Working Paper
366

CAUSALITY AND ERROR CORRECTION IN MARKOV CHAIN: INFLATION IN INDIA REVISITED

Vijayamohanan Pillai N.

December 2004

CAUSALITY AND ERROR CORRECTION IN MARKOV CHAIN: INFLATION IN INDIA REVISITED

Vijayamohanan Pillai N.

December 2004

An earlier version of this study was presented as an invited paper in the 24th Annual Conference of Indian Society for Probability and Statistics (ISPS) and the National Seminar on Recent Advances in Statistical Theory and Applications held at St. Thomas College, Palai, Kerala during 4 - 6 November 2004. I am grateful to KK Jose, RJR Swamy, VS Sampath Kumar and other participants for encouraging discussion, as also to Rju for smiling away my excuses for my absences from her little kingdom.

ABSTRACT

The present paper proposes certain statistical tests, both conceptually simple and computationally easy, for analysing state-specific *prima facie* probabilistic causality and error correction mechanism in the context of a Markov chain of time series data arranged in a contingency table of present versus previous states. It thus shows that error correction necessarily follows causality (that is temporal dependence) or *vice versa*, suggesting *apparently* that the two represent the *same* aspect! The result is applied to an analysis of inflation in India during the last three decades separately and also together based on the monthly general price level (WPI - all commodities) and 23 constituent groups/items, as well as on the three consumer price index (CPI) numbers.

Keywords: Markov chain; Steady state probability; India; Inflation; Return period.

JEL Classification: E31, C1

"Koh addhā veda kah iha pra vocat…"
("Who knows for certain? Who shall here speak it?")
Rg Veda (10. 129. 6)

"Kim kāraṇam?…"
Śvetāśvatara Upaniṣad (1. 1)

“When theory is applied, it is being used as a means of explanation:
we ask not merely what happened, but why it happened.
That is causation: exhibiting the story, so far as we can, as a logical process.”
John Hicks (1979: ix-x)

1. Introduction

Since the turn of the last century, there has been a marked change in the approach of scientific inquiries. Probabilistic models have been increasingly recognised as more realistic than the deterministic ones in many contexts. The probabilistic approach to time series analysis has thus led to what is called the 'dynamic indeterminism' (Neyman, 1960). Physicists have played a leading role in its development; and the innumerable variety of its applications in the realms of physical, biological, economic, social and behavioural sciences has made the approach all the more significant. Markov chain models are useful in analysing situations where the fluctuations of a process are either up or down or constant at a time compared with the preceding period. The scope of its applications has been on the increase in almost every context: from the stellar dynamics and solid-state physics (Chandrasekhar, 1943) to hydrology and meteorology (e.g., Moran, 1959; Klemes, 1970; Gabriel and Neumann 1957, 1962); to social processes (e.g., Bartholomew, 1967; Sampson 1990); and to economic aspects (e.g., Solow 1951; Champernowne 1953; Krenz 1964; Richardson 1973; Tsiang 1978; Whitaker, 1978; McQueen and Thorley 1991; Kawagoe 1999; Brody 2000; Cheshire and Magrini 2000; Masson 2001; Pillai, 2002).

Pillai (2002) applies Markov chain to monthly price movements in India. He proceeds from the premise that ''The price rise becomes inflationary only when every rise in the price level becomes the base for a further rise in the price level and the process becomes not only self-sustaining but also self-accelerating.'' (Rao *et al*. 1973: 6), and that this cumulative process naturally implies a very high long run probability of price rises. Thus he analyses, in the framework of a Markov chain model, the behaviour of the successive monthly changes in a selected set of price index numbers in India to find whether the changes are positive (tentatively suggesting inflation), negative (deflation), or zero (stable prices), and assesses the short-run persistence and/or transition of these states by estimating the (short run) transition probabilities, from which are then derived the long run probabilities of these three states. Both the short-run transition probabilities and the steady state probabilities estimated confirm that in general the monthly price rises in India were cumulative and hence inflationary in effect, and that the probabilities were much higher during the 1990s compared with the 1980s.

The present paper seeks to modify the method and results of Pillai (2002). More specifically, we propose that a price rise becomes cumulative and thus inflationary not just when the short-run and long-run probabilities are ‘higher’, but only if there operates a causality (or temporal dependence). A preceding period state *i* is said to be a *prima facie* cause of a current period state *j* when the corresponding conditional probability (that is, state transition probability in Markov chain) is greater than the unconditional (or, steady state) probability. Thus, a same-state (for example, price rise) transition probability exceeding the corresponding steady state (price rise) probability implies that the current period price rise depends on the previous period price rise. This temporal association (price rise building upon previous price rises) provides a satisfactory explanation of the cumulation of price rise, leading to inflation. Thus we define a price rise as cumulative and hence inflationary if and only if there exists a *prima facie* causality between the two period price rises. While the sign of the distance between a state transition probability and the corresponding long-run probability yields an indication of causality, its absolute value provides a measure of an error correction mechanism. We find that an error correction necessarily follows a causality or *vice versa*, such that the two *apparently* represent the *same* aspect: farther the distance, larger the error correction factor, and stronger the causality. That is, error correction becomes a dynamic process of causality. We make use of the standardised residual method to determine how much stronger causality must be in order to be statistically significant. The study makes use of an earlier result (Pillai 2004) on a simple estimate of steady state probabilities of a Markov chain in the context of time series data arranged in a contingency table of present versus previous states, useful when the number of states considered is very large. The results are considered for the last three decades separately and also together for the monthly general price level (WPI - all commodities) and 23 constituent groups/items, as well as for the three consumer price index (CPI) numbers.

2. The Model

Markov Chain Probability Estimates

The vast scope of applications of Markov chains in diverse fields has initiated many studies into the inference problems, such as estimation and hypothesis testing, about Markov chains (see Anderson and Goodman, 1957; Billingsley, 1961; Lee, Judge, and Zellner, 1970; Collin, 1974). Different methods have been suggested for estimation of transition probabilities under different situations – for instance, one based on linear and quadratic programming procedures to obtain least squares estimates (Lee, *et al.*, 1970) and another on maximum likelihood (ML) method to estimate transition probabilities from individual or micro-unit data (Anderson and Goodman, 1957; Collin, 1974). We make use of the definition of the ML estimator in this study.

Consider a time-homogeneous Markov chain with a finite number, m, of states (S_t = 1, 2, ……, m) and having transition probability matrix $\mathbf{P} = (P_{ij})$, $i, j = 1, 2, \ldots, m$, which is the conditional probability $\Pr\{S_t = j | S_{t-1} = i\}$, denoted by $P(j \mid i)$. Let the number of observed direct transitions from the state i in the previous period to the state j in the current period be n_{ij} and the total number of observations be N. Then the ML

Figure 1 : Frequency Distribution of Transitions from the Previous State *i* to the Present State *j*

Current state j

		1	2	….	j	….	m	Total
	1	n_{11}	n_{12}	….	n_{1j}	….	n_{1m}	$n_{1\bullet}$
Previous	2	n_{21}	n_{22}	….	n_{2j}	….	n_{2m}	$n_{2\bullet}$
state	:	:						
i	i	n_{i1}	n_{i2}	….	n_{ij}	….	n_{im}	$n_{i\bullet}$
	:	:						
	m	n_{m1}	n_{m2}	….	n_{mj}	….	n_{mm}	$n_{m\bullet}$
	Total	$n_{\bullet 1}$	$n_{\bullet 2}$		$n_{\bullet j}$		$n_{\bullet m}$	N

estimate of transition probability P_{ij}, that is, the probability of transition from the preceding state i to the present state j, is given by[1]

$$P_{ij} = n_{ij} / \sum_{j=1}^{m} n_{ij} = n_{ij} / n_{i\bullet}\,, \qquad \text{..... (1)}$$

where $\sum_{j=1}^{m} n_{ij}$ $(\equiv n_{i\bullet})$ is the corresponding row sum (see Figure 1). This ML estimator (1) is consistent, but not generally unbiased (Kendall and Stuart 1961: 39-40, 42); however, as the sample size increases, the bias tends to zero (Kendall and Stuart 1961: 42). It is also shown that the estimates are asymptotically normally distributed (Kendall and Stuart 1961: 43-44; Anderson and Goodman 1957: 95). Given the ML estimates, Anderson and Goodman (1957: 96-103) also provide likelihood ratio tests and χ^2 tests for testing various hypotheses.

Given the sample estimates of the state transition probabilities, we derive the steady state (long run) probabilities as the limiting values reached after a large number of transitions. These state probabilities are independent of the initial state i. This means that regardless of the initial state of (say) price changes or its probability vector, we could predict, subject to the underlying assumptions, the probabilities which the states will eventually take for the system to settle down and become stable.

Now with reference to Fig. 1, the unconditional or marginal probability of current state j, denoted by $P(j)$ is the probability $\Pr\{S_t = j\}$ irrespective of the preceding state i, and its ML estimate is given by

1. Note that for simplicity we do not put a 'hat' over 'Pr' to differentiate it as an estimate. Also note $P(j \mid i) = \dfrac{P(i,j)}{P(i)} = \dfrac{n_{ij} / N}{n_{i\bullet} / N} = \dfrac{n_{ij}}{n_{i\bullet}} = P_{ij}$.

$P(j) = n_{\bullet j}\ /N$, where $n_{\bullet j} \equiv \sum_{i=1}^{m} n_{ij}$, the number of times a particular state j is occupied irrespective of the previous state. Note that this is also the expected probability: we know that in a contingency table as Fig. 1, the theoretical frequency corresponding to n_{ij} is obtained as $n_{ij}^* = n_{\bullet j} \times n_{\bullet i.}/N$, and the associated expected probability estimator, from (1), is $P_{ij}^* = n_{ij}^*/n_{i\bullet} = P(j)$. And this must also be equal to the steady state probability of Markov chain. Indeed it is so in a special case of Markov chain defined particularly for most of the economic time series data arranged in a contingency table framework of current versus previous states. Here we find, for example, with reference to Fig.1, that $P(j) = P(i)$, for $i = j$, where $P(i) = n_{i\bullet}/N$ and $n_{i\bullet} \equiv \sum_{j=1}^{m} n_{ij}$. This is easy to explain in terms of the general result in economics that the long-run equilibrium is independent of time such that in our case $\Pr\{S_t = j\} = \Pr\{S_{t-1} = i\}$ in equilibrium, and thus $P(j) = P(i)$, for $i = j$. Now this, together with the definition of $P(j)$ given above, in turn, implies that $n_{\bullet j} = n_{i\bullet}$, for $i = j$, and hence $n_{ij} = n_{ji}\ \forall\ i, j = 1, 2, \ldots, m$. In some cases, it might be that $n_{ij} = n_{ji} \pm 1,\ \forall\ i, j = 1, 2, \ldots, m$, and $n_{\bullet j} = n_{i\bullet} \pm 1$, for $i = j$. The difference is insignificant for large N (for details see Pillai 2004).

This result might appear strange, but is as true as a mathematical regularity in a special case of a contingency table of time series data on current versus previous states. For an illustration[2], a part of our data set is reproduced in Table 1, which shows the monthly general price inflation (based on wholesale price index for all commodities) in India as estimated over the previous month for the decade of the 1990s. We consider two

2. For similar empirical results in meteorology, see Gabriel and Neumann (1962) and Medhi (1976).

Table 1: General Price Inflation (%) over the Previous Month and the Corresponding States (for the 1990s)

		Monthly Inflation		State of the Nature	
		Current	Previous	Current (S_t)	Previous (S_{t-1})
1989-90	March	0.60			
1990-91	April	1.76	0.60	1	1
	May	0.58	1.76	1	1
	June	1.72	0.58	1	1
	July	1.13	1.72	1	1
	August	0.56	1.13	1	1
	September	0.56	0.56	1	1
	October	1.10	0.56	1	1
	November	1.09	1.10	1	1
	December	1.08	1.09	1	1
	January	1.60	1.08	1	1
	February	1.05	1.60	1	1
	March	0.00	1.05	0	1
1991-92	April	0.52	0.00	1	0
	May	1.04	0.52	1	1
	June	1.54	1.04	1	1
	July	2.53	1.54	1	1
	August	2.96	2.53	1	1
	September	0.48	2.96	1	1
	October	0.00	0.48	0	1
	November	0.95	0.00	1	0
	December	0.47	0.95	1	1
	January	0.94	0.47	1	1
	February	0.47	0.94	1	1
	March	0.93	0.47	1	1
1992-93	April	0.46	0.93	1	1
	May	1.37	0.46	1	1
	June	0.90	1.37	1	1
	July	1.34	0.90	1	1
	August	0.88	1.34	1	1
	September	0.87	0.88	1	1

cont'd....

