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Price Analysis of the World Tea Market

by

Thomas Friedheim

Juni 1992 Nr. 30

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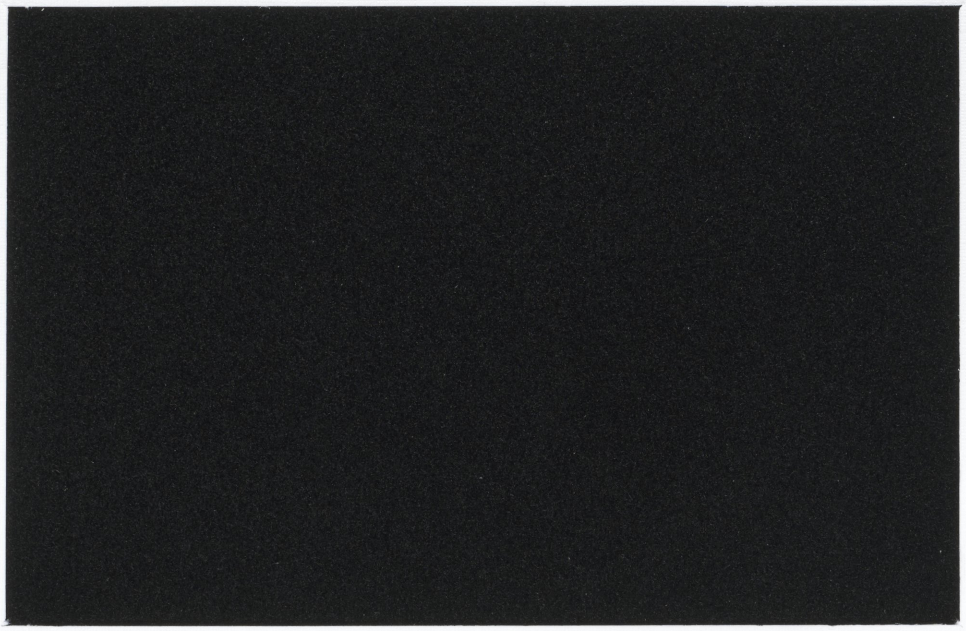

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1. Introduction

A striking discovery of the many instability analyses for commodity markets is the 'rule' that the world tea market is not particularly prone to price volatility. At least this is a lesson of the past. This paper poses the question anew of whether price fluctuations on the coffee and the cocoa markets exceed those on the tea market. Why is this important? One reason is that price instability and uncertainty about its extent are a condition sine–qua–non for viable futures markets. Only if prices fluctuate, are producers, traders and processors potentially interested in hedging against price level fluctuations. The question, for instance, of why there is no futures markets for tea, thus has to start with an analysis of market instability.

On the world markets for coffee and cocoa, futures trading makes price determination a highly organized, centralized and transparent business. Special hedging techniques (straddle) in effect guard against a sustained rise of interregional prices beyond transfer costs.[1] Likewise, prices of substitute qualities are constrained by intra–commodity arbitrage. By contrast, institutionalized price discovery for tea (via auction) is widely dispersed, while, in addition, tea is a far more inhomogeneous product than the other two tropical beverage crops. Thus, it is not obvious a priori whether the law–of–one–price holds on the world tea market. Hence, this paper takes a closer look at the structure of tea price differentials.

Moving to an even higher degree of market disaggregation, this paper asks whether there are stable and characteristic patterns of seasonality which are reflected in prices. The seasonal analysis focuses on Darjeeling, Assam, Ceylon and Indonesian teas.

2. The Volatility of Agricultural Commodity Prices

This chapter deals with the concept of price instability, its measurement and the comparative performance of world tea prices in terms of price volatility.

2.1 Measures of Instability

Price instability is a concept which is not defined in precise terms. Rather, it is generally understood that price volatility is the non–seasonal deviation of prices from what is considered as the trend.[2] Five indices that are frequently used to 'measure' price volatility shall be discussed in this section. The techniques essentially distinguish themselves in the way in which the 'normal' price movement (i.e. the trend) is identified and eliminated from the time–series.

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1 Provided there is a free and competitive play of the market forces (i.e. absence of trade barriers or other interventions).

The first candidate to be introduced is the well-known coefficient of variation (CV) which is defined as the standard deviation (s) divided by the arithmetic mean of the variable ($\bar{x}$):

$$CV = \frac{s}{\bar{x}} \cdot 100$$

A priori, the coefficient of variation is an inappropriate measure for instability analysis unless the time-series exhibits no trend or has been detrended beforehand.[3] However, since one of the intentions of this section is to probe the comparative performance of instability indicators, the coefficient of variation will be calculated on the basis of the un-detrended values of the time-series.

The instability index suggested by CUDDY and DELLA VALLE, the CUDDY – DELLA VALLE index (CDI) for short, is derived from the coefficient of variation under the assumption, however, that time-series are mostly trended.[4] In fact, the index is a trend-adjusted coefficient of variation. It is calculated as:

$$CDI = CV \sqrt{(1 - \bar{R}^2)} \cdot 100$$

with $\bar{R}^2$, the adjusted coefficient of determination, defined as

$$\bar{R}^2 = 1 - \left[(1-R^2) \frac{(N-1)}{(N-k)} \right] ,$$

with N: number of observations
k: number of independent variables.

A particularity of the CUDDY – DELLA VALLE index is that the functional form of the trend is not predetermined. The authors propose instead that the trend having the best goodness-of-fit be selected (linear, log-linear etc.). Given an *untrended* time-series, $\bar{R}^2$ is 0, in which case the CDI equals the CV. Given a *trended* time-series which is not 'distorted' by price instability, $\bar{R}^2$ is unity and the CDI is therefore zero, a result which is also plausible.

The linear trend index (LTI) is defined as[5]:

$$LTI = \sqrt{\frac{1}{N} \Sigma \left[\frac{P_t - \bar{P}^*_t}{\bar{P}^*_t} \right]^2} \cdot 100$$

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2 LIM, p. 37.

3 CUDDY / DELLA VALLE, p. 79.

4 CUDDY / DELLA VALLE, pp. 81 ff.

5 HERRMANN, p. 120.

The underlying trend function is assumed to take on a linear shape yielding constant absolute increases of the trend values ($\bar{P}^*_t$). The index, then, measures the mean squared deviation from the linear trend (expressed as a percentage).

The exponential trend index (ETI) proposed by MACBEAN and NGUYEN is based on the assumption that the trend values increase by a constant growth rate.[6]

$$ETI = \sqrt{\frac{1}{N} \Sigma \left[\frac{P_t - \bar{P}^e_t}{\bar{P}^e_t} \right]^2} \cdot 100$$

The trend values ($\bar{P}^e_t$) have been estimated based on the log-linear function

$P_t = e^{(a + b_t)}$ or

$\ln P_t = a + \ln b_t.$

The MACBEAN index (MBI) differs from the above indices by its trend-following technique: the price trend is calculated as a five-year moving-average. It is referred to as 'moving' because in calculating it, 5 consecutive data are averaged, after which a 'new' value is added while the last is dropped and so on. One disadvantage of calculating moving-averages is the information lost: the time-series of a 5-term moving-average, for instance, is 4 values shorter than the original time-series. The degree of instability is then 'measured' as the mean deviation of the observed values (in absolute terms) relative to the moving-average.[7]

$$MBI = \frac{100}{n - 4} \cdot \sum_{t=1}^{n-4} \left| \frac{5(p_{t+2})}{p_t + \ldots + p_{t+4}} - 1 \right|.$$

2.1 Empirical Results

The 'orthodox' assessment of tea market instability is that world tea prices are relatively stable when compared to other commodities.

In an older study, SARKAR calculated instability indices for the three major tropical beverage crops, coffee, cocoa and tea. He used three different measures, two of which, however, do not take into account the trend factor.[8] His time-series' span the years 1950 to 1966, which include the final years of the International Tea Agreement. Yet, SARKAR points out that the export quota scheme was still in operation formally but had *"little, if any, actual effect in*

6 WELTBANK (1986), p. 99.

7 HERRMANN, p. 121.

controlling exports and prices"[9]. To explain, in 1933, India, Ceylon and the Netherlands East India (Indonesia) agreed to restrict exports so as to boost world tea prices which had been extremely depressed in the preceding years. In those times, these countries were supplying 83% of total world exports. The export quota system was initially considered very successful in raising prices , and was renewed several times, excluding the East African producers at all times, until the scheme was eventually discontinued in 1955[10]

SARKAR found that "*price fluctuations in tea turned out to be less than in coffee execept in the Calcutta auctions, and less than in cocoa in all the auctions*"[11]. According to SARKAR the following factors contributed to the comparative price stability of tea prices[12]:

- Tea production was less prone to fluctuations in supply following good or bad harvests. This, in addition to the fact that world tea production was more diversified among countries than, for instance, coffee, led to comparative stability on the supply side.
- SARKAR argued that tea production could be adjusted even in the short run and jacked up if prices rose because tea leaves could be plucked more or less intensely. This argument would imply that the short–run supply curve was elastic.
- The tea market was not subject to the destabilizing effects of speculation via futures trading. The validity of this argument is dubious (it will be dealt with in a later chapter).
- Finally, SARKAR points to the stabilizing effects of vertical integration and the non–competitive market structure on the demand side, evidenced by a high concentration index in the UK market. This argument will be discussed shortly.

A WORLD BANK survey of the major agricultural commodities and minerals, based on the period 1955–1976 unmistakeably supports SARKAR's conclusion: tea and bananas showed the least price volatility among all commodities as measured by the MACBEAN index (see Fig. A in the Annex).[13] However, what seems to matter here is the way in which the instability index is constructed, or the time period chosen, or both. A more recent WORLD BANK study for the years 1964–84, using the exponential trend index, puts tea in midfield among 14 agricultural commodities. The same calculation made on the basis of the years 1974 to 1984 yields a decrease in price instability for 10 commodities, while tea prices become more volatile (see Fig. B in the Annex).

The author's empirical results shall now be presented. In Fig. 1 the five above–mentioned instability index techniques have been applied to the three predominant tropical beverages (further disaggregated according to countries of origin), Bangladeshi jute and Malaysian rubber. The indices have been calculated on the basis of nominal (undeflated) price data for

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8 SARKAR, pp. 87–91.

9 SARKAR, p. 90.

10 ETHERINGTON (1974), p. 88 and SARKAR, p. 163 ff.

11 SARKAR, p. 91.

12 SARKAR, pp. 92–94.

13 WELTBANK (1978), p. 23

Fig. 1: Commodity Price Instability Indices for the period 1961 to 1990

	Cocoa		Coffee		Tea				Jute	Rubber
	Brazil	Ghana	Brazil	Colombia	London / India	Kenya	Sri Lanka	North India	Bangladesh	Malaysia
Absolute Values										
Coefficient of Variation	68.18	69.46	63.80	56.34	37.26	34.45	41.30	39.92	26.29	40.07
Cuddy - Della Valle Index	45.33	37.80	42.49	33.33	25.74	24.81	29.08	20.59	21.08	26.61
MacBean Index	16.25	16.06	15.87	13.00	10.51	11.38	14.25	9.22	12.98	12.37
Linear Trend Index	35.73	33.87	32.71	26.15	21.09	18.48	22.56	19.80	15.09	21.58
Exponential Trend Index	63.33	52.06	51.95	40.07	25.88	25.79	28.53	20.30	20.75	27.02
Rank										
Coefficient of Variation	2	1	3	4	8	9	5	7	10	6
Cuddy - Della Valle Index	1	3	2	4	7	8	5	10	9	6
MacBean Index	1	2	3	5	9	8	4	10	6	7
Linear Trend Index	1	2	3	4	7	9	5	8	10	6
Exponential Trend Index	1	2	3	4	7	8	5	10	9	6

Notes: Index formulas are explained in the text. Data base: IMF (1991), "International Financial Statistics" (IFS) and INTERNATIONAL TEA COMMITTEE (ITC), "Ann. Bull. of Statistics", var. issues.
1) Cocoa Brazil: line 223 (IMF). 2) Cocoa Ghana: line 652 (IMF), Cocoa beans, London spot market. 3) Coffee Brazil: line 223 (IMF), Arabica. 4) Coffee Columbia: line 223 (IMF), mild Arabica.
5) Tea London / India: London auction average, North Indian tea (ITC). 6) Tea Kenya: Mombasa auction average of Kenyan tea (ITC). 7) Tea Sri Lanka: Colombo auction average (ITC).
8) Tea North India: Calcutta auction average, Assam Leaf (ITC). 9) Jute Bangladesh: line 513 (IFS),raw Bangladesh BWD, fob Chittagong / Chalna (IFS).
10) Rubber Malaysia: line 548 (IFS),No. 1 R.S.S., fob Malaysian ports.
Source: Author's estimates.

the years 1961 to 1990.[14] Only the MACBEAN Index, by way of construction, refers to the years 1963 to 1988.

- The first result is that the absolute values of instability largely differ for each individual commodity depending on which index technique has been applied. For instance, Brazilian cocoa showed a volatility of prices ranging from 16.25 percent relative to the moving-average (MACBEAN Index) up to 68.18 percent relative to the mean (coefficient of variation). The absolute values, thus, crucially depend on the method of measurement.

- The second result is, if ranked according to the extent of price volatility, the vastly divergent techniques yield (surprisingly) a fairly consistent order. In the bottom half of Fig. 1, the commodities have been assigned ranks corresponding to the ordering of the absolute values. For instance, four out of the five chosen techniques indicate that Brazilian cocoa prices were the most volatile in the past three decades. As would be expected in arbitrage markets, the majority of the indices indicate that Ghanaian cocoa held second place.

  Moreover, not only do the measurement techiques discriminate in a (fairly) consistent manner between commodities but they also discriminate within commodity markets, such as the tea market (where the differences in price volatility are presumably more subtle). Thus, all five indices suggest that the tea market in Colombo (Tea Sri Lanka) was more volatile than the auction markets in Mombasa, London, and Calcutta.

  The ranking leads to the general conclusion that in the period 1961–90 the world cocoa market was more price volatile than the coffee market which, in turn, was more unstabile than the world tea market. The world rubber market was roughly on a par with the tea market, while world jute prices fluctuated slightly less than those of the other commodities.

- The fourth result relates to the interchangeability of index techniques. Using the rank numbers in Fig.1, SPEARMAN rank correlation coefficients have been estimated (see Fig. 2). The SPEARMAN rank correlation coefficient (r_s) is defined as[15]:

$$r_s = 1 - \frac{6 \Sigma D^2}{N (N^2 - 1)}$$

  where D is the difference between the rank numbers (N = number of observations).

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14 The trend line estimates are all based on nominal prices. This procedure leads to the assumptions of the method of ordinary least squares probably being violated (notably, absence of autocorrelation in the residuals), see TOMEK / ROBINSON, pp. 310 ff. Therefore, the t-values have been omitted. This is defendable as long as the objective is point estimation of parameters and not inference, i.e. the probability distribution of the parameters of the regression coefficients, see GUJARATI, pp. 123, 226. Furthermore, the CDI trend estimates are based on log-linear functions.

15 SACHS, p. 309.

The rank correlation coefficients indicate that, notably, the CUDDY – DELLA VALLE index, the linear trend index and the exponential trend index are interchangeable as are the coefficient of variation and the linear trend index.[16]

Fig. 2: Rank Correlation Coefficients of Selected Instability Indices

	Coefficient of Variation	Cuddy – Della Valle Index	MacBean Index	Linear Trend Index	Exponential Trend Index
Coeff. of Variation	1.0000	0.8909 **	0.8061*	0.9758 **	0.9152 **
Cuddy – Della Valle		1.0000	0.8909 **	0.9515 **	0.9879 **
MacBean Index			1.0000	0.8303 *	0.9030 **
Linear Trend Index				1.0000	0.9636 **
Exp. Trend Index					1.0000

Note: Formula for SPEARMAN's Rank Correlation Coefficient is explained in the text. Asterisks denote that coefficients are significant at the 5%(*) and 1% (**) level, see Tab. 103 in SACHS, p. 310. Sample size: 10 agricultural commodities. Source: Author's estimates.

Further insights are to be gained from Fig. 3. Since the empirical results have so far left open the question of how price volatility developed over time, the MacBEAN index has been recalculated for the two periods 1963–75 and 1976–88.[17] Given that the chosen index techniques are adequate substitutes, only one index has been recalculated.

Apparently, price volatility of the cocoa market has ebbed somewhat following the years after 1975. On the world coffee market a slightly upward tendency is discernible. As far as tea is concerned, a clear trend is evident: the world market has become substantially more unstable during the more recent period (i.e. 1976–88) if compared to 1963–76. The same development holds true for the jute market.

For some reason, the world tea market has apparently become more volatile since the mid-1970s. The 'structural' change in price behavior over time is visible even to the unaided eye. In Fig. 4, auction prices of Kenyan, Sri Lankan and North Indian tea have been plotted against time. The unit of account is US dollars, while the period spans the past three decades. The figure offers insights both into *price level* changes, which is the topic of this section, and into changes of *relative prices*, the analysis of which follows in the subsequent section.

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16 The maximum r_s can reach is one, meaning here perfect interchangeability of the indices, if the ranks and not the absolute values are of interest.

17 Since it is possible to calculate a moving-average for the entire period and then split the time-series the index spans two years more than is feasible otherwise without extrapolation.

