIT: 1972 1983

F(2, 9): 39.703

REST OF AFRICA - PRODUCTION

0541:

QROAFRI = - 37703.7109 + 2830.0615 TR51 + 342186.3750 WPRICEDF(-1)
(-2.7632) (11.3387) (1.6199)

+ 456086.9688 WPRICEDF(-2) + 342024.8438 WPRICEDF(-3)
(2.8685) (2.1936)

R-SQUARED(CORR.): 0.922 SEE: 3095.8 DW: 1.69

PERIOD OF FIT: 1970 1984

F(3, 11): 55.880

obtained. The statistical fit of the equations appears to be less good than is usual in aggregative time series regressions. However, it has to be remembered that for the most part the variables do not exhibit strong trends.

First, consider the role of "expected" future producer price, denoted generically as PR^e. The approach adopted here to modelling producer's price expectations is to think in terms of the producer's perception of 'normal' price, which is assumed to be a simple function of realised current price and prices in the recent past. For India and Sri Lanka, it is a simple moving average of PR(t-1), PR(t-2) and PR(t-3). In the case of the remaining countries current and/or one or two lagged values have been used. Uprootings and replanting decisions in Sri Lanka and India show <u>little</u> price responsiveness. On the other hand, new plantings in all four countries show statistically significant price responsiveness. The short-run elasticity of new plantings with respect to PR or PR^e varies from about 0.5 for India and Kenya to between 1.5 to 2.0 for Sri Lanka and Malawi. Theoretical considerations suggest that the economic incentives for exploiting the extensive margin of production would be the greatest in countries which are not constrained by availability of suitable land (cost of adjustment factor). That is, relatively new producers would show the largest price elasticities. In contrast, the countries which are long established producers and which have 'used up' the most suitable land would respond to the price incentives at the intensive margin. For these countries it is expected the elasticity of N(t) with respect to PR(t) would be relatively low. The finding of a relatively high value for Sri Lanka and a relatively low one for Kenya is, therefore, a surprise. However, note that the Kenya estates' net new planting is negatively related to yield per acre, which enters as a determinant of $N^*(t)$ and the latter is

positively related to PR. In the case of Malawi a similar tendency is expected because of the importance of estate production in that country, but the lack of disaggregated data precludes a clean test of this hypothesis. It would seem that the impact of changes in real producer price on production takes place in the short run mainly through the changes in the level and intensity of factor use. In the long run they occur through new planting and replanting at unchanged levels of utilization or through variation in the intensity of factor use without any additional new planting, or, more generally, through some mixture of the two. The size of the long-run production response will vary between countries and time periods.

The fact that uprooting and replanting are not found to be price sensitive may be rationalized by recalling the earlier discussion in which it was pointed out that improvement in future expected prices on the one hand tends to make previously uneconomic vintages economic (and thereby reduce uprooting and replanting), while on the other hand it raises the expected rate of profitability on new investment.

Turning now to the role of the replanting subsidy it can be observed that its effect is extremely important in Sri Lanka. The short-run elasticity of uprooting with respect to the real subsidy is close to 2. The long-run effect is less certain as the coefficients on lagged uprooting ($SRIUP_{-1}$) have large standard errors. The importance of the subsidy variable in Sri Lanka is not surprising since it has been evident for some time that a significant proportion of planted area has a low yield, possibly due to the old age of the trees.

In the case of replantings by Kenya smallholders it is evident that the level of KTDA real development expenditure per hectare (KEXPPH) is a

highly significant factor. Indeed, the contribution of price to the explanation of this variable would be negligible before 1975 (Etherington 1973) while the KTDA expenditure variable would provide most of the explanatory power.

Finally, turning to the discussion of 'other factors', note that in the case of India the size of existing total feasible output (TPRODCI), which can be regarded as a proxy for the heterogeneous capital stock, enters the equation with a negative coefficient. The variable TRPODCI is not directly observed. Our measure was calculated using the expression in the square brackets in (3.28) multiplied by A, with nonlinear least squares estimates of A, $\beta(0)$, λ_1 and λ_2 substituted. It is intuitive that a large existing capacity should have a depressing influence on new plantings. For Sri Lanka there is data available on the unit cost of production, which affects the rate of scrapping and hence the level of potential production. Since the unobservable Q^P rather than Q^f is the relevant variable, and the former would be in part determined by the average cost of production, lagged real unit production cost (COPSLR) has been included as an explanatory variable of new plantings. The results indicate that the net effect of an increase in unit production cost is to stimulate new planting. This outcome is possible if the reduction in capacity due to scrapping is substantial. The declining production and yields in Sri Lanka are consistent with the hypothesis that the scrapping effect is substantial. The variable COPSLR was also tried in the uprooting equation but did not give significant results--possibly because of the shortness of the time series but also because since 1967 the replanting subsidies have had a dominant role. Very weak evidence was found to support the notion that the rate of new plantings by Kenyan smallholders was significantly affected by the existing productive capacity. The variable Q^f(QKSE) does not, therefore,

appear in the Kenya smallholders new planting equation. Once again, this reflects an important difference between relatively new producers and the established ones.

III.5.3 Supply Equations

Apart from variations arising from peculiarities of individual countries and from empirical considerations relating to the fit of the equation, the estimated supply functions have been specified as follows: that for India and Sri Lanka is based on equation (3.29), for Kenya equations (3.30) and (3.31), and for Malawi equation (3.31). For the remaining countries the equations (variant 4 of the basic specification) are more ad hoc. However, they can be interpreted to mean that in all these cases potential output behaves as a smooth function of time. Variations from the basic specification take three forms. Firstly, the manner in which (P/P^e) is proxied varies. For India P^e is a moving average of three lagged values, P(t-5), P(t-6) and P(t-7) where the lags are chosen to reflect a gestation period; for Sri Lanka P/P^e is proxied by the ratio of price to the cost of production. In the case of some other countries, current or lagged actual price has been used. Hence, the supply equation ends up as a function of trend, a proxy for potential or feasible output, and current and/or lagged prices. The reported specifications incorporate restrictions which appear empirically reasonable in the light of specification searches. In all cases the price variable is intended to be the real local producer price, net of taxes. For India, Sri Lanka and Kenya this variable can be constructed from the averages of auction prices. (The price variable for India is a value-share weighted average of leaf and dust prices at Calcutta and Cochin auctions.) For those countries for which no local producer price was readily available, as for example when aggregate entities

such as "Rest of Asia" or "Rest of Africa" are considered, the world price was used. The world price variable as used in the supply equations is a weighted average of the price of tea traded at Calcutta, Cochin, Colombo and Mombasa auctions, expressed in the local currency unit.

The second type of variation arises from the need to include lagged values of Q(t) in some countries (e.g. Sri Lanka) to take into account dynamic dependence in production in successive periods, e.g., a biennial cycle. The third type of variation comes from the need to include the effects of known supply shocks, e.g., drought in Sri Lanka in 1983, volcanic eruption in Java in 1982, and so forth. The lack of specific information has prevented taking into account such factors for other countries.

Estimation of (3.29) required nonlinear least squares. A major difficulty arose from the flatness of the residual sum of squares surface so that the major parameters of interest A, $\beta(0)$, λ_1 and λ_2 could not be estimated both freely and precisely. This is essentially an identification problem. After some experimentation which suggested that free estimation of all unknown parameters was not feasible the problem was treated as one of estimation-calibration of the unknown parameters and not one of estimation alone. The values of $\beta(0)$ (and also of A in the case of Sri Lanka) were fixed and the remaining parameters were estimated. For India $\beta(0)$ was fixed at 1.00 (peak yield per hectare in 1952 = 1 metric ton) and for Sri Lanka at 0.80. The scale parameter for Sri Lanka was also fixed at unity. The estimates of λ_1 and λ_2 for India were constrained to be equal--this restriction is consistent with the data. The estimate indicates that the productivity of new plantings as well as the base period capacity has been increasing at an exponential rate of between 1.0 and 1.5 per cent per annum. This could come

about from a more intensive utilization of available inputs or better agricultural practices. By contrast, the value of λ_1 for Sri Lanka is insignificantly different from zero whereas that of λ_2 is negative and this implies zero increase in the productivity of new plantings and a decline in productivity of the base period output at the annual rate of just over 2 per cent--a result which is consistent with the observed fall in yield over time. These rather low values may be compared with much higher values for Kenya estates and for Malawi.

The supply equations for the three major producers appear to fit reasonably well but there are some important qualifications. In all cases there is some evidence of heteroscedastic residuals, which could reflect in part the ubiquity of supply shocks but in part also the effects of misspecification. Every country is in some sense a special case and the adopted specifications reflect this. For example, in Sri Lanka there is a curious biennial production cycle which is captured through the inclusion of Q(t-1) and Q(t-2) as explanatory variables. Kenyan estates show evidence of some outliers (1973, 1976) which contribute significantly to the lack of a good fit. Elsewhere for some of the smaller producers a similar problem arises. The only satisfactory resolution of these difficulties is to obtain additional information about the special circumstances of the producers in these countries and, where necessary, to respecify the equation. This avenue will be explored in the future.

For those countries where an estimate $\hat{Q}^f(t)$ could be constructed, its value as an explanatory variable was extremely high--see the equation for India and for Kenya smallholders. Similarly, the weighted area measure, denoted WAREA, based on data on planted area distinguished by age-class is

also a useful explanatory variable. In those cases where time trends are used to proxy the feasible output variable Q^f, the estimated equations have an acceptable performance in the sample period but could be found to be unsatisfactory in the simulation period. 1/

Finally, consider the estimates of short-run price elasticities which emerge from these results (see Table 4). The majority of elasticities are in the range 0.1-0.2--an exception being Kenya and Rest-of-Africa for which a rather larger value is obtained. Ramanujam (1984) has estimated these short-run elasticities within a Nerlovian framework. His estimates are also given in Table 4. For the calculation of long-run supply elasticities estimates of the price elasticity of new plantings and the elasticity of potential output to changes in new plantings are needed. Such calculations are best done in the context of the complete model simulations. The discussion of these issues is deferred to a later stage.

1/ Indeed, some equations with a simple time-trend such as the ones for the USSR proved to be unsatisfactory in ex-ante simulation exercises. Other trend variables such as log of trend and square-root of trend were used in such cases.

Table 4: SHORT-RUN PRICE ELASTICITIES

	This Study		Ramanujam
	Current	One-Year Lag	
India 0.13	0.15		
Sri Lanka	0.03	-	
Kenya: Smallholders	0.17	0.23	0.16
Estates /a	0.25	0.52-0.87 /b	
Malawi /c	0.21	0.18	
Indonesia	-	0.16	
Bangladesh	0.17	-	
Rest of Africa /d	-	0.11-0.38 /e	.04-0.07
China/Taiwan /f	0.15	-	

/a The numbers are calculated at mean values of price, weighted area and average quantity produced in 1972-1983.
/b Price effects of one- to two-year lags.
/c Calculated from the Malawi yield equation.
/d Includes all African production except Kenya, Malawi and Uganda. Ramanujam's estimates apply to Tanzania and Mozambique.
/e Price effects of one- to three-year lags.
/f Elasticity applies to exports only.

IV. FINAL DEMAND FOR TEA

IV.1 The Demand Specification

In this section, econometric equations are specified to explain the final demand for tea per head of population in major consuming countries. Final demand consists of two components--demand for actual consumption and the demand for stockholding. It is presumed that the major proportion of total stocks is held by traders (importers, exporters, retailers and wholesalers). To the extent that the available data cannot or do not distinguish accurately between the consumption and stockholding components, the consumption data are to be regarded as measures of "apparent consumption".

The treatment of consumption is somewhat simplistic, being based on elementary demand theory. The reason for this has essentially to do with the nonavailability of the price-quantity data required for more sophisticated econometric modelling. An appealing framework for such an analysis is that in which the consumer's utility function is specified to be weakly separable in beverages which would include tea, coffee, and soft drinks of various types. The list of included items could vary from one country to another. One might also include different qualities of tea and coffee. However, the price data required to estimate such a system of demand equations are rarely available. Therefore, a more restrictive assumption has to be adopted, viz. that the utility function is separable in consumption for hot beverages only, so that it is meaningful to talk about aggregate consumption of tea and of coffee and to proceed as if substitution is confined to these two. This is clearly not a satisfactory assumption for all countries. Nevertheless, the lack of retail price data is serious in the case of most developing countries, forcing this simplistic approach.

The basic demand equation used is of the form

$$C = f(PT, PS, t, \underset{\sim}{X}) \qquad (4.1)$$

where C denotes physical consumption per head of population, PT denotes retail tea price inclusive of taxes, PS denotes the price of substitutes, t is a proxy for changes in tastes and $\underset{\sim}{X}$ denotes other variables such as income and price of related goods, such as sugar. The functional form used and the variables subsumed under X vary from one country to the next.

Three functional forms were tried in estimation--semi-logarithmic, logarithmic and linear. In most cases the range of variation in the data is such that it would be hard to distinguish between the three on the grounds of goodness of fit. However, in those countries where income and/or consumption levels are changing relatively rapidly, the assumption of a constant elasticity is not reasonable. A semi-logarithmic or a linear function which allows elasticities to vary is a priori much more appealing. Thus, for instance, the semi-logarithmic form allows for a decline in the income elasticity of consumption.

The inclusion of PT and PS needs no explanation. The inclusion of a time trend can be justified in one or two ways. Firstly, the appearance of "new" beverages may alter the consumer's utility function in some smooth trend-related fashion. The partial derivative $\frac{\partial C}{\partial t}$ would then reflect the exogenously changing marginal utility of consumption. Some authors introduce the trend variable as a proxy for a stock which reflects the effect of habit formation, the assumption being that the stock is a simple function of time (Pollak and Wales 1969). This assumption, however, has the unfortunate

implication that habits and tastes changes continue even if prices and income remain constant. Stigler and Becker (1977) have argued that taste changes should be related to price changes, but the price variable relevant for an individual need not be the observed market price.

It is also possible to offer a justification for the trend variable included in the tea demand equation based on the technology of tea consumption. Write (4.1) in linear or log-linear form thus:

$$C = b_1 PT^* + b_2 PS^* + b_3 t + b_4 \underset{\sim}{X} \qquad (4.2)$$

where PT^* and PS^* now denote the effective prices of the consumption goods. Specifically, the imputed cost of making a cup of tea is included in PT^*. With the introduction of tea bags, "instant" tea, and "iced tea", which simplify the process of tea making, there has been a shift away from the consumption of loose tea. This change has had two effects. The first is that it reduces the effective price of a unit of tea. This can be expressed through a relationship between the measured price variable PT^* and the effective PT:

$$PT^* = PT - \rho t \ , \qquad \rho > 0, \qquad (4.3)$$

where ρ reflects the per period reduction in the unit price. The second effect is that the new technology is more efficient in the sense that it enables the same cuppage to be produced from a smaller amount of loose tea 1/ which is

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1/ Goradia (1977, pp. 9-10) estimates that over the period 1951-70 the global consumption of liquid tea rose by 145% while the consumption of tea leaves increased by only 92%.

also akin to a reduction in the effective price of tea. The parameter ρ captures this to some extent. Similar arguments could apply to the variable PS^*. However, it will be assumed that $PS = PS^*$. An important qualification is that such changes need not be well proxied by a trend. Combining (4.2) and (4.3) leads to

$$C = b_1(PT-\rho t) + b_2 PS + b_3 t + b_4 \underset{\sim}{X}$$

$$= b_1 PT + b_2 PS + (b_3 - b_1\rho)t + b_4 \underset{\sim}{X}. \qquad (4.4)$$

Note now that if $b_3<0$ and also $b_1<0$, then $(b_3-b_1\rho)$ is ambiguous in sign. The price reduction effect due to "technological" changes raises consumption, but the pure taste effect reduces it. On the other hand, if $b_3>0$, so tastes are changing in favor of tea, then the effective price reduction increases consumption and the coefficient of the trend variable will be positive. Unfortunately, however, since b_3 and ρ cannot be identified, a clear interpretation of the trend variable is not possible.

The variables $\underset{\sim}{X}$ will usually include per capita income. In the case of some developing countries where tea is usually consumed with milk and sugar (complementary commodities) the price of sugar has also been included as an additional variable. There are, however, some problems associated with the use of the income variable. The first is that for some countries per capita income shows a strong trend and hence its effects cannot be distinguished satisfactorily from those of the taste-cum-price variable. In several cases, where per capita tea consumption has been rising (as in the United States), a

negative coefficient was obtained on the income variable. As this results was thought to be unacceptable a priori, it was omitted from the specification and the trend variable was retained. Also for some other countries and country groupings such as the USSR, the EEC and North Africa (Algeria, Libya and Tunisia), the trend variable has been preferred to the per capita GDP.

IV.2 Empirical Results

The estimated demand equations are given in Table 5. Table 6 contains a summary of the price and income elasticities. Some estimates from Ramanujam's recent study are also included for purposes of comparison.