		Monthly Inflation		State of the Nature	
		Current	Previous	Current (S_t)	Previous (S_{t-1})
	October	0.43	0.87	1	1
	November	0.00	0.43	0	1
	December	-0.43	0.00	0	0
	January	0.43	-0.43	1	0
	February	0.43	0.43	1	1
	March	0.00	0.43	0	1
1993-94	April	0.86	0.00	1	0
	May	0.85	0.86	1	1
	June	1.27	0.85	1	1
	July	1.25	1.27	1	1
	August	1.65	1.25	1	1
	September	1.62	1.65	1	1
	October	0.40	1.62	1	1
	November	0.00	0.40	0	1
	December	0.00	0.00	0	0
	January	0.40	0.00	1	0
	February	0.79	0.40	1	1
	March	1.18	0.79	1	1
1994-95	April	1.55	1.18	1	1
	May	1.15	1.55	1	1
	June	1.13	1.15	1	1
	July	1.12	1.13	1	1
	August	0.37	1.12	1	1
	September	0.37	0.37	1	1
	October	0.73	0.37	1	1
	November	0.36	0.73	1	1
	December	1.45	0.36	1	1
	January	1.07	1.45	1	1
	February	0.71	1.07	1	1
	March	0.00	0.71	0	1
1995-96	April	1.05	0.00	1	0
	May	1.39	1.05	1	1
	June	0.34	1.39	1	1

cont'd....

		Monthly Inflation		State of the Nature	
		Current	Previous	Current (S_t)	Previous (S_{t-1})
	July	0.34	0.34	1	1
	August	0.68	0.34	1	1
	September	0.34	0.68	1	1
	October	0.34	0.34	1	1
	November	0.34	0.34	1	1
	December	-0.33	0.34	0	1
	January	-0.34	-0.33	0	0
	February	0.34	-0.34	1	0
	March	0.34	0.34	1	1
1996-97	April	1.34	0.34	1	1
	May	0.66	1.34	1	1
	June	0.33	0.66	1	1
	July	1.96	0.33	1	1
	August	0.64	1.96	1	1
	September	0.96	0.64	1	1
	October	0.32	0.96	1	1
	November	0.31	0.32	1	1
	December	0.31	0.31	1	1
	January	0.00	0.31	0	1
	February	0.31	0.00	1	0
	March	0.00	0.31	0	1
1997-98	April	0.31	0.00	1	0
	May	0.00	0.31	0	1
	June	0.31	0.00	1	0
	July	0.62	0.31	1	1
	August	0.31	0.62	1	1
	September	0.92	0.31	1	1
	October	0.91	0.92	1	1
	November	0.00	0.91	0	1
	December	0.90	0.00	1	0

cont'd....

		Monthly Inflation		State of the Nature	
		Current	Previous	Current (S_t)	Previous (S_{t-1})
	January	0.90	0.90	1	1
	February	-0.30	0.90	0	1
	March	0.00	-0.30	0	0
1998-99	April	1.19	0.00	1	0
	May	0.88	1.19	1	1
	June	1.16	0.88	1	1
	July	1.15	1.16	1	1
	August	0.28	1.15	1	1
	September	1.13	0.28	1	1
	October	0.56	1.13	1	1
	November	0.00	0.56	0	1
	December	-0.84	0.00	0	0
	January	-0.53	0.00	0	0
	February	0.34	-0.53	1	0
	March	-0.45	0.34	0	1
1999-2000	April	0.42	-0.45	1	0
	May	0.45	0.42	1	1
	June	0.42	0.45	1	1
	July	0.36	0.42	1	1
	August	0.42	0.36	1	1
	Septemebr	1.44	0.42	1	1
	October	0.85	1.44	1	1
	November	-0.19	0.85	0	1
	December	-0.90	-0.19	0	1
	January	-0.14	-0.90	0	0
	February	-0.41	-0.14	0	0
	March	0.71	-0.41	1	0

Notes: Price inflation (%) based on WPI (all commodities) is estimated over the previous month.

State = 1 for positive price change; and = 0 for non-positive price change.

states of nature of positive price change (S_t = 1) and non-positive price change (S_t = 0). A cross tabulation of the current (S_t) versus previous (S_{t-1}) price inflation states yields a 2 x 2 contingency table (Table 2) that confirms the above result: $n_{\bullet j} = n_{i\bullet}$, for $i = j$, and $n_{10} = n_{01}$, where n_{10} is the total counts of the event $\{S_t = 0 \mid S_{t-1} = 1\}$ and n_{01} that of $\{S_t = 1 \mid S_{t-1} = 0\}$. It is not difficult to see that this result is due to the close association between n_{10} and n_{01}. When S_t = 1 in the case of n_{01}, then S_{t-1} = 1 for n_{10} becomes predetermined. Similarly, when S_t = 0 in the case of n_{10}, then S_{t-1} = 0 gets determined for n_{01}. This regularity almost results in $n_{10} = n_{01}$, as in Table 2. With three states of price change, viz., positive (denoted by 1), zero (by 0) and negative (by – 1), Table 3 gives $n_{\bullet j} = n_{i\bullet}$, for $i = j$, and $n_{ij} = n_{ji} \pm 1$, $\forall$ i, j = 1, 2, 3. We get invariably similar results for any number of states of price change.

Table 2: Frequency Distribution of Inflation States (Based on Table 1)

		Current Month's Price Change		
		Positive (1)	Non-Positive (0)	Total
Previous Month's Price Change	Positive (1)	81	15	96
	Non-Positive (0)	15	9	24
	Total	96	24	120

Table 3: Frequency Distribution of Inflation States (Based on Table 1)

		Current Month's Price Change			
		Positive (1)	Zero (0)	Negative (-1)	Total
Previous Month's Price Change	Positive (1)	81	11	4	96
	Zero (0)	10	1	2	13
	Negative (-1)	5	1	5	11
	Total	96	13	11	120

This result in turn provides a very simple and easy method of computing long run probabilities from such micro data arranged in a contingency table of current and previous states as in Fig. 1. Our new long run probability estimator has very significant advantages in consideration of the increasing computer costs involved in the solution of the simultaneous equations when the number of states *m* becomes larger. Thus

$$\mathrm{P}(j) = n_{\bullet j}/N, \qquad \ldots. (2)$$

gives the long run probability for any state $j = 1, 2, \ldots, m$. Below we prove it for two particular cases of $j = 2$ and 3.

The steady state probabilities in the case of a Markov chain with two states, denoted by 1 and 0, are:

$$\mathrm{P}(0) = \mathrm{P}_{10}/(\mathrm{P}_{10} + \mathrm{P}_{01}), \text{ and}$$

$$\mathrm{P}(1) = \mathrm{P}_{01}/(\mathrm{P}_{10} + \mathrm{P}_{01}), \qquad |1 - \mathrm{P}_{10} - \mathrm{P}_{01}| < 1 \qquad \ldots. (3)$$

The ML estimator of P_{10} is $n_{10}/n_{1\bullet}$ and that of P_{01} is $n_{01}/n_{0\bullet}$. Substituting these estimators in (3) and considering $n_{10} = n_{01}$, and $n_{\bullet j} = n_{i\bullet}$, for $i = j$, we get $\mathrm{P}(1) = n_{\bullet 1}/N$ and $\mathrm{P}(0) = n_{\bullet 0}/N$, as proposed in (2).

In the three-state case, the graph-theoretic method (Solberg 1975) gives the following computable formulae for the steady state probabilities:

$$\mathrm{P}(j) = c_j \Big/ \sum_j c_j, \quad \mathrm{j} = 1, 2, 3, \qquad (4)$$

where

$$c_1 = \mathrm{P}_{12}(\mathrm{P}_{13} + \mathrm{P}_{23}) + \mathrm{P}_{13}\mathrm{P}_{32},$$

$$c_2 = \mathrm{P}_{21}(\mathrm{P}_{13} + \mathrm{P}_{23}) + \mathrm{P}_{31}\mathrm{P}_{23},$$

$$c_3 = \mathrm{P}_{32}(\mathrm{P}_{31} + \mathrm{P}_{21}) + \mathrm{P}_{12}\mathrm{P}_{31}.$$

Substituting here the ML estimators of the state transition probabilities and considering that $n_{ij} = n_{ji}\ \forall\ i, j = 1, 2, 3$, and $n_{\bullet j} = n_{i\bullet}$, for $i = j$, we have the result $P(j) = n_{\bullet j}/N$, $j = 1, 2, 3$, as in (2).

It is obvious that our formula is extendable to any large *m*-state case and is computationally much easier in the special case we consider. An added advantage of this method is that the formula is not based on transition probabilities, so that they need not be estimated at all for finding the long run ones; the method makes use of the number of times a particular state is occupied, independent of the previous state, which is easy to estimate without any computer cost. Moreover, it facilitates analysing some hitherto unconsidered properties of a Markov chain in the above framework, viz., probabilistic causality and error correction.

Causality

Traditional analyses of causality specify causal relations in terms of the usual logical conditions of

i) *necessity*: C is a cause of E iff both are real and C is necessary for E (that is, E cannot occur without C), and

ii) *sufficiency*: C is a cause of E iff both are real and C is sufficient for E (that is, whenever C occurs, E too does).

However, the presence of multiple causes (over-determination) renders the necessary condition in the above specification ineffective. In fact, virtually all the rational schools of Indian philosophy recognized that effects might require a conjunction of causes to occur. Thus the Buddhist scholars emphasized that cause and effect need not be linear in relation, but that desired effect requires a conjunctive set of right conditions for their fruition (*pratītya samutpāda*): thus, for a plant to grow successfully, it would need not only the right seed, but also the right type of soil, fertilisation, sunlight and water. It is partly in recognition of this fact that the INUS condition of causality (Mackie 1965) and the related probabilistic causality (for example, Suppes 1970) emerged to gain some universal acceptance. The INUS condition for some effect is ‘‘an insufficient but necessary part of a condition which is itself unnecessary but sufficient for the result’’(Mackie 1965). Suppose, for example, a short circuit causes a fire in a certain house; but the short circuit is not a necessary condition for the fire, it could happen in a number of other cases, for example, by ‘‘the overturning of a lighted oil stove’’. And the short circuit, by itself, is not sufficient also; the fire would not have broken out had there been no inflammable material nearby, had there been ‘‘an efficient automatic sprinkler at just the right spot’’, and so on. The short circuit is thus a part, ‘‘an indispensable part’’, of some constellation of conditions jointly sufficient for the fire. It is ‘‘an indispensable part’’ because given that it is this set of conditions that has occurred, rather than some other set sufficient for fire, the short circuit is necessary: fire does not occur in such circumstances without short circuit. Thus the short circuit is an insufficiently necessary but unnecessarily sufficient (INUS) condition for the fire. In economics, and in social sciences in general, causality seems to be defined in this sense; the INUS condition corresponds to the *ceteris paribus* condition (also see Hicks 1979: 45).

It is in a similar vein that the probabilistic school defines causality: cause makes its effect more likely. The central idea of probabilistic causality is that cause raises the probability of its effect and is formally expressed using the conditional probability apparatus. If $S_{t-1} = i$ and $S_t = j$ represent events that potentially stand in causal relations, then the event i is said to be a *prima facie* cause [3] of the event j if and only if

3. Note that the true definition of *prima facie* causality is $P(j \mid i) > P(j \mid \text{not-}i)$. When $P(j)$ is strictly between 0 and 1, this true definition turns out to be equivalent to $P(j \mid i) > P(j)$.

$$\Pr\{S_t = j \mid S_{t-1} = i\} > \Pr\{S_t = j\}, \text{ or simply}$$

$$P(j \mid i) > P(j), \qquad \text{....(5)}$$

where $P(j) > 0$, keeping the assumption of the temporal order of the events *a la* Hume (Suppes 1970: 12). Note that i is only a *prima facie* cause, not a cause *simpliciter*, since there may be clear circumstances of no causality between i and j, even though the *prima facie* conditions are satisfied. To cite the classic example, a falling barometer is a *prima facie* cause of a storm, but we do not take it as the genuine cause, since we know that it is a fall in atmospheric pressure that causes both the effects of falling barometer and storm. Such problems of spurious correlation, where both A and B are caused by a third factor C, and A *prima facie* causes B, that is, $P(B \mid A) > P(B \mid \text{not-}A)$, are addressed by requiring that cause raises the probability of its effect *ceteris paribus*. It should be emphasised here that " 'measures of association' is the term commonly used in the statistical literature for measures of causal relationship" required by this definition (Suppes 1970: 13). In this sense, the above definition holds i and j as positively associated; if the inequality is reversed, they are negatively correlated. If equality holds, then the two are probabilistically independent. Hence it is argued by some that 'greater than' be replaced with 'does not equal' in the above definition for causality (such that i causes j if $P(j \mid i) \neq P(j)$), for example, Granger (1980:330).[4] Another argument requires that a causal relationship make the associated event probable, such that i causes j if $P(j \mid i) > 0.5$ (Papineau 1985: 57ff). We, however, follow the original definition of probabilistic causality in terms of strict positive inequality.