Fig. 3: The Pattern of Price Instability over Time
(as measured by the MacBean Index)

		1963–1975	1976–1988
Cocoa			
	Brazil	19.0	13.5
	Ghana	18.7	12.6
Coffee			
	Brazil	14.0	17.7
	Colombia	12.1	13.9
Tea			
	London / India	6.5	14.5
	Kenya	8.1	14.7
	Sri Lanka	5.8	22.7
	North India	7.0	11.4
Jute			
	Bangladesh	6.8	19.2
Rubber			
	Malaysia	13.9	10.7

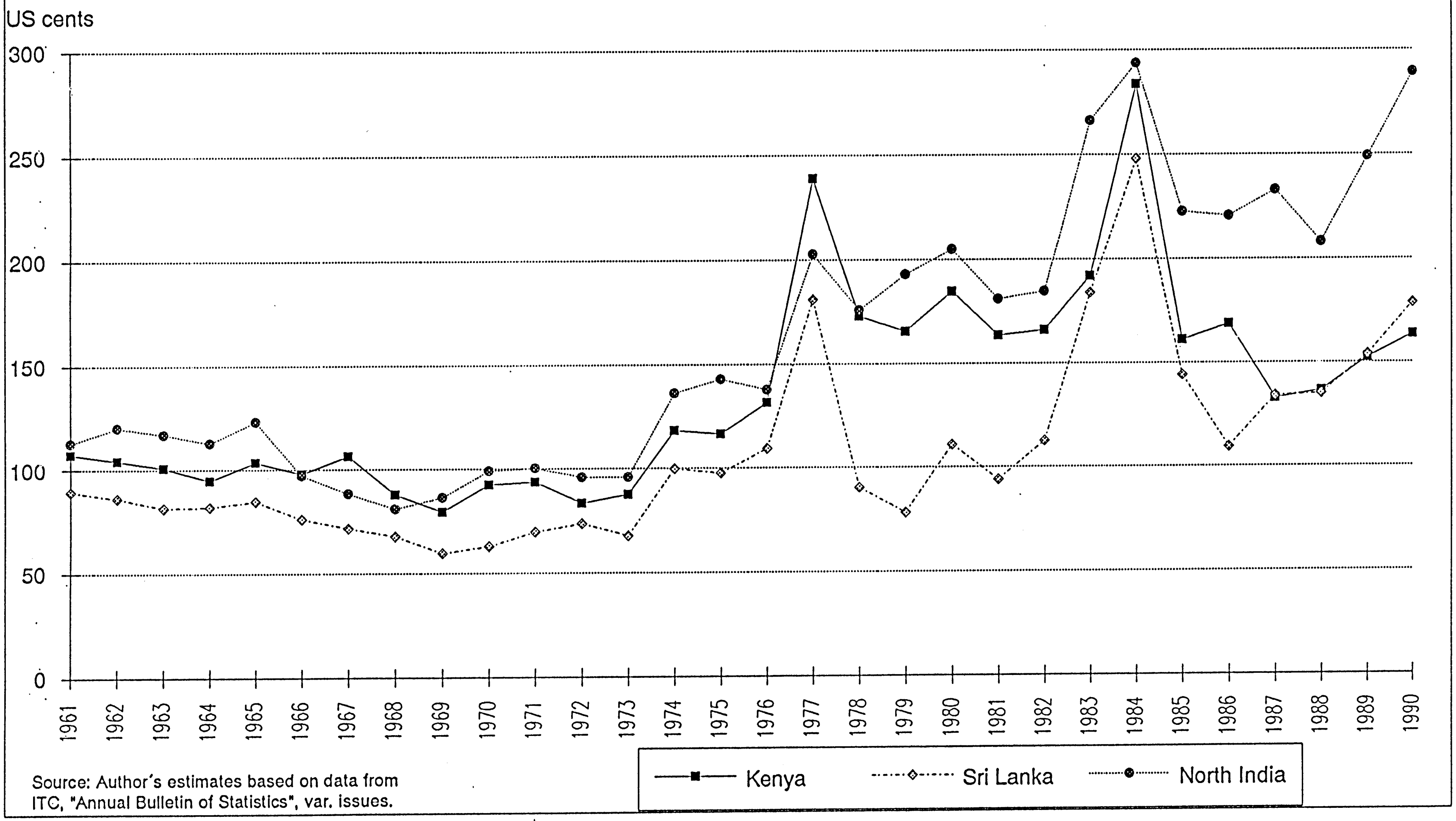
Note: see Fig. 1 for data sources.
Source: Author's calculations.

With respect to the general price level, Kenyan, Sri Lankan and North Indian tea prices hovered close to the one–dollar line (per kilogram) from 1961 to 1975. This period is characterized by relative price stability. Nevertheless, 1969 is remembered by the tea trader as a *baisse*. Then, beginning in 1974 the world tea market fundamentally changed its behavior, evidenced by large price swings. There have been three *hausses* thereafter, namely in 1977, 1984 and 1990. Incidentally, these recurred in seven–year cycles. In 1991, world tea prices were again very depressed.

Why has the world tea market 'all of a sudden' become so volatile ? This querry boils down to the question of whether these enhanced price fluctuations were caused by demand shocks or initiated from the supply side.

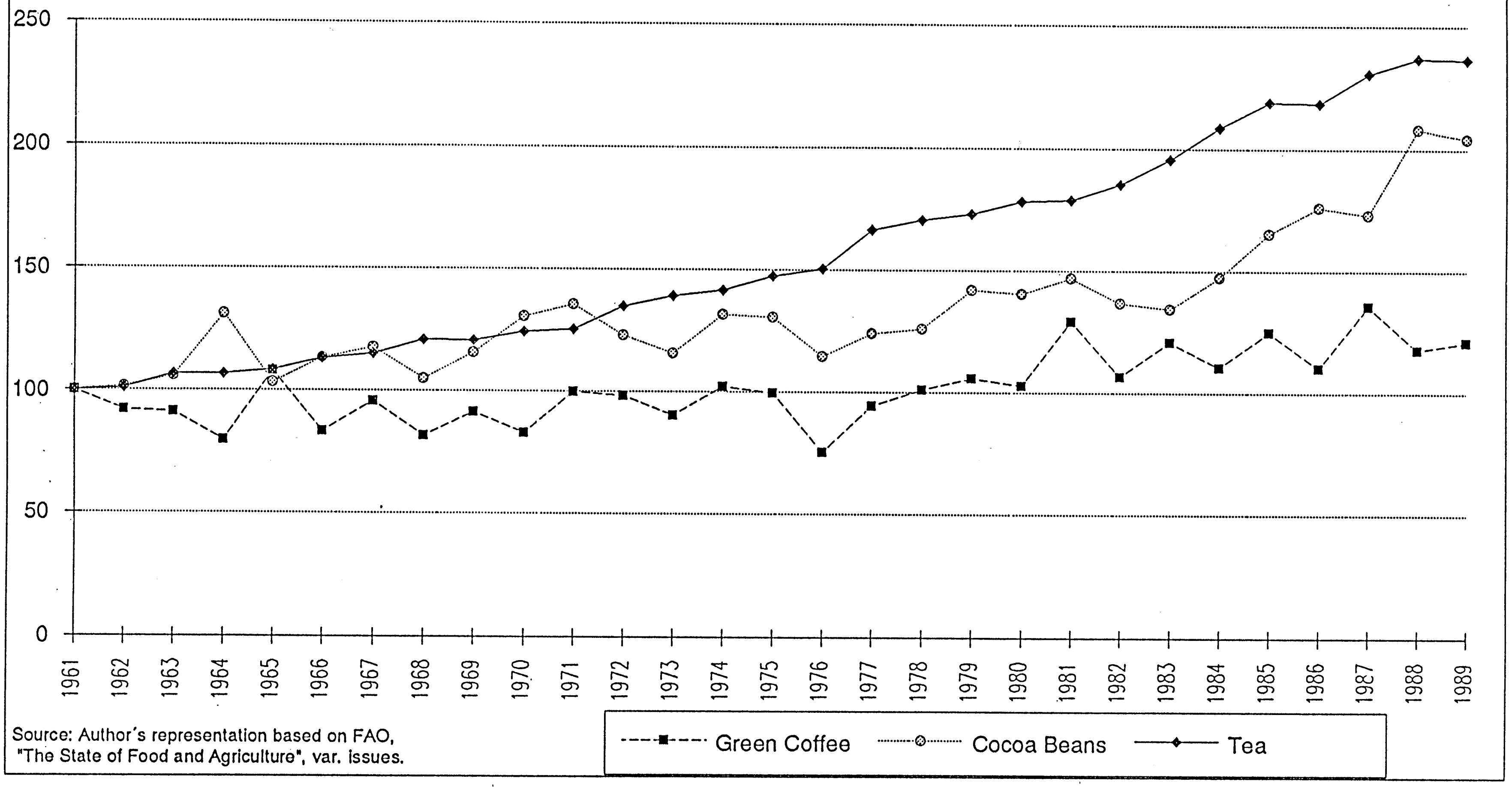
Fig. 5 shows that world tea production has steadily increased over the past three decades without any discernible disruption. Thus, the world tea <u>supply</u> curve has shifted (outward and to the right in a partial equilibrium model) rather than fluctuating from year to year. The overall increase in production amounted to 136% compared to the 1961 base level. By contrast, world coffee production (green beens) has hardly risen since 1961 and substantially fluctuated in the period under consideration.

Fig.4: The Tea Price Concertina



Source: Author's estimates based on data from ITC, "Annual Bulletin of Statistics", var. issues.

Fig. 5: World Production of Tropical Beverage Crops (1961=100)



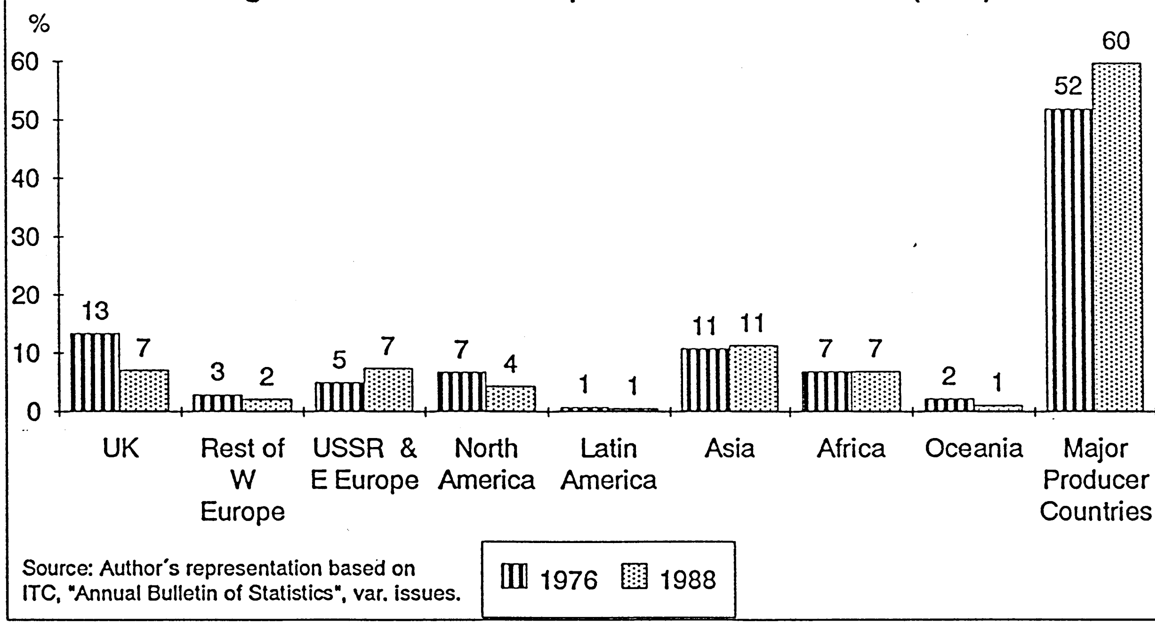
Source: Author's representation based on FAO, "The State of Food and Agriculture", var. issues.

BARON et al. investigated the underlying determinants of commodity price volatility using the OLS method and found that the instability of tea prices in 1950–76 was due to demand shifts.[18] Likewise, HERRMANN's empirical estimates suggest that *revenue instability* with respect to tea exports was determined by demand volatility (1966–78).[19]

In fact, the structure of world demand for tea has undergone major changes over the past two decades (see Fig. 6):

- Unlike coffee and cocoa, more than half of world tea production is nowadays absorbed by the producing countries themselves. The percentage share rose from 52% in 1976 to 60% in 1988.[20] The retention figures are not to be confused with absorption by developing countries since the figures include Japan's and Turkey's production, which is almost entirely destined for the domestic market.
- In the same period, the United Kingdom's imports (for consumption) decreased from 13% of world production in 1976 to just 7% in 1988. Likewise, North America's share of world consumption waned.[21]

Fig. 6: World Tea Absorption in 1976 and 1988 (in %)



Source: Author's representation based on ITC, "Annual Bulletin of Statistics", var. issues.

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18 BARON et al., p. 25.

19 HERRMANN, p. 126.

20 ITC (1987), p. 39.

21 ITC (1987), p. 58.

- In the period under consideration, 18% of world production was absorbed by non-producing Asian and African countries. Notably, Pakistan and the Middle East countries represented strong, emerging consumer markets. In 1988, Pakistan was the number four importer in the world, followed by Egypt, Iraq and Iran.[22]
- In addition to the above noted (secular) changes of the (import) demand structure, major shocks contributed to the instability of world tea demand (notably, the Chernobyl nuclear disaster and, to a lesser extent, the Gulf war).

Exchange rate fluctuations may have also contributed to price volatility. Enhanced market instability set in, seemingly, in the wake of the break-down of the BRETTON-WOODS agreement which gave way to floating dollar and pound sterling exchange rates.[23] Incidentally, most tea export contracts were and still are denominated in these currencies. However, at least in India and Sri Lanka, tea prices denominated in national currencies moved in tandem with the respective dollar prices (see chapter 4). By the same token, in the study on the problem at hand, FAO authors concluded :[24] "*These results suggest that exchange rate fluctuations do not contribute significantly to instability in national currency prices of tea beyond instability due to underlying market fundamentals, seasonal factors and so on.*"

Finally, the intra-market instability analysis also served to answer the question: Is the tea market stabilized through buyer market power? Returning to SARKAR's argument which held that the concentrated structure of the UK tea industry was stabilizing prices, Fig. 7 is instructive. The diagram is a representation of the (consumer) market shares in the UK. The tea companies concerned are manufacturing enterprises with downstream distribution channels, whose operations essentially consist of blending the so-called made tea (black tea in bulk) and of distributing the processed tea as branded products. The major consumer products are tea bags and leaf (loose) tea in packaged form, while instant tea is, as yet, of minor importance.[25]

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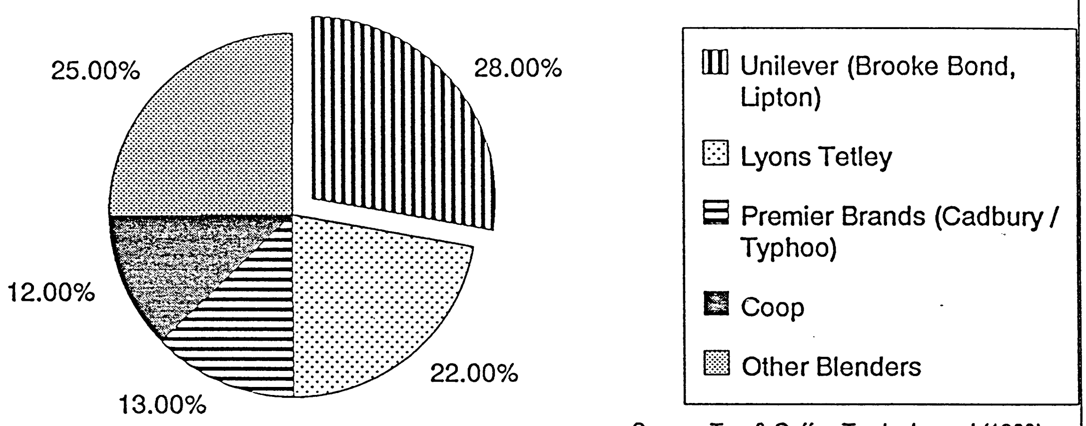
22 ITC (1988), pp. 58ff. The first ranks were held by the UK, the USSR and the USA.

23 The price level effect of the first oil crisis is barely discernible in 1974.

24 FAO (1990), p. 4.

25 TEA & COFFEE TRADE JOURNAL, p. 58. In the producing countries, processed as opposed to bulk tea is often referred to as value-added tea.

Fig. 7: Market Shares of UK Tea Blenders in 1986



Source: Tea & Coffee Trade Journal (1988), Vol.160, No.1, p. 60.