As expected, most of the price elasticities are less than 0.4 in absolute value. Some of the lowest values have been found for relatively large consumers such as Sri Lanka, and the United Kingdom. Some of the largest income elasticities are found for large consumers like India and Pakistan and for some Middle East countries where per capita consumption has grown fast. It is plausible that, in conformity with Engel's law, the income elasticity for tea should be specified to be a declining function of income. A linear or semi-logarithmic demand function can capture this feature. The use of a double logarithmic functional form, by contrast, may lead to an overestimate of the income elasticity which may produce over-estimates of consumption in the simulation period. Thus, even if two functional forms yield similar results in the sample period, they may produce rather different simulation results outside the sample. It would be desirable, therefore, to use a priori information to a greater extent in the selection of the functional form. As a specific example, consider the fact that the double logarithmic equation for India produced an estimate of income elasticity of around 2, whereas the semi-logarithmic equation implies an estimate of about 1.7 at the sample mean and

Table 5: ESTIMATED EQUATIONS FOR CONSUMPTION BLOCK *

SOUTH AFRICA - CONSUMPTION

0145: LN C1SO = 7.1601 - 0.0622 LN PTWSO(-1) - 0.0277 LN ET2
(17.0161 (-0.6067) (-5.6328)

R-SQUARED(CORR.): 0.696 SEE: 0.73452E-01 DW: 1.21

PERIOD OF FIT: 1971 1984

F(2, 11): 15.873

U.S. - CONSUMPTION

0101: C1US2 = 349.1718 + 0.1104 ATEMP12 - 0.4660 PTUS2 + 1.8351 T2
(9.3594) (1.8787) (-2.4651) (3.3393)

R-SQUARED(CORR.): 0.720 SEE:
16.216 DW: 1.32

PERIOD OF FIT: 1954 1983

F(3, 26): 25.880

U.K. - CONSUMPTION

0104: LN C1UK = 8.5546 - 0.0173 LN ET2 - 0.0295 LN PTUKCH
(370.187 (-15.7797) (-0.9677)

R-SQUARED(CORR.): 0.915 SEE: 0.38976E-01 DW: 1.68

PERIOD OF FIT: 1960 1984

F(2, 22): 130.479

INDIA - CONSUMPTION

0160: CIN = 140.1597 + 697.5458 GDPCINL - 418.9983 PTIN2
(1.9218) (10.6003) (-1.9380)

R-SQUARED(CORR.): 0.886 SEE: 25.997 DW: 1.41

PERIOD OF FIT: 1960 1983

F(2, 21): 90.697

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* See Glossary of Variables for definition of variables.

continued...

...continued

AUSTRALIA - CONSUMTPION

0506:
LN CAU = 3.8946 - 0.9015 LN TR51 - 0.0740 LN PTAU(-1)
(9.3872) (-12.7538) (-1.2250)

R-SQUARED(CORR.): 0.920 SEE: 0.44409E-01 DW: 1.81

PERIOD OF FIT: 1970 1984

F(2, 12): 81.329

CANADA - CONSUMTPION

0108: LN CCA = 0.8935 - 0.1437 LN PTCA - 0.0580 LN PTCA(-1) - 0.0199 LN ET2
(2.8038)(-1.9086) (-0.9010) (-16.1241)

+ 0.1023 LN PCWCA
(2.8267)

R-SQUARED(CORR.): 0.912 SEE:
0.49682E-01 DW: 1.97

PERIOD OF FIT: 1954 1984

F(4, 26): 79.039

TURKEY - CONSUMPTION

0112: C1TUR = + 0.9673 QCTUR
(104.8762)

R-SQUARED(CORR.): 0.987 SEE:
52.817 DW: 1.12

PERIOD OF FIT: 1976 1984

F(1, 8): 625.395

continued...

...continued

USSR - CONSUMPTION

0513:
LN C1USSR = -5.6556 + 1.3624 LN TR51 - 0.1569 LN WPRICEDF(-1)
(-18.2152 (14.8110) (-1.5216)

R-SQUARED(CORR.): 0.960 SEE: 0.63600E-01 DW: 1.95

PERIOD OF FIT: 1967 1984

F(2, 15): 206.998

EGYPT - CONSUMPTION

0125: LN C1EG = - 5.7449 + 0.9846 LN GDPC2EG - 0.0609 LN PSWEG
(-4.2247) (4.2108) (-0.8899)

R-SQUARED(CORR.): 0.428 SEE: 0.21692 DW: 1.53

PERIOD OF FIT: 1962 1983

F(2, 19): 8.868

SAUDI ARABIA - CONSUMPTION

0127:
LN C1SA2 = 1.2282 + 0.4974 LN GDPC2SA2 - 0.2990 LN PTWSA2 - 0.2357 LN PSWSA2
(0.3472) (1.1742) (-0.8088) (-3.5073)

R-SQUARED(CORR.): 0.765 SEE: 0.13792 DW: 1.67

PERIOD OF FIT: 1969 1983

F(3, 11): 16.231

SRI LANKA - CONSUMPTION

0128:
LN C1SL = 1.1775 + 0.8208 LN C1SL(-1) - 0.0114 LN PRS(-1) - 0.0375 LN PRS
(1.1823) (6.0094) (-0.3704) (-1.2725)

R-SQUARED(CORR.): 0.701 SEE: 0.21731E-01 DW: 2.11

PERIOD OF FIT: 1965 1982

F(3, 14): 14.271

continued...

...continued

REST OF WESTERN EUROPE - CONSUMPTION

0140:
LN CN1RWE1 = 10.5726 + 0.0179 LN ET2 + 0.1115 LN PCWORLD
(74.5790) (5.2353) (2.8144)

- 0.1521 LN PTLOND(-1)
(-2.0857)

R-SQUARED(CORR.): 0.937 SEE: 0.45174E-01 DW: 2.14

PERIOD OF FIT: 1961 1983

F(3, 19): 110.638

EASTERN EUROPE - CONSUMPTION

0130:
CN1EE = 6769.7065 - 276339.2500 WPRICEDF + 962.8294 T2
(1.0277) (-2.1912) (4.6623)

R-SQUARED(CORR.): 0.949 SEE: 2098.9 DW: 2.15
RHO(1): 0.756

PERIOD OF FIT: 1960 1983

F(2, 20): 204.402

PAKISTAN - CONSUMPTION

0133:
LN C1PAK2 = -1.1317 - 0.0753 LN PSWPA2 + 0.8635 LN GDPC2PA2
(-4.6962)(-2.0039) (6.0697)

- 0.0518 LN PTWPA2
(-0.3862)

R-SQUARED(CORR.): 0.806 SEE: 0.63683E-01 DW: 1.52

PERIOD OF FIT: 1972 1983

F(3, 8): 16.191

continued...

...continued

CHILE - CONSUMPTION

0134:
LN C1CH = 7.3810 + 0.7215 LN EDM74 + 0.6256 LN PCWCH
(16.1212 (6.2948) (4.9271)

- 0.6024 LN PTLCH - 0.1407 LN PSWCH(-1)
(-3.1206) (-3.3640)

R-SQUARED(CORR.): 0.764 SEE: 0.10647 DW: 2.26

PERIOD OF FIT: 1965 1983

F(4, 14): 15.562

SYRIA - CONSUMPTION

0535:
LN C1SYR2 = -1.3676 + 0.4249 LN GDPC2SYR2 + 0.6690 LN C1SYR2(-1)
(-1.5203) (2.6496) (6.0528)

R-SQUARED(CORR.): 0.869 SEE: 0.13877 DW: 1.91

PERIOD OF FIT: 1957 1983

F(2, 24): 86.867

NORTH AFRICA - CONSUMPTION

0138:
LN CN1NA = 7.3428 + 0.0258 LN ET2 - 0.5258 LN WPRICEDF
(10.1954 (2.8081) (-2.2482)

R-SQUARED(CORR.): 0.778 SEE: 0.16665 DW: 2.01

PERIOD OF FIT: 1960 1983

F(2, 21): 41.403

continued...

... continued

NEW ZEALAND - CONSUMPTION

0142:

```
LN C1NZ  = 7.4567 - 0.0259 LN ET2 - 0.2423 LN PTWNZ(-1) + 0.0192 LN PCWNZ(-1)
          (18.5655 (-5.6188)       (-1.8997)              (0.2961)

R-SQUARED(CORR.): 0.784          SEE: 0.81175E-01                    DW: 1.91

PERIOD OF FIT:   1955   1984

F(  3, 26):    36.024
```

OTHER ARAB COUNTRIES

0158:

```
CN1ARAB  =  8342.0508  -  709063.2500 PTWORLD  +  4388.8398 PCWORLD
             (0.4389)       (-1.7307)              (1.5107)

         +  771.4318 TRARA  -  9237.0986 DM82
             (1.2180)           (-2.3802)

R-SQUARED(CORR.): 0.754            SEE:  4340.8                      DW: 0.99

RHO(1):  0.698

PERIOD OF FIT:   1970   1983

F(  4,  8):    10.183
```

REST OF WORLD - CONSUMPTION

0161:

```
LN CN1ROW  =  11.9103  -  0.6049 LN PTLOND  -  0.3321 LN PTLOND(-1)
             (76.2005)  (-3.0176)            (-2.1167)

           +  0.2338 LN PCWORLD  -  0.1782 LN EDM80
              (2.3421)             (-1.8418)

R-SQUARED(CORR.): 0.624          SEE: 0.90744E-01                    DW: 2.49

PERIOD OF FIT:   1970   1983

F(  4,  9):     6.403
```

Table 6: PRICE AND INCOME ELASTICITIES OF DEMAND FOR TEA

	This study		Ramanujam	
	Retail Price	Income	Retail Price	Income
Australia (*)	-.07	-	-.09	
Canada	-.20	0.10	-0.09	.66
Chile	-.60	-		
Eastern Europe (*)	-.40	-		
Egypt	-	0.98		
India (**)	-.23	-1.71	-.09	.09
New Zealand	-.24	-		
North Africa	-.53	-		
Other Arab Countries	-.73	-		
Pakistan	-.05	0.86		
Rest of W. Europe	-.15	-	-	-.09/-.31
Saudi Arabia	-.30	0.50		
South Africa	-.06	-	-.18	
Sri Lanka	-	0.42	-.26	
Syria	-.14	0.76		
U.K.	-.03	-	-.18	
US (*)	-.34	-	-.41	
USSR	-.16	-		
REST OF WORLD	-.93			

Notes: *Indicates a linear specification, ** indicates a semi-logarithmic specification. In the remaining cases, the specification is double logarithmic.

about 1.3 for 1983. The two estimates have vastly different implications for the behavior of prices in view of the fact that India is such an important consuming country.

Turning to the time trend variable, it is worth noting that the United States, USSR, Eastern Europe, North Africa and Rest of Western Europe all show positive coefficients while the remaining countries have negative coefficients. In all these cases, the positive coefficient could reflect exogenous growth in the taste for tea, or the effect of income growth, or the trend component of effective price reduction. But it is also not realistic to suppose that the trend variable can satisfactorily capture all these effects.

V. PRICE DETERMINATION

V.1. Specification of the Price Equation

The general question of price determination is a complex one since it involves questions concerning the structure of markets in which a commodity is traded and the question of whether these conditions can lead to disequilibrium. In the specific case of commodities like tea and coffee, and perhaps also other tree crops, there is a widespread presumption that price determination conforms to the basic paradigm of competitive markets, at least as a good first-order approximation. If this position is accepted, the "price equation" of the model should be one that corresponds to the standard "law of supply and demand" in which the change of price is a function of the gap between market demand and supply.

In the context of the elementary static market model consisting of three equations, viz. supply, demand and the equilibrium condition, the model will determine three endogenous variables, quantity demanded, quantity supplied and the price. If an inventory accumulation identity is added to the model, so that equality of production and demand period by period is no longer required, the basic picture does not change much since a new equilibrium condition would replace replacing the old one. This equilibrium condition would stipulate that the price must be such that the excess of production over demand must be willingly held. In a model with inventories no price equation is required to close the model.

In extending these basic ideas to a global dynamic model of a perennial crop, several complications need to be considered. First, there is the complication arising from the existence of a production lag or the gestation lag. Production is determined in part by price expectations held in the past

about the future price level. The second complication arises when the existence of demand for inventories (consisting of a transactions component and a speculative component) is introduced. The latter component, in the usual specification, depends upon the difference between the prevailing market price and the expected future price of that commodity. There is an intimate connection between the current price and the expected, past, current and future prices. The third complication arises from the hypothesis of rational expectations which implies certain restrictions on the equation of the model and on the errors of expectation.

If commodity market disequilibria last for relatively short periods of time only, and hence the market clearing model applies, the assumption of rational expectations has considerable appeal. It is then necessary to consider how prices will behave along the rational expectation equilibrium path. To characterize the response of the equilibrium price level to stochastic demand and supply shocks in this case involves a derivation of the rational expectations solution to the model. Such an exercise can involve considerable complications in a global commodity model which would necessarily have a large number of exogenous variables (both on the demand and on the supply side) and which is highly likely to be nonlinear. Furthermore, within a global model the demand and supply equation would be specified in terms of local consumer and producer prices which would reflect the effects of local taxes, exchange rates and so forth. "The price" which clears the market, however, is the average world price. In that sense "the price equation" of the model should be specified to explain the variation in the average world price. If this approach is accepted, then two issues have to be tackled, viz., (i) the specification of a model-closure equation which, in conjunction with the

rest of the model, determines the average world price; and (ii) the specification of linkage equations which connect the average world price with various local prices.

The approach taken to this problem is to begin with a linear anolog model of the global model specified in terms of average world prices. This model is solved to yield a rational expectations solution and to derive the theoretical price equation. The insights provided by the analog model are used to specify the empirical price equation. However, given the gap between the linear analog model and the actual nonlinear empirical model, the connection between the theoretical and empirical price equations remains a loose one.

V.2 Linear Analog Model

The linearized model of world demand and world supply consists of the following equations:

$$Q_t = \gamma_1 P_t + \gamma_2 P_t^e + \psi_1 X_{1t} + u_{1t} \qquad \text{(production)} \qquad (5.1)$$

$$Q_t^d = -\beta_1 P_t + \psi_2 X_{2t} + u_{2t} \qquad \text{(demand)} \qquad (5.2)$$

$$P_t^e = E[P_t | I_{t-1}] \qquad \text{(expectations)} \qquad (5.3)$$

$$H_t^d = \delta_1 (P_{t+1}^e - P_t) + \delta_2 Q_{t+1}^{d,e} \qquad \text{(inventory demand)} \qquad (5.4)$$

$$H_t = H_{t-1} + Q_t - Q_t^d \qquad \text{(market clearing)} \qquad (5.5)$$

$$H_t^d = H_t \, . \qquad \text{(market clearing)} \qquad (5.6)$$

The current meaning of the symbols is as follows:

Q : World production

Q^d : World demand for consumption

P : World price

P_t^e : World price for period t expected in period t-1

X_{1t}, X_{2t} : Vectors of exogenous variables

H_t : Inventories at the end of period t

$Q_{t+1}^{d,e}$: World demand for period t+1 expected in period t

H_t^d : World demand for inventories

u_{1t}, u_{2t} : Stochastic disturbances

I_t : Information set at time t

It is not necessary to provide a detailed justification of equations (5.1) and (5.2) which are consistent with the production and demand equations developed earlier in this paper. We assume δ_1, δ_2, β_1, γ_1, γ_2, to be positive. To preserve the homogeneity property of the demand and supply functions the price variable appearing in such equations should be the real price. In the context of a world demand and supply model the appropriate deflators to use in (5.1), (5.2) and (5.4), respectively, will be different and will be functions of the general world price level and exchange rates in the producing, consuming and stockholding countries. At the theoretical level the simplifying assumption is made that the deflators are all the same, implying that the price variable(s) in different equations as the same. An alternative possibility is to interpret P as the nominal price but to include the relevant deflators and exchange rates as exogenous variables in all equations where the price variable appears. To ensure the homogeneity property the parameters of the equation would be subject to additional restrictions.

Now consider equation (5.4) which is a variant of the standard inventory equation used in the supply of storage literature. See Weymar (1968). The first term on the right-hand side is the speculative component. Strictly speaking this component should depend upon the expected price change net of the cost of storage (usually proxied by an interest rate variable), but for simplicity storage costs are ignored. It is assumed $\delta_1 > 0$. Some derivations of the demand for speculative inventories show the coefficient δ_1 to be a nonlinear function of higher moments of the distribution of P but this possibility is also ignored. The second term in (5.4) reflects transactions demand for inventories. That is, it is hypothesized that inventories produce a positive convenience yield and that the transations component reflects this. The demand for inventories for transactions purposes depends upon expected future consumption demand, denoted $Q^{d,e}_{t+1}$.

Equation (5.4) may be thought of as the price equation of the model. Combining (5.4) and (5.6) and normalizing on P_t leads to

$$P_t = \frac{1}{\delta_1} H_t + P^e_{t+1} + \frac{\delta_2}{\delta_1} Q^{d,e}_{t+1}$$

$$= -\frac{1}{\delta_1} H_t + P^e_{t+1} + \frac{\delta_2}{\delta_1} (-\beta_1 P^e_{t+1} + \Psi_2 X_{2,t+1} + u_{2,t+1}) \qquad (5.7)$$

whence it is seen that the period t price will depend, inter alia, upon expected future price and on the expected future values of X_2. Equation (5.7) is "structural" in the sense that its parameters have a behavioral interpretation. However, if additional assumptions are made about the process generating future values of X_2, and if these are substituted into (5.6), then the resulting equation contains some parameters which are not "structural" in one

sense. If an acceptable proxy for P^e_{t+1} is available, as will be the case when a futures market exists, and if a proxy variable for $X_{2,t+1}$ can also be found, then (5.7) can be estimated directly. However, as no futures price variable is available for tea, estimation is approached indirectly by first solving the model to obtain a reduced form solution for P^e_{t+1} and then substituting it back into (5.7) to produce a pseudo-structural equation for P_t.

V.3 Solution of the Model

Combining (5.1) ~ (5.6) and solving for P_t yields the following linear equation:

$$P_t = \lambda P_{t-1} + \alpha P^e_{t+1} + \beta P^e_t + v_t \qquad (5.8)$$

where λ, α, β and v_t are defined as follows:

$$\lambda = \delta_1 d^{-1}$$

$$d = \gamma_1 + \beta_1 + \delta_1$$

$$\alpha = (\delta_2\beta_1 - \delta_1)d^{-1}$$

$$\beta = (\delta_2\beta_1 - \gamma_2 - \delta_1)d^{-1}$$

$$v_t = [\delta_2 u^e_{2,t+1} - \delta_2 u^e_{2t} + u_{2t} - u_{1t} - \psi_1 X_{1t}$$

$$+ \delta_2\psi_2(X^e_{2,t+1} - X^e_{2t}) + \psi_2 X_{2t}]d^{-1}.$$

The superscript e denotes the value expected in the previous period. Note that the stochastic demand and supply disturbances, the current and expected future values of X_2 and the current value of X_1 all appear as components of v_t. The explicit solution of the equation (5.8) depends upon the roots of the quadratic equation

$$\alpha\mu^2 - (1-\beta)\mu + \lambda = 0. \tag{5.9}$$

Although there are several cases to consider, a special case of some interest is one in which equation (5.9) will have two real roots μ_1 and μ_2, $\mu_1 < 1$ and $\mu_2 > 1$. This is sometimes referred to as the 'regular' case.