4. Granger (1969: 376), however, defines causality in the old terms of an increase of conditional over unconditional probability.

In the context of our Markov chain, P(j | i) is the state transition probability and P(j), the steady state (or long run) probability, and the probabilistic causality condition is satisfied when the former is greater than the latter. Here *prima facie* causality in fact boils down to the familiar condition for 'statistical association' that observed frequency (O) in a contingency table cell be greater than the corresponding expected frequency (E), that is, $O - E > 0$: the causality condition being $P(j \mid i) > P(j)$, we have from (1) and (2),

$$n_{ij} / n_{i\bullet} > n_{\bullet j} / N \text{, giving}$$

$$n_{ij} > n_{i\bullet} n_{\bullet j} / N = n_{ij}^{*} \, , \qquad \ldots.(6)$$

where n_{ij} and n_{ij}* are respectively the number of observed and the expected direct transitions from the state i to j in a Markov chain. That *prima facie* causality in this Markov chain is equivalent to positive statistical association between the previous period state i and the present period state j of price changes helps us account for the significance of expectations in actual inflation. In the naïve adaptive expectation model, previous period inflation (π_{t-1}) proxies for the expected one (π_t *), and the relationship between the previous and the current period inflation is taken in this sense to explain that between the expected and the actual inflation, *ceteris paribus*.[5] Thus, in the context of our Markov chain of price changes, *prima facie* causality provides a general indication of the significance of expectations in determining, *ceteris paribus*, the current period state of price change. In addition to analysing the nature of cumulation of price changes through the instantaneous and long run

5. Also note that the Markov chain, as given in figure 1, may also be represented, with a one-period ahead specification, as one with the current period (S_t) versus next period (S_{t+1}) states.

probabilities, this framework helps us identify the role of expectations also in such cumulation.

We further see that the causality condition is possible to be associated with an error correction mechanism defined for a Markov chain, to which we turn now.

Error Correction and Causality in Markov Chain

Let us consider a two-state Markov chain for the distribution of the series of price changes between successive months. The model classifies the price changes into ‘increasing’ and ‘non-increasing’ states, denoted respectively by 1 and 0. Thus, for example, P_{10} gives the probability of transition from the state of price rise in the last month to the state of no price rise this month. The two-state specification enables us to distinguish between the *t*-step transition probability (which we call ‘instantaneous probability’, that is, at a particular time *t*), denoted by $P_{ij}(t)$ and steady state probability, as $t \to \infty$, denoted by $P(j)$. The *t*-step transition probability matrix in this case is given by:

$$\mathbf{P}_t = \mathbf{A} + (1 - P_{10} - P_{01})^t\,\mathbf{B}, \qquad |1 - P_{10} - P_{01}| < 1, \qquad \text{…. (7)}$$

where $A = \begin{bmatrix} \dfrac{P_{01}}{P_{10}+P_{01}} & \dfrac{P_{10}}{P_{10}+P_{01}} \\ \dfrac{P_{01}}{P_{10}+P_{01}} & \dfrac{P_{10}}{P_{10}+P_{01}} \end{bmatrix}$ and $B = \begin{bmatrix} \dfrac{P_{10}}{P_{10}+P_{01}} & \dfrac{-P_{10}}{P_{10}+P_{01}} \\ \dfrac{-P_{01}}{P_{10}+P_{01}} & \dfrac{P_{01}}{P_{10}+P_{01}} \end{bmatrix}$

and the steady state probability matrix **P** is:

$$P = \lim_{t\to\infty} \mathbf{P}_t = \mathbf{A}\text{, as given in (3), and also in (2) using our method.}$$

The condition $|1 - P_{10} - P_{01}| < 1$ ensures convergence to the steady state; the smaller the magnitude, the sooner the system settles down.

Thus, $(1 - P_{10} - P_{01})$ determines the speed of convergence towards the steady state probability. Since the move towards steady state can be viewed as an error correction process, gravitating to equilibrium, the estimate may be interpreted as an indicator of error correction factor (ECF). When $t = 1$, we have from (5),

$$\mathbf{P_1} = \mathbf{A} + (1 - P_{10} - P_{01})\mathbf{B}, \qquad |1 - P_{10} - P_{01}| < 1, \qquad \ldots.(8)$$

where $\mathbf{P}_1 = \begin{bmatrix} P_{11} & P_{10} \\ P_{01} & P_{00} \end{bmatrix}$, the transition probability matrix.[6] Note that $(\mathbf{P_1} - \mathbf{A})$ gives the first period distance (which is a proportion of the original one) between transition probability and steady state probability (that is $[P_{ij} - P(j)]$, and that its sign suggests causality: that is, if the distance is positive, then the previous state i *prima facie* causes the current one j. Also note that

$$(1 - P_{10} - P_{01}) = \text{ECF} = [P_{ij} - P(j)]/[1 - P(j)],\ i = j, \qquad \ldots.(9a)$$

or

$$(1 - P_{10} - P_{01}) = \text{ECF} = \{1 - [P_{ij} / P(j)]\},\ i \neq j. \qquad \ldots.(9b)$$

In this light, $(1 - P_{10} - P_{01})$ not only represents the proportion of the distance covered between the transition and the steady state probability and thus the speed of error correction, but also indicates *prima facie* causality, that is, significance of expectations.[7] If $(P_{10} + P_{01}) < 1$, then both causality and error correction are defined, but neither causality nor any error correction, if the sum equals unity. Again, closer this sum

6. Note that $\mathbf{P}_0 = \mathbf{A} + \mathbf{B}$ is an identity matrix.

7. It is significant to note that this error correction, as the transition probability converges to the steady state one, is different from the adaptive expectation process.

to unity, quicker the correction and weaker the causality. In other words, a large error correction factor reflects, and is reflected by, a strong causality. Thus it seems causality, or more precisely here, role of expectation through temporal dependence, and the Markov chain error correction represent *the same aspect* in our case!

Note that the error correction factor $(1 - P_{10} - P_{01})$ can also be stated in terms of the sum of the distances of the steady state probabilities from the corresponding state transition probabilities: since $P_{10} = 1 - P_{11}$ and $P_{01} = 1 - P_{00}$, and also $P(0) + P(1) = 1$, we have

$$ECF = (1 - P_{10} - P_{01}) = [P_{00} - P(0)] + [P_{11} - P(1)]$$

$$= \Sigma[P_{jj} - P(j)],\ j = 0, 1; \qquad \text{....(10a)}$$

or

$$ECF = (1 - P_{10} - P_{01}) = -[P_{10} - P(0)] + [P_{01} - P(1)]$$

$$= -\Sigma[P_{ij} - P(j)],\ i \neq j,\ \ i, j = 0, 1. \qquad \text{....(10b)}$$

RHSs of (10a) and (10b) are just mirror images: we have

$$[P_{01} - P(1)] = -[P_{00} - P(0)] \text{ and}$$

$$[P_{10} - P(0)] = -[P_{11} - P(1)]. \qquad \text{....(10c)}$$

We have now a significant result: farther the transition probability from the steady state probability, larger the error correction factor, and stronger the causality. That is, a slow adjustment process implies a strong causality. This specification facilitates to find out which state contributes more to the adjustment factor as well as to causality. Since both the expressions are equal, we need to consider any one, and P_{jj} being the same-state persistence probability, (10a) would be more useful in the context of most of the time series analysis.

Now it is straightforward to generalise: we have at any time t, $[P_{ij} - P(j)] = C^t\varepsilon$, where ε is error and $|C| < 1$ is the error correction factor. Then, from (9a) it follows that $\Sigma[P_{jj} - P(j)]$, $j = 0, 1, 2, \ldots, m$, provides detailed (state-specific) information on causality and error correction in a Markov chain of a time series data set arranged in a contingency table of current versus preceding states. Note that the given quantity raised to the power of t measures causality and error correction at any particular time t.

As already explained, a large error correction factor reflects, and is reflected by, a strong causality (or role of expectation); but how much strong it must be to become statistically significant is also to be ascertained. For this purpose, here we make use of the *standardised residual method* due to Haberman (1973, 1978), by which a standardised residual (SR) for each cell of a contingency table is computed to find which cell-specific distances between the observed and the expected frequencies are larger than might be expected by chance. SRs are estimated as the square root of the cell chi-square values (that is SR = $(O - E)/\sqrt{E}$), keeping the sign of the difference between the observed (O) and the expected (E) values. By a rule of thumb, suggested by Haberman (1973), if a SR is greater than 2 in absolute value, then it may be concluded that the cell residual contributes to the overall significant chi-square value. Note that this approximates the two-tailed critical value of the unit normal variate z at 5 percent significance level. With strict positive inequality for causality, the corresponding critical value is 1.645. Since in our case, $(O - E) > 0$ indicates causality, as seen above, we can estimate cell-specific SR to find which state transitions (cells) are statistically significant cases of causality. Thus from (1), (2) and (6), and remembering $n_{\bullet j} = n_{i\bullet}$, for $i = j$, we have

$$\mathrm{SR} = [P_{ij} - P(j)]\sqrt{N}, \; i = j, \text{ and}$$

$$\text{SR} = [\text{P}_{ij} - \text{P}(j)]\ \frac{\sqrt{P(i)}}{\sqrt{P(j)}}\sqrt{N}\ ,\ i \neq j. \qquad \text{....(11)}$$

Thus a positive SR greater than 1.645 concludes in favour of a significant causality. In other words, if $[\text{P}_{jj} - \text{P}(j)] > 1.645/\sqrt{N}$, then it can be concluded that P_{jj} is significantly greater than its expectation, that defines causality, as per (5). Similarly we can conclude for the second case where $i \neq j$.

Since a strong or significant causality requires a large ECF, it must now be found out how large it should be in order to be statistically significant. From the definition of ECF in (10a) and of SR in (11), we have

$$\text{SR} = [\text{P}_{jj} - \text{P}(j)]\sqrt{N} = \text{ECF}[1 - \text{P}(j)]\sqrt{N}\ , \qquad \text{....(12)}$$

such that if the estimated value of ECF > $1.645/[1 - \text{P}(j)]\sqrt{N}$, then it is significant at 5 percent level. Note that this significance is specific to a particular state j, even though ECF is a constant, irrespective of state transitions. In short, it then follows that if causality is significant, then the corresponding ECF also is necessarily significant.

We now proceed to express the chi-square test statistic in terms of ECF, so that the general test for association in the context of Markov chain can be done using ECF. Since SR is the square root of the cell chi-square value, the sum of the squares of all SRs, given in (10) yields the omnibus chi-square value. That is, [8]

---

8. Note that SR and hence the cell chi-square value, is the same for all off-diagonal ($i \neq j$) cells since $n_{ij} = n_{ji}\ \forall\ i, j = 1, 2, \ldots, m,\ i \neq j$. hence the omnibus chi-square value for a m-state Markov chain contingency table of the special case we consider can also be obtained from: $\chi^2 = N\sum_{i=j}[P_{ij} - P(j)]^2 + mN\sum_{i<j}[P_{ij} - P(j)]^2\ \frac{P(i)}{P(j)}$.

$$\chi^2 = N\sum_{i=j}[P_{ij} - P(j)]^2 + N\sum_{i\neq j}[P_{ij} - P(j)]^2 \frac{P(i)}{P(j)}, j = 0, 1. \qquad \text{....(13)}$$

Considering $|P_{ij} - P(j)| = |P_{ii} - P(i)|$ from (10c), we can rewrite (13) as

$$\chi^2 = N\Sigma\,[P_{jj} - P(j)]^2/[1 - P(j)], j = 0, 1. \qquad \text{....(14)}$$

which by (10a) or (12) simply reduces to

$$\chi^2 = N(\text{ECF})^2. \qquad \text{....(14)}$$

In the context of a two-state Markov chain contingency table, the previous state in general *prima facie* causes the present state if the estimated $\chi^2 > 3.841$ at 5 percent level for one degree of freedom. The same can be now found using ECF > $\sqrt{3.841/N}$.

Thus we have the following two significance tests for causality based on ECF of a Markov chain:

1. General causality: statistical association between previous period states and present period states in totality, using chi-square values [by (14): ECF > $\sqrt{3.841/N}$].
2. State-specific causality: statistical association between a particular previous state and present state, using z- values [by (12): ECF > $1.645/[1 - P(j)]\sqrt{N}$.

Since ECF is easy to estimate as the sum of the distances of the steady state probabilities from the corresponding state transition probabilities [that is, ECF = $\Sigma[P_{jj} - P(j)]$, from (10a), where the steady state probability, $P(j)$, also is easy to compute from the marginal totals, from (2) in our special case of Markov chain], the statistical tests are also easy to perform. And this is the beauty of our paper.