In 1986 UNILEVER held a market share of 28 percent. The cumulative market shares of the LYONS TETLEY, PREMIER BRANDS and COOP yielded a four–firm concentration ratio of 75 percent –– a market structure, which is aptly called oligopsony.[26] Not surprisingly, the buyer concentration in the UK tea market is mirrored in the London tea auction. If the 'Big Four' were indeed exerting (monopoly) market power in the London tea auction, one would expect –– following SARKAR –– that prices are relatively stable compared to more competitive auctions. A priori, a monopsony or an oligopsony–cartel would lead one to expect depressed and flat rather than volatile prices. The empirical evidence does not confirm this hypothesis. Looking at the results in Fig. 1, London auction prices for tea of North Indian origin were, if anything, more volatile than the tea prices in the Calcutta auction, with the Calcutta auction being a very competitive market place by any standards.[27]

At this stage, the main actor on the international tea scene, UNILEVER, deserves a few words. The world's largest food conglomerate also has a global stake in tea production, trade, processing and distribution represented (inter alia) by LIPTON and BROOKE BOND. The transnational corporation considerably increased the extent of its (partial) vertical integration and geographical diversification with the acquisition of the BROOKE BOND group in October 1984. In terms of global importance and market share, UNILEVER's interest in production is

[26] Futhermore, the market structure held fairly fast with hardly any change over previous years, see UNCTAD (1984), p. 25.

neglible (most plantations are located in Eastern Africa), whereas in the world tea trade it stands out as the dominating market participant. According to one UNILEVER source, its share of the world trade amounts to some 20%, which is roughly consistent with an estimate given by an Indian report.[28] Hence, UNILEVER is far from monopolizing world tea trade. UNILEVER plays a major part in the consumer markets in India (with an estimate market share of 75 of the branded tea market), Pakistan, Indonesia, the United States (LIPTON), Canada (BROOKE BOND) etc. Worldwide, it is estimated that UNILEVER's sales account for one–fifth of the consumer market.[29]

3. The Structure of Tea Price Differentials

So far, the analysis focused on the general price level of world (tea) prices. This section takes a closer look at the structure of relative tea prices.

3.1 Market Integration

World prices for cocoa and coffee are determined at the terminal markets in New York and London. Both cities operate futures markets, which serve as the principal price discovery institutions to which local prices anywhere in the world tend to be geared.[30] By contrast, price discovery on the world tea market has a less hierarchical and more decentralized structure. World tea prices are determined both at the London tea auction and at the various domestic spot markets within the producing countries (the tea auctions in Colombo, Mombasa, Calcutta etc.). At one time, the London auction served as a price barometer for world tea prices but the London terminal market lost its 'price–leadership' concurrently with the decline of turnover (see also Fig. 6). The decentralized structure of price discovery raises the question of whether international tea auction prices are linked in the process of price determination? Moreover, do the forces of arbitrage work between the auction centres? These questions touch on the issue of market integration and the efficiency of arbitrage.

The concept of market integration wears several guises: it appears as a spatial concept, in an intertemporal setting, or as a concept in differentiated product markets.[31]

The spatial concept of market integration. According to the classical economists (MARSHALL and COURNOT), *"two regions are in the same economic market for a*

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27 The tea auctions will be analyzed in more detail in a later chapter.

28 According to a confidential ITPA (Calcutta) report which was made available to the author.

29 ITPA estimate.

30 Spot markets, such as the Nairobi coffee auction, are essentially complementary institutions, the price level of which is normally geared to the world prices established in New York and London.

31 see FAMINOW / BENSON and SEXTON et al. and RAVALLION, p. 103 and MONKE / PETZEL.

homogeneous good if the prices for that good differ by exactly the interregional transportation cost"[32]. This condition is referred to as the law–of–one–price or market integration.

The principle of the law–of–one–price has been widely tested in applied analysis of marketing margins. As HARRIS notes, market integration analysis has been a standard component of market(ing) studies in developing countries following the structure–conduct–performance approach.[33] Bivariate regression analysis served to detect whether spatial price differentials were covering tranfer costs. Otherwise, allocative inefficiency was suggested. There are, however, substantial inferential hazards in deriving positive and normative conclusions from the data since in practice violations of the law–of–one–price may occur, inter alia, due to the following reasons:[34]

- Trade barriers or other price–distorting interventions may affect interregional price spreads.
- Imperfect information, risk aversion, or product preferences on the part of traders (arbitrageurs) may entail seemingly excessive transfer costs. These market imperfections are not easily discernible from market power exerted in the trading business.
- Traditional trading arrangements may conflict with short–run market integration, as marketing margins may stray from their long–run equilibrium. Thus, a structure of distribution, which may be technically superior, may suggest short–run allocative inefficiency.

Market Integration in differentiated product markets. As regards the tea market, the spatial dimension of tea prices is of secondary importance. Price discovery is not influenced by visible trade between the tea auctions (i.e. there are no shipments from Sri Lanka to Kenya and vice versa), which would tend to condition price differentials exceeding inter–regional transfer costs. The only exception is the London auction, where one would therefore expect tea prices to be linked with tea prices in the countries of origin. In fact, the analysis of the spatial price spreads for Assam tea auctioned in Calcutta and in London yields some interesting insights into the workings of the Indian tea plantation industry (this issue will be discussed in detail a later chapter).

Methodology. The more relevant question pertains to the validity of the law–of–one–price in a differentiated product market. Since tea is an extremely inhomogeneous product, it seems well worth asking whether the world market can be modeled as one commodity market or whether price linkages between differentiated tea qualities are so weak that it is not justified to refer unquestionably to a unique 'tea market'. As MONKE and PETZEL note,[35] "*Although prices of differentiated products may differ, this phenomenon does not preclude an aggregate treatment of these products. If differentiated products demonstrate a high degree of substitutability in production or consumption, the shocks from changes in the supply and*

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32 SEXTON et al., p. 568.

33 HARRIS, p. 198.

34 TOMEK / ROBINSON, pp. 143–144.

demand of one product are transmitted to other products in the commodity group. This mechanism leads to price linkages across the differentiated products that can be identified statistically." Thus, they define integrated markets "*as markets in which prices of differentiated products do not behave independently.*"[36] The authors suggest that the price relationships between two product qualities be written as

$$P_A = \alpha + \beta P_B$$

The crucial empirical question is whether the price relationship remains stable over time, i.e. if changes of relative prices are proportional. Statistical hypothesis testing based on the above bivariate regression model may yield price linkages representing one of the following five relevant types:

a) $H_0: \beta = 0$

If the β coefficient is not significantly different from zero (null hypothesis H_0), the time series are independent in a statistical sense. Such a result would suggest that the tea products are not closely related substitutes affected by arbitrage.

b) $H_0: \alpha = 0,\ \beta = 1$

If the null hypothesis with the intercept being zero and the slope coefficient not significantly differing from unity cannot be rejected, both price series are identical in a statistical sense. This result would suggest perfect product substitutability as well as efficient (product) arbitrage.

c) $H_0: \alpha = 0,\ \beta \neq 0, \beta \neq 1$

If the *t*–statistic is significant, with the slope coefficients differing from zero and unity, the price relationship is characterized by a percentage premium or discount. Thus, a significant β coefficient greater than one would suggest a percentage discount of the dependent variable.

d) $H_0: \alpha \neq 0,\ \beta = 1$

In this case, rejecting the null hypothesis would suggest an absolute premium or discount of the dependent variable. Both absolute and percentage premiums are consistent with the law–of–one–price as long as these are stable and predictable.

e) $H_0: \alpha \neq 0,\ \beta \neq 0, \beta \neq 1$

The case in which the price linkage is characterized by both percentage and absolute premiums, is liable to interpretative difficulties and inconsistencies. For example, an inconsistency may arise if hypothesis testing yields an absolute premium and a percentage discount. By contrast, if both parameters have the same signs, MONKE and PETZEL suggest that the absolute magnitude of α / P_B be compared to the β coefficient.

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35 MONKE / PETZEL, p. 481.

36 MONKE / PETZEL, p. 482.

If the former is large relative to ß "*relative prices of the two commodities are likely to vary substantially as commodity prices change and a differentiated product approach is necessary.*"[37]

Two data sets have been subjected to the above analysed hypothesis tests (based an OLS estimators). The first set represents the London auction where the entire spectrum of tea qualities of Asian, African, and South American origin has been auctioned for the past 30 years. The second set is comprised of the domestic auctions in the producing countries.

For empirical testing of market integration, the London auction has some major practical advantages: length and continuity of the auction time-series, a large spectrum of tea qualities, a single currency unit, a single deflator. On the other hand, the London auction has had only a small turnover, notably in recent years, compared to other auction centres. The institution's major draw-back, here, is its concentrated market structure on the buying side.

The regression analysis of the London auction is based on price data (annual auction averages) as published by the London-based INTERNATIONAL TEA COMMITTEE, the primary data source of tea market researchers. The selection of countries includes the major tea suppliers, i.e. Kenya, North and South India, Sri Lanka, Tanzania, Bangladesh and Malawi. Unfortunately, China cannot be included, since Chinese black tea is not auctioned anywhere in the world (except some minute quantities). The time-series for Indonesian tea as well as for teas of some other African producers, such as Uganda, have considerable gaps and had therefore to be omitted. The time series span the years 1961 to 1990 and are deflated by the 'industrial countries GDP deflator' published by the IMF.

As to the overseas auctions, the selection of countries is identical to that of the London auction, except that Tanzania has been replaced by Indonesia (for lack of continuity of Tanzanian tea sales in the Mombasa auction). The price data have been deflated by the 'manufacturing unit value index of industrial countries' calculated by the WORLD BANK.

A statistical problem often encountered in time-series analysis is the presence of autocorrelated (or serially-correlated) error terms. Autocorrelation occurs when the error terms are not independent over time, which violates the assumption of the linear regression model stating that error terms u_i are random, i.e[38]

$$E\,(u_i\,u_j) = 0.$$

PINDYCK and RUBINFELD note that "*As a general rule, the presence of serial correlation will not affect the unbiasedness or consistency of the ordinary least squares regression estimators, but it does affect their efficiency.*"[39] Unbiasedness or lack of estimation bias refers to a statistical property of the parameter's probability distribution in repeated sampling. The estimator $\hat{\beta}$ is taken to be *unbiased* if the expected value of $\hat{\beta}$ equals its 'true' value, i.e.

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37 MONKE / PETZEL, p. 482.

38 GUJARATI, p. 219.

39 PINDYCK / RUBINFELD, p. 107.

if $E(\hat{\beta}) = \beta$.[40] Moreover, an unbiased estimator is defined as *efficient* if its variance is smaller than any other unbiased estimator. Inefficiency of an otherwise unbiased estimator has the effect of distorting the standard error in the sense that its standard error deviates from the 'true' standard error. Thus, in the case of positive serial correlation the standard errors of the estimators are biased downward, resulting in an upward bias of the *t*–statistic. The *t*–statistic is defined as:

$$t_{N-2} = (\hat{\beta} - \beta) / s_{\hat{\beta}},$$

with s: standard deviation.

The upshot is that autocorrelation entails the inferential danger that the null hypothesis regarding the OLS estimators will be rejected although it should not be rejected.[41]

In order to correct for serially correlated error terms the DURBIN two–stage procedure has been applied when indicated by the DURBIN–WATSON test. To briefly explain the DURBIN two–stage procedure, one may start with the bivariate model[42]:

$$(1)\ Y_t = \alpha + \beta X_t + u_t.$$

The disturbance terms are assumed (as a first approximation) to be autocorrelated in the following manner:

$$(2)\ u_t = \mu\, u_{t-1} + v_t$$

with: $-1 < \mu < 1$.

The coefficient μ is known as the first–order serial correlation coefficient. Since the linear model is valid for all time periods, it can be rewritten as

$$(3)\ Y_{t-1} = \alpha + \beta X_{t-1} + u_{t-1}.$$

Multiplying equation (3) by μ and subtracting (3) from (1) yields

$$(4)\ Y_t - \mu Y_{t-1} = \alpha (1-\mu) + \beta X_t - \mu \beta X_{t-1} + u_t - \mu u_{t-1} \quad \text{or}$$

$$(5)\ Y_t = \alpha (1-\mu) + \mu Y_{t-1} + \beta (X_t - \mu X_{t-1}) + v_t$$

The model in equation (5) can now be estimated, yielding an estimator of the autocorrelation coefficient μ. Finally, to improve the parameter estimates, the estimator $\hat{\mu}$ can be introduced into equation (5):

$$(6)\ Y_t - \hat{\mu} Y_{t-1} = \alpha (1-\hat{\mu}) + \beta (X_t - \hat{\mu} X_{t-1}) + v_t$$

The resulting estimators satisfy the BLUE properties of the OLS estimators (best or most efficient, linear, and unbiased).

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40 Consistency refers to the desired property that, as the the sample size increases, the estimator $\hat{\beta}$ converges towards its 'true' value.

41 PINDYCK / RUBINFELD, p. 107.

42 PINDYCK / RUBINFELD, p. 113.

Empirical results. The two matrices in Fig. 8 represent a synopsis of the main results derived from the regression analysis. The latter are found with full coverage of the estimators and test statistics in Fig. 9.

Bivariate regression analysis of the London auction reveals that, by and large, the commodity market is homogeneous. Auction prices of 14 out of 21 tested price relationships are identical in a statistical sense. Thus, tea prices of Kenya, North India, South India, Sri Lanka, Tanzania, Bangladesh are not significantly different from each other, save three exceptions. These pertain to Bangladeshi vis–à–vis Kenyan and North Indian tea prices as well as to the North India – South India price relationship: in these cases Kenya`s and North India`s prices are quoted at a premium. Apparently, tea from Bangladesh falls in the bottom part of the tea quality spectrum studied, only followed by Malawi tea. Malawi tea is discounted vis–à–vis most origins either by an absolute discount or a percentage discount. The results include only one implausible estimate, this being the price linkage between Malawi and South Indian tea (absolute discount of South Indian tea adding to a percentage premium).

However, the results should not be taken as evidence that, generally, there are no significant quality differences between various countries of origins. In fact, there is a wide spectrum of tea qualities

- between countries of origin
- according to type of manufacture (orthodox or CTC tea)
- between grades (e.g. BOP, BOPF, Pekoe, OP)
- between seasons (discussed in the next chapter).

Even within each of the above categories tea traders quote price ranges rather than averages (with price differentials often exceeding 100 percent). Why, then, were quality–induced price differentials not significant in the case of the London auction? The main reason is that only a quality selection is offered which is suitable for the tea bag fillings in the UK tea market, i.e. notably CTC PF (Pekoe Fannings) and CTC PD (Pekoe Dust). One might raise the argument that widespread uniformity of London auction prices over time are a result of market power exerted by the UK tea industry. To begin with, this argument cannot be discarded entirely. On the other hand, the following facts have to be considered:

- Price instability analysis has shown that the London auction prices are (at least) as flexible as overseas auction prices.
- The countries of origin could be expected to withdraw their support of the London auction and alternatively auction the tea at their domestic auction, should London prices be rigged.

Bivariate regression analysis of the overseas auction prices yields a far more heterogeneous picture than the London auction. Whereas in the London auction two–thirds of the tested price relationships could be interpreted as identical prices, the percentage drops to one–third in the overseas auctions.

Fig. 8: Prices Linkages in the London Auction and the Overseas Tea Auctions

a) London Auction

Dep. Var.	Independent Variables						
	Kenya	North India	South India	Sri Lanka	Tanzania	Bangladesh	Malawi
Kenya	1	Id Pric	Abs Prem	Id Pric	Id Pric	Abs Prem	Perc Prem
North India		1	Id Pric	Id Pric	Id Pric	Abs Prem	Abs Prem
South India			1	Id Pric	Id Pric	Id Pric	Abs Disc / Perc Prem
Sri Lanka				1	Id Pric	Id Pric	Id Pric
Tanzania					1	Id Pric	Perc Prem
Bangladesh						1	Id Pric
Malawi							1

b) Overseas Auctions

Dep. Var.	Independent Variables						
	Kenya	North India	South India	Sri Lanka	Indonesia	Bangladesh	Malawi
Kenya	1	Id Pric	Id Pric	Id Pric	Id Pric	Id Pric	Independent
North India		1	Id Pric	Abs Prem / Perc Disc	Abs Prem / Perc Disc	Abs Prem	Independent
South India			1	Abs Prem / Perc Disc	Abs Prem / Perc Disc	Abs Prem	Abs Prem / Perc Disc
Sri Lanka				1	Perc Disc	Id Pric	Abs Prem / Perc Disc
Indonesia					1	Perc Prem	Independent
Bangladesh						1	Abs Prem / Perc Disc
Malawi							1

Notes:
Id Pric: identical prices
Abs Prem: absolute premium of the dependent variable
Perc Prem: percentage premium of the dependent variable
Perc Disc: percentage discount of the dependent variable
Independent: prices are statistically independent at the 5% significance level.