The general solution for P_t involves a "backward" and "forward" infinite series in v_t. Also, if no further restrictions are imposed, such a solution need not be unique. There are a number of ways of achieving a unique solution. One of these is to assume that the stochastic process generating input variables in the difference equation (5.8) is stationary. In this case a unique stable "forward" solution will exist. To show this explicitly define the process

$$V_t = (1-\alpha\mu_1)^{-1} \sum_{i=0}^{\infty} \mu_2^{-i} E(v_{t+i}|I_t) \tag{5.10}$$

and assume that this is a realizable stationary process. Then using the theory of martingale difference processes it can be shown that the reduced form (unique) forward solution for P_t is given by

$$P_t = \mu_1 P_{t-1} + V_t - \omega E[V_t|I_{t-1}] \tag{5.11}$$

where $\omega = (\delta_2\beta_1 - \gamma_2 - \delta_1)/[(\delta_2\beta_1 - \delta_1)\mu_2]$.

(5.10) and (5.11) show that P_t is determined by current and expected future values of the X_1 and X_2 and of u_{1t} and u_{2t}. If the stochastic process generating the exogenous variables X_1 and X_2 can be specified explicitly, then it may be possible to replace the last term in equation (5.11) by an expression in terms of observable variables only. Some commonly used assumptions include the following: X_t is generated by (i) random walk with a drift, (ii) a first order autoregression, and (iii) random walk with a first order moving average process. 1/ Under assumption (i) the future values of exogenous variables are obtained by adding a constant to the known current value. So the reduced form equation ends up with only current dated exogenous variables in it. Under assumption (ii) also the future dated values of X_1 and X_2 can be reexpressed in terms of the current values. 2/

V.4 Derivation of the "Structural" Equation

The "structural" version of the price equation is obtained as follows. Using (5.11)

1/ Given assumption (iii) the optimal forecasting procedure is to use the adaptive expectations formula.

2/ Given assumption (iii) lagged values of X_1 and X_2 will appear in the equation though the usual transformation may be applied to eliminate them.

$$P^{e}_{t+1} = E[P_{t+1}|I_t]$$

$$= \mu_1 P_t + (1-\omega)E[V_{t+1}|I_t] \qquad (5.12)$$

which is then substituted into (5.7) and the equation rearranged. This yields a forward-looking price equation:

$$P_t = (1-\mu_1 + \frac{\mu_1\beta_1\delta_2}{\delta_1})^{-1} [-\delta_1 H_t + (1-\omega)(1 + \frac{\delta_2}{\delta_1})] E(V_{t+1}|I_t)$$

$$+ \psi_2 X_{2,t+1} + u_{2,t+1}]. \qquad (5.13)$$

To turn (5.13) into an estimatable equation the simplest procedure would be to replace the last three terms by a linear function of the current values of X_1 and X_2 and any other variable which is useful for forecasting future demand and supply shocks. Clearly this procedure still leaves scope for 'experimentation'.

V.5 Empirical Application

In the empirical implementation of (5.13) the first task to be tackled concerns the definition of the price variable and the choice of the deflator. The empirical counterpart of nominal P is WPRICE which denotes the weighted average of the price of tea at four auction centers--Calcutta, Cochin, Colombo and Mombasa--denominated in US dollars per Kg. The weights used are shares in the total value of tea traded with the qualification that dust tea is excluded. The price includes export taxes and cesses which are important in Sri Lanka and which have been imposed periodically in India.

The next question concerns the appropriate deflator for WPRICE. The chosen deflator is the ratio of weighted CPI for the United Kingdom, India and Sri Lanka divided by the weighted exchange rate for the same three countries. The weights used in each case are the total tea stocks held in each of the three countries, expressed as a proportion of the total stocks in the three countries combined. The rationale for this index is as follows. Firstly, it is broadly true that proportionally the largest amount of tea stocks are held in India, Sri Lanka and the United Kingdom. Since the stocks data for other countries are somewhat fragmentary the simplifying assumption is adopted that total 'world' stocks consist of the stocks in the United Kingdom, India and Sri Lanka; which implies that the equation (5.4) represents inventory demand in those three countries alone. It follows that the appropriate deflator is the three-country weighted CPI, denoted CPI3. Secondly, since WPRICE is expressed in US dollars an exchange rate conversion is required. Therefore, CPI3 is divided by EXW3, which denotes a weighted average of exchange rates in the three countries--the weights being the same as those used for constructing CPI3.

The dependent variable in the price equation is (log of) WPRICE and not WPRICE x EXW3/CPI3. If the latter were used, the equation would explain the <u>real</u> price of tea. This would be equivalent to specifying a homogeneous-of-degree-zero inventory equation. However, given the approximations implicit in the construction of CPI3 and EXW3 it does not seem appropriate to impose the homogeneity assumption. Instead CPI3/EXW3 has been included as an independent variable on the right-hand side. (The estimates show that the elasticity of WPRICE with respect to this deflator is 1.18 with a standard

error of 0.16, somewhat greater than the value of unity which would apply if the homogeneity postulate was completely consistent with the data.)

Turn now to the proxy variables for the future-dated exogenous variables in the price equation. Clearly these should be the aggregate world counterparts of the exogenous variables which enter the demand and production equations for individual countries. On the supply side the most important exogenous variables are time trend, various country specific price deflators and exchange rates, and subsidies. On the demand side, time trend has also been found to be an important explanatory variable, being a proxy for, inter alia, growth in per capita income and changes in taste. Another exogenous variable included in some demand equations is the price of coffee, though this variable has not been found to be particularly important. Nevertheless, it may have special value in forecasting future demand disturbances, i.e., in calculating $E(u_{2,t+1}|I_t)$. That is, the importance of the coffee price variable may derive not only from its power to predict the future coffee price, which probably has a rather small direct impact on tea consumption, but also from its usefulness as a predictor of future demand disturbances $(u_{2,t+i},\ i \geq 1)$.

The WPRICE equation estimated for the model is log-linear. The exogenous variables included CPI3/EXW3, TYT, TYT_{-1}, lagged values of CN4W and a time trend. The variable CPI3/EXW3 is included because of its role as a deflator in the inventory equation. Its inclusion can also be justified on the argument that its current value may be useful for predicting future values which belong in the price equation. (This gives yet another reason for not imposing the homogeneity constraint.) TYT denotes the coffee price variable denominated in US dollars. CN4W denotes the total world consumption of tea.

The price equation was estimated by ordinary least squares and the Hausman-Wu test of exogeneity of the 'world' stock variable (TWS) was made. The results indicated (as expected) that TWS should be treated as an endogenous variable. The equation was then estimated by the generalized instrumental variable method. Whether ordinary least squares or instrumental variables are used, it is found that the current and lagged coffee price variable is extremely important in explaining WPRICE. The same is also true for the deflator CPI3/EXW3. The total 'world' inventory variable TWS has the expected negative coefficient with a t-ratio between 2.6 and 3.8, depending upon the estimation procedure. When the predicted value of TWS is used, based on a first stage log-linear regression of TWS on a number of exogenous variables (including the trend and lagged value of CN4W), the stock variable was highly significant in the equation, but not the trend variable. The reason seems to be that the predicted value of TWS is quite smooth and hence highly correlated with the trend variable and with CN4W which is also trend-like. If, on the other hand, the ordinary least squares procedure is used only the TWS variable has a small coefficient (about 0.6 rather than 1.0) while the trend variable has a positive coefficient and t-ratio approaching 1.8.

In conclusion, although the basic specification derived in this section gets substantial empirical support, the final point estimates reported are sensitive to the choice of the estimation method and the exogenous and lagged endogenous variables used as proxies for their future values. It is hard to see how to avoid a degree of arbitrariness in choosing a specification.

V.6 Price Linkage Equations

From the view point of model closure it is essential to relate WPRICE to local prices.

The "world" price in the model is a value-weighted average of auction prices from Calcutta, Cochin, Colombo and Mombasa in US dollars, inclusive of sales tax, cesses and export duties, i.e.

$$WPRICE = \frac{\sum PA_i^2 * EX_i * QA_i}{\sum PA_i * EX_i * QA_i}$$

where PA_i = Auction price in local currency

EX_i = Exchange rate between the US dollar and local currency

QA_i = Quantity of tea sold at i

WPRICE is linked to five major auction prices (4 auction places plus London) through equations given in Table 7. As the equations show, the price movements in all auctions closely follow the "world" price. Any deviation could be due to differences among auctions in quality, transportation costs and relative availabilities of tea. The high correlation among major auction prices suggests that the assumption of tea being a homogenous commodity is acceptable.

An equation linking the Calcutta and Cochin auction prices to the unit value of tea produced in India also estimated. The unit value of tea was taken as a proxy for producer prices in India. Before this price linkage equation was finalized, two intermediate steps were taken. First, Calcutta and Cochin auction prices (in US dollars), which refer only to leaf, were linked to the unit value of tea inclusive of dust in the two auctions. The weighted average of these unit values were linked to unit value of tea in India.

Table 7: PRICE AND LINKAGE EQUATIONS *

WORLD PRICE

9969: WPRICEL = 4.7486 + 0.2479 TYT + 0.4162 TYT(-1)
(4.9879) (4.5334) (6.4177)

+ 1.2722 III - 1.3359 TWSLHAT3 + 0.0152 TR61
(8.2859) (-6.7953) (1.4579)

R-SQUARED(CORR.): 0.974 SEE: 0.57394E-01 DW: 1.64

PERIOD OF FIT: 1964 1983

F(5, 14): 143.496

PRICE LINKAGE EQUATIONS

Calcutta auction price in US dollars

LN PRICCALC2$ = 0.0662 + 1.0813 LN WPRICE
(6.3680) (43.7006)

R-SQUARED (CORR.): 0.991 SEE: 0.38195E-01 DW: 1.30

PERIOD OF FIT: 1965-1983

Cochin auction price in US dollars

LN PRICOCH2$ = -0.0639 + 1.0492 LN WPRICE
(-6.4656) (36.9010)

R-SQUARED (CORR.): 0.978 SEE: 0.46204E-01 DW: 2.02

PERIOD OF FIT: 1952-1983

Colombo auction price in US dollars

LN PRICOLO$ = -0.0197 + 0.9346 LNWPRICE
(1.9299)(31.8995)

R-SQUARED (CORR.): 0.970 SEE: 0.47614E-01 DW: 1.02

PERIOD OF FIT: 1952-1983

See Glossary of Variables for definition of variables.

continued...

...continued

Mombasa auction price in US dollars

LN PRIMOMB$ = -0.0442 + 0.9650 LNWPRICE - 0.1613 LN EDM78
(-2.1465)(20.3521) (-2.2558)

R-SQUARED (CORR.): 0.966 SEE: 0.65942E-01 DW: 2.11

PERIOD OF FIT: 1965-1983

London auction price in US dollars

LN TPLOND = 4.8041 + 0.8974 LN WPRICE
(256.725) (20.1394)

R-SQUARED (CORR.): 0.957 SEE: 0.68779E-01 DW: 1.39

PERIOD OF FIT: 1965-1983

Linkage between leaf auction price and average of leaf and dust auction price in Calcutta and Cochin.

LN PRICALC = -0.2258 + 1.0441 LN PRICALC3
(-5.8880)(64.9806)

R-SQUARED (CORR.): 0.996 SEE: 0.31885E-01 DW: 0.74

LN PRICOCH = -0.1285 + 1.0257 LN PRICOCH3
(-5.8087)(98.3440)

R-SQUARED (CORR.): 0.998 SEE: 0.24017E-01 DW: 1.31

PERIOD OF FIT: 1965-1983

Linkage between weighted average auction prices of leaf and dust in Calcutta and Cochin to unit value of tea produced in India.

LN PRIIND1 = 0.0107 + 0.9956 LN PRIINDW
(1.3749) (253.3529)

R-SQUARED (CORR.): 1.000 SEE: 0.10922E-01 DW: 1.44

PERIOD OF FIT: 1952-1983

continued...

...continued

Linkage between Mombassa auction price and price paid by KTDA to Kenya smallholders.

LN PRIKTDA = -1.7205 + 0.9808 LN PRIMOMB
(-10.4500) (14.3009)

R-SQUARED (CORR.): 0.940 SEE: 0.11614 DW: 1.04

PERIOD OF FIT: 1970-1983

Retail Price in the US

LN TPUS = 1.7877 + 0.4601 LN WPRICE + 0.6432 LN TPUS(-1)
(3.8038) (4.2863) (6.8342)

R-SQUARED (CORR.): 0.940 SEE: 0.94048E-01 DW: 1.64

PERIOD OF FIT: 1960-1983

Retail Price in UK

LN TPUK = -0.5287 + 0.6811 LN TPUK (-1) + 0.4936 LN TPLONDUK
(-1.7797) (7.9504) (4.8186)

R-SQUARED (CORR.): 0.957 SEE: 0.12610 DW: 2.24

PERIOD OF FIT: 1965-1983

Retail Price in Australia

LN TPAU$ = -2.3246 + 1.4980 LN TPLOND
(-3.4368)(11.1121)

R-SQUARED (CORR.): 0.872 SEE: 0.19061 DW: 1.11

PERIOD OF FIT: 1965-1983

Retail Price in Canada

LN TPCA = 0.8311 + -0.5176 LN TPLONDCA + 0.6440 LN TPCA (-1)
(-3.7215) (5.6044) (7.5587)

R-SQUARED (CORR.): 0.968 SEE: 0.85377E-01 DW: 1.38

PERIOD OF FIT: 1960-1983

continued...

...continued

Retail Price in India

LN TPIN = 0.8443 + 0.8330 LN PRIINDW
(8.2495)(18.2237)

R-SQUARED (CORR.): 0.948 SEE: 0.94211E-01 DW: 0.67

PERIOD OF FIT: 1965-1983

An equation linking the price paid by KTDA to Kenya smallholders and the Mombasa auction price was also estimated.

These linkage equations give a very good fit and the coefficients are well within the expected range, i.e. close to unity.

The "world price" and some auction prices were linked to retail prices in the United States, United Kingdom, India, Australia and Canada. In the United States, United Kingdom and Canada evidence was found of delayed adjustments of retail prices to "world" or auction prices.

Prices used in the demand and supply equations for other countries are the "world" or auction prices adjusted by corresponding exchange rates and consumer price indices.

VI. MODEL SIMULATIONS

Dynamic ex-post and ex-ante model eimulations were carried out. The purposes of this simulation exercise were to examine how the model performs in simulating the past and in forecasting, and to investigate its prominent characteristics.

VI.1 Results of Ex-Post Simulation

An ex-post simulation with the model was carried out for the period 1975-83. The simulated values can be compared with the actual historical values to evaluate the model's performance. Some statistics on the simulation results for selected variables are given in Table 8.

As Table 8 shows, the dynamic ex-post simulation results are satisfactory. The nominal and real world prices yield root-mean-square percentage errors of 11% and for world consumption and production they are about 1%. The model captures all the significant turning points of the key variables. Significantly, the model captures the sharp rise in the world price in 1977 and 1983. The rise in 1977 was, in the main, caused by low stock levels and the boom in coffee prices; the sharp rise in the world price in 1983 was caused by a decline in stocks which in turn was the cumulation of steadily increasing demand and stagnant production in the preceding 3-4 years.

Table 8: RESULTS OF EX-POST SIMULATION
ACTUAL AND PREDICTED VALUES OF SELECTED VARIABLES: 1975-83

WORLD DEMAND

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	1217453.625	1200485.625	16968.000	1.394
197601	1277629.875	1288592.375	-10962.500	-0.858
197701	1316020.625	1296932.375	19088.250	1.450
197801	1319398.250	1310620.875	8777.375	0.665
197901	1407339.500	1397360.750	9978.750	0.709
198001	1457335.000	1448943.125	8391.875	0.576
198101	1453270.000	1434582.875	18687.125	1.286
198201	1457848.000	1456025.750	1822.250	0.125
198301	1535750.000	1538569.875	-2819.875	-0.184

```
DATE          GRAPH RANGE OF VALUES: 1200485.625 TO  1538569.875
      .....................................................
197501 .+ *                                                .
197601 .          * +                                      .
197701 .             +   *                                 .
197801 .                +*                                 .
197901 .                          + *                      .
198001 .                                +*                 .
198101 .                             +   *                 .
198201 .                                 X                 .
198301 .                                               X   .
      .....................................................
```

SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	10832.8887
MEAN ABSOLUTE % ERROR	0.8052
ROOT MEAN SQUARED ERROR	12382.6631
ROOT MEAN SQUARED % ERROR	0.9287

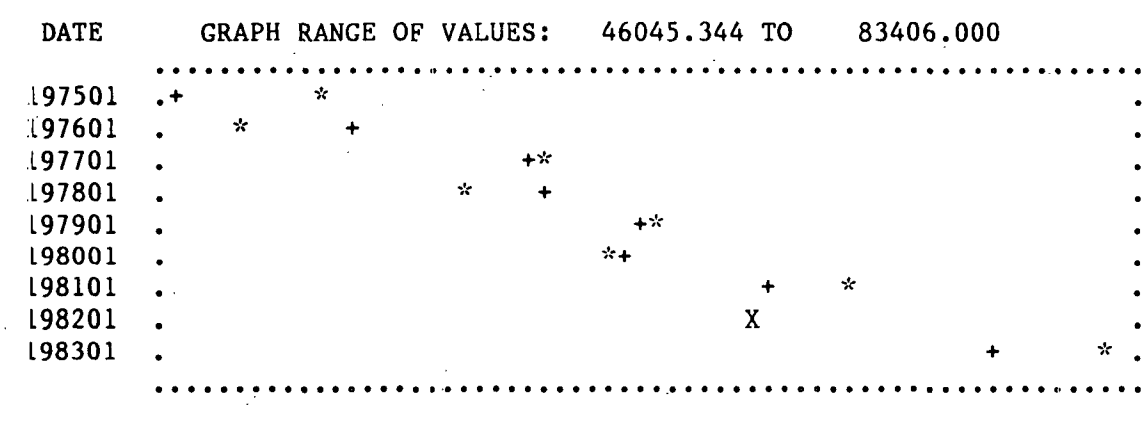
ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