In what follows we apply these results to a Markov chain of price movements in India and discuss the implications.

Inflation in India Revisited

Now we turn to the results of the application of Markov chain to monthly price movements in India during the last three decades. We consider, besides the general price level (WPI – all commodities), the wholesale price levels of 23 constituent groups/items and the retail price levels in terms of the 3 consumer price index (CPI) numbers - that for industrial workers (CPI – IW), for urban non-manual employees (CPI - UNME) and for agricultural labourers (CPI –AL). The sectional prices we analyse are of primary articles, food articles, food grains, cereals, rice, wheat, pulses, fruits and vegetables, milk and milk products, eggs, fish and meat, non-food articles, fuel, power, light and lubricants, mineral oils, electricity, manufactured products, food products, sugar, khandsari and gur, edible oils, salt, textiles, drugs and medicines, fertilisers and cement, lime and plaster. Sequences of monthly price changes (over the previous month) based on each of these price indices for 360 months from April 1971 to March 2001 are then used to obtain the ML estimates of their state transition probabilities in each category. We consider the temporal behaviour pattern of price change in its 2 states - positive and zero/negative (equivalently, the price level as 'increasing' and 'non-increasing'), denoted respectively by 1 and 0. The estimated probabilities of transition of price change from one state in the previous month to another state in the current month are given in Table 4 for each of the 27 categories of price indices; we also report the results of Chi-square test on the null hypothesis of equal state probability (P_{ij} = 0.5, for all i, j = 1, 0).

The results (Table 4) in general show the short-run persistence of increasing price level to be significantly high in most of the categories in all the periods considered. For the general as well as the retail price levels, the probability of such persistence is as high as around 0.80. The increase in this probability in the case of the general price level and the CPI (AL) over the three decades is noteworthy. In the case of individual prices under consideration, this probability ranges between 0.79 for rice and 0.53 for electricity during the whole period. In most of the categories, the short run probability of inflation is much higher for the post-liberalisation period. While the high chi square values confirm that the probabilities are not at all equal for the whole period, it is not so for the decadal probabilities in the case of some of the sectional prices.

Thus we find that the monthly changes in the general price level in India had substantially higher short-run probability for positive state transition, and this probability in the post-liberalisation period was much higher.

The possibility that a Markov chain may make repeated, consecutive transitions back to the same state helps us estimate the number of times in succession that the same state is occupied once it is entered, *i.e.*, the expected duration (or holding time) of the same state, along with its variance (see Gabriel and Neumann 1957). For example, the average duration of an inflationary spell in the case of the general price level [given by $1/(1 - P_{jj})$] is [$1/(1 - 0.753) =$] 4.1 months in the 1970s and 4 and 6.3 months respectively in the 1980s and the 1990s. The corresponding variances [given by $P_{jj} /(1 - P_{jj})^2$] are 12.4, 12 and 33.8 (months squared), giving coefficients of variation (CV) of 86.8, 86.6 and 91.8 per cent for the three periods respectively. Similarly, the mean holding time of the 'non-increasing' state in the three decades are 1.9, 1.8, and 1.56 months. The mean durations of the two states give an expected cycle of about 6 months in the first two decades and about 8 months in the 1990s, suggesting that out of every 8 months, we had a short run spell of inflation for more than 6 months in the 1990s, while inflation persisted for 4 months in every 6-month cycle in the earlier decades.

Thus we also get the additional insight into the short-run price increases in terms of its longer expected duration compared with the state of falling/stable price (Table 5; variances or coefficients of variation are not reported, considering space constraint). These price rises are also found to have held on for longer time in the post-liberalisation period than in the previous periods. The findings in turn suggest that the short-run rises in the general price level in India were more likely to cumulate in general and much disastrously in the post-liberalisation period.

Table 6 presents the long run probabilities of the 2 states of price level changes. As may be expected, inflation (as measured over the previous month) persists in the long run with very high probability in general, though the 1990s had higher probabilities for most of the WPIs. There is hardly any significant difference in the long run probabilities of inflation in the 3 periods in the case of the CPI(IW), while those for the other two indices were much higher in the 1990s compared with the 1970s. Both the CPI(IW) and CPI(UNME) had much higher inflation probabilities than CPI(AL). In the case of sectional prices we consider, the steady state probability for the whole period lies between 0.68 for manufactured products and 0.27 for fertilizers. It is remarkable to note that most of the sectional prices at the wholesale level in the 1980s and some of them in the 1990s appear to have equal state probabilities, as evidenced by the results of Z-tests (the test statistics are not reported here). That is, the 1980s, as compared with the 1970s, stand unique in experiencing an almost equal number of occurrences of increase and non-increase in these price indices. However, most of these indices, considered over the whole period of three decades, do have very high probabilities for cumulative rise (over the previous month).

Table 7 reports the corresponding measures of the error correction force (ECF) or causality – smaller the estimate, greater the convergence force and weaker the causality. The results indicate that most of the price indices in general are chracterised by very slow adjustment dynamics towards equilibrium. To be specific, more than 10 transitions (months) are required for the concerned system to settle down, after a one-time disequilibrium, in each of these cases. The retail price indices often stand out with the most sluggish dynamics, the CPI(UNME) in the 1980s being the only exception with an adjustment period of about 5 months. A feeble ECF indicates much longer persistence of short run, and this is of significant implications for cumulative price increases when the short run probability of price rises are much higher (than the long run ones), indicating causality. Here we have the following results:

1. As we have seen, a positive cell-specific SR greater than 1.645 concludes in favour of a significant causality from that specific state transition. That is, if $[P_{jj} - P(j)] > 1.645/\sqrt{N} = 0.1502$, where N = 120 months in each decade (it is equal to 0.0867 for the overall period with N = 360), then it can be concluded that P_{jj} is significantly greater than its expectation that defines causality from the state j. Table 7 shows that for the three decades as a whole, both the states, ‘positive and non-positive price change’, contribute significantly to causality in most of the cases of price indices. However, the decadal contribution of the two states is significant in a very few cases only. It is significant to note that in the case of general as well as consumer price indices it was the state of ‘non-positive price change’ that significantly contributed to causality during the 1970s and 1990s, whereas both the states significantly affected causality during the 1980s and 1990s in the case of CPI (AL). The same result on state-specific causality is obtained using z-values: ECF > $1.645/[1 - P(j)]\sqrt{N}$. For example, for the general price level during the 1970s the critical

value corresponding to the state 'positive price change' is $1.645/ [1 – P(1)]\sqrt{N} = 1.645/[0.325]\sqrt{120} = 0.462$ and that for the state 'non-positive price change' is 0.222. The ECF (= 0.24) is significant in this case with respect to the latter state only.

2. We also have Chi-square test results for general causality: ECF > $\sqrt{3.841/N}$. For each of the three decades, the critical value is 0.1789 (with N = 120), and for the overall period it is 0.1033 (with N = 360). Table 7 shows that general causality was significant in most of the cases during the overall period and almost so during the 1990s and 1970s. This indicates a weak adjustment process and a long short run persistence, leading to cumulative price rises, as we have explained above.

Thus we have sufficient evidence to recognize the cumulative dynamics of price rises in breeding inflation in India. Given this fact, we can now extend the model to analyze the behaviour of inflation in multiple states such as of degrees of intensity. For example, we consider 8 states of inflation: negative, zero, and 6 other states of inflation ranges as follows: $0 < \rho < 2$; $2 \leq \rho < 5$; $5 \leq \rho < 10$; $10 \leq \rho < 15$; $15 \leq \rho < 20$; and $\rho \geq 20$; where ρ is the monthly inflation rate, defined, following the usual official procedure, on a point to point basis, rather than over the previous month as in our earlier exercise, where we were examining whether price changes were cumulating over previous months. Here we limit this analysis to only a few categories of prices – WPIs of all commodities, primary articles, food articles, food grains, fuel, power, light and lubricants, manufactured products, and the 3 CPIs, for the last three decades. We make use of our computation method (2) in the estimation of the steady state probabilities here; the state transition probabilities are not computed, since our interest is only in the long run ones.

Table 8 reports the results. A marked pattern in the behaviour of the prices subject to their respective environment is clearly seen in the 1970s. Though the general trend is upward-biased, the prices of the primary articles, food articles and food grains capture in their movements the market fluctuations characteristic of them, as evidenced by the long-run probabilities of positive and negative price changes along with very negligible long-run probability of zero price change. Expectedly, the CPI(AL) too reflects this pattern. The manufactured products and the CPI(IW) also had some experiences with deflationary spells during this decade. However, this period witnessed very high double-digit inflation. On the other hand, the next two decades had very little scope for market fluctuation, signifying the possible one-sided price determination. Inflation in the range of $5 \leq \rho < 10$ appears to have ruled the roost, with very high probability in general, though double digit inflation also had its effect. The influence of price control regime is pronounced in the case of fuel, power, light and lubricants with only upward price movement throughout the period.

Given the steady state probability P_j, we can estimate the expected return period of the state j as $1/P_j$. The persistence of inflation in general implies shorter return periods. The results associated with the long run probabilities of Table 8 are shown in Table 9. Thus, the steady state probability of double digit general price inflation of 20 per cent and above during the 1970s being 0.183, the expected return period of such an inflationary state is 1/0.183 = 5.45 months. This means that the 1970s witnessed on an average general price inflation of 20 per cent and above once in 5.45 months. It can be seen that during the past 3 decades, single digit price inflation of 5 and above both at the general and at the retail level (except for the agricultural labourers) visited us almost every 2 months

4. Conclusion

In the present paper, we propose that a price rise becomes cumulative and thus inflationary *not* just when the short-run and long-run probabilities are 'higher', but only if there operates a causality (or temporal dependence). Thus we define a price rise as cumulative and hence inflationary if and only if there exists a *prima facie* causality between the two period price rises. While the sign of the distance between a state transition probability and the corresponding long-run probability yields an indication of causality, its absolute value provides a measure of an error correction mechanism. We find that an error correction necessarily follows a causality or *vice versa*, such that the two *apparently* represent the *same* aspect: farther the distance, larger the error correction factor, and stronger the causality. We make use of the standardised residual method to determine how much stronger causality must be in order to be statistically significant. Our long run probability estimate is based on an earlier result in the context of time series data arranged in a contingency table of present versus previous states, useful when the number of states considered is very large. The results are considered for the last three decades separately and also together for the monthly general price level (WPI – all commodities) and 23 constituent groups/items, as well as for the three consumer price index (CPI) numbers.

The short run transition probabilities estimated clearly indicate a general persistence of increasing price level, with very high probability in the case of most of the price indices in all the three periods, the last period probabilities being much higher. The corresponding expected state duration and the steady state probabilities, computed for all the 27 items under study, also confirm this result that in general inflation persists with high probability in the long-run, suggesting that the monthly price rises were cumulative and hence inflationary in effect. Our two-state Markov chain specification has facilitated easy computation of the measure of error correction force, and helped us quantify the persistence of the short run. The results indicate that most of the price indices in general are chracterised by very slow adjustment dynamics towards equilibrium and thus by a strong causality, and this is of significant implications for cumulative price increases when the short run probability of price rises are much higher (than the long run ones).

Once it has been proved that the monthly price rises in India during the last three decades were inflationary, we have also carried out an analysis of inflation, considering a number of states covering negative, zero, single-digit and double-digits inflation. We have found that higher rates of inflation (i.e., of above 5 per cent) persisted in India in general.

Vijayamohanan Pillai N. *is Associate Fellow at the Centre for Development Studies, Thiruvananthapuram. His main areas of research interest are: Energy Economics, Applied Statistics and Econometrics, Development Economics and Political Economy.*

Email contact: vijayamohan@cds.ac.in

Table 4: Transition Probabilities of Price Changes

	1970s					1980s				
	Positive change		Non-positive		χ^2	Positive change		Non-positive		χ^2
	P_{11}	P_{01}	P_{10}	P_{00}	value	P_{11}	P_{01}	P_{10}	P_{00}	value
1. All Commodities	0.753	0.513	0.247	0.487	20.78	0.75	0.556	0.25	0.444	21.44
2. Primary Articles	0.718	0.524	0.282	0.476	14.92	0.686	0.44	0.314	0.56	10.38
3. Food Articles	0.724	0.477	0.276	0.523	15.3	0.677	0.382	0.323	0.618	11.21
4. Food grains	0.747	0.422	0.253	0.578	19.34	0.657	0.434	0.343	0.566	7.51
5. Cereals	0.682	0.389	0.318	0.611	11.39	0.716	0.358	0.284	0.642	16.8
6. Rice	0.784	0.348	0.216	0.652	28.1	0.818	0.326	0.182	0.674	36.41
7. Wheat	0.735	0.346	0.265	0.654	19.98	0.763	0.475	0.237	0.525	22.15
8. Pulses	0.716	0.457	0.284	0.543	14.19	0.667	0.368	0.333	0.632	10.95
9. Fruits and Vegetables	0.621	0.537	0.379	0.463	4.18*	0.587	0.456	0.413	0.544	2.36*
10. Milk and Milk Products	0.538	0.545	0.462	0.455	0.84*	0.688	0.558	0.312	0.442	11.5
11. Eggs, Fish and Meat	0.574	0.558	0.426	0.442	2.16*	0.636	0.642	0.364	0.358	8.54
12. Non-Food Articles	0.724	0.477	0.276	0.523	15.3	0.623	0.51	0.377	0.49	4.21*
13. Fuel, Power, Light, etc.	0.643	0.5	0.357	0.5	5.71*	0.453	0.433	0.547	0.567	1.68*
14. Mineral Oils	0.591	0.237	0.409	0.763	22.51	0.558	0.358	0.442	0.642	20.33

cont'd...