Source: Author's estimates

Fig. 9: Bivariate Regression Results of International Tea Prices

a) London Auction

Dependent Variable	Independent Variable	alpha	beta	Adj. R squared	DW	N	Procedure	SCC	Diagnosis
Kenya	North India	-0.06	0.98	0.92	2.26	29	two-stage	0.72	identical prices
		t = -0.04	*t = 17.46*						
	South India	17.44	0.96	0.91	1.56	27			absolute premium
		t= 4.06	*t= 16.78*						
	Sri Lanka	-1.18	1.11	0.92	2.08	22	two-stage	0.54	identical prices
		t = -.53	*t = -15.90*						
	Tanzania	1.77	1.04	0.97	1.83	29	two-stage	0.42	identical prices
		t = 1.13	*t = 29.81*						
	Bangladesh	11.56	1.04	0.89	1.72	19			absolute premium
		t = 2.33	*t = 11.84*						
	Malawi	0.06	1.28	0.88	1.69	30			percentage premium
		t = 0.28	*t = 15.03*						
North India	South India	8.26	1.05	0.82	1.45	26	two-stage	0.35	identical prices
		t= 1.82	*t = 10.73*						
	Sri Lanka	-0.11	1.11	0.94	2.45	22	two-stage	0.85	identical prices
		t= -0.11	*t = 18.24*						
	Tanzania	1.21	1.03	0.90	1.60	29	two-stage	0.77	identical prices
		t= 0.92	*t = 15.76*						
	Bangladesh	18.68	0.92	0.91	2.22	19			absolute premium
		t= 4.82	*t = 13.42*						
	Malawi	9.48 (20,17)	1.00	0.61	1.67	29	two-stage	0.53	absolute premium
		t= 2.11	*t = 6.66*						
South India	Sri Lanka	-4.13	0.91	0.89	1.42	21			identical prices
		t= -.79	*t = 12.71*						
	Tanzania	-6.11	0.96	0.95	1.51	27			identical prices
		t= -1.78	*t = 23.37*						
	Bangladesh	4.90	0.92	0.77	1.49	16			identical prices
		t= .65	*t = 7.23*						
	Malawi	-16.65	1.33	0.92	2.03	27			abs. prem., perc. disc.
		t= -3.2	*t = 17.43*						
Sri Lanka	Tanzania	2.62	0.99	0.98	1.60	23			identical prices
		t= 1.18	*t = 30.95*						
	Bangladesh	10.86	0.97	0.87	1.42	18			identical prices
		t= 2.1	*t = 10.72*						
	Malawi	3.83	1.14	0.84	1.45	23			identical prices
		t= .61	*t = 10.66*						
Tanzania	Bangladesh	7.77	1.00	0.89	1.55	19			identical prices
		t= 1.68	*t = 12.13*						
	Malawi	-5.67	1.31	0.92	1.69	30			percentage premium
		t= -1.22	*t = 18.36*						
Bangladesh	Malawi	-0.06	1.01	0.84	2.13	19			identical prices
		t= -0.01	*t = 9.95*						

b) Overseas Auctions

Dependent Variable	Independent Variable	alpha	beta	Adj. R squared	DW	N	Procedure	SCC	Diagnosis
Kenja	North India	-0.11 *t = -0.65*	0.96 *t = 6.21*	0.57	1.90	29	two-stage	0.58	identical prices
	South India	-0.08 *t = -0.48*	1.10 *t = 7.57*	0.67	1.95	29	two-stage	0.50	identical prices
	Sri Lanka	0.17 *t = 1.99*	0.99 *t = 8.81*	0.73	2.06	29	two-stage	0.64	identical prices
	Indonesia	0.18 *t = 1.88*	0.87 *t = 13.25*	0.93	2.07	15	two-stage	0.27	identical prices
	Bangladesh	0.49 *t = 1.18*	0.99 *t = 3.42*	0.37	1.45	19			identical prices
	Malawi	1.24 *t = 3.62*	0.50 *t = 2.03*	0.16	1.99	18			independent
North India	South India	0.18 *t = 2.04*	1.05 *t = 16.70*	0.91	1.57	29	two-stage	0.38	identical prices
	Sri Lanka	0.55 (1,17) *t = 6.22*	0.79 *t = 8.17*	0.70	1.55	29	two-stage	0.53	abs. prem., perc. disc.
	Indonesia	0.73 (1,40) *t = 7.31*	0.48 *t = 5.57*	0.68	1.60	15	two-stage	0.48	abs. prem., perc. disc.
	Bangladesh	1.36 *t = 5.48*	0.65 *t = 3.82*	0.43	1.96	19			absolute premium
	Malawi	1.94 *t = 8.85*	0.26 *t = 1.60*	0.08	1.84	18			independent
South India	Sri Lanka	0.39 (0,78) *t = 5.48*	0.79 *t = 10.98*	0.81	1.79	29	two-stage	0.50	abs. prem., perc. disc.
	Indonesia	0.45 (0,90) *t = 5.77*	0.55 *t = 7.76*	0.81	1.86	15	two-stage	0.50	abs. prem., perc. disc.
	Bangladesh	0.87 *t = 3.31*	0.75 *t = 4.14*	0.47	2.09	19			absolute premium
	Malawi	1.45 *t = 6.38*	0.35 *t = 2.13*	0.17	1.90	18			abs. prem., perc. disc.
Sri Lanka	Indonesia	0.02 *t = 0.35*	0.76 *t = 9.37*	0.86	1.45	15	two-stage	0.71	percentage discount
	Bangladesh	0.16 *t = 0.44*	0.95 *t = 3.85*	0.43	1.63	19			identical prices
	Malawi	0.87 *t = 2.92*	0.48 *t = 2.21*	0.19	1.99	18			abs. prem., perc. disc.
Indonesia	Bangladesh	0.10 *t = 0.20*	1.23 *t = 3.63*	0.45	1.85	16			percentage premium
	Malawi	1.20 *t = 2.89*	0.54 *t = 1.71*	0.11	2.01	16			independent
Bangladesh	Malawi	0.79 *t = 4.74*	0.50 *t = 4.13*	0.49	1.65	18			abs. prem., perc. disc.

Notes:
Alpha: has been adjusted, i.e. alpha (1-mu), only when significant, to be found in brackets.
DW: Durbin Watson statistic
N: Number of observations
Procedure: Durbin two-stage
SCC: Serial Correlation Coefficient
Diagnosis: with respect to dependent variable
The t-test was based on the 5% significance level.
Data base:
London auction: ITC, "Annual Bulletin of Statistics", var. issues. Deflator: industrial countries GDP deflator, see IMF (1991), "International Financial Statistics Yearbook", p. 166-67, line 110.
Overseas auctions: ITC, source as above. Deflator: manufacturing unit value index of industrial countries (MUV), see WORLD BANK, "Commodity Trade and Price Trends".
Source: Author's estimates

Unfortunately, the matrix is not apt to provide many insights. In fact, it raises more questions than answers. Notably, Indian and Malawi tea prices are related to other countries' prices in a way that is difficult to explain (i.e. absolute premium concurrently with percentage discount). A possible explanation is the distorting effects of the Indian tea policy, which pushed Indian tea prices out of line relative to the rest of the world market (via domestic price controls and the highly distorted, preferential bilateral exchange rate granted to the USSR). Strikingly, Limbe auction prices (Malawi) are either totally unrelated or ambiguously related to the remainder of world market prices.

Correlation analysis. The analysis was aimed so far at hypothesis testing that determines whether the world tea prices can be trusted to follow the law–of–one–price. Presumably, tea prices of some countries moved more coherently than others –– thus, the issue is also a matter of degree. In order to obtain an indicator for the degree of the synchronous price movement, the zero order correlation coefficient r (PEARSON's product–moment coefficient) has been estimated for pairs of prices. Its formula is defined as[43]

$$r\,(x,y)= \frac{\Sigma x_i y_i}{\sqrt{(\Sigma x_i^2)\,(\Sigma y_i^2)}}$$

The correlation coefficient measures the degree of linear association between two stochastic variables.[44] Thus, the correlation coefficient of two variables which are statistically independent variables is zero. In the words of RAVALLION, "*Though much maligned, static price correlations remain the most common measure of spatial market integration in agriculture.*"[45] A correlation coefficient of one came to be interpreted and confused with, as HARRIS notes, perfect competition. As one example, a WORLD BANK study on the structure and performance of the world tea market finds:[46] "*Despite the market structure discussed, the process of price arbitrage for tea seems to work very well across major auction markets... Given the differences in market levels (and the need to adjust for transport cost changes), correlations among the prices in the five major markets are surprisingly very high.*" However, the results of correlation analysis are subject to inferential errors, as noted above in the case of bivariate regression analysis. HARRIS, therefore concludes that[47], "*It is quite clear that by itself the correlation coefficient is inadequate as a proof of either market integration or competition; it can only serve as an indicator of likelihoods given many assumptions about market structure and conduct. Until the technique is greatly refined, its diagnostic use should be abandoned.*"

Despite its weaknesses as a diagnosistic tool, correlation analysis can, if applied with caution and understanding of the underlying market, offer some insights. Fig. 10 represents a cor–relation matrix of nominal tea prices (converted into US dollars) of the major auction centers.

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43 GUJARATI, p. 50.

44 GUJARATI, p. 16.

45 RAVALLION, p. 102.

46 CHUNG / UKPONG, p. 5 of appendix I.

47 HARRIS, p. 203.

Fig. 10: Correlation Coefficients of International Tea Auction Prices (monthly averages of 1976 - 1990)

	Jakarta	Colombo	Cochin	Calcutta	Mombasa	Limbe (Mal.)	Chittagong	London
Jakarta	1.00 <179>	0.84 <179>	0.70 <179>	0.49 <179>	0.89 <179>	0.92 <132>	0.79 <173>	0.88 <179>
Colombo		1.00	0.85 <180>	0.68 <180>	0.74 <180>	0.76 <132>	0.78 <174>	0.72 <180>
Cochin			1.00	0.78 <180>	0.63 <180>	0.64 <132>	0.68 <174>	0.62 <180>
Calcutta				1.00	0.41 <180>	0.44 <132>	0.69 <174>	0.40 <180>
Mombasa					1.00	0.94 <132>	0.73 <174>	0.93 <180>
Limbe (Mal.)						1.00	0.80 <127>	0.89 <132>
Chittagong							1.00	0.72 <174>
London								1.00

Notes: Estimates are based on average prices of monthly sales, J. THOMAS & Co., "Tea Statistics", var. issues". Jakarta: all teas. Colombo: all teas. Cochin: leaf & dust combined. Calcutta: leaf & dust combined. Mombasa: all origins (East Africa). Limbe: all teas. London: all origins. In brackets <>: number of observations.

Source: Author's estimates.

While the above regression analysis was based on yearly averages, prices, here, are monthly averages covering the years 1976–1990 (for some auction centers, the available time–series are shorter, e.g. Limbe in Malawi). The correlation coefficients are presented without *t*–values since the data deviate from the normal distribution. As long as the sole purpose of the analysis is to diagnose relative price behavior in the past, this procedure is defendable.[48]

The major insights gleaned from the correlation matrix can be summarized as follows:

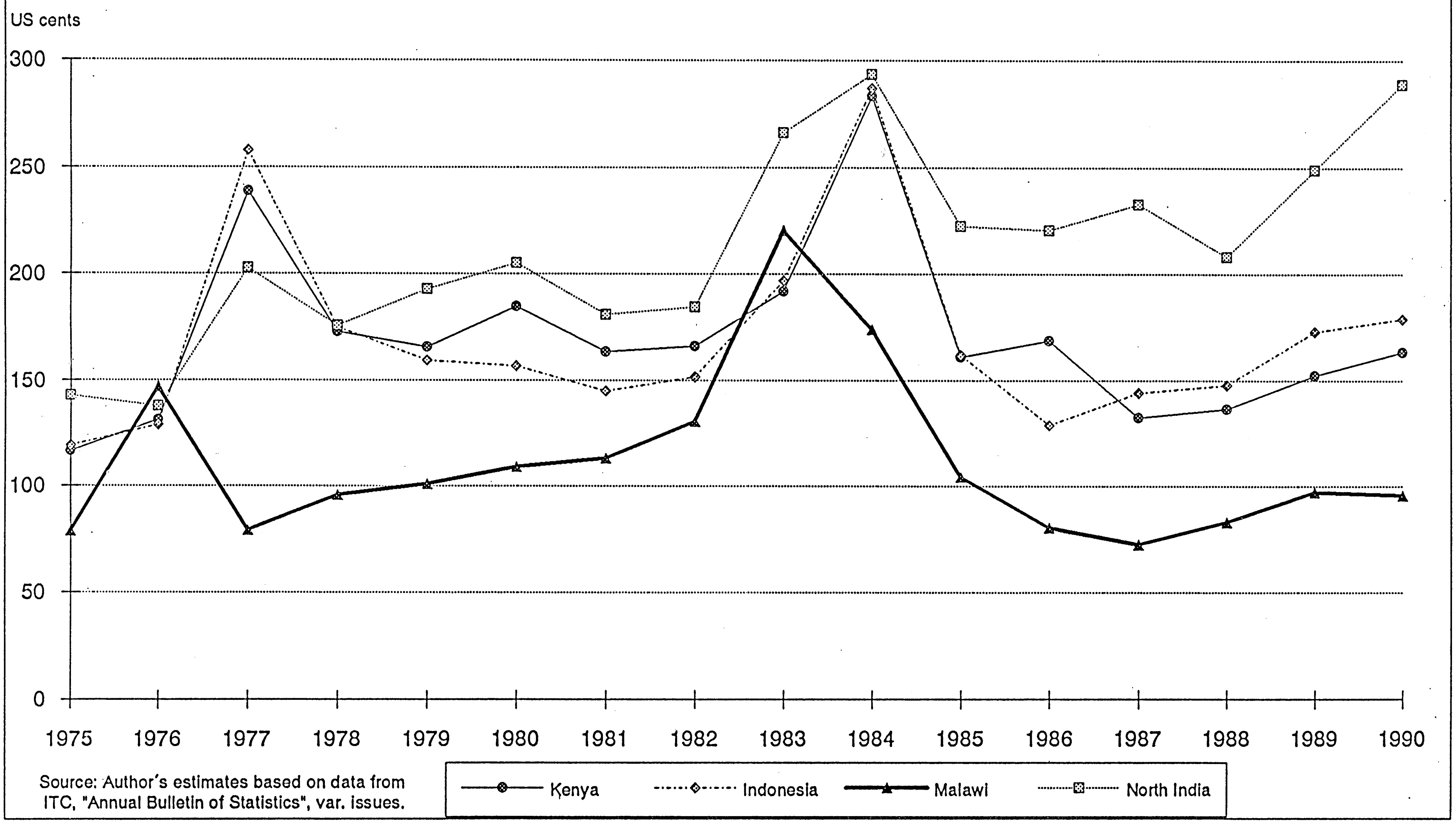
- First, price correlation was found to be very high between the Mombasa and the London auctions (r = 0.93) and the Limbe and the London auctions (r = 0.89). These results are unsurprising since the above markets are linked by trade: in fact, both countries were among the major suppliers of the London auction.
- Second, knowledge of production technology in Sri Lanka, South India and Indonesia would lead one to expect Colombo, Cochin and Jakarta tea prices to be closely correlated. As it happens, these countries are the major competitors offering orthodox black tea on the world market. Orthodox tea –– as opposed to CTC tea –– can be regarded as an intra–commodity product group. The correlation coefficients are among the highest for Colombo–Jakarta prices (r = 0.84) and for Colombo–Cochin prices (r = 0.85) and are below average for Jakarta–Cochin prices (r = 0.70) with the median being r = 0.72. Surprisingly, the Jakarta–Chittagong association of prices (where product substitution and arbitrage is less likely) is closer than for Jakarta–Cochin.
- Third, the auctions in Mombasa and Limbe (r = 0.94), Mombasa and Jakarta (r = 0.89), and Limbe and Jakarta (r = 0.92) appear to be closely linked price–wise. These results stand in striking contrast to bivariate regression results which suggest that Limbe prices are independent of Kenyan and Indonesian tea prices. This is puzzling.
- Four, the correlation coefficients calculated for the Calcutta prices were among the lowest of all. In other words, between 1976 and 1990 Calcutta tea prices least followed the general pattern of world prices (see interpretation given above).

3.2 The Concertina Effect

An explorer of international tea prices is likely to discover a peculiar behavior of relative tea prices. Once again, Fig. 4 lends itself to a first diagnosis. From 1961 to 1975/76, auction prices of Kenyan, Sri Lankan and North Indian prices followed a relatively stable pattern: they moved jointly in what looks like a constant band. Only in 1967 and 1968, did North Indian tea prices dip below Kenyan tea prices. By and large, tea prices evolved 'consistently' also after 1975/76, with consistently meaning that price peaks, troughs, and turning points occurred (more or less) simultaneously. Admittedly, there are some outliers, such as Kenyan tea prices moving down in 1987, while Sri Lankan and North Indian tea prices rose.

48 GUJARATI, p. 136.

Fig. 11: Malawi Tea Prices in Baisse and Hausse



Source: Author's estimates based on data from ITC, "Annual Bulletin of Statistics", var. issues.

However, the major revelation of the figure relates to the interaction of the general price level and relative tea prices (and this is discernible only after 1976). The peculiarity after 1976 is this: the price band narrowed in times of hausse (1977 and 1984) and widened in times of baisse (the remainder of the years). During hausse, price differentials were squeezed, while in baisse they became larger. In other words, in times of relative scarcity world tea demand was more discriminating with respect to the different origins and different qualities of tea, whereas in times of plenty tea buyers were heavily discounting minor qualities. Over time, the pattern made by tea prices resembles the movement of a concertina, hence the metaphor.

Figure 11 confirms the concertina effect. In 1984 (hausse), average prices were almost US dollars 3,000 per ton regardless of whether the tea was of Kenyan, North Indian or Indonesian origin. Likewise, in 1977 price differentials were extremely squeezed. However, the behavior of Malawi tea prices shows itself to be a major exception from the 'rule'. Prices for Malawi tea were heavily discounted in the intermezzo of the hausses in 1977 and 1984, and thereafter, a behavior which is consistent with the concertina effect. Yet, it remains a puzzle as to why Malawi tea prices peaked in the year prior to the world tea hausse as experienced by the remaining tea producing countries. The Limbe auction market seemingly anticipated the coming hausse, while the prices fell when the tea boom affected the other countries.