DEMAND IN PAKISTAN

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	52000.000	46045.344	5954.656	11.451
197601	49100.000	53418.250	-4318.250	-8.795
197701	60700.004	60374.637	325.367	0.536
197801	57500.000	60896.848	-3396.848	-5.908
197901	65330.000	64979.285	350.715	0.537
198001	63599.000	64020.789	-421.789	-0.663
198101	73252.000	69691.766	3560.234	4.860
198201	69136.000	69282.742	-146.742	-0.212
198301	83406.000	78645.336	4760.664	5.708



SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	2581.6963
MEAN ABSOLUTE % ERROR	4.2967
ROOT MEAN SQUARED ERROR	3356.7725
ROOT MEAN SQUARED % ERROR	5.7797

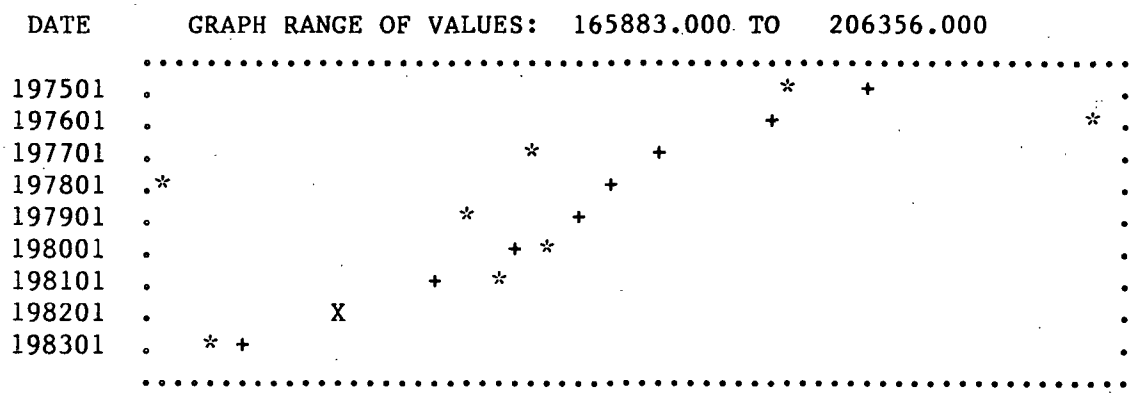
ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

DEMAND IN UNITED KINGDOM

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	193153.000	196615.672	-3462.672	-1.793
197601	206356.000	192327.391	14028.609	6.798
197701	181738.000	187481.984	-5743.984	-3.161
197801	165883.000	185143.625	-19260.625	-11.611
197901	179002.000	183907.250	-4905.250	-2.740
198001	182882.000	181493.281	1388.719	0.759
198101	180467.000	177797.578	2669.422	1.479
198201	173706.000	173630.172	75.828	0.044
198301	167992.000	169957.563	-1965.563	-1.170



SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	5944.5190
MEAN ABSOLUTE % ERROR	3.2839
ROOT MEAN SQUARED ERROR	8496.6797
ROOT MEAN SQUARED % ERROR	4.7828

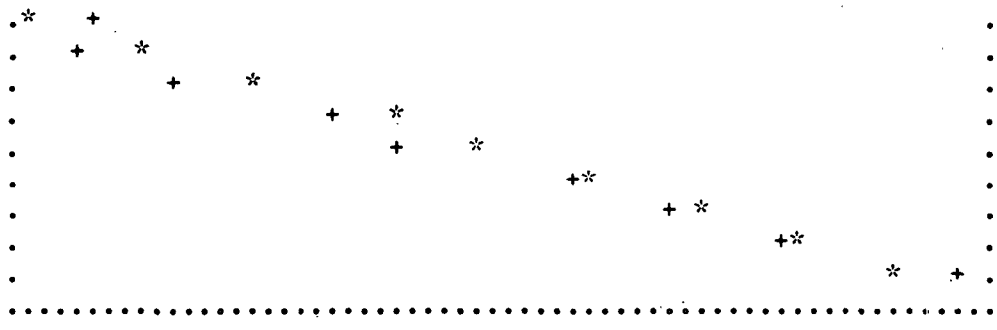
ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

...continued

DEMAND IN INDIA

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	272000.000	280498.469	-8498.469	-3.124
197601	287000.000	279657.906	7342.094	2.558
197701	302000.000	292612.750	9387.250	3.108
197801	320000.000	312350.000	7650.000	2.391
197901	332000.000	320213.406	11786.594	3.550
198001	346000.000	343171.656	2828.344	0.817
198101	360000.000	356969.969	3030.031	0.842
198201	372000.000	371089.531	910.469	0.245
198301	386000.000	394409.375	-8409.375	-2.179

DATE GRAPH RANGE OF VALUES: 272000.000 TO 394409.375



SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	6649.1807
MEAN ABSOLUTE % ERROR	2.0905
ROOT MEAN SQUARED ERROR	7456.7217
ROOT MEAN SQUARED % ERROR	2.3681

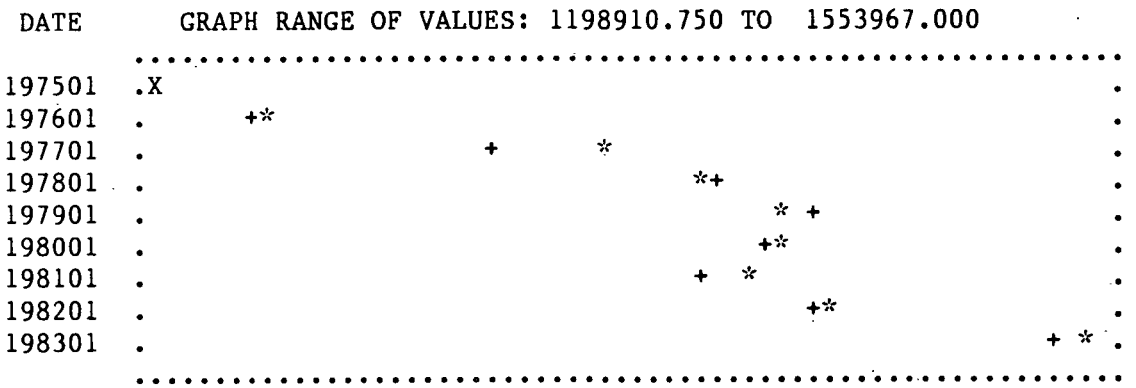
ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

WORLD PRODUCTION

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	1200494.000	1198910.750	1583.250	0.132
197601	1246042.000	1236819.250	9222.750	0.740
197701	1370261.000	1330406.250	39854.750	2.909
197801	1407164.000	1411555.875	-4391.875	-0.312
197901	1439309.000	1447506.500	-8197.500	-0.570
198001	1439347.000	1432909.000	6438.000	0.447
198101	1426039.000	1404363.125	21675.875	1.520
198201	1456660.000	1446046.125	10613.875	0.729
198301	1553967.000	1538400.500	15566.500	1.002



SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	13060.4863
MEAN ABSOLUTE % ERROR	0.9289
ROOT MEAN SQUARED ERROR	17090.3359
ROOT MEAN SQUARED % ERROR	1.2244

ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

PRODUCTION IN INDIA

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	487137.000	496078.063	-8941.063	-1.835
197601	511817.000	504903.688	6913.313	1.351
197701	556267.000	538680.750	17586.250	3.161
197801	563846.000	576420.750	-12574.750	-2.230
197901	543776.000	576122.313	-32346.313	-5.948
198001	569550.000	577079.688	-7529.688	-1.322
198101	560041.000	574561.313	-14520.313	-2.593
198201	560732.000	574227.125	-13495.125	-2.407
198301	587795.000	599219.813	-11424.813	-1.944

```
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197601  .         +  *                                               .
197701  .                           +        *                       .
197801  .                                       *     +              .
197901  .                             *                +              .
198001  .                                          *   +             .
198101  .                                     *       +              .
198201  .                                     *      +               .
198301  .                                                  *     + .
        ..............................................................
```

SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	13925.7363
MEAN ABSOLUTE % ERROR	2.5324
ROOT MEAN SQUARED ERROR	15711.2891
ROOT MEAN SQUARED % ERROR	2.8594

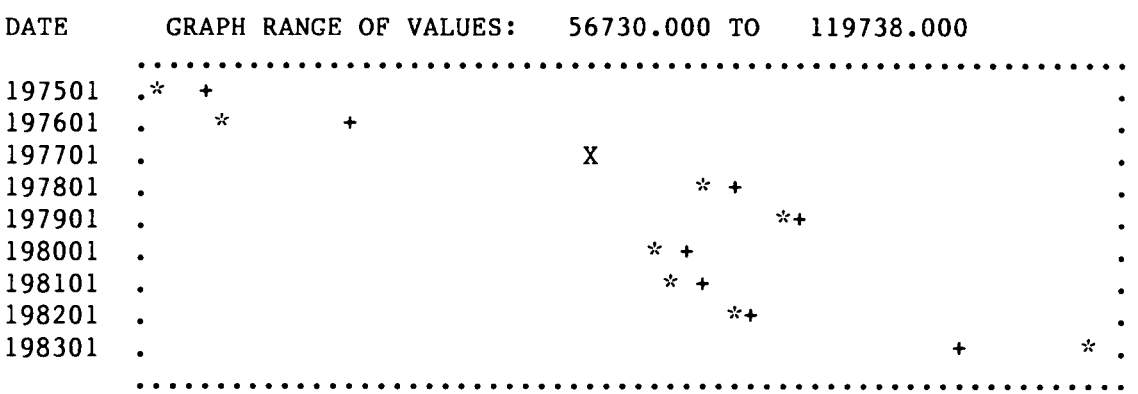
ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

PRODUCTION IN KENYA

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	56730.000	60632.945	-3902.945	-6.880
197601	61984.000	70204.508	-8220.508	-13.262
197701	86291.000	85944.086	346.914	0.402
197801	93373.000	96199.594	-2826.594	-3.027
197901	99275.000	100309.461	-1034.461	-1.042
198001	89893.000	92876.219	-2983.219	-3.319
198101	90941.000	93879.570	-2938.570	-3.231
198201	96033.000	97110.539	-1077.539	-1.122
198301	119738.000	110158.570	9579.430	8.000



SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	3656.6865
MEAN ABSOLUTE % ERROR	4.4762
ROOT MEAN SQUARED ERROR	4742.8447
ROOT MEAN SQUARED % ERROR	5.9661

ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

PRODUCTION IN SRI LANKA

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	213679.000	209108.484	4570.516	2.139
197601	196606.000	200857.688	-4251.688	-2.163
197701	208572.000	207749.672	822.328	0.394
197801	198981.000	204465.813	-5484.813	-2.756
197901	206417.000	204997.469	1419.531	0.688
198001	191375.000	196162.922	-4787.922	-2.502
198101	210148.000	199283.391	10864.609	5.170
198201	187816.000	192542.969	-4726.969	-2.517
198301	179287.000	173295.031	5991.969	3.342

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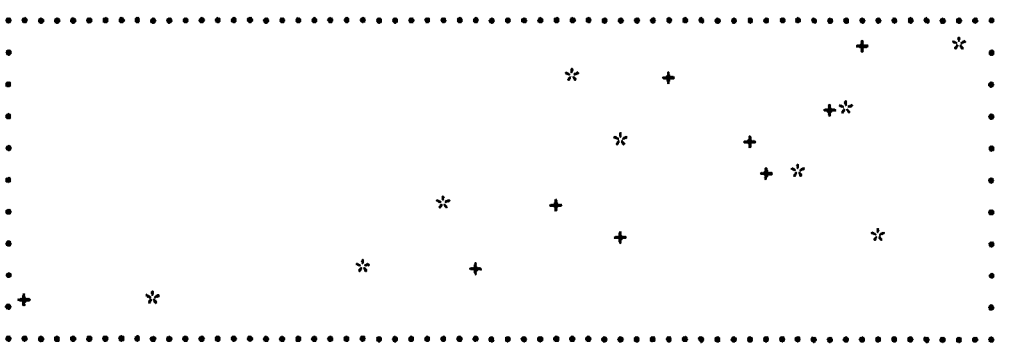


SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	4768.9272
MEAN ABSOLUTE % ERROR	2.4079
ROOT MEAN SQUARED ERROR	5486.8813
ROOT MEAN SQUARED % ERROR	2.7481

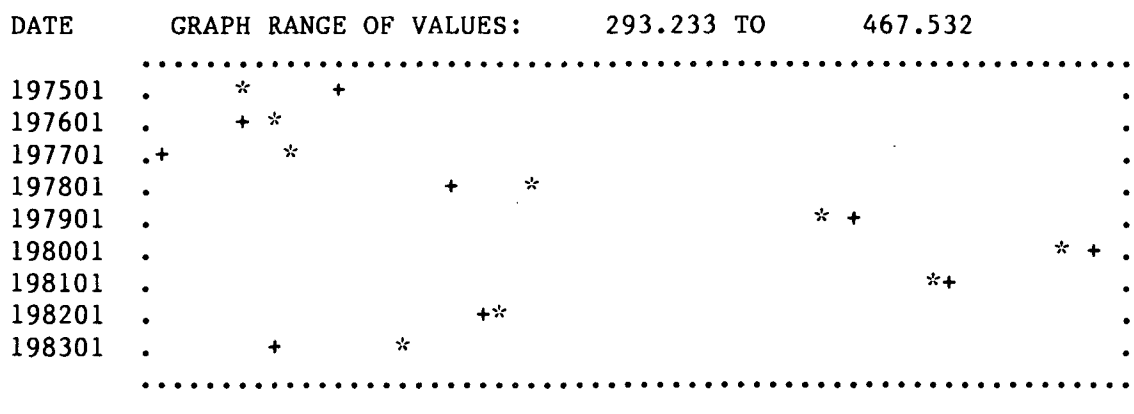
ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

WORLD STOCKS

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	310.900	326.285	-15.385	-4.948
197601	315.600	310.799	4.801	1.521
197701	318.800	293.233	25.567	8.020
197801	361.600	349.202	12.398	3.429
197901	415.500	421.278	-5.778	-1.391
198001	459.800	467.532	-7.732	-1.682
198101	435.900	440.644	-4.744	-1.088
198201	356.600	352.552	4.048	1.135
198301	338.200	315.766	22.434	6.633



SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	11.4319
MEAN ABSOLUTE % ERROR	3.3163
ROOT MEAN SQUARED ERROR	13.7537
ROOT MEAN SQUARED % ERROR	4.1380

ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

WORLD NOMINAL PRICE

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	1.243	1.077	0.165	13.310
197601	1.296	1.237	0.059	4.551
197701	2.199	2.432	-0.234	-10.637
197801	2.023	2.275	-0.252	-12.473
197901	1.744	1.673	0.071	4.043
198001	1.870	1.669	0.201	10.745
198101	1.635	1.577	0.058	3.532
198201	1.657	1.996	-0.339	-20.446
198301	2.336	2.439	-0.102	-4.387

```
DATE      GRAPH RANGE OF VALUES:       1.077 TO        2.439
         ..............................................................
197501   .+      *                                                   .
197601   .      +  *                                                 .
197701   .                                                 *        + .
197801   .                                         *          +       .
197901   .                         +  *                              .
198001   .                         +        *                        .
198101   .                     +  *                                  .
198201   .                         *             +                   .
198301   .                                                     *   + .
         ..............................................................
```

SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	0.1646
MEAN ABSOLUTE % ERROR	9.3470
ROOT MEAN SQUARED ERROR	0.1895
ROOT MEAN SQUARED % ERROR	10.7916

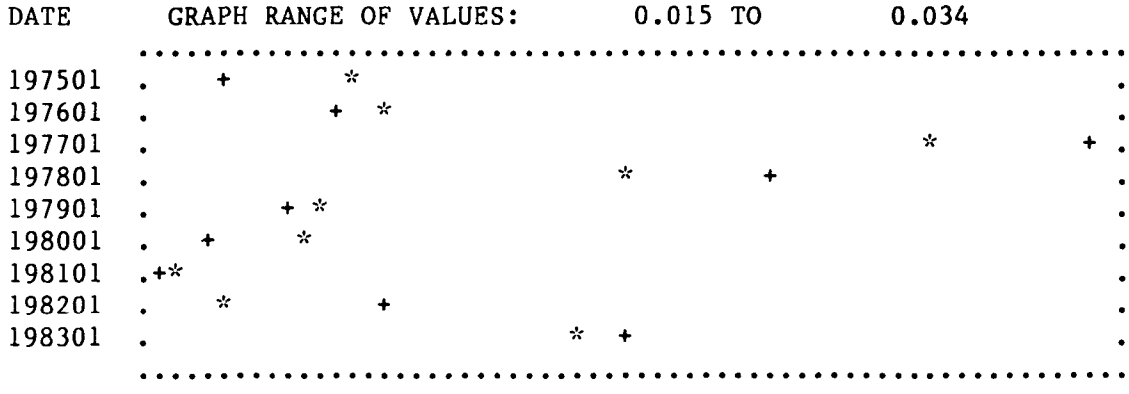
ACTUAL COLUMN: ZERO SECTOR
PREDICTED COLUMN: TEA100.XP

continued...

...continued

WORLD REAL PRICE

DATE	ACTUAL (*)	PREDICTED (+)	DIFFERENCE (TIE = X)	% DIFFERENCE
197501	0.019	0.017	0.003	13.282
197601	0.020	0.019	0.001	4.635
197701	0.030	0.034	-0.003	-10.603
197801	0.024	0.027	-0.003	-12.392
197901	0.018	0.018	0.001	3.971
198001	0.018	0.016	0.002	10.778
198101	0.016	0.015	0.001	3.572
198201	0.016	0.020	-0.003	-20.430
198301	0.023	0.024	-0.001	-4.375



SUMMARY STATISTICS:

MEAN ABSOLUTE ERROR	0.0019
MEAN ABSOLUTE % ERROR	9.3374
ROOT MEAN SQUARED ERROR	0.0022
ROOT MEAN SQUARED % ERROR	10.7759

VI.2 Results of Base Ex-Ante Simulation

Ex-ante simulations were made for the period 1984-2000. Assumptions about future values of important exogenous variables were:

(i) Worldwide inflation of 4% p.a. Purchasing power parity is assumed to hold for the period 1986-2000. To implement this assumption in the model all exchange rates were kept at the value of the average of the first 10 months of 1985 while all CPI's increased at 4% p.a.