	1970s					1980s				
	Positive change		Non-positive		χ^2	Positive change		Non-positive		χ^2
	P_{11}	P_{01}	P_{10}	P_{00}	value	P_{11}	P_{01}	P_{10}	P_{00}	value
15. Electricity	0.444	0.455	0.556	0.545	1.21*	0.623	0.407	0.377	0.593	5.74*
16. Manufactured Products	0.783	0.486	0.217	0.514	26.64	0.639	0.521	0.361	0.479	5.64*
17. Food Products	0.681	0.431	0.319	0.569	10.02	0.619	0.404	0.381	0.596	5.69*
18. Sugar, Khandsari & Gur	0.676	0.423	0.324	0.577	9.7	0.667	0.351	0.333	0.649	12.07
19. Edible Oils	0.647	0.462	0.353	0.538	6.19	0.672	0.415	0.328	0.585	9.42
20. Salt	0.699	0.468	0.301	0.532	11.71	0.59	0.441	0.41	0.559	2.81*
21. Textiles	0.729	0.657	0.271	0.343	21.35	0.651	0.386	0.349	0.614	8.7
22. Drugs and Medicines	0.615	0.294	0.385	0.706	14.3	0.52	0.343	0.48	0.657	6.99
23. Fertilisers	0.659	0.177	0.341	0.823	37.05	0.25	0.054	0.75	0.946	91.29
24. Cement, Lime & Plaster	0.39	0.316	0.61	0.684	12.62	0.569	0.419	0.431	0.581	2.72*
25. CPI (Industrial Workers)	0.865	0.387	0.135	0.613	49.05	0.87	0.393	0.13	0.607	51.55
26. CPI (UNME)	0.807	0.432	0.193	0.568	32.01	0.781	0.833	0.219	0.167	41.04
27. CPI (Agricultural Labourers)	0.732	0.388	0.268	0.612	17.81	0.792	0.349	0.208	0.651	30.23

Note: * = Not significant at 5 per cent level; H_0: $P_{ij} = 0.5$, for all $i, j = 0, 1$. The 2 states, 'positive price change' and 'non-positive price change' are denoted respectively by 1 and 0.

Table 4: Transition Probabilities of Price Changes (Continued)

		1990s					Overall				
		Positive change		Non-positive		χ^2 value	Positive change		Non-positive		χ^2 value
		P_{11}	P_{01}	P_{10}	P_{00}		P_{11}	P_{01}	P_{10}	P_{00}	
1.	All Commodities	0.844	0.625	0.156	0.375	46.94	0.785	0.56	0.215	0.44	85.69
2.	Primary Articles	0.747	0.444	0.253	0.556	18.81	0.717	0.467	0.283	0.533	42.78
3.	Food Articles	0.685	0.489	0.315	0.511	10.01	0.696	0.444	0.304	0.556	34.73
4.	Food grains	0.732	0.408	0.268	0.592	16.99	0.714	0.422	0.286	0.578	42.48
5.	Cereals	0.71	0.392	0.29	0.608	14.56	0.703	0.38	0.297	0.62	42.43
6.	Rice	0.768	0.526	0.232	0.474	23.72	0.79	0.394	0.21	0.606	83.96
7.	Wheat	0.763	0.409	0.237	0.591	22.51	0.754	0.404	0.246	0.596	62.99
8.	Pulses	0.676	0.442	0.324	0.558	9.16	0.688	0.419	0.312	0.581	32.95
9.	Fruits and Vegetables	0.613	0.517	0.387	0.483	4.89*	0.607	0.467	0.393	0.533	9.52
10.	Milk and Milk Products	0.623	0.51	0.377	0.49	4.21*	0.621	0.537	0.379	0.463	13.14
11.	Eggs, Fish and Meat	0.603	0.5	0.397	0.5	2.88*	0.606	0.558	0.394	0.442	11.47
12.	Non-Food Articles	0.627	0.491	0.373	0.509	4.33*	0.66	0.493	0.34	0.507	21.84
13.	Fuel, Power, Light, etc.	0.687	0.396	0.313	0.604	11.61	0.605	0.441	0.395	0.559	10.77
14.	Mineral Oils	0.636	0.211	0.364	0.789	28.75	0.595	0.231	0.405	0.769	70.84
15.	Electricity	0.489	0.329	0.511	0.671	8.58	0.525	0.394	0.475	0.606	9.3

cont'd...

		1990s					Overall				
		Positive change		Non-positive		χ^2	Positive change		Non-positive		χ^2
		P_{11}	P_{01}	P_{10}	P_{00}	value	P_{11}	P_{01}	P_{10}	P_{00}	value
16.	Manufactured Products	0.8	0.633	0.2	0.367	34.53	0.747	0.539	0.253	0.461	60.46
17.	Food Products	0.703	0.357	0.297	0.643	15.13	0.668	0.396	0.332	0.604	29.27
18.	Sugar, Khandsari & Gur	0.703	0.339	0.297	0.661	16.35	0.682	0.37	0.318	0.63	37.06
19.	Edible Oils	0.625	0.328	0.375	0.672	11.06	0.649	0.396	0.351	0.604	24.26
20.	Salt	0.702	0.27	0.298	0.73	22.63	0.665	0.385	0.335	0.615	29.78
21.	Textiles	0.744	0.526	0.256	0.474	19.62	0.713	0.5	0.287	0.5	41.76
22.	Drugs and Medicines	0.597	0.414	0.403	0.586	4.05*	0.579	0.347	0.421	0.653	22.49
23.	Fertilisers	0.673	0.225	0.327	0.775	27.32	0.633	0.137	0.367	0.863	144.68
24.	Cement, Lime & Plaster	0.652	0.426	0.348	0.574	7.25	0.558	0.379	0.442	0.621	13.52
25.	CPI (Industrial Workers)	0.844	0.5	0.156	0.5	42.71	0.86	0.427	0.14	0.573	142.21
26.	CPI (UNME)	0.824	0.586	0.176	0.414	39.11	0.804	0.589	0.196	0.411	102.46
27.	CPI(Agricultural Labourers)	0.8	0.356	0.2	0.644	30.76	0.776	0.365	0.224	0.635	77.84

Note: * = Not significant at 5 per cent level; H_0: P_{ij} = 0.5, for all *i*, *j* = 0, 1. The 2 states, ‘positive price change’ and ‘non-positive price change’ are denoted respectively by 1 and 0.

Table 5: Expected Short Run Duration and Cycle (in Months) of Price Changes .

	1970s			1980s			1990s			Overall		
	H_{11}	H_{00}	Cycle	H_{11}	H_{00}	Cycle	H_{11}	H_{00}	Cycle	H_{11}	H_{00}	Cycle
1. All Commodities	4.05	1.95	6	4	1.8	5.8	6.33	1.56	7.89	4.64	1.79	6.43
2. Primary Articles	3.55	1.91	5.46	3.18	2.27	5.45	3.95	2.25	6.2	3.54	2.14	5.68
3. Food Articles	3.62	2.1	5.72	3.1	2.62	5.72	3.17	2.04	5.21	3.29	2.25	5.54
4. Foodgrains	3.95	2.37	6.32	2.91	2.3	5.21	3.74	2.45	6.19	3.49	2.37	5.86
5. Cereals	3.14	2.57	5.71	3.53	2.79	6.32	3.45	2.55	6	3.37	2.63	6
6. Rice	4.63	2.88	7.51	5.5	3.07	8.57	4.32	1.9	6.22	4.76	2.54	7.3
7. Wheat	3.78	2.89	6.67	4.21	2.11	6.32	4.22	2.44	6.66	4.07	2.47	6.54
8. Pulses	3.52	2.19	5.71	3	2.71	5.71	3.09	2.26	5.35	3.2	2.38	5.58
9. Fruits and Vegetables	2.64	1.86	4.5	2.42	2.19	4.61	2.58	2.42	5	2.55	2.14	4.69
10. Milk and Milk Products	2.17	1.86	4.03	2.42	2.19	4.61	2.58	2.42	5	2.55	2.14	4.69
11. Eggs, Fish and Meat	2.34	1.79	4.13	2.75	1.59	4.34	2.52	2	4.52	2.54	1.79	4.33
12. Non-Food Articles	3.62	2.1	5.72	2.65	1.96	4.61	2.68	2.04	4.72	2.94	2.03	4.97
13. Fuel, Power, Light, etc.	2.8	2	4.8	1.83	2.31	4.14	3.19	2.52	5.71	2.53	2.27	4.8
14. Mineral Oils	2.44	4.22	6.66	2.26	4.05	6.31	2.75	4.75	7.5	2.47	4.32	6.79
15. Electricity	1.8	2.2	4	2.65	2.46	5.11	1.96	3.04	5	2.1	2.54	4.64
16. Manufactured Products	4.61	2.06	6.67	2.77	1.92	4.69	5	1.58	6.58	3.95	1.85	5.8

cont'd...

	1970s			1980s			1990s			Overall		
	H_{11}	H_{00}	Cycle	H_{11}	H_{00}	Cycle	H_{11}	H_{00}	Cycle	H_{11}	H_{00}	Cycle
17. Food Products	3.14	2.32	5.46	2.63	2.48	5.11	3.37	2.8	6.17	3.02	2.52	5.54
18. Sugar, Khandsari & Gur	3.09	2.36	5.45	3	2.85	5.85	3.37	2.95	6.32	3.15	2.7	5.85
19. Edible Oils	2.83	2.17	5	3.05	2.41	5.46	2.67	3.05	5.72	2.85	2.52	5.37
20. Salt	3.32	2.14	5.46	2.44	2.27	4.71	3.35	3.71	7.06	2.98	2.6	5.58
21. Textiles	3.7	1.52	5.22	2.86	2.59	5.45	3.9	1.9	5.8	3.48	2	5.48
22. Drugs and Medicines	2.6	3.4	6	2.08	2.92	5	2.48	2.42	4.9	2.38	2.88	5.26
23. Fertilisers	2.93	5.64	8.57	1.33	18.67	20	3.06	4.44	7.5	2.72	7.28	10
24. Cement, Lime & Plaster	1.64	3.16	4.8	2.32	2.38	4.7	2.87	2.35	5.22	2.26	2.64	4.9
25. CPI (Industrial Workers)	7.42	2.58	10	7.67	2.55	10.22	6.43	2	8.43	7.13	2.34	9.47
26. CPI (UNME)	5.19	2.31	7.5	4.57	1.2	5.77	5.69	1.71	7.4	5.09	1.7	6.79
27. CPI (AL)	3.74	2.58	6.32	4.81	2.87	7.68	5	2.81	7.81	4.46	2.74	7.2

Note: H_{11}, H_{00} = Holding time of P_{11} and P_{00}.

Table 6: Long Run Probabilities of Price Changes

	1970s		1980s		1990s		Overall	
	P_1	P_0	P_1	P_0	P_1	P_0	P_1	P_0
1. All Commodities	0.675	0.325	0.7	0.3	0.792	0.208	0.722	0.278
2. Primary Articles	0.65	0.35	0.583	0.417	0.625	0.375	0.619	0.381
3. Food Articles	0.633	0.367	0.542	= 0.458	0.608	0.392	0.594	0.406
4. Foodgrains	0.625	0.375	0.558	= 0.442	0.592	0.408	0.592	0.408
5. Cereals	0.55	= 0.45	0.558	= 0.442	0.575	0.425	0.561	0.439
6. Rice	0.617	0.383	0.642	0.358	0.683	0.317	0.647	0.353
7. Wheat	0.567	0.433	0.667	0.333	0.633	0.367	0.622	0.378
8. Pulses	0.617	0.383	0.525	= 0.475	0.567	0.433	0.569	0.431
9. Fruits and Vegetables	0.55	= 0.45	0.525	= 0.475	0.517	= 0.483	0.531	= 0.469
10. Milk and Milk Products	0.542	= 0.458	0.642	0.358	0.575	0.425	0.586	0.414
11. Eggs, Fish and Meat	0.567	0.433	0.642	0.358	0.567	0.433	0.592	0.408
12. Non-Food Articles	0.633	0.367	0.575	0.425	0.558	= 0.442	0.589	0.411
13. Fuel, Power, Light, etc.	0.583	0.417	0.442	= 0.558	0.558	= 0.442	0.528	= 0.472
14. Mineral Oils	0.367	0.633	0.358	0.642	0.367	0.633	0.364	0.636

cont'd...