4. The Seasonality of Tea Prices

Twenty years ago SARKAR stated in his monograph on the *World Tea Economy* that "*tea turns out to be a commodity free from regularly marked intra-year or seasonal price fluctuations.*"[49] This contention is the starting-point for the following analysis. Is there indeed no seasonal pattern formed by the tea prices? There is reason for doubt. As the tea traders are quick to point out, tea owes its inhomogeneous nature last, but not least to the seasonality of its flavour. In fact, in most of the tea producing countries there are distinct quality tea seasons. During these periods, favourable climatical conditions give rise to an aroma which is better than normal. The purpose of this chapter is, therefore, to estimate the seasonal component which is, possibly, concealed within the tea prices. The method of time-series analysis which shall be applied here is referred to as the so-called ratio-to-moving-average method.

4.1 The Ratio-to-Moving-Average Method

The ratio-to-moving-average method is based on the idea that the observed data as they unfold over time can be decomposed into the underlying determinants. Commonly, time-series models consist of four components: first, the general long-run tendency of the observed data, the trend; second, wave-like swings around the trend which exceed one year, referred to as the cycle; third, a regular and repeated behavior, the seasonal component;

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49 SARKAR, p. 86.

fourth, the residual and random component, referred to as the irregular component.[50] The decomposition technique is based on the working assumption that the above components exist. The next step is to identify and separate them.

Two frequently employed time–series models represent the additive model and the multiplicative model. In the additive model, the above components are combined as

$$Y_t = T_t + S_t + I_t$$

where Y_t is the observed data over time, T_t is the trend–cycle, S_t is the seasonal component and I_t represents the irregular component, which is not captured by any of the other factors.

Moving–average methods, thus, assume that the trend and the cycle can be identified jointly as the trend–cycle.[51] The additive model is appropriate when all the components seem to affect the observed values but do not influence each other.

The multiplicative model takes the form of

$$Y_t = T_t * S_t * I_t$$

Here, the components are assumed to influence each other, i.e. the trend–cycle values influence the seasonal component.

Time–series decomposition crucially depends on the assumption that the multiplicatively or additively joined components are not caused by a common variable since, in that case, they cannot be isolated as independent components.[52] If both the trend and the seasonal component were, for instance, determined by income, there would be no justification to separate their impact on the time–series. The choice of the time–series model implies the procedure by which the components are isolated: the additive model is treated with a subtraction strategy (difference–from–moving–average method), and the multiplicative model is decomposed with a division strategy on which we concentrate here (ratio–to–moving–average method).

For the empirical estimates, the software package *Statgraphics (Version 5)* has been used. The *Season procedure* of Statgraphics resembles the *X11 procedure* of the, more popular, statistical software package *SAS*. As BURMAN notes the *X11 procedure* was first introduced by the US Bureau of the Census and is now in worldwide use for the seasonal adjustment of data.[53] Both procedures apply the ratio–to–moving–average method but there are subtle differences in the techniques employed (the *X11 procedure*, for instance, makes corrections for varying numbers of work–days per month). The *Season procedure* runs a decomposition technique which proceeds from

$$Y_t = T_t * S_t * I_t.$$

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50 MILLS, p. 445.

51 BURMAN, p. 45.

52 MILLS, p. 447.

53 Burman, p. 48.

Next, the observed data are divided by a 12–term unweighted moving–average is:

$$\frac{Y_t}{MA_t} = \frac{T_t * C_t * S_t * I_t}{T_t * C_t} = S_t * I_t$$

with MA_t being the moving–average centered to period t.[54] The method of moving–averages is a smoothing technique which serves to identify the trend–cycle of a time–series by eliminating repeated and random price fluctuations. The underlying assumption is: since the seasonal and irregular price fluctuations are assumed to 'average out' over the period of one year (i.e. add up to a factor equal to 1), the moving–average (hopefully) isolates the trend including the cycle.[55] The division of the Y_t data by the moving–average, thus, removes the trend–cycle from the time–series yielding the $S_t * I_t$ ratios.

The next step is to compute a <u>seasonal index</u> from the $S_t * I_t$ numbers. This involves smoothing the seasonal–irregular series so as to remove random price fluctuations from the assumed stable seasonal component. The monthly seasonal–irregular factors are averaged over the entire period while the lowest and the highest values (extreme values) are dropped, a procedure called the 'calculation of the modified mean'.[56] Then, the seasonal averages are adjusted or normalized in order to add up to 1. The seasonal index numbers are often expressed as a percentage, the arithmetic mean of which is 100% (in the additive model the sum of the seasonal factors must be zero). Finally, it remains to derive the irregular factors by dividing the $S_t * I_t$ data by the seasonal index.

In summary, the time–series decomposition yields two important outputs for the purpose of this study: one is the seasonally–adjusted data or de–seasonalized data (in which case the original data are multiplied by the seasonal index numbers). The second important result is the isolated seasonal component, the seasonal index.

Some critical remarks are in order. MILLS concedes, "*By now it should be painfully clear that there is as much 'art' as science to time–series analysis. The 'subtraction strategy', the* choice *of the type of trend line that will be used, the* choice *of smoothing technique, the* choice *of adjustment procedure and averaging technique for the seasonal component all leave plenty of room for human judgment.*"[57] To calculate seasonal indices is one thing, to lend it credibility to the results is another thing. Thus, the additive and multiplicative time–series models assume time to be the <u>only</u> explanatory variable. It remains unexplained why the trend moves up or down. On the other hand, the seasonality or periodicity of nature undeniably influences crop yields in agriculture, a pattern which is aptly described by time. Finally, the procedure is of a non–statistical nature, that is, a statistical assessment of the results (in terms of significance) is side–stepped.

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54 Centering refers to the arithmetic of obtaining a value for period 7 rather than in between period 6 and 7.

55 HAMBURG, p. 565.

56 HAMBURG, p. 565.

57 MILLS, p. 467.

4.2 Empirical Estimates of Seasonal Tea Price Indices

The results of the empirical work shall now be presented. We start with the case of India and then study the seasonal tea price fluctuations in Sri Lanka and Indonesia.

A note on the data base: The empirical estimates of the Indian and Sri Lankan seasonal price indices are based on monthly price data of 1976 – 1990. The Indonesian index is based on the sample months of 1982 – 1990. The Jakarta auction prices are denominated in US–dollars, whereas in the Indian and Sri Lankan auctions, prices are chanted out loud in the local currency. Hence, the raw data are composed of Rupees quotations (the export contracts are, of course, denominated in hard currency). In order to check whether exchange rate fluctuations affected the seasonal indices they have been estimated both on the basis of Rupee prices and US dollar prices. For the currency conversion, the exchange rates issued by the INTERNATIONAL MONETARY FUND have been used. They are monthly, average market rates of the local currencies vis–à–vis the US–dollar, and are to be found in line 'rf' of the *International Financial Statistics*.

These are the details of the price data:

- Darjeeling: Calcutta auction prices, monthly averages of 'Darjeeling–Leaf', in Rupees, 1976–1990 (180 values). Source: "Tea Statistics" (var. issues) by J. THOMAS & Co., a Calcutta–based broker company.
- Calcutta: Calcutta auction prices, monthly averages of 'Leaf and Dust combined', 1976–1990. Same source as above.
- South India: Cochin auction prices, monthly averages of 'Cochin monthly sales – Leaf and Dust combined', 1976–90. Same source as above.
- Sri Lanka: Colombo auction prices, monthly averages of 'All teas', 1976.–1990. Same source as above.
- Indonesia: Jakarta auction prices, monthly averages of 'All teas', 1982–90. Same source as above.

India. The first two seasonal price index estimates relate to the North Indian tea–growing regions of Assam and Darjeeling. Some background information seems in order. If scenic Darjeeling, at the borders of Sikkim and Nepal, a mountainous and often cold hill resort facing the Himalayas, is a polar extreme among the world's tea growing areas, Assam lies at the other extreme. Assam is extraordinary because –– to quote HARLER –– "*although the Brahmaputra Valley is surrounded by high mountains, almost the whole area is flat, level plain.*"[58] Assam is, in a sense, a single vast tea garden at the shores of the Brahmaputra covering a total of 192,000 hectares (1987) compared to only 20,000 ha in Darjeeling.[59]

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[58] HARLER, p. 119.

[59] J. THOMAS (1990), p. 6.

In Assam and Darjeeling, production ceases between January and March since the tea bushes fall dormant during winter time.[60] Then, at the end of March the first quality–teas are plucked, the so–called first flush Assam tea and Darjeeling tea. The first flush season lasts some 4–6 weeks until lack of rainfall induces the tea bushes to fall dormant for another brief period – the leaves turn 'banji' in the planters' jargon. With some delay, but usually beginning in mid–May the well–known second flush teas are plucked. The second flush season ends, sometimes rather abruptly, with the arrival of the monsoon. During the rainy season the flavour of the tea markedly deteriorates while yields increase substantially. Four to five months of rain and mist give rise to the monsoon tea or rains tea. The tea's flavour improves again in autumn. Planters and tea traders call it autumnal quality, by which they mean a distinct tea flavour characteristic in October and November.[61]

– **Darjeeling:** Fig. 12 is a graphical representation of the seasonal price index for Darjeeling tea, based on dollar prices and the multiplicative model. It is to be interpreted as follows: the dollar tea prices in April, say, were in the time under consideration on average some 75% above the trend value – this is solely attributable to seasonal market forces. If measured in rupees, the deviation in April from the moving–average value was the same, roughly 75% (see Fig. 13). More importantly, the scale, i.e. the unit of account, had almost no effect on the shape of the seasonal index curves. In fact, peaks, troughs and turning points were perfectly identical regardless of whether the estimate was based on rupee or dollar prices. In other words, exchange rate fluctuations (of the rupee–dollar rate), and the secularly depreciating rupee did not distort the long–run seasonal price pattern. The seasonal estimates exhibit the expected price peaks during the months of April and July, corresponding to the first flush and second flush harvest period, while in the first quarter last year's stocks are auctioned, reflected in prices below trend values.

  Behold now the stylized graphical representation of seasonal tea quality variations which was prepared by the Hamburg–based tea trading company HÄLSSEN & LYON (Fig. 14). The company distinguishes between fine, medium and low quality rather than applying a seasonal index. The top panel concerns North India tea originating in Darjeeling and Assam, while the panel below relates to South Indian tea. In order to compare the author's estimates with HÄLSSEN & LYON's stylized version, two preliminary remarks should be made: first, the estimated seasonal index lacks the smoothness of HÄLSSEN & LYON's version because it is a 12 point graph. Moreover, HÄLSSEN & LYON's graph is a scale–free representation. Second, the estimated curve lags behind HÄLSSEN & LYON's version by about one month. The reason for this is that it takes nearly one month for quality changes observed in Darjeeling tea production to be reflected in auction prices (on which the author's estimates are based).

  Despite these limitations, the estimates of the seasonal indices for Darjeeling tea track very well the general movement of Darjeeling quality. In particular, the results are consistent with quality peaks and turning points as observed by HÄLSSEN & LYON.

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60 compare J. THOMAS (1990), p. 12.

61 Account based on interviews with tea planters in Darjeeling and Assam in spring 1991.

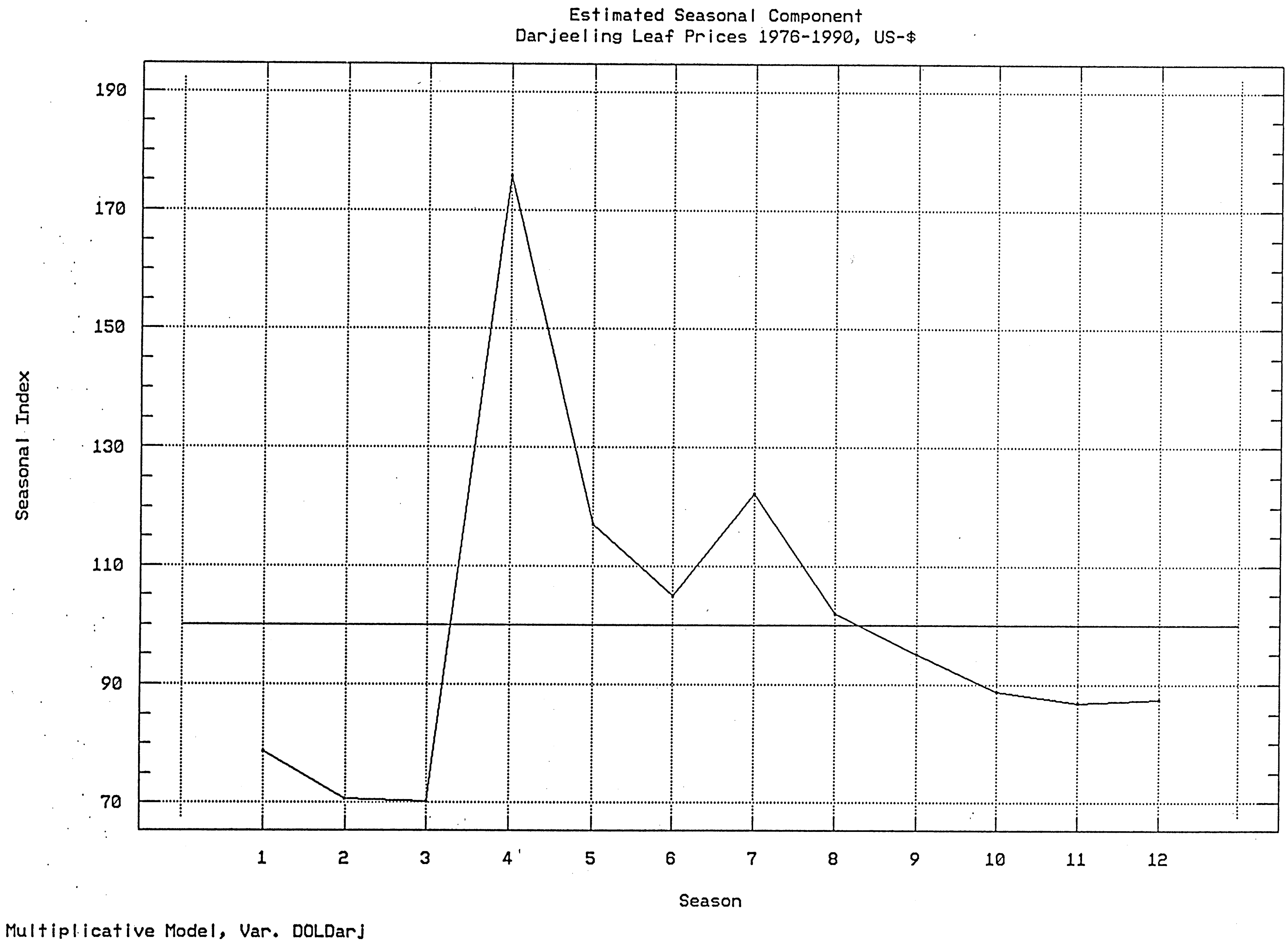
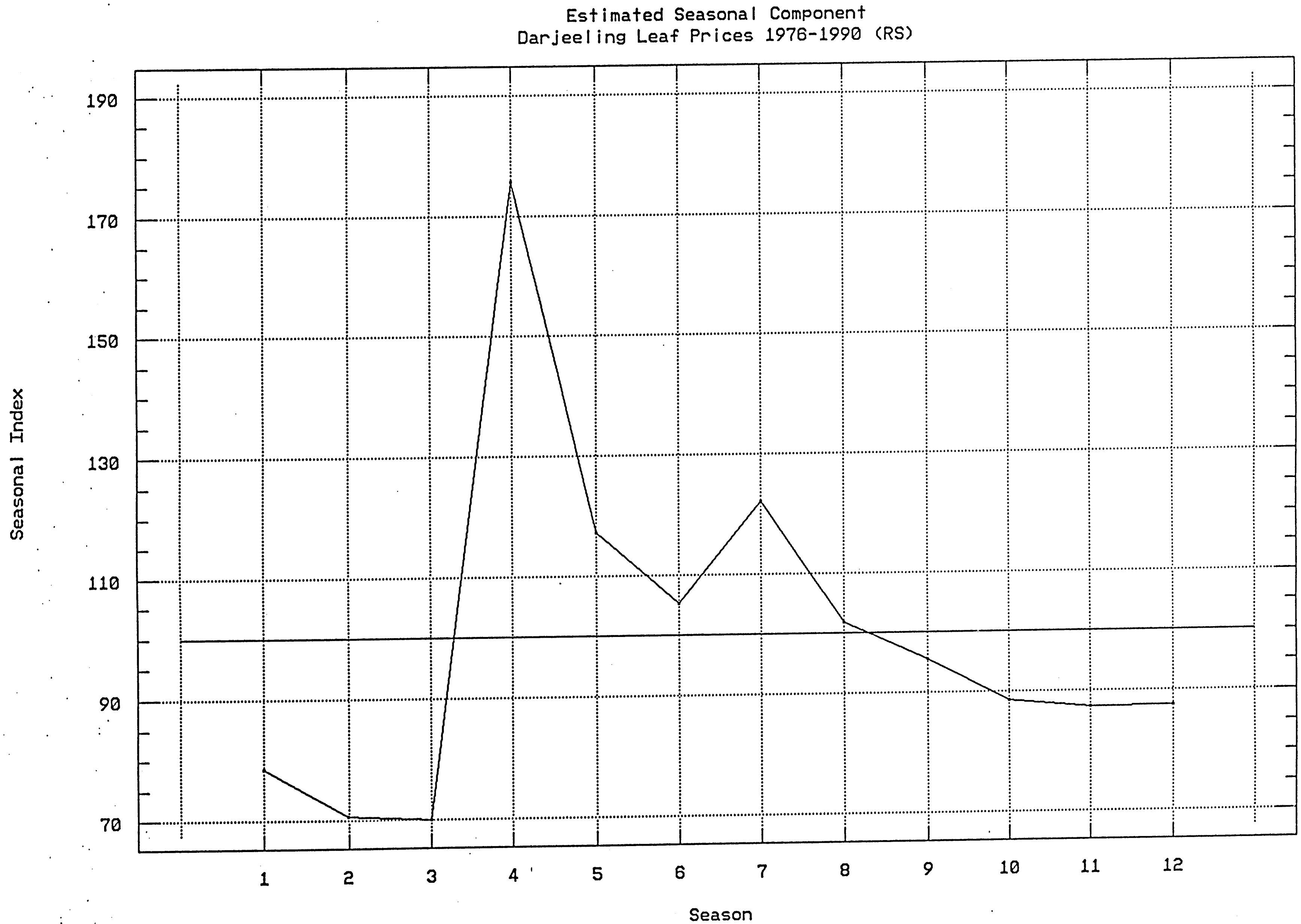