(ii) GDPs of developing countries appearing in the model increased at 5% p.a.

(iii) Subsidies on new plantings in Sri Lanka and Kenya and real development expenditure and cost of production in Sri Lanka were assumed to stay at the same level in real terms as the last available data in real terms.

(iv) Population increases at the rate given in the World Development Report of 1985.

(v) Projections of coffee and sugar prices were those made by the World Bank.

(vi) Exogenized tea consumption and production variables increase at the following rates:

	% p.a.
Production:	
Argentina	3.0%
Turkey	3.0%
Iran	1.0%
South America, excluding Argentina	0.5%
Uganda	8.5%
Asia, excluding India, Sri Lanka Indonesia, Iran, Bangladesh, China, Japan	1.0
Consumption:	
Afghanistan	1.0%
Iraq	2.0%
Indonesia	2.0%
Iran	3.0%

When the simulation was first performed, the model gave a much lower world price level in 1984 than was actually realized. The model failed to project the panic buying in 1984 caused by India's imposition of export limitations. Therefore, a dummy variable was put into the model to adjust the 1984 price. The ex-ante simulation results with this adjustment are given in Table 9.

The model predicts the sharp price fall in 1985 well. Nevertheless, it still underestimates the nominal world price by about 20%. This forecast error is mainly due to the actual high prices of the early months of 1985, when prices were still influenced by the boom.

An interesting aspect of the model is the ability of the price to return quickly to $2.00/Kg in 1984 U.S. dollar prices which the model gives as the stable price level of the 1980s after the 1983-84 shock. This feature of the model is examined in more detail in Section VI.4.

VI. 3 Evaluation of Some Key Elasticities

As discussed in Section III, long-term price elasticities of supply cannot be calculated easily from the estimated equations for major producing countries. A way to evaluate the implied long-term price elasticities is by simulating the whole model. For this purpose the "world" price was exogenized and increased by 10% from the base run simulation during the period 1990-2000. Table 10 shows the differences in the key variables between the base run and the run with higher world prices.

Table 9: RESULTS OF EX-ANTE SIMULATION FORECAST VALUES OF SELECTED VARIABLES: 1984-200

DEMAND IN PAKISTAN

VARIABLE GRAPHED : CN1PAK

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)	GRAPH RANGE OF VALUES: 0.000 TO 187657.094
198401	81497.664	-81497.664	.* + .
198501	90606.617	-90606.617	.* + .
198601	97463.539	-97463.539	.* + .
198701	109049.633	-109049.633	.* + .
198801	107430.391	-107430.391	.* + .
198901	120007.586	-120007.586	.* + .
199001	117583.906	-117583.906	.* + .
199101	130848.648	-130848.648	.* + .
199201	128901.039	-128901.039	.* + .
199301	143332.453	-143332.453	.* + .
199401	141306.234	-141306.234	.* + .
199501	156737.984	-156737.984	.* + .
199601	155120.219	-155120.219	.* + .
199701	171661.469	-171661.469	.* + .
199801	170044.391	-170044.391	.* + .
199901	187657.094	-187657.094	.* + .
200001	186343.234	-186343.234	.* + .

continued...

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DEMAND IN U.K.

VARIABLE GRAPHED : CN1UK

DATE	PREDICTED (+)	DIFFERENCE TIE = X)	GRAPH RANGE OF VALUES: 0.000 TO 179854.656
198401	179854.656	-179854.656	.* + .
198501	157659.078	-157659.078	.* + .
198601	162541.047	-162541.047	.* + .
198701	159831.375	-159831.375	.* + .
198801	157344.578	-157344.578	.* + .
198901	154703.594	-154703.594	.* + .
199001	151938.328	-151938.328	.* + .
199101	149443.750	-149443.750	.* + .
199201	146936.984	-146936.984	.* + .
199301	144523.703	-144523.703	.* + .
199401	142077.047	-142077.047	.* + .
199501	139723.641	-139723.641	.* + .
199601	137398.078	-137398.078	.* + .
199701	135141.813	-135141.813	.* + .
199801	132858.625	-132858.625	.* + .
199901	130647.070	-130647.070	.* + .
200001	128399.273	-128399.273	.* + .

continued...

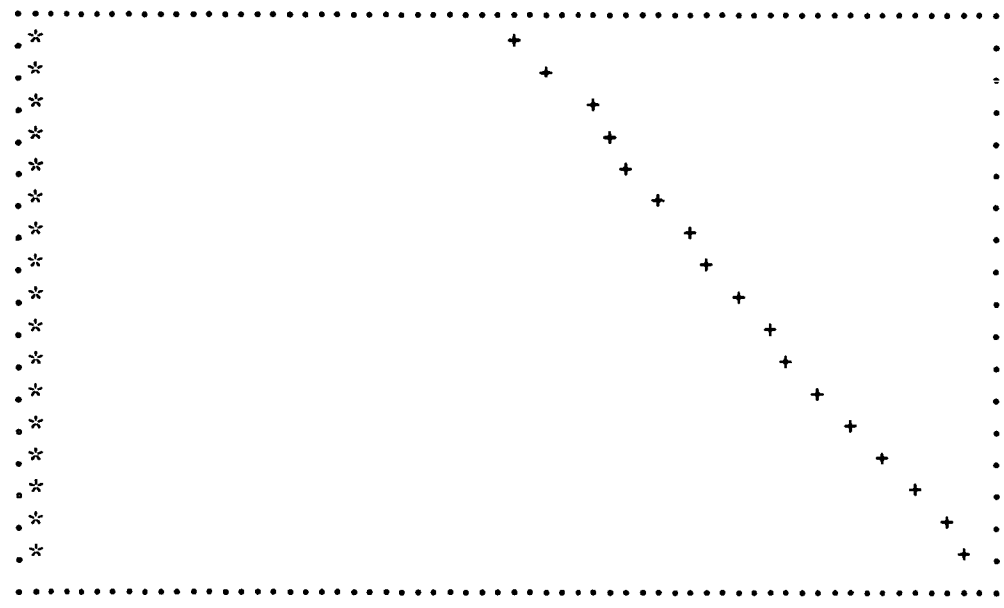
...continued

DEMAND IN INDIA

VARIABLE GRAPHED : CONIN

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)
198401	396811.938	-396811.938
198501	419689.906	-419689.906
198601	457006.719	-457006.719
198701	470261.500	-470261.500
198801	492660.875	-492660.875
198901	516398.563	-516398.563
199001	535535.875	-535535.875
199101	554175.125	-554175.125
199201	575197.688	-575197.688
199301	597981.938	-597981.938
199401	620038.375	-620038.375
199501	642576.625	-642576.625
199601	666742.875	-666742.875
199701	691552.063	-691552.063
199801	715828.250	-715828.250
199901	740215.625	-740215.625
200001	765367.188	-765367.188

GRAPH RANGE OF VALUES: 0.000 TO 765367.188



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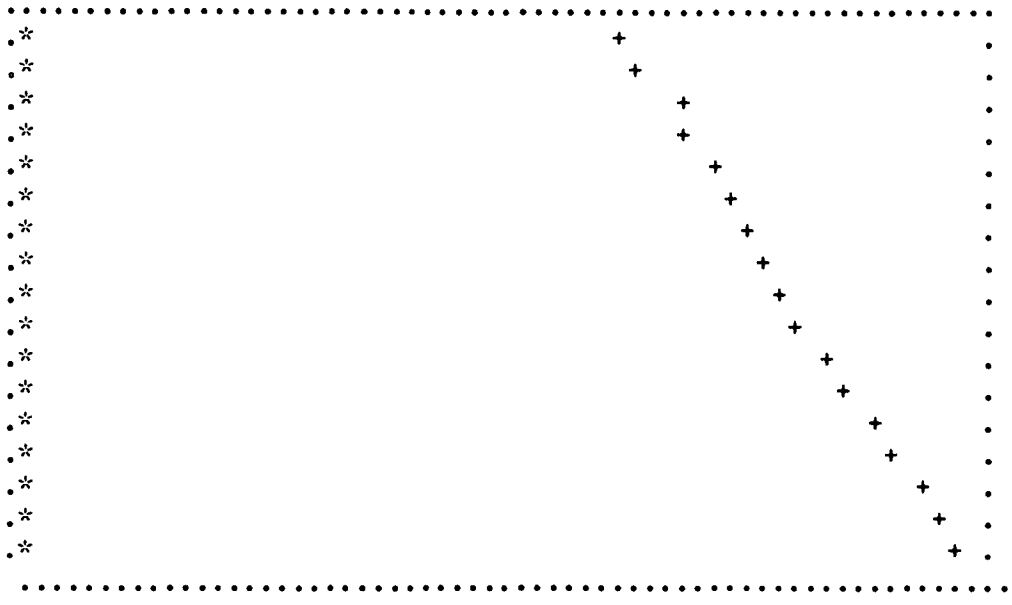
WORLD DEMAND

VARIABLE GRAPHED : CN4W

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)	GRAPH RANGE OF VALUES: 0.000 TO 2509368.750
198401	1596509.625	-1596509.625	
198501	1640176.375	-1640176.375	
198601	1770166.500	-1770166.500	
198701	1770058.250	-1770058.250	
198801	1837755.500	-1837755.500	
198901	1878252.375	-1878252.375	
199001	1937444.750	-1937444.750	
199101	1966275.125	-1966275.125	
199201	2032940.125	-2032940.125	
199301	2076846.000	-2076846.000	
199401	2148491.750	-2148491.750	
199501	2189954.000	-2189954.000	
199601	2264451.250	-2264451.250	
199701	2312160.750	-2312160.750	
199801	2387170.250	-2387170.250	
199901	2432494.500	-2432494.500	
200001	2509368.750	-2509368.750	



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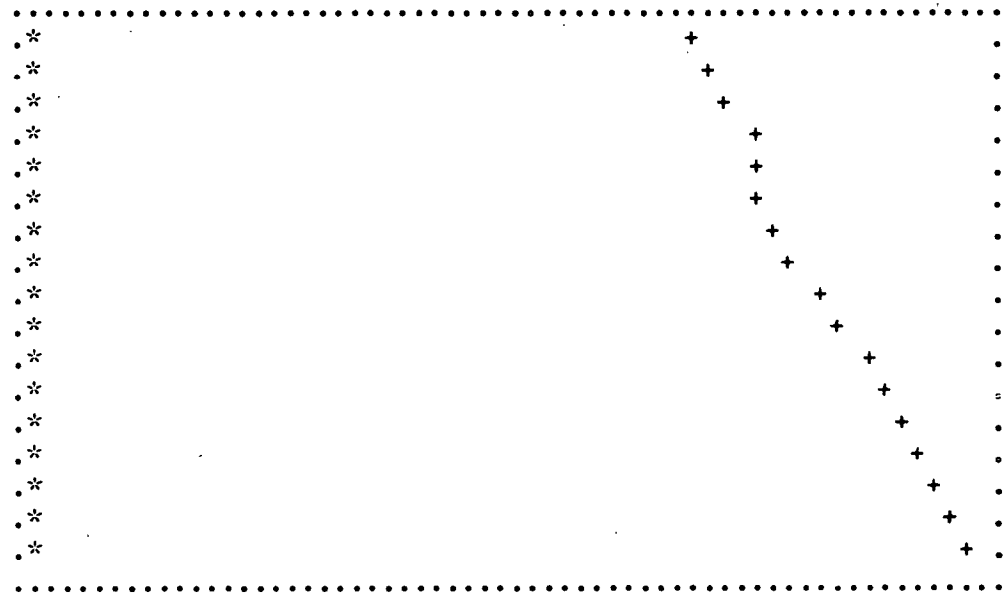
PRODUCTION IN INDIA

VARIABLE GRAPHED : QIND

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)
198401	645742.438	-645742.438
198501	663975.375	-663975.375
198601	671537.750	-671537.750
198701	704563.438	-704563.438
198801	712016.813	-712016.813
198901	703449.688	-703449.688
199001	720885.875	-720885.875
199101	744910.500	-744910.500
199201	776140.063	-776140.063
199301	791738.438	-791738.438
199401	812070.938	-812070.938
199501	832492.750	-832492.750
199601	848955.625	-848955.625
199701	864050.438	-864050.438
199801	880743.625	-880743.625
199901	898439.250	-898439.250
200001	916563.750	-916563.750

GRAPH RANGE OF VALUES: 0.000 TO 916563.750



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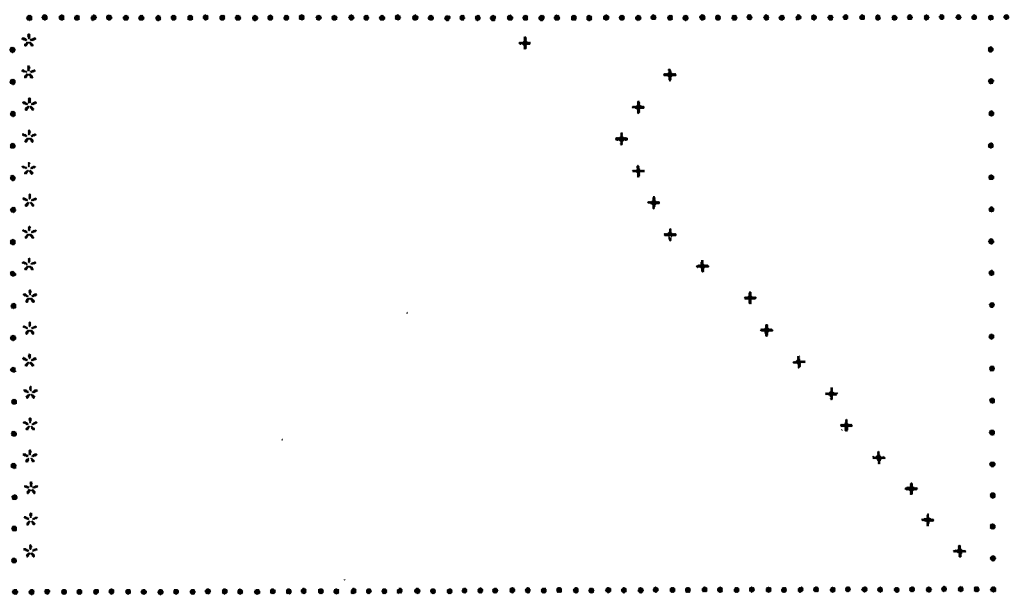
PRODUCTION IN KENYA

VARIABLE GRAPHED : QKEN

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)	GRAPH RANGE OF VALUES: 0.000 TO 212434.609
198401	113790.375	-113790.375	
198501	145994.016	-145994.016	
198601	137901.922	-137901.922	
198701	133514.766	-133514.766	
198801	140340.750	-140340.750	
198901	142895.688	-142895.688	
199001	147367.422	-147367.422	
199101	154715.344	-154715.344	
199201	162691.719	-162691.719	
199301	168219.016	-168219.016	
199401	174648.750	-174648.750	
199501	180599.484	-180599.484	
199601	186973.766	-186973.766	
199701	191837.484	-191837.484	
199801	198404.281	-198404.281	
199901	204709.016	-204709.016	
200001	212434.609	-212434.609	



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PRODUCTION IN SRI LANKA

VARIABLE GRAPHED : QSL

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)	GRAPH RANGE OF VALUES: 0.000 TO 228338.125
198401	208700.406	-208700.406	.* + .
198501	215093.344	-215093.344	.* + .
198601	210313.938	-210313.938	.* + .
198701	217854.547	-217854.547	.* + .
198801	212836.563	-212836.563	.* + .
198901	218527.531	-218527.531	.* + .
199001	214022.844	-214022.844	.* + .
199101	219844.500	-219844.500	.* + .
199201	215882.156	-215882.156	.* + .
199301	221335.844	-221335.844	.* + .
199401	217514.250	-217514.250	.* + .
199501	223023.094	-223023.094	.* + .
199601	219596.328	-219596.328	.* + .
199701	225207.516	-225207.516	.* + .
199801	222327.609	-222327.609	.* + .
199901	228338.125	-228338.125	.* + .
200001	225990.328	-225990.328	.* + .

continued...

...continued

WORLD PRODUCTION

VARIABLE GRAPHED : QW

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)	GRAPH RANGE OF VALUES: 0.000 TO 2538232.750
198401	1650433.125	-1650433.125	.* + .
198501	1749152.250	-1749152.250	.* + .
198601	1776665.500	-1776665.500	.* + .
198701	1840020.000	-1840020.000	.* + .
198801	1870630.875	-1870630.875	.* + .
198901	1896264.000	-1896264.000	.* + .
199001	1941836.375	-1941836.375	.* + .
199101	2009314.000	-2009314.000	.* + .
199201	2075236.125	-2075236.125	.* + .
199301	2132423.500	-2132423.500	.* + .
199401	2186828.500	-2186828.500	.* + .
199501	2250880.000	-2250880.000	.* + .
199601	2302258.500	-2302258.500	.* + .
199701	2360414.750	-2360414.750	.* + .
199801	2414284.750	-2414284.750	.* + .
199901	2479133.250	-2479133.250	.* + .
200001	2538232.750	-2538232.750	.* + .

continued...