	1970s		1980s		1990s		Overall	
	P_1	P_0	P_1	P_0	P_1	P_0	P_1	P_0
15. Electricity	0.45	= 0.55	0.508	= 0.492	0.392	0.608	0.45	0.55
16. Manufactured Products	0.692	0.308	0.6	0.4	0.75	0.25	0.681	0.319
17. Food Products	0.575	0.425	0.525	= 0.475	0.533	= 0.467	0.544	0.456
18. Sugar, Khandsari & Gur	0.567	0.433	0.525	= 0.475	0.533	= 0.467	0.542	0.458
19. Edible Oils	0.567	0.433	0.558	= 0.442	0.467	= 0.533	0.531	= 0.469
20. Salt	0.608	0.392	0.508	= 0.492	0.475	= 0.525	0.531	= 0.469
21. Textiles	0.708	0.292	0.525	= 0.475	0.683	0.317	0.639	0.361
22. Drugs and Medicines	0.433	0.567	0.417	0.583	0.517	= 0.483	0.456	0.544
23. Fertilisers	0.342	0.658	0.067	0.933	0.408	0.592	0.272	0.728
24. Cement, Lime & Plaster	0.342	0.658	0.483	= 0.517	0.55	= 0.45	0.458	0.542
25. CPI (Industrial Workers)	0.742	0.258	0.767	0.233	0.75	0.25	0.753	0.247
26. CPI (UNME)	0.692	0.308	0.8	0.2	0.758	0.242	0.75	0.25
27. CPI (AL)	0.592	0.408	0.642	0.358	0.625	0.375	0.619	0.381

Note: ‘=’ means the two probabilities are not significantly different by *z*-test of proportions.

The 2 states, ‘positive price change’ and ‘non-positive price change’ are denoted respectively by 1 and 0.

Table 7: Measures of Error Correction Factor/Causality

	1970s					1980s				
	$P_{11} - P(1)$	$P_{00} - P(0)$	ECF	CV(j = 1)	CV(j = 0)	$P_{11} - P(1)$	$P_{00} - P(0)$	ECF	CV(j = 1)	CV(j = 0)
1. All Commodities	0.078	0.162*	0.24*	0.462	0.222	0.060	0.134	0.194*	0.484	0.218
2. Primary Articles	0.068	0.126	0.194*	0.429	0.231	0.102	0.144	0.246*	0.361	0.257
3. Food Articles	0.091	0.156*	0.247*	0.410	0.237	0.135	0.16*	0.295*	0.328	0.277
4. Food grains	0.122	0.203*	0.325*	0.401	0.240	0.098	0.125	0.223*	0.340	0.269
5. Cereals	0.132	0.161*	0.293*	0.334	0.273	0.158*	0.2*	0.358*	0.339	0.269
6. Rice	0.167*	0.269*	0.436*	0.392	0.243	0.176*	0.316*	0.492*	0.419	0.234
7. Wheat	0.169*	0.22*	0.389*	0.346	0.265	0.096	0.192*	0.288*	0.451	0.225
8. Pulses	0.099	0.16*	0.259*	0.392	0.243	0.142	0.157*	0.299*	0.316	0.286
9. Fruits and Vegetables	0.035	0.049	0.084	0.363	0.273	0.062	0.069	0.131	0.316	0.286
10. Milk and Milk Products	-0.003	-0.004	-0.007	0.327	0.277	0.047	0.083	0.130	0.419	0.234
11. Eggs, Fish and Meat	0.007	0.009	0.016	0.347	0.265	-0.002	-0.004	-0.006	0.415	0.235
12. Non-Food Articles	0.091	0.156*	0.247*	0.410	0.237	0.048	0.065	0.113	0.353	0.261
13. Fuel, Power, Light, etc.	0.060	0.083	0.143	0.360	0.257	0.011	0.009	0.020	0.269	0.340
14. Mineral Oils	0.224*	0.130	0.354*	0.237	0.409	0.111	0.090	0.2*	0.272	0.335
15. Electricity	-0.006	-0.005	-0.011	0.273	0.334	0.104	0.112	0.216*	0.312	0.296
16. Manufactured Products	0.092	0.205*	0.297*	0.486	0.217	0.048	0.070	0.118	0.367	0.254
17. Food Products	0.106	0.144	0.25*	0.353	0.261	0.104	0.111	0.215*	0.309	0.286
18. Sugar, Khandsari & Gur	0.110	0.143	0.253*	0.346	0.265	0.154*	0.162*	0.316*	0.308	0.286

cont'd...

	1970s					1980s				
	P_{11} – P(1)	P_{00} – P(0)	ECF	CV(*j* = 1)	CV(*j* = 0)	P_{11} – P(1)	P_{00} – P(0)	ECF	CV(*j* = 1)	CV(*j* = 0)
19. Edible Oils	0.080	0.105	0.185*	0.347	0.265	0.113	0.144	0.257*	0.340	0.269
20. Salt	0.090	0.141	0.231*	0.384	0.247	0.072	0.077	0.149	0.312	0.296
21. Textiles	0.021	0.051	0.072	0.514	0.212	0.126	0.139	0.265*	0.316	0.286
22. Drugs and Medicines	0.182*	0.139	0.321*	0.265	0.347	0.103	0.074	0.177	0.257	0.360
23. Fertilisers	0.317*	0.165*	0.482*	0.228	0.439	0.183*	0.013	0.196*	0.161	2.236
24. Cement, Lime & Plaster	0.049	0.025	0.074	0.228	0.440	0.076	0.074	0.150	0.296	0.311
25. CPI (Industrial Workers)	0.124	0.354*	0.478*	0.581	0.203	0.119	0.358*	0.477*	0.604	0.200
26. CPI (UNME)	0.116	0.259*	0.375*	0.486	0.217	-0.011	-0.041	-0.052	0.721	0.190
27. CPI (Agricultural Labourers)	0.141	0.203*	0.344*	0.368	0.254	0.165*	0.278*	0.443*	0.402	0.240
Critical Values	0.1502	0.1502	0.1789			0.1502	0.1502	0.1789		

Notes: ECF = Error Correction Factor, equal to [P_{11} – P(1)] + [P_{00} – P(0)]. CV = Critical Value; * = Significant at 5% level (right-tailed test).
The 2 states, 'positive price change' and 'non-positive price change' are denoted respectively by 1 and 0.

Table 7: Measures of Error Correction Factor/Causality (Continued)

	1990s					Overall				
	P_{11} – P(1)	P_{00} – P(0)	ECF	CV(j = 1)	CV(j = 0)	P_{11} – P(1)	P_{00} – P(0)	ECF	CV(j = 1)	CV(j = 0)
1. All Commodities	0.044	0.175*	0.219*	0.752	0.188	0.062	0.163*	0.225*	0.313	0.120
2. Primary Articles	0.110	0.193*	0.303*	0.414	0.236	0.094*	0.156*	0.25*	0.230	0.139
3. Food Articles	0.077	0.119	0.196*	0.383	0.247	0.102*	0.15*	0.252*	0.213	0.146
4. Food grains	0.128	0.196*	0.324*	0.379	0.249	0.118*	0.174*	0.292*	0.215	0.145
5. Cereals	0.135	0.183*	0.318*	0.353	0.261	0.142*	0.181*	0.323*	0.198	0.154
6. Rice	0.074	0.168*	0.242*	0.491	0.216	0.138*	0.258*	0.396*	0.249	0.133
7. Wheat	0.130	0.224*	0.354*	0.409	0.237	0.132*	0.218*	0.35*	0.229	0.139
8. Pulses	0.099	0.135	0.234*	0.355	0.260	0.115*	0.154*	0.269*	0.203	0.151
9. Fruits and Vegetables	0.041	0.055	0.096	0.351	0.290	0.064	0.076	0.14*	0.190	0.163
10. Milk and Milk Products	0.048	0.065	0.113	0.353	0.261	0.035	0.049	0.084	0.210	0.148
11. Eggs, Fish and Meat	0.046	0.057	0.103	0.339	0.269	0.020	0.028	0.048	0.209	0.148
12. Non-Food Articles	0.059	0.077	0.136	0.348	0.269	0.068	0.099*	0.167*	0.212	0.146
13. Fuel, Power, Light, etc.	0.128	0.163*	0.291*	0.340	0.269	0.077	0.087*	0.164*	0.183	0.164
14. Mineral Oils	0.269*	0.156*	0.425*	0.237	0.409	0.232*	0.132*	0.364*	0.136	0.239
15. Electricity	0.097	0.063	0.160	0.247	0.383	0.072	0.059	0.131*	0.159	0.191
16. Manufactured Products	0.040	0.127	0.167	0.625	0.198	0.066	0.142*	0.208*	0.271	0.127
17. Food Products	0.157*	0.189*	0.346*	0.331	0.282	0.124*	0.148*	0.272*	0.190	0.159
18. Sugar, Khandsari & Gur	0.17*	0.194*	0.364*	0.322	0.282	0.144*	0.168*	0.312*	0.188	0.161

cont'd...

	1990s					Overall				
	$P_{11} - P(1)$	$P_{00} - P(0)$	ECF	CV(j = 1)	CV(j = 0)	$P_{11} - P(1)$	$P_{00} - P(0)$	ECF	CV(j = 1)	CV(j = 0)
19. Edible Oils	0.158*	0.139	0.297*	0.282	0.322	0.119*	0.134*	0.253*	0.185	0.163
20. Salt	0.227*	0.205*	0.432*	0.286	0.316	0.13*	0.15*	0.28*	0.186	0.163
21. Textiles	0.071	0.147	0.218*	0.459	0.223	0.078	0.135*	0.213*	0.238	0.136
22. Drugs and Medicines	0.090	0.093	0.183*	0.304	0.290	0.127*	0.105*	0.232*	0.158	0.192
23. Fertilisers	0.265*	0.183*	0.448*	0.253	0.368	0.361*	0.135*	0.496*	0.119	0.319
24. Cement, Lime & Plaster	0.102	0.124	0.226*	0.334	0.273	0.096*	0.083	0.179*	0.161	0.188
25. CPI (Industrial Workers)	0.082	0.262*	0.344*	0.631	0.197	0.107*	0.326*	0.433*	0.351	0.115
26. CPI (UNME)	0.055	0.183*	0.238*	0.650	0.195	0.054	0.161*	0.215*	0.347	0.116
27. CPI (Agricultural Labourers)	0.16*	0.284*	0.444*	0.417	0.235	0.156*	0.255*	0.411*	0.228	0.140
Critical Values	0.1502	0.1502	0.1789			0.0867	0.0867	0.1033		

Notes: ECF = Error Correction Factor, equal to $[P_{11} - P(1)] + [P_{00} - P(0)]$. CV = Critical Value; * = Significant at 5% level (right-tailed test).
The 2 states, 'positive price change' and 'non-positive price change' are denoted respectively by 1 and 0.

Table 8: Long-Run Probabilities of Inflation

	$\rho < 0$	$\rho = 0$	$0 < \rho < 2$	$2 \leq \rho < 5$	$5 \leq \rho < 10$	$10 \leq \rho < 15$	$15 \leq \rho < 20$	$\rho \geq 20$
1970s								
1. All Commodities	0.167	0.008	0.083	0.092	0.192	0.117	0.158	0.183
2. Primary Articles	0.283	0.025	0.142	0.075	0.092	0.1	0.083	0.2
3. Food Articles	0.25	0.008	0.083	0.075	0.142	0.217	0.075	0.15
4. Food grains	0.208	0	0.058	0.075	0.142	0.183	0.167	0.167
5. Fuel, Power, Light, etc.	0	0	0.150	0.233	0.225	0.092	0.025	0.275
6. Manufactured Products	0.142	0	0.108	0.075	0.125	0.283	0.075	0.192
7. CPI (Industrial Workers)	0.125	0.017	0.067	0.167	0.267	0.167	0.05	0.142
8. CPI (UNME)	0.1	0.017	0.042	0.217	0.275	0.208	0.058	0.083
9. CPI (AL)	0.275	0.008	0.025	0.067	0.100	0.217	0.167	0.142
1980s								
1. All Commodities	0.008	0	0.008	0.167	0.675	0.125	0.017	0
2. Primary Articles	0	0.025	0.092	0.208	0.333	0.283	0.058	0
3. Food Articles	0.042	0.033	0.033	0.183	0.35	0.225	0.117	0.017
4. Food grains	0.125	0.017	0.067	0.192	0.217	0.183	0.183	0.017
5. Fuel, Power, Light, etc.	0	0	0.017	0.267	0.458	0.133	0.058	0.067
6. Manufactured Products	0.067	0	0.025	0.192	0.625	0.083	0.008	0
7. CPI (Industrial Workers)	0	0	0	0.025	0.708	0.25	0.017	0
8. CPI (UNME)	0	0	0	0	0.8	0.2	0	0
9. CPI (AL)	0.025	0.008	0.1	0.275	0.25	0.283	0.058	0

cont'd...