Fig. 12: Seasonal Price Index: Darjeeling Tea (US Dollar Prices)



Multiplicative Model, Var. RSDarj

Fig. 13: Seasonal Price Index

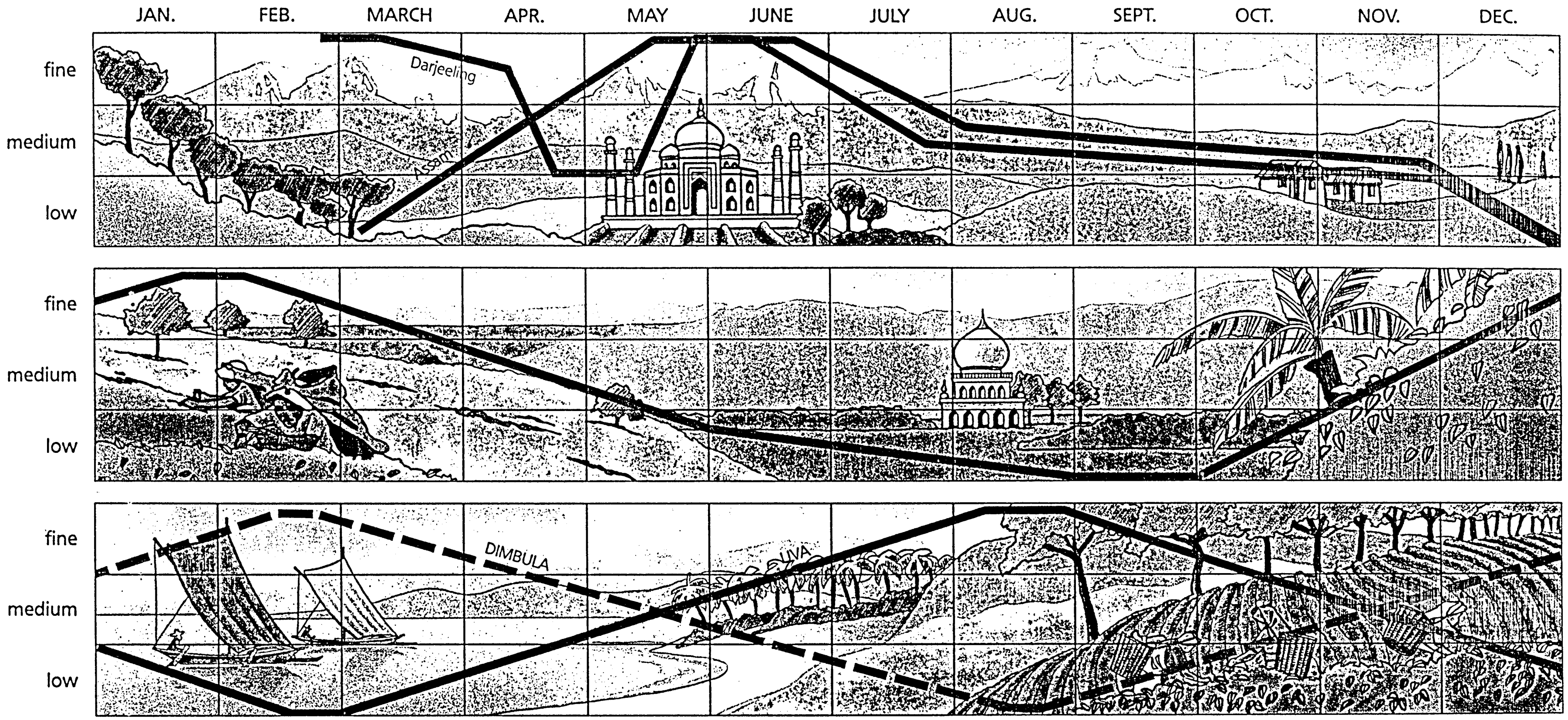


Fig. 14: Hälssen & Lyon's Seasonal Tea Quality Assessment

- **Calcutta:** The seasonal index for Calcutta prices picks up the effects of seasonality of Assam tea since Assam is the dominant supplying region of the auction (see Fig. 15). This becomes obvious by comparing the graph to HÄLSSEN & LYON's portrayal of the Assam quality curve, which increases in the beginning of March until it peaks in May and declines thereafter. Taking into account that the estimates incorporate a transportation lag of one month, vis–à–vis HÄLSSEN & LYON's version, the similarity is striking. Note, however, that since there is no tea production in January and February, HÄLSSEN & LYON's graphical representation offers no quality appraisal for these months. But, as there is a carry–over of tea stocks with auction sales in January and February, the seasonal index has 12 data. Again, the seasonal pattern is not at all affected by the exchange rate (compare Fig. 15 with Fig. C in the annex).

- **South India:** Again, the empirical estimates shall be confronted with the tea traders' observations. HÄLSSEN & LYON states with respect to South Indian tea quality: "*South India steadily increases its importance. Situated geographically between Assam and Ceylon. The highgrown Nilgiri tea is rather like fine Ceylon, whereas lowgrown teas from Kerala are more similar to a light Assam. In Cochin the finest coldweather teas are sold from December to February. In March/April quality declines slowly until poorest quality period is reached in May/July. From August onwards quality improves again. Twelve months production.*" Both HÄLLSEN & LYON's graph and their comment corroborate the empirical estimates (compare second panel from the top with Fig. 16 and Fig. D in the annex).

  Note the differences with respect to the amplitudes of the seasonal indices in Darjeeling, Assam and South India. In Darjeeling, the annual price swings attributable to seasonality amounted to some 100% (in dollar terms), in Assam to 18% and in South India to 14% only. Darjeeling is, to my knowledge, the tea–growing area with the most extreme seasonality in the world.

- **Sri Lanka:** For Sri Lanka, HÄLLSEN & LYON's description of seasonal quality variation reads like this (see also bottom panel in Fig. 14): "*The quality periods coincide with the two monsoons. During June/September the south–west monsoon sheds its rain on the west of the island and dry winds prevail in the Uva and eastern districts. These dry winds produce the special Uva character. From December to March the north–east monsoon rain falls on the eastern side. The dry cool weather in the west of the island produces seasonal Dimbula and Dickoya quality. The central mountain range around Nuwara Eliya divides these two growing districts. Twelve months production.*"

  Unfortunately, auction data at this degree of disaggregation are not available for empirical estimation. Thus, no time–series for the Uva and the Dimbula regions are available. In Sri Lanka, the auction price data are lumped together according to elevation and not according to the areas hit by the monsoon, whose impact determines seasonal quality.

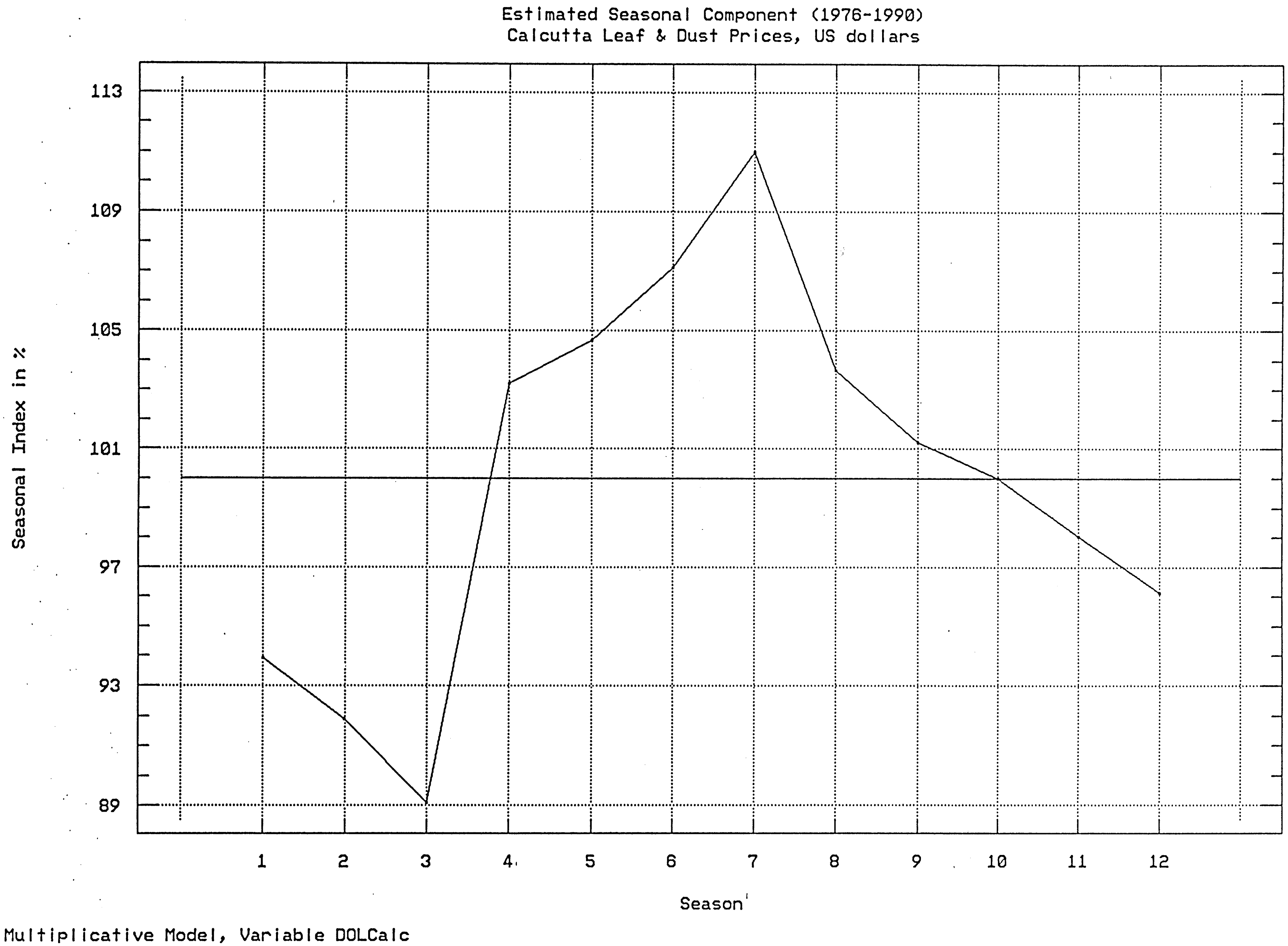


Fig. 15: Seasonal Price Index: Assam Tea (US Dollar Prices)

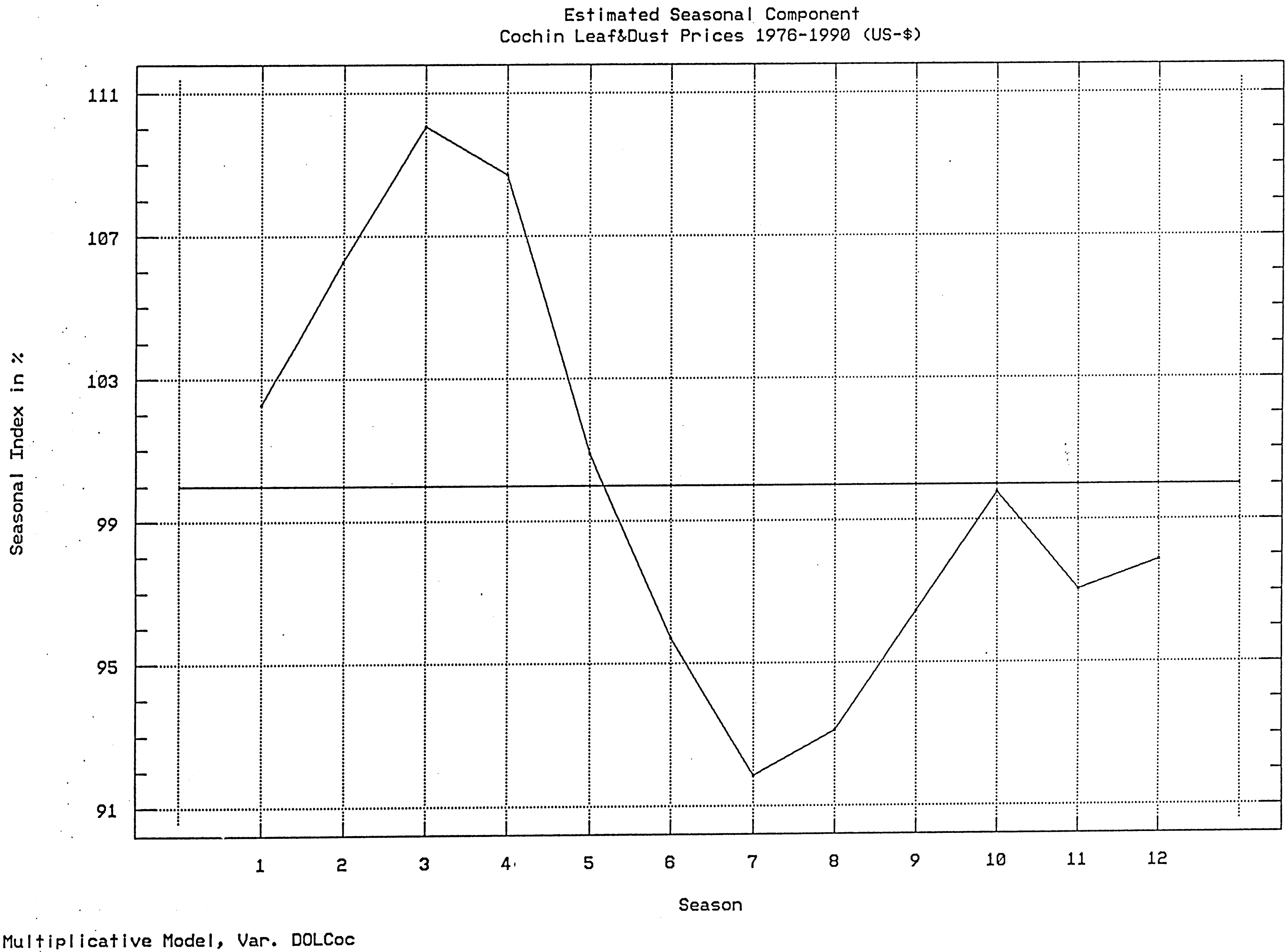


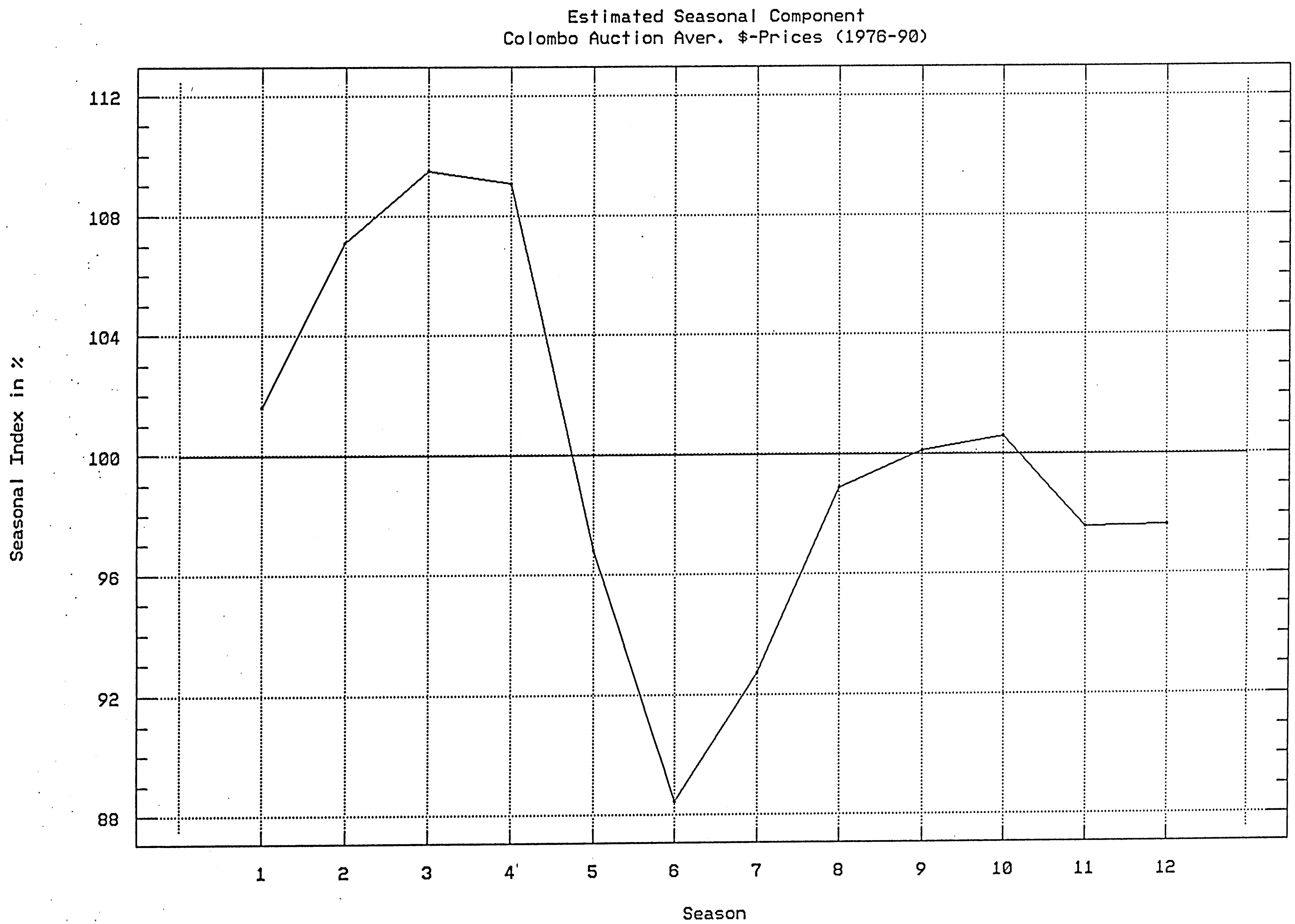
Fig. 16: Seasonal Price Index: Nilgiri Tea (US Dollar Prices)

Even so, the seasonal indices, as represented in Fig. 17 and Fig. E in the annex, convey the seasonal impact of both Dimbula tea and Uva tea according to two tea traders consulted in Hamburg. January to March is the Dimbula season with top-quality production. There is a considerable drop in tea quality thereafter, with it sliding into a trough in June, a time that coincides with the period of maximum production in Sri Lanka. The Uva season is reflected in the increase of prices from August onwards.