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WORLD STOCKS

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)
198401	355.824	-355.824
198501	428.499	-428.499
198601	398.698	-398.698
198701	432.360	-432.360
198801	428.936	-428.936
198901	410.647	-410.647
199001	378.739	-378.739
199101	385.478	-385.478
199201	391.474	-391.474
199301	410.751	-410.751
199401	412.788	-412.788
199501	437.414	-437.414
199601	438.921	-438.921
199701	450.875	-450.875
199801	441.690	-441.690
199901	452.029	-452.029
200001	444.593	-444.593

GRAPH RANGE OF VALUES: 0.000 TO 452.029

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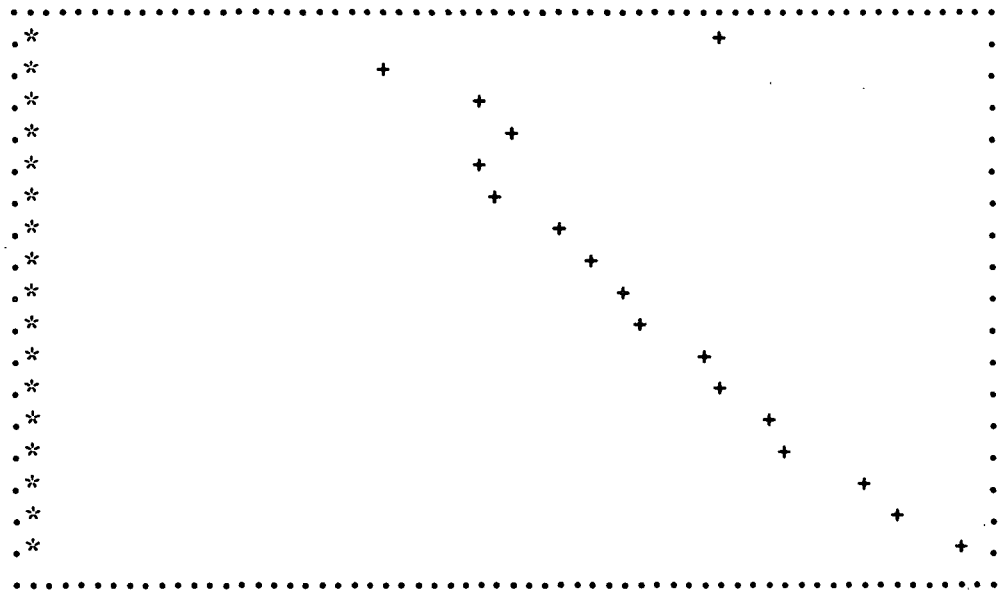
WORLD NOMINAL PRICE

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)
198401	3.315	-3.315
198501	1.694	-1.694
198601	2.173	-2.173
198701	2.289	-2.289
198801	2.206	-2.206
198901	2.272	-2.272
199001	2.560	-2.560
199101	2.708	2.708
199201	2.881	-2.881
199301	2.945	-2.945
199401	3.238	-3.238
199501	3.317	-3.317
199601	3.547	-3.547
199701	3.625	-3.625
199801	3.977	-3.977
199901	4.115	-4.115
200001	4.490	-4.490

GRAPH RANGE OF VALUES: 0.000 TO 4.490



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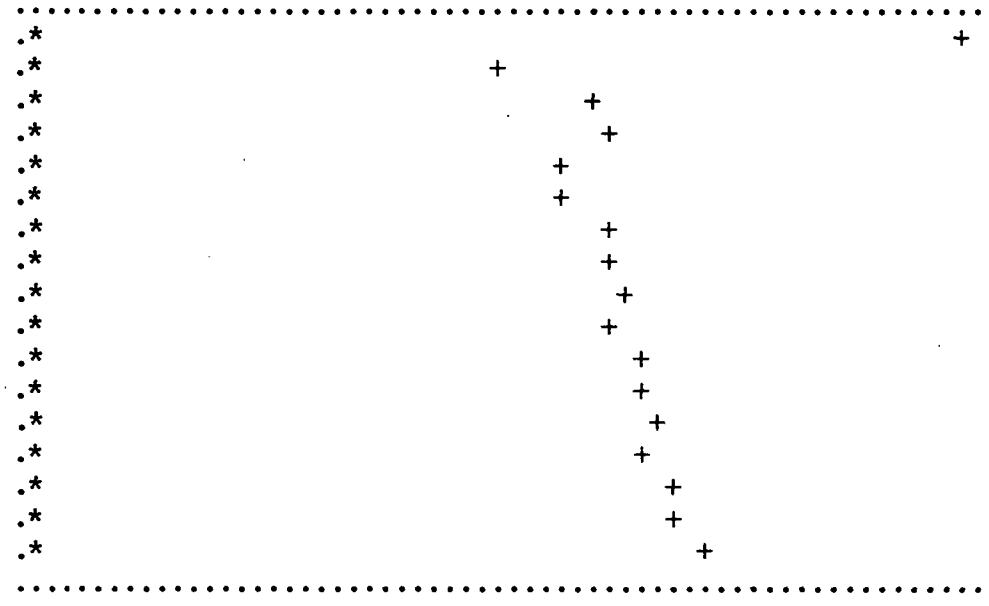
WORLD REAL PRICE

DATE	PREDICTED (+)	DIFFERENCE (TIE = X)
198401	0.033	-0.033
198501	0.016	-0.016
198601	0.020	-0.020
198701	0.020	-0.020
198801	0.019	-0.019
198901	0.019	-0.019
199001	0.020	-0.020
199101	0.021	-0.021
199201	0.021	-0.021
199301	0.021	-0.021
199401	0.022	-0.022
199501	0.022	-0.022
199601	0.022	-0.022
199701	0.022	-0.022
199801	0.023	-0.023
199901	0.023	-0.023
200001	0.024	-0.024

GRAPH RANGE OF VALUES: 0.000 TO 0.033



As can be seen in Table 10, the supply response to the price change of the world and the major producing countries is low in 1990 when the price change is introduced. In the following year, the supply response is much higher, although still not very high. Except for India (where they decline after the fourth year), the price elasticities remain relatively stable through the second to fifth or sixth year then increase thereafter. This increase is due to the maturing of the plantings undertaken in response to higher prices. The deviation from this time pattern of supply elasticities in India is due to the coefficient of the relative price term in the estimated supply equation for India being larger than the coefficient on the price level term. The inference from these estimates is that the long-run elasticity of supply response to a permanent price change is about 0.1 for the old-established producers (India and Sri Lanka) and 0.5 for newer producers such as Kenya. In global terms the elasticity is about 0.2. A negative response of a similar size is observed in world consumption.

VI.4 Simulation of a One Time Supply Shock

In the base ex-ante simulation run, there was a sharp price decline in 1985 and a return of the price level quickly to the $2.00/kg level. To investigate this particular characteristic of the model, a simulation was carried out wherein world production was reduced by 200,000 mt in 1990. In Table 11 the results of this scenario are compared with the results from the base run simulation. The comparison is made in terms of level and percentages changes.

Table 10: CHANGES IN KEY VARIABLES IN CASE WORLD PRICE IS INCREASED BY 10% DURING 1990-2000

(shown as comparison with Base Run in percentage terms)

YEAR	Production				Consumption
	India	Sri Lanka	Kenya	World	World
1990	0.356	0.005	1.644	0.388	-0.740
1991	1.387	0.383	3.429	1.089	-1.366
1992	1.604	0.213	4.569	1.311	-1.396
1993	1.572	0.477	4.528	1.358	-1.401
1994	1.531	0.331	4.519	1.345	1.429
1995	1.349	0.600	4.545	1.303	-1.418
1996	0.800	0.530	4.645	1.107	-1.425
1997	0.557	0.811	4.771	1.048	-1.406
1998	0.540	0.788	4.973	1.064	-1.412
1999	0.723	1.071	5.210	1.170	-1.395
2000	0.593	1.079	5.511	1.149	-1.389

Source: World Bank, Economic Analysis and Projections Department.

Table 11: SIMULATION RESULTS WITH 200,000 MT WORLD PRODUCTION DECLINE IN 1990

Year	World Production (mt)	(%)	World Consumption (mt)	(%)	World Stocks (mt)	(%)	World Price (Nominal) (US$/kg)	(%)
1990	-162865	-8.481	-62895	-3.296	-99970	-26.362	1.290	50.503
1991	62738	3.168	-48107	2.483	10875	2.818	-0.099	-3.644
1992	8950	0.436	7708	0.384	12117	3.054	-0.111	-3.939
1993	56	0.003	6229	0.304	5944	1.432	-0.055	-1.882
1994	-4015	-0.186	1547	0.073	382	0.091	-0.004	-0.122
1995	-10069	-0.453	-3398	-0.157	-6289	-1.416	0.063	1.924
1996	-8491	-0.373	-7051	-0.315	-7730	-1.730	0.082	2.359
1997	-2042	-0.088	-5711	-0.250	-4061	-0.887	0.042	1.198
1998	8851	0.371	-454	-0.019	5245	1.172	-0.060	-1.544
1999	8271	0.338	5542	0.231	7974	1.754	-0.092	-2.296
2000	1138	0.045	5209	0.210	3903	0.875	-0.051	-1.158

Source: World Bank, Economic Analysis and Projections Department.

The exogenously imposed supply shortage of 200,000 mt is reduced to 100,000 mt in 1990 as world production increases by 37,000 mt (therefore the "effective" supply shock is 163,000mt) and world consumption reduces by 63,000 mt. The world price increases by 51%. This large price increase is due to the low short-run price elasticities of supply and demand. In the following year, world production increases by 63,000 mt and world consumption declines by 48,000 mt compared with the base run. The combined effect of 111,000 mt is more than enough to fill the reduction in stocks of 100,000 mt of 1990. Thus the eventual stock in 1991 is higher than the base run and the price is lower. The effects in following years are small.

This simulation gives an insight into the "spike" type of price movements observed in tea and in many other commodities. A prime example is sugar. Because short-run price responses in demand and supply are so low, an exogenous supply shock (which could, for example, be caused by weather) causes price to change by a large amount. Although the supply and demand elasticities in the following year are still low the product of the small elasticities and the large price change is fairly large, because the price change is very large. As a consequence, the price declines sharply in the year following an exogenous supply shock, often to a lower level than the price level preceding the shock.

VII. CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

In the introductory section several distinguishing features of this new global tea model were described. It seems appropriate to begin with an assessment of their usefulness in the light of the results of the various simulation exercises.

(i) Structure of the model: The results of estimated equations and several simulation runs indicate that the basic assumptions made about the world tea market, i.e., perfect competition, market clearing equilibrium price and homogeneity of the commodity are fundamentally correct. Noteworthy, however, is the model's inability to simulate the market in 1984 when the impact of India's export limitations led to panic buying. Further detailed research on what happened in 1984 is necessary to improve the model.

(ii) Vintage production framework: In the case of the major producers the use of constructed measures of feasible output, in conjunction with the theoretical concepts of potential output, is a very useful innovation. (It should be mentioned that some of these ideas have previously been incorporated in World Bank models of cocoa and coffee; see Akiyama and Bowers (1984), Akiyama (1982).) But it is clear that to properly exploit this idea, reliable additional information is needed on: (a) the average yield-age profiles for hybrids and vegetatively propagated clones; (b) the age-structure of the existing capital stock; and (c) current practices with respect to the application of fertilizers and other inputs. The nonlinear supply function for India and Sri Lanka assumed a constant rate of disembodied technological change with respect to yields. This is a

strong assumption. Information is needed to improve understanding of this issue.

(iii) New plantings and replantings: The low long-run elasticities implied by the model were a surprise. Except for Kenya they turned out not a great deal larger than the short-run elasticities. The main reason for the low long-run elasticities is that new plantings and replantings in India and Sri Lanka are relatively small and, furthermore, not very price sensitive. At present there cannot be complete confidence on this point because adequate data on planting subsidies in India are lacking and it is suspected that the new planting equation may be misspecified. However, the conclusion that new planting is relatively price insensitive in old established producing countries is not entirely surprising. The finding may reflect the role of land constraints or it may reflect the importance of non-price exogenous factors in determining new investment. Once again, the matter needs more investigation.

(iv) Intercountry differences: It is evident that the three major producers are quite different in their behavior. Institutional factors and the structure of the capital stock both contribute to this. A clear implication is that there should be more attempt to distinguish between the smallholders and estates. The analysis of Kenyan production highlights this point. It is believed that this distinction is highly relevant to Indonesia but we lack the data to investigate it thoroughly. Thus disaggregation by country alone may not be enough.

(v) Price determination: It is believed that the forward-looking price equation is also a useful advance. In conjunction with the rest of the model it is capable of replicating the historically observed "spikes" in the time-series data. It supports strongly the view that the tea economy is basically rather stable but the equilibrium situation is punctuated by supply shocks whose effects are magnified by the low short-run demand and supply elasticities. Nevertheless, since the linkages between the world price and country prices are strong, lagged adjustment is not important and equilibrium is reestablished relatively rapidly.

Potentially the forward-looking price equation harbors numerous difficulties of specification and estimation. While the specification used here appears to be quite successful, greater rigor in arriving at the final estimating equation is clearly desirable.

(vi) Demand for tea: Excessive reliance on the trend variable to represent the effects of income and tastes was necessary. Again, this specification was forced by lack of data. But it seems unlikely that things will proceed in a trend-like manner in the future. It seems desirable, therefore, to estimate the demand equations with time-varying coefficients.

The demand equations were much more disaggregated by country than in previous studies. This is very desirable. It is also clear that careful attention must be paid to the functional form, especially in the case of countries with rising consumption. In the case of an important consumer like India this point cannot be over-emphasised.

(vii) Econometric Methodology: There is much scope for improving the estimation of the model. There was excessive reliance on the use of ordinary least squares. The sensitivity of the conclusions to other estimation methods remains a matter for future investigation.

GLOSSARY OF VARIABLES

VARIABLE	FROM/TO	DESCRIPTION	UNITS	SOURCE
AIEXT	1952-1983	ALL INDIA EXTENSIONS	HA	ITC
AIREPL	1952-1983	ALL INDIA REPLANTINGS	HA	ITC
AIREPM	1952-1983	ALL INDIA REPLACEMENTS	HA	ITC
ATEMP1	1953-1984	DeflatedRETAIL PRICE OF COFFEE, US	US$/KG	ICO
ATEMP12	1954-1984	TWO PERIOD MOVING AVERAGE OF DEFLATED REAL PRICE OF COFFEE, US ATEMP12 = (ATEMP1 + ATEMP1(-1))/2	US$/KG	ICO
C1CH	1952-1984	APPARENT TEA CONSUMPTION PER CAP, CHILE C1CH = CN1CH/POP2CH	MT/1000 HEAD	ITC & IFS
C1EG	1962-1983	APPARENT TEA CONSUMPTION PER CAP, EGYPT C1EG = CN1EG/(POP2EG * 1000)	MT/HEAD	ITC & IFS
C1NZ	1952-1983	APPARENT TEA CONSUMPTION PER CAP, NEW ZEALAND C1NZ = CN1NZ/POP2NZ	MT/1000 HEAD	ITC & IFS
C1PAK	1950-1984	APPARENT TEA CONSUMPTION PER CAP, PAKISTAN C1PAK = CN1PAK/POPPAK	MT/1000 HEAD	ITC & IFS
C1PAK2	1951-1984	TWO PERIOD M A OF APPARENT TEA CONSUMPTION PER CAP, PAKISTAN C1PAK2 = (C1PAK + C1PAK(-1))/2.0	MT/1000 HEAD	ITC & IFS
C1SA	1968-1984	APPARENT TEA CONSUMPTION PER CAP, SAUDI ARABIA C1SA = CN1SA/POP2SA	MT/1000 HEAD	ITC & IFS
C1SA2	1969-1984	TWO PERIOD M A OF APPARENT TEA CONSUMPTION PER CAP, SAUDIA ARABIA C1SA2 = (C1SA + C1SA(-1))/2	MT/1000 HEAD	ITC & IFS
C1SL	1961-1983	APPARENT TEA CONSUMPTION PER CAP, SRI LANKA C1SL = CN2SL/POP2SL	MT/1000 HEAD	ITC & IFS
C1SO	1952-1984	APPARENT TEA CONSUMPTION PER CAP, SOUTH AFRICA C1SO = CN1SO/POP2SO	MT/1000 HEAD	ITC & IFS
C1SYR	1952-1984	APPARENT TEA CONSUMPTION PER CAP, SYRIA C1SYR = CN1SYR/POP2SYR	MT/1000 HEAD	ITC & IFS
C1SYR2	1953-1984	TWO PERIOD M A OF APPARENT TEA CONSUMPTION PER CAP, SYRIA C1SYR2 = (C1SYR + C1SYR(-1))/2	MT/1000 HEAD	ITC & IFS
C1TUR	1953-1984	APPARENT TEA CONSUMPTION PER CAP, TURKEY C1TUR = CN1TUR/POP2TU	MT/1000 HEAD	ITC & IFS
C1UK	1953-1984	CONS PER CAP IN UK C1UK = CN1UK/POPUK	MT/1000 HEAD	ITC & IFS
C1US	1953-1984	APPARENT TEA CONSUMPTION PER CAP, US C1US = CN1US/POPUS	MT/1000 HEAD	ITC & IFS