	$\rho < 0$	$\rho = 0$	$0 < \rho < 2$	$2 \le \rho < 5$	$5 \le \rho < 10$	$10 \le \rho < 15$	$15 \le \rho < 20$	$\rho \ge 20$
1990s								
1. All Commodities	0	0	0	0.233	0.525	0.225	0.017	0
2. Primary Articles	0.008	0	0.033	0.217	0.308	0.267	0.142	0.025
3. Food Articles	0.05	0	0.067	0.2	0.325	0.158	0.108	0.092
4. Food grains	0.183	0	0.025	0.1	0.183	0.25	0.167	0.092
5. Fuel, Power, Light, etc.	0.008	0	0.108	0.125	0.158	0.283	0.217	0.1
6. Manufactured Products	0	0	0	0.26	0.41	0.33	0.00	0
7. CPI (Industrial Workers)	0	0.008	0.017	0.158	0.467	0.3	0.05	0
8. CPI (UNME)	0	0	0.008	0.067	0.625	0.275	0.025	0
9. CPI (AL)	0.1	0.017	0.075	0.125	0.258	0.275	0.058	0.092
Overall Period								
1. All Commodities	0.058	0.003	0.031	0.164	0.464	0.156	0.064	0.061
2. Primary Articles	0.097	0.017	0.089	0.167	0.244	0.217	0.094	0.075
3. Food Articles	0.114	0.014	0.061	0.153	0.272	0.200	0.100	0.086
4. Food grains	0.172	0.006	0.050	0.122	0.181	0.206	0.172	0.092
5. Fuel, Power, Light, etc.	0.003	0	0.092	0.208	0.281	0.169	0.100	0.147
6. Manufactured Products	0.069	0	0.044	0.175	0.386	0.233	0.028	0.064
7. CPI (Industrial Workers)	0.042	0.008	0.028	0.117	0.481	0.239	0.039	0.047
8. CPI (UNME)	0.033	0.006	0.017	0.094	0.567	0.228	0.028	0.028
9. CPI (AL)	0.133	0.011	0.067	0.156	0.203	0.258	0.094	0.078

Note: ρ = Rate of Inflation (%).

Table 9: Return Periods of Inflation (in Months)

	$\rho < 0$	$\rho = 0$	$0 < \rho < 2$	$2 \leq \rho < 5$	$5 \leq \rho < 10$	$10 \leq \rho < 15$	$15 \leq \rho < 20$	$\rho \geq 20$
1970s								
1. All Commodities	6	120	12	10.91	5.22	8.57	6.32	5.45
2. Primary Articles	3.53	40	7.06	13.33	10.91	10	12	5
3. Food Articles	4	120	12	13.33	7.06	4.62	13.33	6.67
4. Food grains	4.8	-	17.14	13.33	7.06	5.45	6	6
5. Fuel, Power, Light, etc.	-	-	6.67	4.29	4.44	10.91	40	3.64
6. Manufactured Products	7.06	-	9.23	13.33	8	3.53	13.33	5.22
7. CPI (Industrial Workers)	8	60	15	6	3.75	6	20	7.06
8. CPI (UNME)	10	60	24	4.6	3.6	4.8	17.14	12
9. CPI (AL)	3.64	120	40	15	10	4.62	6	7.06
1980s								
1. All Commodities	120	-	120	6	1.48	8	60	-
2. Primary Articles	-	40	10.91	4.8	3	3.53	17.14	-
3. Food Articles	24	30	30	5.45	2.86	4.44	8.57	60
4. Food grains	8	60	15	5.22	4.62	5.45	5.45	60
5. Fuel, Power, Light, etc.	-	-	60	3.75	2.18	7.5	17.14	15
6. Manufactured Products	15	-	40	5.22	1.6	12	120	-
7. CPI (Industrial Workers)	-	-	-	40	1.41	4	60	-
8. CPI (UNME)	-	-	-	-	1.25	5	-	-
9. CPI (AL)	40	120	10	3.64	4	3.53	17.14	-

cont'd...

	$\rho < 0$	$\rho = 0$	$0 < \rho < 2$	$2 \leq \rho < 5$	$5 \leq \rho < 10$	$10 \leq \rho < 15$	$15 \leq \rho < 20$	$\rho \geq 20$
1990s								
1. All Commodities	-	-	-	4.29	1.90	4.44	60	-
2. Primary Articles	120	-	30	4.62	3.24	3.75	7.06	40
3. Food Articles	20	-	15	5	3.08	6.32	9.23	10.91
4. Food grains	5.45	-	40	10	5.45	4	6	10.91
5. Fuel, Power, Light, etc.	120	-	9.23	8	6.32	3.53	4.62	10
6. Manufactured Products	-	-		3.87	2.45	3	-	-
7. CPI (Industrial Workers)	-	120	60	6.32	2.14	3.33	20	-
8. CPI (UNME)	-	-	120	15	1.6	3.64	40	-
9. CPI (AL)	10	60	13.33	8	3.87	3.64	17.14	10.91
Overall Period								
1. All Commodities	17.14	360	32.73	6.10	2.16	6.43	15.65	16.36
2. Primary Articles	10.29	60	11.25	6	4.09	4.62	10.59	13.33
3. Food Articles	8.78	72	16.36	6.55	3.67	5	10	11.61
4. Food grains	5.81	180	20	8.18	5.54	4.86	5.81	10.91
5. Fuel, Power, Light, etc.	360	-	10.91	4.8	3.56	5.90	10	6.79
6. Manufactured Products	14.4	-	22.5	5.71	2.59	4.29	36	15.65
7. CPI (Industrial Workers)	24	120	36	8.57	2.08	4.19	25.71	21.18
8. CPI (UNME)	30	180	60	10.59	1.76	4.39	36	36
9. CPI (AL)	7.5	90	15	6.43	4.93	3.87	10.59	12.86

Notes: ρ = Rate of Inflation (%); ' – ' denotes infinity.

References

Adelman, I. G. (1958) "A Stochastic Analysis of the Size Distribution of Firms", *Journal of the American Statistical Association*, 53: 893-904.

Anderson, T. W. and Goodman, L. A. (1957). 'Statistical Inference about Markov Chains', *Annals Mathematical Statistics*, Vol. 28: 89-110;

Ash, Robert and Bishop, Richard (1972). 'Monopoly as a Markov Process', *Mathematics Magazine* Vol. 45, January: 26-29.

Bartholomew, D. J. (1967). *Stochastic Models for Social Processes*, John Wiley & Sons, London.

Billingsley, P. (1961). "Statistical Methods in Markov Chains', *Annals Mathematical Statistics*, Vol. 32: 12-40;

Blumen, I., Kogan, M. and McCarthy, P. J. (1955) *The Industrial Mobility of Labour as a Probability Process*, Cornell University Press, Ithaca.

Brody, Andras (2000). 'The Monetary Multiplier', *Economic Systems Research*, Vol. 12 (2), June: 215-219.

Champernowne, D. B. (1953) "A Model of Income Distribution", *Economic Journal*, 63: 318-351.

Chandrasekhar, S. (1943). 'Stochastic Problems in Physics and Astronomy', *Review of Modern physics*, 15: 1 – 89.

Cheshire, Paul and Magrini, Stefano (2000), 'Endogenous Processes in European Regional Growth: Convergence and Policy', *Growth & Change*, 31 (4), Fall: 455-479.

Clark, W. A. V. (1965). 'Markov Chain Analysis in Geography: An Application to the Movement of Rental Housing Areas', *Annals of the Association of American Geographers*, 55: 351-359.

Clark, A. B. and Disney, R. L. (1970) *Probability and Random Processes for Engineers and Scientists*, John Wiley, New York.

Collin, L. (1974). "Estimating Markov Transition Probabilities from Micro-Unit Data', *Applied Statistics*, Vol. 23: 355-371.

Dardanoni, Valentino (1995). 'Income Distribution Dynamics: Monotone Markov Chains Make Light Work', *Social Choice and Welfare*, Vol. 12 (2), March: 181-192.

Debanne, Sara M. et al. (2000). 'Multivariate Markovian Modelling of Tuberculosis: Forecast for the United States', *Emerging Infectious Diseases*, Vol. 6 (2), March/April: 148-157.

Duan, Jin-Chuan and Simonato, Jean-Guy (2001). 'American Option Pricing Under GARCH by a Markov Chain Approximation', *Journal of Economic Dynamics and Control*, Vol. 25 (11), November: 1689-1718.

Gabriel, K. R., and Neumann, J. (1957). 'On a Distribution of Weather Cycles by Length', *Quarterly Journal of Royal Meteorological Society*, Vol. 83: 375-380.

Gabriel, K. R., and Neumann, J. (1962). 'A Markov Chain Model for Daily Rainfall Occurrence at Tel Aviv', *Quarterly Journal of Royal Meteorological Society*, Vol. 88:. 90 – 95.

Hackett, E. Raymond and Magg, Alexander A. (1999). 'Modelling Faculty Replacement Strategies Using A Time-dependent Finite Markov-chain Process', *Journal of Higher Education Policy & Management*, Vol. 21 (1), May: 81-93.

Harris, C. M., Rattner, E. and Sutton, C. (1992). 'Forecasting the Extent of the HIV/AIDS Epidemic', *Socio-Economic Planning Sciences*, Vol. 26 (3), July: 149-168.

Hart, P. E. and Prais, S. J. (1956) "The Analysis of Business Concentration: A Statistical Approach", *Journal of the Royal Statistical Society (A)*, 119: 150-175.

Hicks, John R. (1979) *Causality in Economics*. Oxford: Basil Balckwell

Kawagoe, Masaaki (1999), 'Regional Dynamics in Japan: A Reexamination of Barro Regressions', *Journal of the Japanese and International Economies*, Vol. 13 (1), March: 61-72.

Kendall, M. G. and Stuart, A. (1961) *The Advanced Theory of Statistics*, Vol. 2, Charles Griffin and Co., Ltd., London.

Klemes, V. (1970). "On One Difference between the Gould and Moran Storage Models', *Water Resources Research*, Vol. 7, pp. 410 – 414.

Krenz, Ronald D. (1964). 'Projection of Farm Numbers for North Dakota with Markov Chains', *Agricultural Economics Research*, Vol. 16 (3), July: 77.

Lee, T. C., Judge, G. G. and Zellner, A. (1970). *Estimating the Parameters of the Markov Probability Model for Aggregate Time Series Data*, North Holland, Amsterdam.

Masson, Paul R. (2001). 'Exchange Rate Regime Transitions', *Journal of Development Economics*, Vol. 64 (2), April: 571-586.

McMillen, Daniel P. and McDonald, John F. (1991). 'A Markov Chain Model of Zoning Change', *Journal of Urban Economics*, Vol. 30 (2), September: 257-270.

McQueen, Grant and Thorley, Steven (1991). 'Are Stock Returns Predictable? A Test Using Markov Chains', *Journal of Finance*, 46 (1), March: 239-263.

Medhi, J. (1976). 'A Markov Chain Model for the Occurrence of Dry and Wet Days', *Indian Journal of Meteorology, Hydrology and Geophysics*, 27, pp. 431 – 435.

Moran, P. A. P. (1959). *The Theory of Storage*, Methuen, London.

Neyman, J. (1960). 'Indeterminism in Science and New Demands for Statisticians', *Journal of American Statistical Association*, 55: 625 – 639.

Pillai, N. Vijayamohanan (2002) 'A Markov Chain Model of Inflation in India', *Indian Economic Review*, 37 (1): 91 – 116.

Pillai, N. Vijayamohanan (2004) 'A New Estimate of the Steady State Probability of a Markov Chain: An Application to Power System Reliability Analysis' Centre for Development Studies, *Processed*.

Richardson, Harry W. (1973). 'A Markov Chain Model of Interregional Savings and Capital Growth', *Journal of Regional Service*, 13 (1) April: 17-27.

Rao, V. K. R. V., et al. (1973). *Inflation and India's Economic Crisis*, Institute of Economic Growth and Vikas Publishing House, Delhi.

Sampson, Michael (1990). 'A Markov Chain Model for Unskilled Workers and the Highly Mobile', *Journal of the American Statistical Association*, 85 (409), March: 177-180.