- **Indonesia:** In Indonesia, tea production is confined to the islands of Java and Sumatra. In Sumatra, seasonal variation of tea quality is neglible. Sumatran tea is therefore considered almost a standard quality -- not so in Java. According to HÄLLSEN & LYON, "*There is heavy rain from November to February which can extend until June. July, August and September are extremely dry. During these months the best quality is produced. From April to June and during October and November weather conditions are unsettled and it is during this time that the bright golden tippy teas are produced. Plucking continues from January to December.*" In the case of Indonesia, the seasonal index has been estimated for the years 1982 to 1990 only, omitting 1976–1981. The reason is that the index over the entire time span yielded an estimate which lacked credibility. For more recent years, the peak season was October (see Fig. 18 and Fig. F in the annex).

Finally, the seasonal indices for South India, Sri Lanka and Indonesia can be compared (see Fig. 19). As noted already, these tea-producing regions are the main competitors of orthodox tea on the world market. The indices roughly have the same wave-like shape with a trough in June/July. Even though Sri Lanka showed the most pronounced, and Indonesia only minor, seasonality, the three countries exhibit nearly synchronized seasonality.

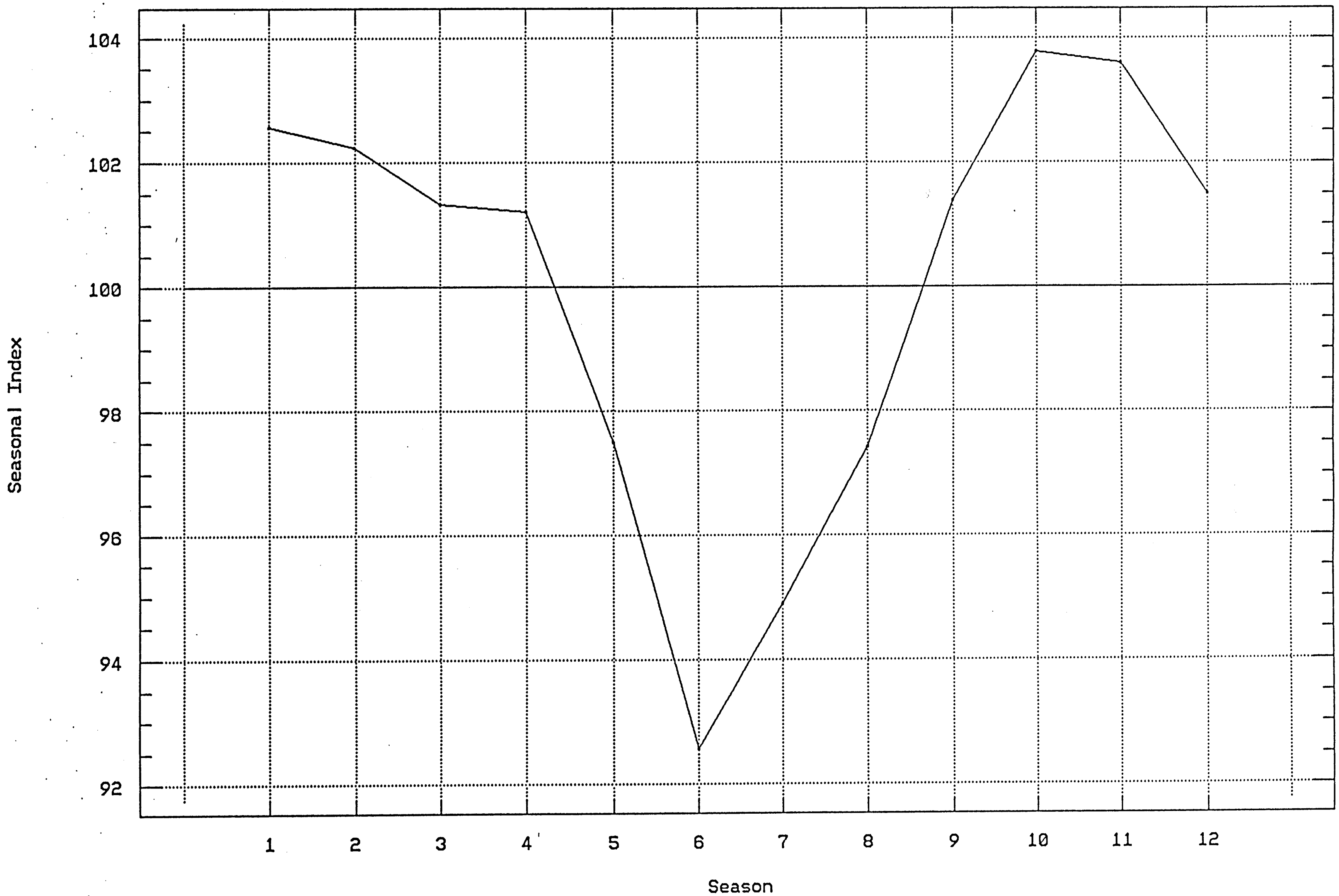
The existence of price seasonality, as shown for India, Sri Lanka and Indonesia, has a bearing on the correlation coefficients of time-series. Hence, seasonally-adjusted time-series might be a better basis for correlation analysis. Fig. 20 represents a portion of the correlation matrix including those intra-market correlations where de-seasonalization substantially affected the results (emphasized by the shaded areas both in Fig. 10 and Fig. 20). Notably, seasonally-adjusted Calcutta auction prices showed a closer correlation with other auction markets. Note the 'improved' price correlation with Cochin in South India. Obviously, de-seasonalization will not affect the results if 'synchronized seasonality' exists (compare coefficients for Cochin, Sri Lanka and Indonesia in both variants).



Multiplicative Model, var. Sriladol

Fig. 17: Seasonal Price Index: Ceylon Tea (US Dollar Prices)

Estimated Seasonal Component
Jakarta Auction Dollar Prices (1982-90)



Multiplicative Model, var. Jakadolnew

Fig. 18: Seasonal Price Index: Indonesian Tea (US Dollar Prices)

Fig. 19: Seasonal Tea Price Index for India, Sri Lanka and Indonesia (1976–1990)

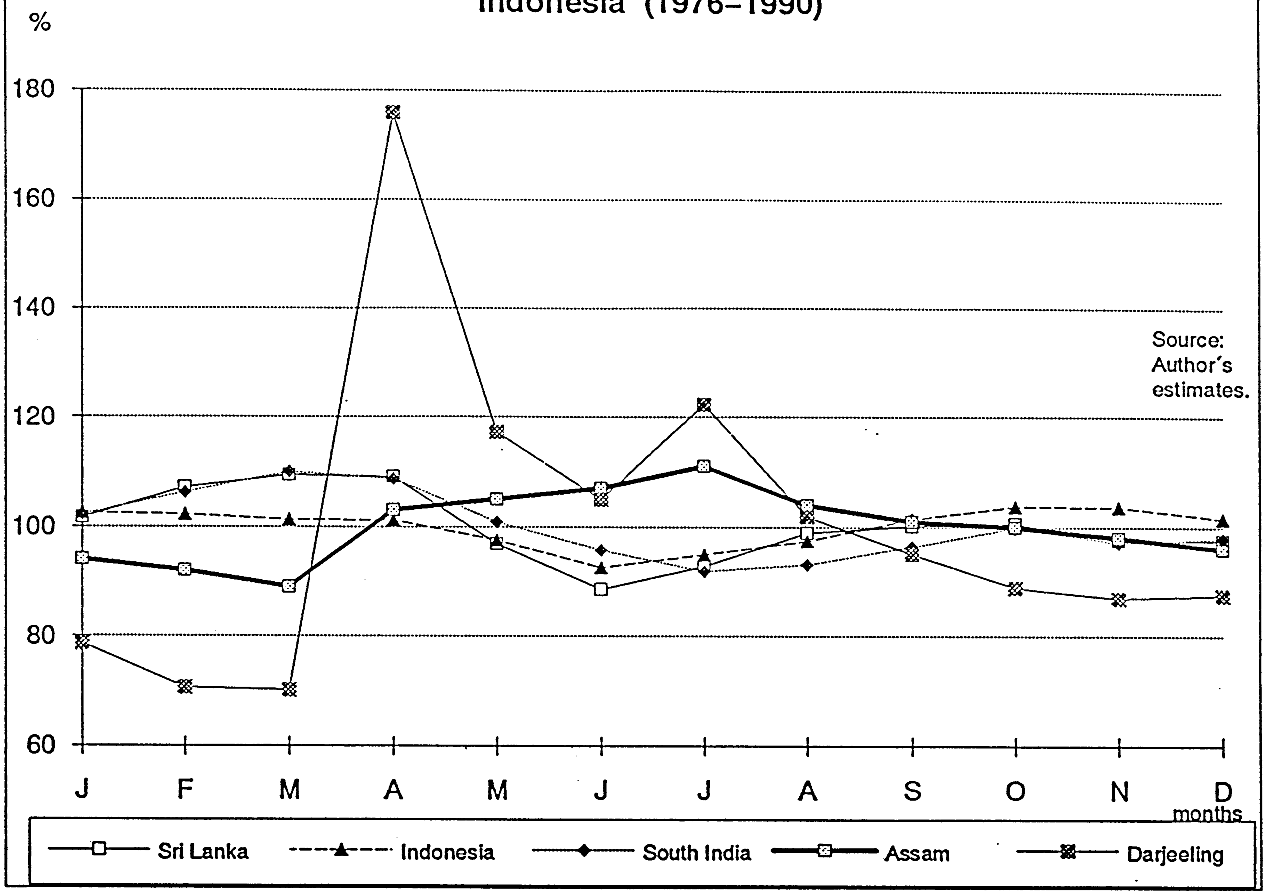


Fig. 20: Correlation Coefficients of International Tea Auction Prices (De-Seasonalized Data)

	Jakarta	Colombo	Cochin	Calcutta	Mombasa	Limbe	Chittagong	London
Jakarta	1.00 <180>	0.83 <180>	0.69 <180>	0.54 <180>	0.88 <180>	0.92 <132>	0.82 <174>	0.88 <180>
Colombo		1.00	0.84 <180>	0.75 <180>	0.72 <180>	0.76 <132>	0.83 <174>	0.70 <180>
Cochin			1.00	0.89 <180>	0.61 <180>	0.64 <132>	0.74 <174>	0.59 <180>
Calcutta				1.00	0.47 <180>	0.51 <132>	0.69 <174>	0.48 <180>

Note: Jakarta, Colombo, Cochin and Calcutta prices are de-seasonalized.
Source: Author's estimates based on data from J.THOMAS, "Tea Statistics", var. issues.

5. Summary and Conclusions

Commodity price volatility. Most empirical research in the past found that the world tea market was characterized by relative price stability when compared to major world tradeables (both agricultural and mineral commodities). In particular, the major competing beverage crops -- coffee and cocoa -- were substantially more price volatile. The author's estimates for the years 1961–1990, based on five different price instability measures, confirm these results. However, the diagnosis changes completely for the more recent past: in the period 1976–1990, tea, cocoa and coffee fell in the same category in terms of price volatility. Hence, the view that world tea prices are comparatively stable appears to be unfounded.

All indications point to the demand side as the shock–emitter leading to enhanced price volatility on the tea market. World tea supply grew almost 140 percent over the past three decades without a single disruption (i.e. a decrease in production relative to the preceding year). On the other hand, world tea demand has undergone significant structural changes (with demand shifting notably towards the Middle East countries) and experienced major shocks (Chernobyl). Globally speaking, tea has increasingly become a drink of the poor (countries). Thus, in 1988 some 60 percent was consumed by tea producing countries themselves, while the UK's share of consumption (the No.1 importer) had dropped to 7%, down from 13% in 1976.

Market Integration. Abstracting from movements of the general price level, the question of whether the law–of–one–price holds for the world tea market has been pursued. Arbitrage is not seen as an a priori guarantor of market integration, since price discovery is dispersed among the various tea auctions in the producing countries and intra–commodity quality differences range from subtle to substantial (commanding premiums of several hundred percent). Therefore, the analysis was focused on price differentials in a differentiated product market rather than on relative prices in a spatial setting.

The law–of–one–price is defined as a price constellation in which prices do not move independently, in which case the market is taken to be integrated. A bivariate regression model has been used in order to test for market integration. Thus, a zero intercept and a slope coefficient which does not differ significantly from unity would suggest perfect collinearity of two time–series. However, market integration is also compatible with stable discounts and premiums, both in absolute and percentage terms.

The results are unambiguous for the London auction prices (as between 1961 and 1990). The market was indeed very much integrated, as was evidenced by tea prices of South Asian and African origin that were identical in a statistical sense. It appears that Bangladeshi and Malawi tea occupied the lower market spectrum, with regression estimators indicating discounts vis–à–vis Kenyan, Tanzanian, North Indian, South Indian and Sri Lankan suppliers.

In contrast, the domestic auction prices of the tea producing countries (yearly averages) were much less integrated than the London spot market. There seems to be an inherent instability of price differentials over time, leading to the conclusion: For the overseas tea auctions, the law–of–one–price can neither be rejected nor refuted with the proposed methodology.

Exploratory analysis of relative tea prices on the world market reveals a peculiar phenomenon in times of *hausse* and *baisse*. In times of scarcity (hausse), international price differentials almost disappear, whereas in times of plenty (baisse) intra–commodity price differentials are substantial. Relative prices behave like a price concertina, because prices, if plotted against time, describe what resembles the movement of a concertina. To offer an economic interpretion of this phenomenon, it appears that the forces of international price arbitrage are particularly vigorous during price hausse giving way to widespread product and price differentiation in the subsequent baisse.

Seasonality. Market integration may be masked to the extent that *monthly* price data incorporate unsynchronized seasonality. As it happens, Indian tea in particular is known for the seasonality of its flavour. The empirical estimates using the ratio–to–moving–average method confirm the hypothesis that seasonal appreciation of the aroma is reflected in prices. The results indicate that prices for Darjeeling tea, Assam tea, South India tea, Ceylon tea and Indian tea are characterized by inherent seasonal patterns. In fact, tea traders easily associate the distinct price patterns with the origin of the tea. A further insight of the empirical estimates is that seasonality of the major orthodox tea producers (South India, Sri Lanka and Indonesia) is highly synchronized.

The seasonal analysis suggests that the tea–growing countries and regions could be ranked according to price amplitude due to seasonality. Darjeeling tea prices exhibited, by far, the most pronounced seasonality, followed by Sri Lanka, Assam, South India and Indonesia.

One might object that exchange rate fluctuations and devaluations possibly distort the seasonal price pattern. By the same token, the absolute values of seasonal (percentage) indices might differ depending on whether prices are denominated in local or foreign currency. However, both in India and Sri Lanka, exchange rate movements (vis–à–vis the US dollar) did not affect the pattern of price seasonality in terms of peaks, troughs and turning points. In the period under consideration (1976–1990) the seasonal indices in Indian rupees differed by less than half a percentage point on average from the respective dollar indices. In Sri Lanka, the difference was slightly higher (but not exceeding 3 percentage points).