C1US2	1954-1984	TWO PERIOD M A OF APPARENT TEA CONSUMPTION PER CAP, US C1US2 = (C1US + C1US(-1))/2	MT/1000 HEAD	ITC & IFS
C1USSR	1955-1984	APPARENT TEA CONSUMPTION PER CAP, USSR C1USSR = CN1USSR/POPUSR	MT/1000 HEAD	ITC & IFS
CAU	1953-1984	APPRENT TEA CONSUMPTION PER CAP, AUSTRALIA CAU = CONAU/(POPAU * 1000)	MT/1000 HEAD	ITC & IFS
CCA	1953-1984	APPARENT TEA CONSUMPTION PER CAP, CANADA CCA = CONCA/(POPCA * 1000)	MT/1000 HEAD	ITC & IFS
CIN	1953-1984	APPARENT TEA CONSUMPTION PER CAP, INDIA CIN = CONIN/POPIN	MT/1000 HEAD	ITC & IFS
CN1AFG	1952-1984	APPARENT TEA CONSUMPTION, AFGHANISTAN	MT	ITC
CN1ARAB	1970-1984	APPARENT TEA CONSUMPTION, ABU DHABI, BAHRAIN, DUBAI, KUWAIT, OMAN, QATAR, OTHER ARABIAN STATES	MT	ITC
CN1CH	1952-1984	APPARENT TEA CONSUMPTION, CHILE	MT	ITC
CN1EE	1952-1984	TOTAL CONSUMPTION OF TEA, EASTERN EUROPE LESS USSR	MT	ITC
CN1EG	1952-1984	APPARENT TEA CONSUMPTION, EGYPT	MT	ITC
CN1IR	1952-1984	APPARENT TEA CONSUMPTION, IRAN	MT	ITC
CN1IRQ	1952-1984	APPARENT TEA CONSUMPTION, IRAQ	MT	ITC
CN1NA	1952-1984	APPARENT TEA CONSUMPTION, ALGERIA, LYBIA, TUNISIA	MT	ITC
CN1NZ	1952-1984	APPARENT TEA CONSUMPTION, NEW ZEALAND	MT	ITC
CN1PAK	1950-1984	APPARENT TEA CONSUMPTION, PAKISTAN	MT	ITC
CN1ROW	1970-1983	APPARENT TEA CONSUMPTION, REST OF WORLD	MT	ITC
CN1RWE1	1952-1984	APPARENT TEA CONSUMPTION, WESTERN EUROPE EXCLUDING U.K.	MT	ITC
CN1SA	1968-1984	APPARENT TEA CONSUMPTION, SAUDI ARABIA	MT	ITC
CN1SO	1952-1984	APPARENT TEA CONSUMPTION, SOUTH AFRICA	MT	ITC
CN1SYR	1952-1984	APPARENT TEA CONSUMPTION, SYRIA	MT	ITC
CN1TUR	1952-1984	APPARENT TEA CONSUMPTION, TURKEY	MT	ITC
CN1UK	1950-1984	APPARENT TEA CONSUMPTION, UK	MT	ITC
CN1US	1953-1984	APPARENT TEA IN US	MT	ITC
CN1USSR	1955-1984	APPARENT TEA CONSUMPTION, USSR	MT	ITC
CN4W	1970-1983	APPARENT TEA CONSUMPTION, WORLD CN1W = CN1UK + CN1US + CN1RWE1 + CN1USSR + CN1EE + CONCA; + CONAU; CN1NZ + CN1SO + CN1PAK + CN1SA + CN1TUR + CN1IR; +CN1IRQ + CN1SYR + CN1CH + CN1AFG + CN1NA + CN1ARAB + CN2INDO; + CN2SL + CN1EG + CONIN; + CN1ROW	MT	ITC
CN2INDO	1952-1984	APPARENT TEA CONSUMPTION, INDONESIA	MT	ITC
CN2SL	1961-1983	APPARENT TEA CONSUMPTION, SRI LANKA	MT	ITC
CONAU	1953-1984	APPARENT TEA CONSUMPTION, AUSTRALIA	MT	ITC
CONCA	1953-1984	APPARENT TEA CONSUMPTION, CANADA	MT	ITC
CONIN	1953-1984	APPARENT TEA CONSUMPTION, INDIA	MT	ITC
COPSL	1963-1983	COST OF PROD. OF TEA -BASED ON SAMPLE SURVEY IN SRI LANKA	RS/KG	CENT.BANK OF SRI LANKA

(Glossary continues on the following page.)

COPSLCHR	1964-1983	CHANGE IN REAL COST OF TEA PRODUCTION IN SRI LANKA COPSLCHR = COPSL/CPISL - COPSL(-1)/CPISL(-1)	
COPSLR	1963-1983	REAL COST OF TEA PRODUCTION COPSLR = COPSL/CPISL	
CPI1AU	1953-1984	CPI, AUSTRALIA	IFS
CPI1CA	1953-1984	CPI, CANADA	IFS
CPI1UK	1953-1984	CPI, UK	IFS
CPI1US	1953-1984	CPI, US	IFS
CPI2ARG	1950-1984	CPI, ARGENTINA	IFS
CPI2BAN	1972-1984	CPI, BANGLADESH	IFS
CPI2CH	1950-1984	CPI, CHILE	IFS
CPI2EG	1948-1984	CPI, EGYPT	IFS
CPI2INDO	1957-1984	CPI, INDONESIA	IFS
CPI2NZ	1954-1984	CPI, NEW ZEALAND	IFS
CPI2PA	1953-1984	CPI, PAKISTAN	IFS
CPI2SA	1954-1984	CPI, SAUDI ARABIA	IFS
CPI2SO	1948-1984	CPI, SOUTH AFRICA	IFS
CPI2SYR	1950-1984	CPI, SYRIA	IFS
CPI2TU	1953-1984	CPI, TURKEY	IFS
CPI3	1957-1985	STOCK SHARE WEIGHTED CPI CPI3 = CPIUK * TSUK/TWS + CPIIND * TSIND/TWS + CPISL * TSSL/TWS	
CPIIND	1952-1985	CPI, INDIA	IFS
CPIKEN	1952-1984	CPI, KENYA	
CPIMAL	1968-1984	CPI, MALAWI	IFS
CPISL	1952-1985	CPI, SRI LANKA	IFS
CPITIN	1957-1984	CPI, INDIA	IFS
DM82	1960-1985	DUMMY VARIABLE FOR 1982	
DM83	1960-1985	DUMMY VARIABLE FOR 1983	
DM84	1960-85	DUMMY VARIABLE FOR 1984	
DUMINDO	1961-1985	INDONESIA VOLCANIC ERUPTION DUMMY	
DX	1957-1985	POST 1968 YIELD GROWTH DUMMY VARIABLE FOR INDIA	
EDM74	1955-1985	DUMMY VARIABLE FOR 1974 EDM74 = EXP(DM74)	
EDM78	1960-1985	DUMMY VARIABLE FOR 1978 EDM78 = EXP(DM78)	
EDM80	1960-1985	DUMMY VARIABLE FOR 1980 EDM80 = EXP(DM80)	
ET2	1953-1984	EXPONENTIAL TREND VARIABLE 1953 = 1.0 ET2 = EXP(T2)	

ETRCH	1961-1984	CHILE EXPONENTIAL TIME TREND	
		ETRCH = EXP(TRCH)	
EX2ARG	1957-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, ARGENTINA	IFS
EX2BAN	1971-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, BANGLADESH	IFS
EX2CH	1957-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, CHILE	IFS
EX2EG	1948-1983	NATIONAL CURRENCY/US $ EXCHANGE RATE, EGYPT	IFS
EX2INDO	1967-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, INDONESIA	IFS
EX2NZ	1954-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, NEW ZEALAND	IFS
EX2PA	1953-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, PAKISTAN	IFS
EX2SA	1954-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, SAUDI ARABIA	IFS
EX2SO	1948-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, SOUTH AFRICA	IFS
EX2SYR	1950-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, SYRIA	IFS
EX2TU	1953-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, TURKEY	IFS
EXAU	1953-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, AUSTRALIA	IFS
EXCA	1953-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, CANADA	IFS
EXRIND	1952-1985	NATIONAL CURRENCY/US $ EXCHANGE RATE, INDIA	IFS
EXRKEN	1952-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, KENYA	IFS
EXRMAL	1952-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, MALAWI	
EXRMK	1960-1983	RELATIVE EXCHANGE RATE OF MALAWI TO KENYA	IFS
		EXRMK = EXRMAL/EXRKEN	
EXRSRI	1952-1985	NATIONAL CURRENCY/US $ EXCHANGE RATE, SRI LANKA	IFS
EXUK	1953-1985	NATIONAL CURRENCY/US $ EXCHANGE RATE, UK	IFS
EXW3	1957-1985	WEIGHTED AVERAGE EXCHANGE RATE, WEIGHTED BY SHARES OF STOCKS IN UK, SRI LANKA, INDIA	IFS
		EXW3 = (TSUK * EXUKX + TSSL * EXRSRIX + TSIND * EXRINDX)/TWS	
EXWG	1953-1984	NATIONAL CURRENCY/US $ EXCHANGE RATE, WEST GERMANY	IFS
GDP2EG	1948-1983	REAL GDP - 1980 PRICES, EGYPT	
GDP2PA	1953-1984	REAL GDP - 1980 PRICES, PAKISTAN	IFS
GDP2SA	1954-1984	REAL GDP - 1980 PRICES, SAUDI ARABIA	IFS
GDP2SYR	1956-1983	REAL GDP - 1980 PRICES, SYRIA	IFS
GDPC2EG	1948-1983	PER CAP REAL GDP - 1980 PRICES, EGYPT	IFS
		GDPC2EG = GDP2EG/POP2EG	
GDPC2PA	1953-1984	PER CAP REAL GDP - 1980 PRICES, PAKISTAN	IFS
		GDPC2PA = GDP2PA/POP2PA	
GDPC2PA2	1972-1984	TWO PERIOD MOVING AVERAGE PER CAP REAL GDP, PAKISTAN	
		GDPC2PA2 = (GDPC2PA + GDPC2PA(-1)/2	
GDPC2SA	1954-1984	PER CAP REAL GDP - 1980 PRICES, SAUDI ARABIA	IFS
		GDPC2SA = GDP2SA/POP2SA	
GDPC2SA2	1955-1984	TWO PERIOD MOVING AVERAGE PER CAP REAL GDP, SAUDI ARABIA	
		GDPC2SA2 = (GDPC2SA + GDPC2SA(-1))/2	

(Glossary continues on the following page.)

GDPC2SL	1950-1984	PER CAP REAL GDP - 1980 PRICES, SRI LANKA GDPC2SL = GDP2SL/POP2SL		IFS
GDPC2SYR	1956-1983	PER CAP REAL GDP - 1980 PRICES, SYRIA GDPC2SYR = GDP2SYR/POP2SYR		IFS
GDPC2SYR2	1957-1983	TWO PERIOD MOVING AVERAGE PER CAP REAL GDP, SYRIA GDPC2SYR2 = (GDPC2SYR + GDPC2SYR(-1))/2		
GDPCIN	1960-1984	PER CAP REAL GDP - 1980 PRICES, INDIA GDPCIN = GDPIN/POPIN		IFS
GDPCINL	1960-1984	LOG OF PER CAP GDP, INDIA GDPCINL = LOG(GDPCIN)		
GDPCPAK	1956-1984	PER CAP REAL GDP - 1980 PRICES, PAKISTAN GDPCPAK = GDPPAK/POPPAK		IFS
GDPIN	1960-1984	REAL GDP IN INDIA		IFS
HADJ	1972-1983	CORRECTION FACTOR FOR THE CALCULATED WORLD STOCKS HADJ = TWS - TWS(-1) - (QW - CN4W)/1000.0		
III	1957-1985	PRICE DEFLATOR FOR WORLD TEA PRICE EQUATION III = LOG(CPI3/EXW3)		
INM8TRS	1953-1983	TOTAL TREES OF VINTAGE 8 YEARS AND OLDER IN INDIA	HA	ITC
INNEWTRS	1953-1983	TOTAL NEW TREE AREA IN INDIA INNEWTRS = AIEXT + AIREPL + AIREPM	HA	ITC
KEXPPH	1963-1983	PER HECTARE KTDA DEVELOPMENT EXPENDITURE KEXPPH = KTDDER/KSHAREAT(-1)	SHILLINGS	KTDA
KEXPPHD	1964-1983	FIRST DIFFERENCE IN KEXPPH KEXPPHD = KEXPPH - KEXPPH(-1)		
KM10TRS	1963-1983	TOTAL TREES OF VINTAGE 10 YEARS AND OLDER IN KENYA	HA	KTDA
KSHAREAT	1900-1983	TOTAL SMALLHOLDER AREA IN KENYA KSHAREAT = KSHAREAT + 2497.5	HA	KTDA
KSHNP	1963-1983	KENYA SMALLHOLDER NEWPLANT - CALENDER YR	HA	KTDA
KSHNPRT	1963-1983	RATIO OF NEW PLANTINGS TO SMALLHOLDER AREA KSHNPRT = KSHNP/KSHAREAT(-1)		
KTDDE	1963-1983	KTDA DIRECT EXPENDITURE LESS DEPRECIATION		KTDA
KTDDER	1963-1983	KTDDE IN REAL TERMS KTDDER = KTDDE/CPIKEN	SHILLINGS	KTDA
LEDM	1965-1983	EXPONENTIAL OF DUMMY VARIABLE FOR 1983 DROUGHT IN SRI LANKA		
MUV	1960-1983	MANUFACTURES UNIT VALUE INDEX WORLD BANK		WORLD BANK
PC1UK	1962-1983	DEFLATED RETAIL COFFEE PRICE, UK PC1UK = RPCUK/CPI1UK	PENCE/KG	ICO
PCWCA	1953-1984	DEFLATED WORLD COFFEE PRICE, CANADA PCWCA = PGUT * EXCA/CPI1CA	CENTS/KG	ICO
PCWCH	1965-1984	DEFLATED WORLD COFFEE PRICE, CHILE PCWCH = PGUT * EX2CH/CPI2CH	PESO/KG	ICO

PCWNZ	1954-1984	DEFLATED WORLD COFFEE PRICE, NEW ZEALAND PCWNZ = PGUT * EX2NZ /CPI2NZ	NZ$/KG	ICO
PCWORLD	1960-1983	WORLD COFFEE PRICE, DEFLATED BY MUV PCWORLD = PGUT/MUV	US$/MT	ICO
PGUT	1950-1984	GUATEMALAN COFFEE PRICE	$/MT	WORLD BANK
POP2CH	1950-1984	POPULATION, CHILE	MILLION	IFS
POP2EG	1948-1983	POPULATION, EGYPT	MILLION	IFS
POP2NZ	1954-1984	POPULATION, NEW ZEALAND	MILLION	IFS
POP2PA	1953-1984	POPULATION, PAKISTAN	MILLION	IFS
POP2SA	1954-1984	POPULATION, SAUDI ARABIA	MILLION	IFS
POP2SL	1950-1984	POPULATION, SRI LANKA	MILLION	IFS
POP2SO	1948-1984	POPULATION, SOUTH AFRICA	MILLION	IFS
POP2SYR	1950-1984	POPULATION, SYRIA	MILLION	IFS
POP2TU	1953-1984	POPULATION, TURKEY	MILLION	IFS
POPAU	1953-1984	POPULATION, AUSTRALIA	MILLION	IFS
POPCA	1953-1984	POPULATION, CANADA	MILLION	IFS
POPIN	1953-1984	POPULATION, INDIA	MILLION	IFS
POPPAK	1950-1990	POPULATION, PAKISTAN	MILLION	IFS
POPUK	1953-1984	POPULATION, UK	MILLION	IFS
POPUS	1953-1984	POPULATION, US	MILLION	IFS
POPUSR	1950-1990	POPULATION, USSR	MILLION	IFS
PRCHS	1953-1983	FIRST DIFFERENCE OF LOG OF REAL PRODUCER PRICE OF TEA, SRI LANKA PRCHS = LOG(PRS) - LOG(PRS(-1))	SL RUP/KG	ITC
PREI	1953-1983	THREE YEAR MOVING AVERAGE OF PRODUCER PRICE OF TEA IN INDIA, LAGGED THREE YEARS		
PREIREV	1956-1983	FIRST MOVING AVERAGE DIFFERENCE OF PRODUCER PRICE OF TEA IN INDIA PREIREV = PREI - PREI(-1)		
PRES	1955-1984	THREE YEAR MOVING AVERAGE OF PRODUCER PRICE OF TEA IN SRI LANKA, LAGGED THREE YEARS		
PRESREV	1956-1983	REVISION TO PRICE EXPECTATIONS PRESREV = PRES - PRES(-1)		
PRI	1953-1983	DEFLATED PRODUCER TEA PRICE, INDIA PRI = PRIIND/CPIIND	RUP/KG	INDIA TEA BOARD
PRIARGE	1957-1983	DEFLATED WORLD TEA PRICE, ARGENTINA PRIARGE = WPRICE * EX2ARG/CPI2ARG	LOCAL CURR/KG	WORLD BANK
PRIBAN	1972-1983	DEFLATED WORLD TEA PRICE, BANGLADESH PRIBAN = WPRICE * EX2BAN/CPI2BAN	LOCAL CURR/KG	WORLD BANK
PRICALC	1952-1984	WEIGHTED PRICE OF ALL TEA -CALCUTTA	RS/KG	ITC/WB
PRICALC2	1952-1984	PRICE AT CALCUTTA AUCTION WITH CESSES & EXPORT DUTY	RS/KG	ITC
PRICALC2$	1952-1984	PRICE AT CALCUTTA AUCTION WITH CESSES & EXPORT DUTY IN US$ PRICALC2$ = PRICALC2/EXRIND	US/KG	ITC
PRICALC3	1953-1983	PRICE AT CALCUTTA AUCTION WITHOUT EXPORT DUTY	RS/KG	ITC
PRICOCH	1953-1983	VALUE WGTD. PRICE OF ALL TEA -COCHIN	RS/KG	ITC

(Glossary continues on the following page.)

PRICOCH2	1952-1984	PRICE AT COCHIN AUCTION WITH EXPORT DUTY	RS/KG	ITC
PRICOCH2$	1952-1984	PRICE AT COCHIN AUCTION WITH EXPORT DUTY IN US$	US$/KG	ITC
PRICOCH3	1953-1983	PRICE AT COCHIN AUCTION WITHOUT EXPORT DUTY	RS/KG	ITC
PRICOLO	1952-1984	TEA PRICE AT COLOMBO AUCTION WITH SALES CESS & EXPORT TAX	RP/KG	ITC & FAO
PRICOLO$	1952-1984	TEA PRICE AT COLOMBO AUCTION WITH SALES CESS & EXPORT TAX, IN US$	US$/KG	ITC & FAO
PRICOLO1	1952-1984	TEA AUCTION PRICE AT COLOMBO, NET OF SALES TAX	RS/KG	ITC
PRIIND	1953-1983	PRODUCER PRICE OF TEA IN INDIA	RS/KG	ITC
PRIINDO	1967-1983	REAL TEA PRICE IN INDONESIA		
		PRIINDO = WPRICE * EX2INDO/CPI2INDO		
PRIINDOL	1967-1983	LOG OF PRIINDO		
		PRIINDOL = LOG(PRIINDO)		
PRIINDW	1952-1983	WEIGHTED AVERAGE OF CALCUTTA AND COCHIN AUCTION PRICES		
		PRIINDW=0.33*PRICOCH + 0.67*PRICALC		
PRIKTDA	1963-1983	PRODUCER PAYMENT FOR GREEN LEAF - KTDA	SHILL/KG	KTDA ANN. RPTS
PRIKTDAR	1963-1983	REAL PRODUCER PAYMENT FOR GREEN LEAF - KTDA	SHILL/KG	KTDA ANN. RPTS
		PRIKTDAR = PRIKTDA/CPIKEN		
PRIKTDARL	1963-1983	LOG OF PRIKTDAR		
		PRIKTDARL = LOG(PRIKTDAR)		
PRIMALR	1968-1983	REAL TEA PRICE IN MALAWI DERIVED FROM PRIMOMB	LOCAL CURR/KG	ITC
PRIMALRD	1969-1983	FIRST DIFFERENCE OF PRIMALR		
		PRIMALRD = PRIMALR/PRIMALR(-1)		
PRIMOMB	1958-1984	TEA AUCTION PRICE AT MOMBASA	SH/KG	ITC
PRIMOMB$	1958-1984	DEFLATED TEA AUCTION PRICE AT MOMBASA IN US$	SH/KG	ITC
		PRIMOMB$ = PRIMOMB/EXRKEN		
PRITUR	1953-1983	DEFLATED WORLD TEA PRICE, TURKEY	LOCAL CURR/KG	WORLD BANK
		PRITUR = WPRICE * EX2TU/CPI2TU		
PRK	1958-1983	DEFLATED AUCTION PRICE AT MOMBASA	SH/KG	ITC
		PRK = PRIMOMB/CPIKEN		
PRKD	1959-1983	DEFLATED MOMBASA AUCTION PRICE RATIO		
		PRKD = PRK/PRK(-1)		
PRLSL	1958-1983	THREE YEAR MOVING AVERAGE PRODUCER PRICE, LAGGED THREE YEARS, SRI LANKA		
		PRLSL = 3.0 * PRS/(PRS(-4) + PRS(-5) + PRS(-6))		
PRS	1953-1983	DEFLATED TEA PRODUCER PRICE, SRI LANKA		
		PRS = PRICOLO1/CPISL		
PSWCH	1957-1984	ADJUSTED, DEFLATED WORLD SUGAR PRICE, CHILE	LOCAL CURR/KG	WORLD BANK
		PSWCH = WPRSU * EX2CH/CPI2CH		
PSWEG	1950-1983	DEFLATED WORLD SUGAR PRICE, EGYPT	LOCAL CURR/KG	WORLD BANK
		PSWEG = WPRSU * EX2EG/CPI2EG		
PSWPA	1953-1984	DEFLATED WORLD SUGAR PRICE, PAKISTAN		WORLD BANK
		PSWPA = WPRSU * EX2PA/CPI2PA		

PSWPA2	1954-1984	2 YR MOVING AV DEFLATED WORLD SUGAR PRICE, PAKISTAN PSWPA2 = (PSWPA + PSWPA(-1))/2		WORLD BANK
PSWSA	1954-1984	DEFLATED WORLD SUGAR PRICE, SAUDI ARABIA PSWSA = WPRSU * EX2SA/CPI2SA		WORLD BANK
PSWSA2	1968-1984	2 YR MOVING AV DEFLATED WORLD SUGAR PRICE, SAUDI ARABIA PSWSA2 = (PSWSA + PSWSA(-1))/2		WORLD BANK
PSWSYR	1950-1984	DEFLATED WORLD SUGAR PRICE, SYRIA PSWSYR = WPRSU * EX2SYR /CPI2SYR		WORLD BANK
PSWSYR2	1951-1984	2 YR MOVING AV DEFLATED WORLD SUGAR PRICE, SYRIA PSWSYR2 = (PSWSYR + PSWSYR(-1))/2		WORLD BANK
PTAU	1953-1983	DEFLATED RETAIL TEA PRICE, AUSTRALIA PTAU = TPAU/CPI1AU	LOCAL CURR/KG	NZ OFFICIAL YRBK
PTCA	1953-1984	DEFLATED RETAIL TEA PRICE, CANADA LOCAL PTCA = TPCA/CPI1CA	LOCAL CURR/KG	NZ OFFICIAL YRBK
PTIN	1957-1983	DEFLATED RETAIL TEA PRICE, INDIA PTIN = TPIN/CPITIN	LOCAL CURR/KG	INDIA TEA BOARD
PTIN2	1958-1983	2 YR MOVING AV DEFLATED RETAIL TEA PRICE, INDIA PTIN2 = (PTIN + PTIN(-1))/2.0	LOCAL CURR/KG	ITC
PTLCH	1957-1984	DEFLATED LONDON RETAIL TEA PRICE, CHILE PTLCH = TPLOND * EX2CH/CPI2CH	LOCAL CURR/KG	ITC
PTLOND	1960-1983	LONDON TEA AUCTION PRICE DEFLATED BY MUV PTLOND = TPLOND/MUV	LOCAL CURR/MT	ITC/WB
PTUK	1953-1984	DEFLATED RETAIL TEA PRICE, UK PTUK = TPUK/CPI1UK	LOCAL CURR/KG	NZ OFFICIAL YRBK
PTUKCH	1954-1984	DEFLATED UK RETAIL TEA PRICE RATIO PTUKCH = PTUK/PTUK(-1)		
PTUS	1953-1984	DEFLATED RETAIL TEA PRICE, US PTUS = TPUS/CPI1US	LOCAL CURR/KG	NZ OFFICIAL YRBK
PTUS2	1954-1984	2 YR MOVING AV DEFLATED RETAIL TEA PRICE, US PTUS2 = (PTUS + PTUS(-1)) /2	LOCAL CURR/KG	
PTWCH	1957-1983	DEFLATED WORLD TEA PRICE, CHILE PTWCH = WPRICE * EX2CH/CPI2CH	LOCAL CURR/KG	ITC
PTWNZ	1954-1983	DEFLATED WORLD TEA PRICE, NEW ZEALAND PTWNZ = WPRICE * EX2NZ/CPI2NZ	LOCAL CURR/KG	ITC
PTWORLD	1960-1983	WORLD TEA PRICE DEFLATED BY MUV PTWORLD = WPRICE/MUV		
PTWPA	1953-1983	DEFLATED WORLD TEA PRICE, PAKISTAN PTWPA = WPRICE * EX2PA/CPI2PA	LOCAL CURR/KG	ITC
PTWPA2	1954-1983	2 YR MOVING AV DEFLATED WORLD TEA PRICE, PAKISTAN PTWPA2 = (PTWPA + PTWPA(-1))/2	LOCAL CURR/KG	ITC

(Glossary continues on the following page.)

PTWSA	1954-1983	DEFLATED WORLD TEA PRICE, SAUDI ARABIA PTWSA = WPRICE * EX2SA/CPI2SA	LOCAL CURR/KG	ITC
PTWSA2*	1955-1983	2 YR MOVING AV DEFLATED WORLD TEA PRICE, SAUDI ARABIA PTWSA2 = (PTWSA + PTWSA(-1))/2	LOCAL CURR/KG	ITC
PTWSO	1953-1983	DEFLATED WORLD TEA PRICE, SOUTH AFRICA PTWSO = WPRICE * EX2SO/CPI2SO	LOCAL CURR/KG	ITC
Q1INDO	1952-1984	TEA PRODUCTION, INDONESIA		
Q1MALAY	1970-1983	TEA PRODUCTION, MALAYSIA	MT	ITC
Q1ROW	1970-1984	TEA PRODUCTION, REST OF WORLD	MT	ITC
QARGE	1954-1984	TEA PRODUCTION, ARGENTINA	MT	ITC
QBAN	1972-1984	TEA PRODUCTION, BANGLADESH	MT	ITC
QBANL	1972-1984	LOG(QBAN)		
QCTUR	1965-1984	PER CAPITA TEA PRODUCTION, TURKEY QCTUR = QTUR/POP2TU	MT/1000 HEAD	ITC & IFS
QIND	1952-1984	TEA PRODUCTION, INDIA	MT	ITC
QINDO	1952-1984	TEA PRODUCTION, INDONESIA	MT	ITC
QINDOL	1952-1984	LOG OF TEA PRODUCTION		
QIRAN	1970-1984	TEA PRODUCTION, IRAN	MT	ITC
QKEN	1954-1984	TEA PRODUCTION, KENYA	MT	ITC
QKES	1963-1983	ESTATE TEA PRODUCTION, KENYA	MT	KTDA
QKSE	1967-1983	KENYA SMALLHOLDER PROD. ESTIMATED	1000 KG	
QKSEL	1967-1983	LOG KENYA SMALLHOLDER PROD. ESTIMATED	1000 KG	
QKSH	1971-1983	SMALLHOLDER TEA PRODUCTION, KENYA	1000 KG	KTDA
QKSHL	1971-1983	LOG KENYA SMALLHOLDER PRODUCTION	KG	
QMAL	1954-1984	TEA PRODUCTION, MALAWI	MT	
QOAS	1961-1984	TEA PRODUCTION, OTHER ASIA	MT	ITC
QPNG	1970-1984	TEA PRODUCTION, PNG	MT	ITC
QROAFRI	1970-1984	TEA PRODUCTION, REST OF AFRICA (AFRICA LESS KENYA,MALAWI,UGANDA)	MT	ITC
QROAFRIL	1970-1984	LOG OF REST OF AFRICA PRODUCTION	MT	ITC
QSAREST	1970-1984	TEA PRODUCTION, SOUTH AMERICA LESS ARGENTINA	MT	ITC
QSL	1954-1984	TEA PRODUCTION, SRI LANKA	MT	ITC
QTAFR	1970-1984	TEA PRODUCTION, AFRICA	MT	ITC
QTSAM	1970-1984	TEA PRODUCTION, SOUTH AMERICA	MT	ITC
QTUR	1961-1984	TEA PRODUCTION, TURKEY	MT	ITC
QUG	1952-1984	TEA PRODUCTION, UGANDA	MT	ITC
QUSSR	1955-1984	TEA PRODUCTION, USSR	MT	ITC
QVIET	1970-1984	TEA PRODUCTION, VIET NAM	MT	ITC
QW	1972-1984	TEA PRODUCTION, WORLD QW = QIND + QSL + QKEN + QINDO + QBAN + QOAS + QMAL + QTUR+ QUSSR; + QROAFRI + QARGE + QSAREST + QIRAN + QUG + XBTCHT	MT	ITC

RATPC	1963-1983	RATIO OF PRODUCER PRICE TO COST OF PRODUCTION, SRI LANKA RATPC = PRS/COPSL		
RPCUK	1962-1984	RETAIL COFFEE PRICE, UK	PENCE/KG	ICO
RSSL	1966-1984	REPL SUBSIDY PAID -SL '68 '69 ESTIMATES	SLRS. MILL	CEN. BANK OF SRI LANKA
RSSLREAL	1966-1983	RSSL DEFLATED BY CPI	MILL. SL RP	
RSSLREALCH	1967-1983	RSSLREALCH = RSSLREAL - RSSLREAL(-1)		
SQTR61	1961-1984	SQUARE-ROOT OF TIME TREND SQTR61 = SQRT(TR61)		
SRINEWP	1956-1983	SRI LANKA- NEW PLANTINGS	HA	ITC
SRIREPL	1956-1983	SRI LANKA REPLANTINGS	HA	ITC
SRIUP	1956-1983	SRI LANKA - UPROOTINGS	HA	ITC
SRIUPMA	1958-1983	M A OF SRIUP(-1) AND SRIUP(-2)		
SRM8TRS	1954-1983	SRI LANKA - AREA OF TREES MORE THAN 8 YEARS OLD		
SRNEWTRS	1956-1983	TOTAL NEW PLANTINGS IN SRI LANKA SRNEWTRS = SRINEWP + SRIREPL	HA	ITC
STXSL	1952-1984	TEA SALES TAX IN SRI LANKA STXSL = PRICOL02 - PRICOL01	RPS/KG	
T2	1953-1984	TREND VARIABLE BEGINNING YEAR=1953		
TPAU	1953-1983	RETAIL TEA PRICE, AUSTRALIA	CENTS/KG	NZ OFFICIAL YRBK
TPAU$	1953-1983	RETAIL TEA PRICE, AUSTRALIA IN US$	US$/KG	ITC
TPCA	1953-1984	RETAIL TEA PRICE, CANADA	CENTS/KG	ITC
TPIN	1953-1983	RETAIL TEA PRICE, INDIA	RUPEES/KG	INDIA TEA BOARD
TPLOND	1953-1984	LONDON AUCTION PRICE IN US $		
TPLONDCA	1953-1984	LONDON AUCTION PRICE, CANADA TPLONDCA = TPLOND * EXCA	LOCAL CURR/KG	ITC
TPLONDDF	1960-1983	LONDON AUCTION PRICE, DEFLATED BY MUV TPLONDDF = TPLOND/MUV	US $/KG	WORLD BANK
TPLONDUK	1953-1984	LONDON AUCTION PRICE, UK TPLONDUK = TPLOND * EXUK	LOCAL CURR/KG	ITC
TPRODCI	1957-1983	PRODUCTION CAPACITY IN INDIA TPRODCI = 1.1942 * (1.0 * TPRODI + 283500.0) * EXP(0.00994 *; DX * TXIN)		
TPRODCICH	1958-1983	TPRODCICH = TPRODCI - TPRODCI(-1)		
TPRODI	1953-1983	INDIA NEW PLANTING PRODUCTION CAPACITY	HECTARES	ITC
TPRODSL	1956-1983	SRI LANKA NEW PLANTING PRODUCTION CAPACITY	KG	
TPUK	1953-1983	TEA RETAIL PRICE IN UK	PENCE /KG	NZ OFFICIAL YRBK
TPUS	1953-1984	TEA RETAIL PRICE IN US	CENTS/KG	ITC
TR51	1951-1984	LINEAR TIME TREND - START 1951		
TR51L	1951-1984	LOG OF TR51		
TR61	1961-1984	LINEAR TIME TREND - START 1961		
TR65	1965-1983	LINEAR TIME TREND - START 1965		

(Glossary continues on the following page.)

TRARA	1965-1985	LINEAR TIME TREND FOR OTHER ARAB COUNTRIES-START 1851		
TRCH	1961-1984	TIME TREND CHINA- START 1961		
TRINDO	1961-1984	TIME TREND INDONESIA - START 1961		
TSIND	1957-1983	TEA STOCKS IN INDIA END YR.	1000 MT	FAO
TSSL	1957-1983	TEA STOCKS IN YR. SRI LANKA END YEAR	1000 MT	FAO
TSUK	1953-1983	TEA STOCKS IN UK END YR.	1000 MT	ITC
TWS	1957-1983	TOTAL WORLD TEA STOCK	MT	ITC/FAO
		TWS = TSUK + TSSL + TSIND		
TWSL	1957-1983	LOG TOTAL WORLD TEA STOCK		
TWSLHAT3	1964-1983	ESTIMATES OF TOTAL WORLD TEA STOCKS	MT	
TXIN	1957-1984	TIME TREND FOR INDIA SUPPLY EQUATION		
TXSL	1958-1984	TIME TREND FOR SRI LANKA SUPPLY EQUATION		
TYT	1957-1983	LOG OF ADJUSTED WORLD COFFEE PRICE		
		TYT = LOG(PGUT * EXW3/CPI3)		
WPRICE	1952-1984	WORLD PRICE INCLUSIVE OF EXPORT TAXES & CESSES	US$/KG	
WPRICEDF	1960-1983	WORLD PRICE INCLUSIVE OF EXPORT TAXES & CESSES DEFLATED BY MUV	US$/KG	
		WPRICEDF = WPRICE/MUV		
WPRICEDFL	1960-1983	LOG DEFLATED WORLD PRICE INCLUSIVE OF EXPORT TAXES & CESSES		
		WPRICEDFL = LOG(WPRICEDF)		
WPRICEDFLD	1961-1983	CHANGE IN LOG DEFLATED WORLD PRICE AS GIVEN ABOVE		
		WPRICEDFLD = WPRICEDFL - WPRICEDFL(-1)		
WPRICEDL	1953-1983	LOG RATIO OF WORLD PRICE INCLUSIVE OF EXPORT TAXES & CESSES		
		WPRICEDL = LOG(WPRICE/WPRICE(-1))		
WPRICEL	1953-1983	LOG OF WORLD PRICE INCLUSIVE OF EXPORT TAXES & CESSES	US$/KG	
		WPRICEL = LOG(WPRICE)		
WPRSU	1950-1984	WORLD SUGAR PRICE	CENTS/KG	WORLD BANK
WPRSUDF	1960-1983	WORLD SUGAR PRICE DEFLATED BY MUV	CENTS/KG	WORLD BANK
		WPRSUDF = WPRSU/MUV		
XBTCHT	1972-1984	EXPORT OF BLACK TEA FROM CHINA & TAIWAN	MT	ITC
XDCSL	1952-1984	CESSES & EXPORT DUTY IN SRI LANKA	RPS/KG	ITC
XTCALC	1953-1983	EXPORT TAX IN CALCUTTA	RPS/KG	FAO
XTCOCH	1953-1983	EXPORT TAX IN COCHIN	RPS/KG	FAO
YLDKES	1972-1983	KENYA ESTATES TEA PRODUCTION YIELDS	MT/HA	ITC
		YLDKES = QKES/ZKEAW		
YLDMAL	1965-1983	MALAWI TEA PRODUCTION YIELDS	MT/HA	ITC
		YLDMAL = QMAL/ZMALAW		
ZKEAW	1972-1983	KENYA ESTATE TOTAL AREA EQUAVALENT MATURITY AREA	HA	KTDA/WB
		ZKEAW = .12 * ZKEA5 + .76 * ZKE510 + ZKEA10		
ZKEAWL	1972-1983	ZKEAWL = LOG(ZKEAW)		
ZMALAW	1965-1983	AGE WEIGHTED TEA AREA IN MALAWI		
		ZMALAW = .12 * ZM5 + .76 * ZM510 + ZM10	HA	ITC
ZMALAWL	1965-1983	ZMALAWL = LOG(ZMALAW)		

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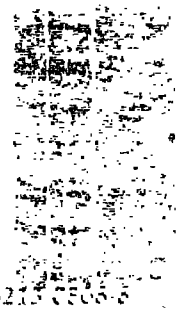

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