Annex

Fig. A: Primary Commodities Classified by Degree of Price Instability

Index of Instability[a]							
0-5		5-10		10-15		Over 15	
Tea	1.3	Coffee	6.5	Sugar	13.9	Copper	5.0
Bananas	1.2	Cotton	4.0	Rubber	3.5	Cocoa	2.6
		Iron Ore	3.6	Phosphate Rock	2.6	Zinc	0.7
		Maize	2.3	Rice	1.6	Fishmeal	0.5
		Logs	2.2	Palm Oil	1.4	Copra	0.4
		Tobacco	1.9	Beef	0.7	Sisal	0.2
		Tin	1.7	Wool	0.6		
		Oranges	1.4	Coconut Oil	0.5		
		Soybean Meal	0.8	Groundnut Oil	0.4		
		Bauxite	0.7	Lead	0.4		
		Manganese Ore	0.6	Lemons	0.2		
		Wheat	0.6				
		Grain Sorghum	0.5				
		Groundnuts	0.5				
		Jute	0.2				
Total	2.5		27.5		25.8		9.4

Note: The figure shown against each commodity indicates its percentage share in total developing country exports of all primary commodities, excluding fuel, in 1975.

[a]The index is based on a five-year moving average of prices for 1955-76. It measures the average percentage deviation of the annual price from the five-year moving average. It does not take account of short-term fluctuations in prices.

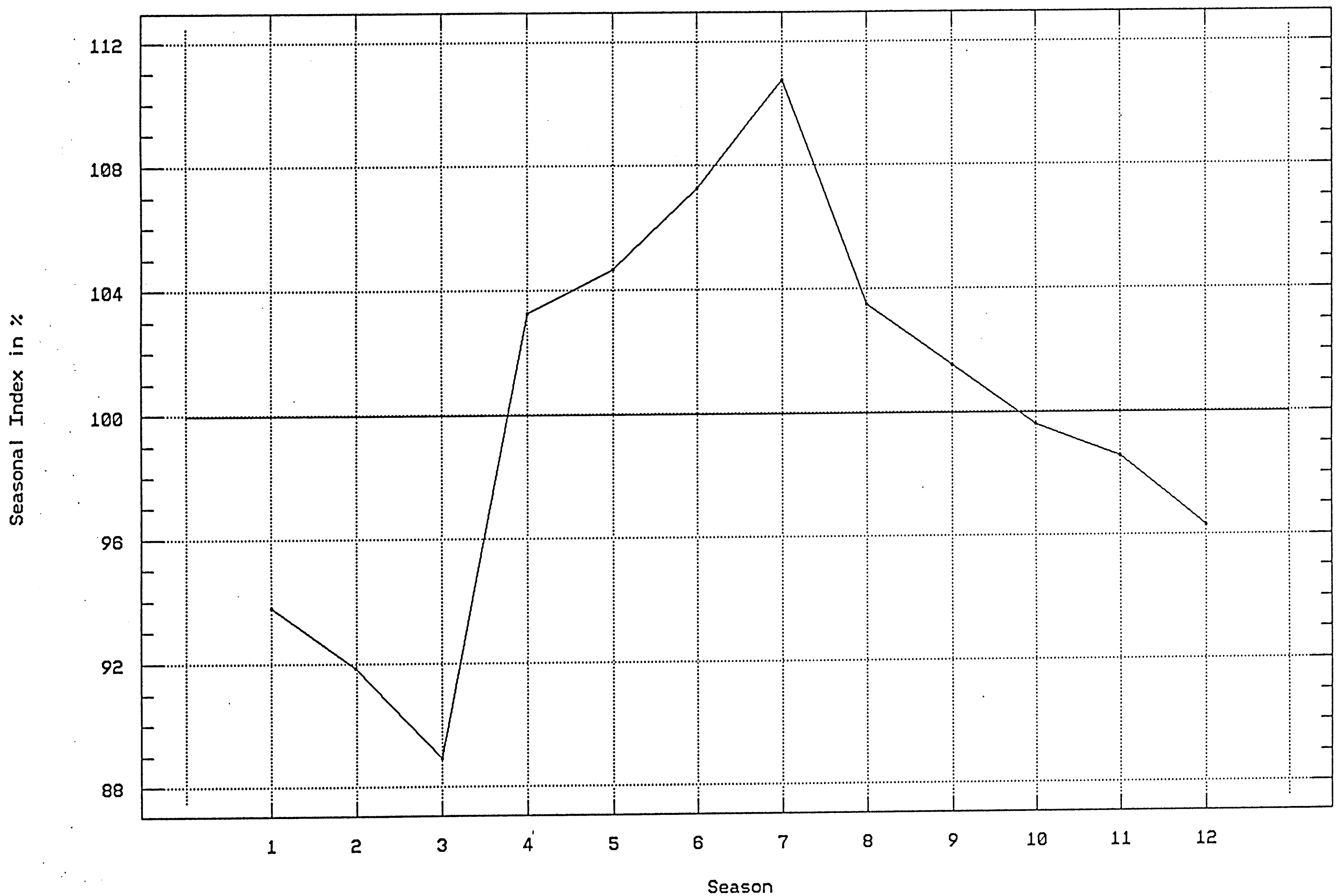
Source: World Bank (1978): World Development Report, p. 20

Fig. B: Price Instability Indices (1964–84)

Commodity	1964–84	1974–84
Sugar	90.8	51.5
Cocoa	37.3	34.1
Rice	33.0	21.9
Coffee	32.0	37.7
Palm Kernels	27.5	32.5
Wheat	24.3	16.9
Tea	*21.7*	*23.6*
Jute	21.2	26.8
Soybeans	20.8	9.9
Beef	16.7	11.3
Corn	16.6	15.6
Rubber	16.1	14.0
Sorghum	15.6	13.6
Cotton	14.3	10.7

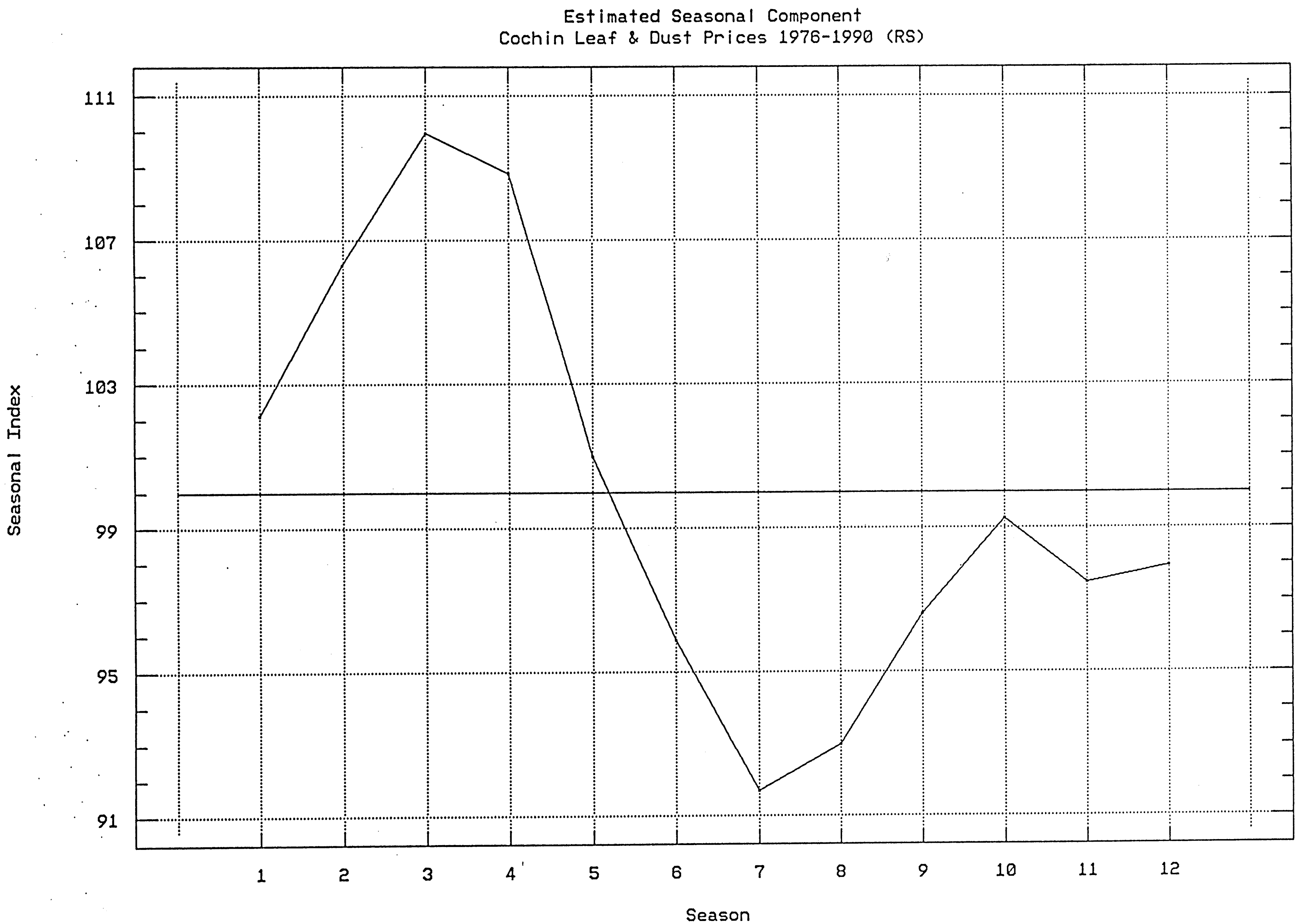
Note: calculated as exponential trend index, see text.
Source: WORLD BANK (1986), "World Development Report".

Estimated Seasonal Component (1976-1990)
Calcutta Leaf & Dust Prices, rupees



Multiplicative Model, Variable RSCalc

Fig. C: Seasonal Price Index: Assam Tea (Rupee Prices)



Multiplicative Model, Var. RSCoc

Fig. D: Seasonal Price Index: Nilgiri Tea (Rupee Prices)

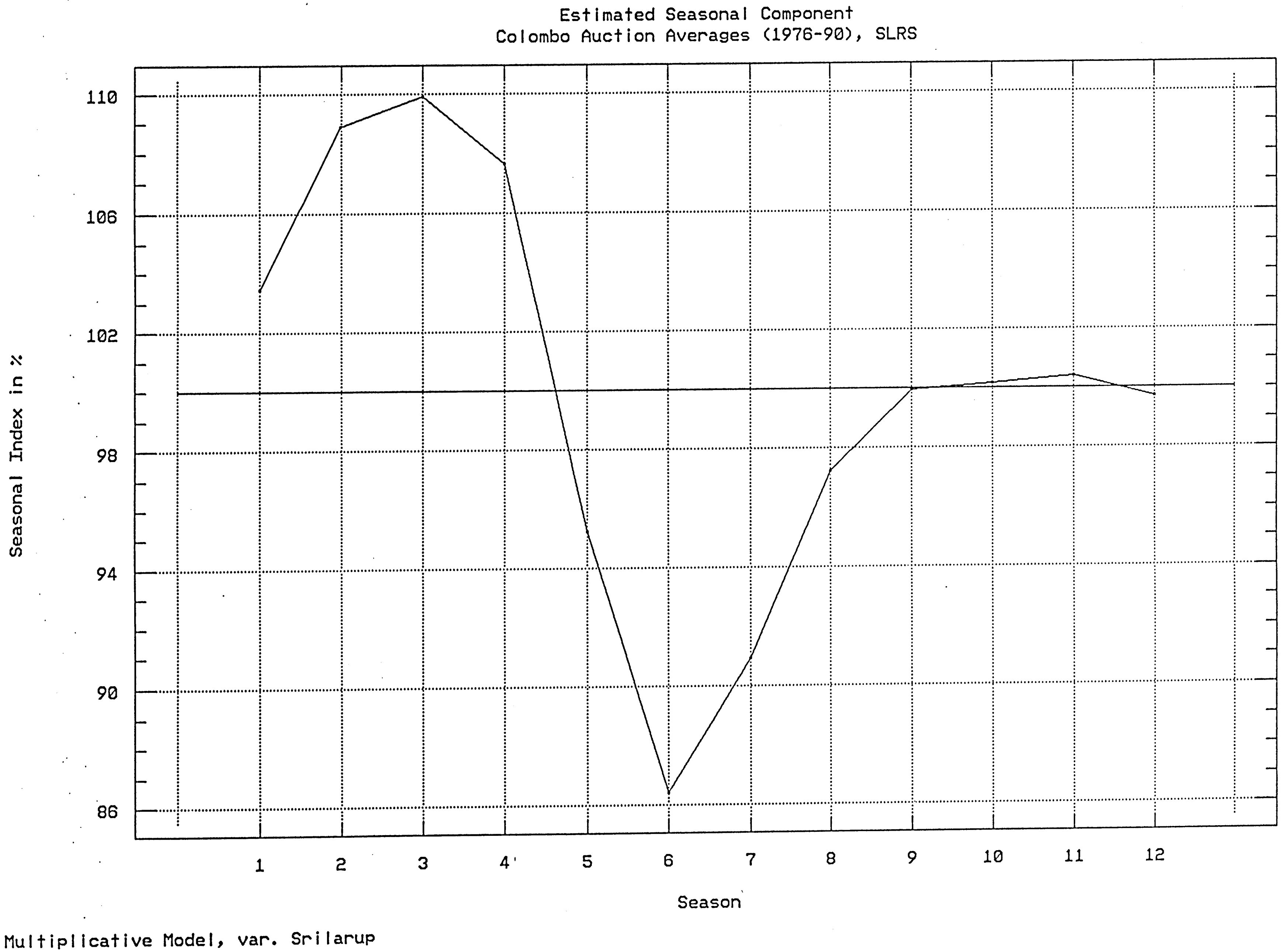
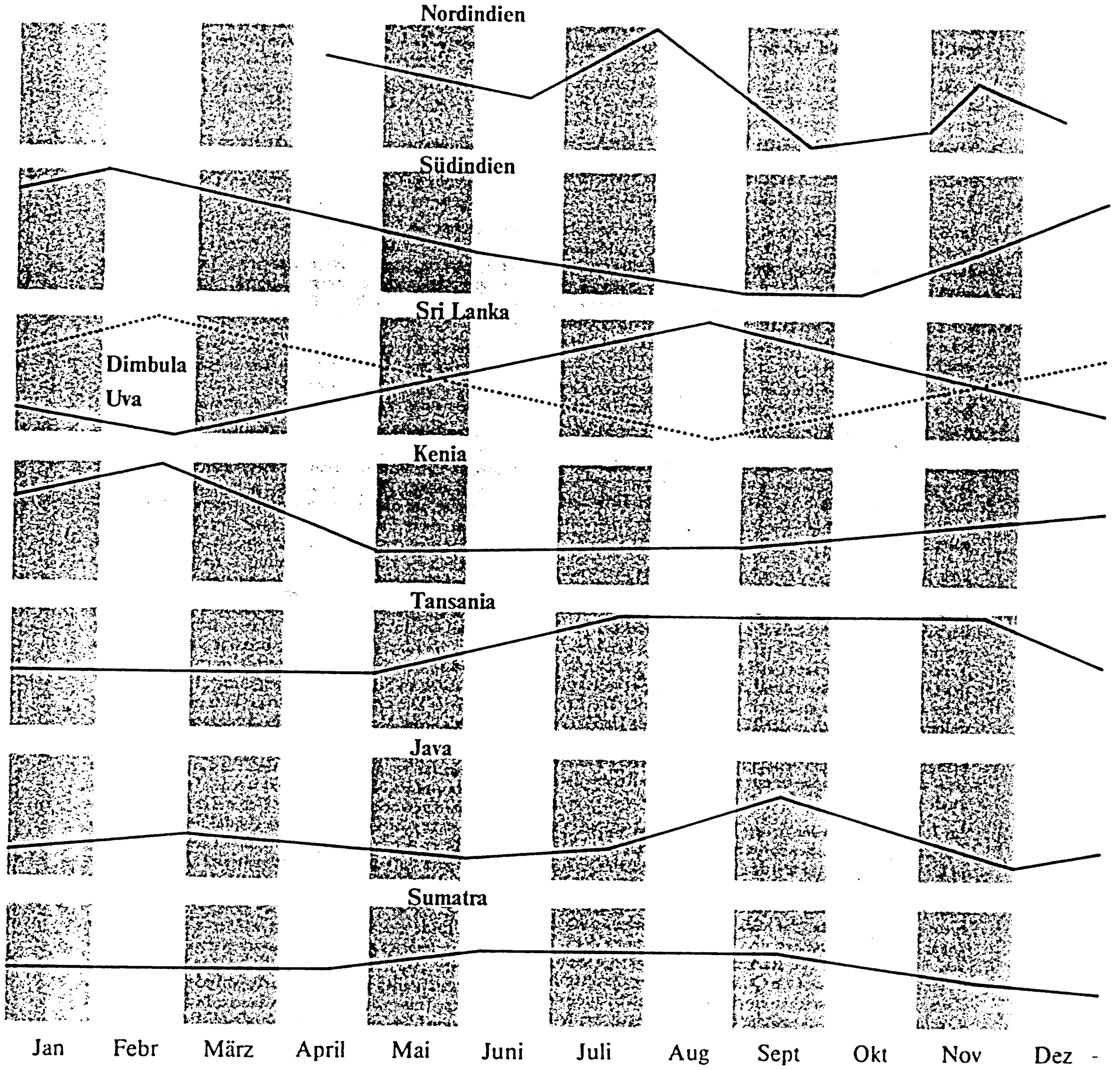


Fig. E: Seasonal Rice Index: Ceylon Tea (Sri Lankan Rupee Prices)

Fig. F: Lipton's Tea Quality Curves



Quelle: *Lipton International*, Walton-upon-Thames

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