Sendi, Peter P. et al. (1999). 'Systematic Validation of Disease Models for Pharmacoeconomic Evaluations', *Journal of Evaluation in Clinical Practice*, 5 (3), August: 283-295.

Solow, R. (1951) "Some Long-Run Aspects of the Distribution of Wage Incomes", *Econometrica*, 19: 333-334.

Steindl, J. (1965) *Random Processes and the Growth of Firms*, Hafner Publishing Company, New York.

Solberg, J. J. (1975) "A Graph Theoretic Formula for the Steady State Distribution of Finite Markov Processes", *Management Science*, 21: 1040-1048.

Stewart, Ian (1996). 'Monopoly Revisited', *Scientific American*, Vol. 275 (4), October: 116-118.

Temel, T., Tansel, A. and Albersen, P. J. (1999). 'Covergence and Spatial Patterns in Labour Productivity: Nonparametric Estimations for Turkey', *Journal of Regional Analysis and Policy*, 29 (1): 3-19.

Tsiang, S. C. (1978). 'The Diffusion of Reserves and the Money Supply Multiplier', *Economic Journal*, 88 (350), June: 269-284.

Webber, Don J. (2001). 'Convergence of Labour's Factor Reward Between Regions of The EU', *Applied Economics Letters*, 8 (5), May: 355-357.

Whitaker, D. (1978). 'The Derivative of a Measure of Brand Loyalty using a Markov Brand Switching Model', *Journal of Operations Research Society*, Vol. 29, pp. 959 – 970.

CENTRE FOR DEVELOPMENT STUDIES
LIST OF WORKING PAPERS
[New Series]

The Working Paper Series was initiated in 1971. A new series was started in 1996 from WP. 270 onwards. Working papers beginning from 279 can be downloaded from the Centre's website (www.cds.edu)

W.P. 365 **R. MOHAN.** *Central Finances in India - Alternative to Procrustean Fiscal Correction.* November 2004.

W.P. 364 **SUNIL MANI.** *Coping with Globalisation Public R&D Projects in Telecommunications Technologies in Developing Countries.* November 2004.

W.P. 363 **K C ZACHARIAH, S IRUDAYA RAJAN**. *Gulf Revisited Economic Consequences of Emigration From Kerala, Emigration and Unemployment.* September 2004.

W.P. 362 **M. VENKATANARAYANA.** *Educational Deprivation of Children in Andhra Pradesh, Levels and Trends, Disparities and Associative Factors.* August 2004.

W.P. 361 **K. P. KANNAN, VIJAYAMOHANAN PILLAI N.** *Development as a Right to Freedom: An Interpretation of the Kerala Model.* August 2004.

W.P. 360 **VIJAYAMOHANAN PILLAI N.** *CES Function, Generalised Mean and Human Poverty Index: Exploring Some Links.* July 2004.

W.P. 359 **PRAVEENA KODOTH,** *Shifting the Ground of Fatherhood: Matriliny, Men and Marriage in Early Twentieth Century Malabar.* May 2004.

W.P. 358 **MRIDUL EAPEN.** *Women and Work Mobility: Some Disquieting Evidences from the Indian Data.* May 2004.

W.P. 357 **K. RAVI RAMAN.** *The Asian Development Bank Loan for Kerala (India): The Adverse Implications and Search for Alternatives,* March 2004.

W.P. 356 **VIJAYAMOHANAN PILLAI N.** *Liberalisation of Rural Poverty: The Indian Experience*, March 2004.

W.P. 355 **P.L.BEENA** *Towards Understanding the Merger-Wave in the Indian Corporate Sector: A Comparative Perspective,* January 2004.

W.P. 354 **K.P. KANNAN AND R. MOHAN** *India's Twelfth Finance Commission A View from Kerala,* December 2003.

W.P. 353 **K.N. HARILAL AND P.L. BEENA** *The WTO Agreement on Rules of Origin Implications for South Asia,* December 2003.

W.P. 352 **K. PUSHPANGADAN** *Drinking Water and Well-being In India: Data Envelopment Analysis,* October 2003.

W.P. 351 **INDRANI CHAKRABORTY** *Liberalization of Capital Inflows and the Real Exchange Rate in India : A VAR Analysis,* September 2003.

W.P. 350 **M.KABIR** *Beyond Philanthropy: The Rockefeller Foundation's Public Health Intervention in Thiruvithamkoor, 1929-1939,* September 2003.

W.P. 349 **JOHN KURIEN** *The Blessing of the Commons : Small-Scale Fisheries, Community Property Rights, and Coastal Natural Assets,* August 2003.

W.P. 348 **MRIDUL EAPEN,** *Rural Industrialisation in Kerala: Re-Examining the Issue of Rural Growth Linkages,* July 2003.

W.P. 347 **RAKHE PB,** *Estimation of Tax Leakage and its Impact on Fiscal Health in Kerala,* July 2003.

W.P. 346 **VIJAYAMOHANAN PILLAI N,** *A contribution to Peak load pricing theory and Application.* April 2003.

W.P. 345 **V.K. RAMACHANDRAN, MADHURA SWAMINATHAN, VIKAS RAWAL** *Barriers to Expansion of Mass Literacy and Primary Schooling in West Bengal: Study Based on Primary Data from Selected Villages.* April 2003.

W.P. 344 **PRADEEP KUMAR PANDA** *Rights-Based Strategies in the Prevention of Domestic Violence,* March 2003.

W.P. 343 **K. PUSHPANGADAN** *Remittances, Consumption and Economic growth in Kerala: 1980-2000,* March 2003.

W.P. 342 **D NARAYANA** *Why is the Credit-deposit Ratio Low in Kerala?* January 2003.

W.P. 341 **MRIDUL EAPEN, PRAVEENA KODOTH** *Family Structure, Women's Education and Work: Re-examining the High Status of Women in Kerala.* November 2002.

W.P. 340 **J. DEVIKA,** *Domesticating Malayalees: Family Planning, the Nation and Home-Centered Anxieties in Mid- 20th Century Keralam.* October, 2002.

W.P. 339 **M PARAMESWARAN,** *Economic Reforms and Technical Efficiency: Firm Level Evidence from Selected Industries in India.* October, 2002.

W.P. 338 **PRAVEENA KODOTH,** *Framing Custom, Directing Practices: Authority, Property and Matriliny under Colonial Law in Nineteenth Century Malabar,* October 2002.

W.P. 337 **K.NAVANEETHAM**, *Age Structural Transition and Economic Growth: Evidence From South and Southeast Asia,* August 2002.

W.P. 336 **PULAPRE BALAKRISHNAN, K. PUSHPANGADAN, M. SURESH BABU,** *Trade Liberalisation, Market Power and Scale Efficiency in Indian Industry,* August 2002.

W.P. 335 **J. DEVIKA,** *Family Planning as 'Liberation': The Ambiguities of 'Emancipation from Biology' in Keralam* July 2002.

W.P. 334 **E. ABDUL AZEEZ,** *Economic Reforms and Industrial Performance an Analysis of Capacity Utilisation in Indian Manufacturing,* June 2002.

W.P. 333 **K. PUSHPANGADAN** *Social Returns from Drinking Water, Sanitation and Hygiene Education: A Case Study of Two Coastal Villages in Kerala*, May 2002.

W.P. 332 **K. P. KANNAN,** Th*e Welfare Fund Model of Social Security for Informal Sector Workers: The Kerala Experience.* April 2002.

W.P. 331 **SURESH BABU,** *Economic Reforms and Entry Barriers in Indian Manufacturing.* April 2002.

W.P. 330 **ACHIN CHAKRABORTY,** *The Rhetoric of Disagreement in Reform Debates* April 2002.

W.P. 329 **J. DEVIKA,** *Imagining Women's Social Space in Early Modern Keralam.* April 2002.

W.P. 328 **K. P. KANNAN, K. S. HARI,** *Kerala's Gulf Connection Emigration, Remittances and their Macroeconomic Impact 1972-2000.* March 2002.

W.P. 327 **K. RAVI RAMAN,** *Bondage in Freedom, Colonial Plantations in Southern India c. 1797-1947.* March 2002.

W.P. 326 **K.C. ZACHARIAH, B.A. PRAKASH, S. IRUDAYA RAJAN,** *Gulf Migration Study : Employment, Wages and Working Conditions of Kerala Emigrants in the United Arab Emirates.* March 2002.

W.P. 325 **N. VIJAYAMOHANAN PILLAI,** *Reliability and Rationing cost in a Power System.* March 2002.

W.P. 324 **K. P. KANNAN, N. VIJAYAMOHANAN PILLAI,** *The Aetiology of the Inefficiency Syndrome in the Indian Power Sector Main Issues and Conclusions of a Study.* March 2002.

W.P. 323 **V. K. RAMACHANDRAN, MADHURA SWAMINATHAN, VIKAS RAWAL,** *How have Hired Workers Fared? A Case Study of Women Workers from an Indian Village, 1977 to 1999.* December 2001.

W.P. 322 **K. C. ZACHARIAH,** *The Syrian Christians of Kerala: Demographic and Socioeconomic Transition in the Twentieth Century,* November 2001.

W.P. 321 **VEERAMANI C.** *Analysing Trade Flows and Industrial Structure of India: The Question of Data Harmonisation,* November 2001.

W.P. 320 **N. VIJAYAMOHANAN PILLAI, K. P. KANNAN,** *Time and Cost Over-runs of the Power Projects in Kerala,* November 2001.

W.P. 319 **K. C. ZACHARIAH**, **P. R. GOPINATHAN NAIR, S. IRUDAYARAJAN** *Return Emigrants in Kerala: Rehabilitation Problems and Development Potential.* October 2001

W.P. 318 **JOHN KURIEN, ANTONYTO PAUL** *Social Security Nets for Marine Fisheries-The growth and Changing Composition of Social Security Programmes in the Fisheries Sector of Kerala State, India.* September 2001.

W.P. 317 **K. J. JOSEPH, K. N. HARILAL** *India's IT Export Boom: Challenges Ahead.* July 2001.

W.P. 316 **K. P. KANNAN, N. VIJAYAMOHANAN PILLAI** *The Political Economy of Public Utilities: A Study of the Indian Power Sector,* June 2001.

W.P. 315 **ACHIN CHAKRABORTY** *The Concept and Measurement of Group Inequality,* May 2001.

W.P. 314 **U.S.MISHRA, MALA RAMANATHAN** *Delivery Compli-cations and Determinants of Caesarean Section Rates in India - An Analysis of National Family Health Surveys, 1992-93,* March 2001.

W.P. 313 **VEERAMANI. C** *India's Intra-Industry Trade Under Economic Liberalization: Trends and Country Specific Factors,* March 2001

W.P. 312 **N. VIJAYAMOHANAN PILLAI** *Electricity Demand Analysis and Forecasting –The Tradition is Questioned,* February 2001

W.P. 311 **INDRANI CHAKRABORTY** *Economic Reforms, Capital Inflows and Macro Economic Impact in India,* January 2001

W.P. 310 **K. K. SUBRAHMANIAN. E. ABDUL AZEEZ***, Industrial Growth In Kerala: Trends And Explanations* November 2000

W.P. 309 **V. SANTHAKUMAR, ACHIN CHAKRABORTY,** *Environmental Valuation and its Implications on the Costs and Benefits of a Hydroelectric Project in Kerala, India,* November 2000.

W.P. 308 **K. P. KANNAN, N . VIJAYAMOHANAN PILLAI,** *Plight of the Power Sector in India : SEBs and their Saga of Inefficiency* November 2000.

W.P. 307 **K. NAVANEETHAM, A. DHARMALINGAM,** *Utilization of Maternal Health Care Services in South India,* October 2000.

W.P. 306 **S. IRUDAYA RAJAN,** *Home Away From Home: A Survey of Oldage Homes and inmates in Kerala,* August 2000.

W.P. 305 **K. N. HARILAL, K.J. JOSEPH,** *Stagnation and Revival of Kerala Economy: An Open Economy Perspective,* August 2000.

W.P. 304 **K. P. KANNAN,** *Food Security in a Regional Perspective; A View from 'Food Deficit' Kerala,* July 2000.

W.P. 303 **K. C. ZACHARIAH, E. T. MATHEW, S. IRUDAYA RAJAN ,** *Socio-Economic and Demographic Consequenes of Migration in Kerala,* May 2000.

W.P. 302 **K. PUSHPANGADAN, G. MURUGAN,** *Gender Bias in a Marginalised Community: A Study of Fisherfolk in Coastal Kerala,* May 2000.

W.P. 301 **P. L. BEENA** *An Analysis of Mergers in the Private Corporate Sector in India,* March, 2000.

W.P. 300 **D. NARAYANA** *Banking Sector Reforms and the Emerging Inequalities in Commercial Credit Deployment in India,* March, 2000.

W.P. 299 **JOHN KURIEN** *Factoring Social and Cultural Dimensions into Food and Livelihood Security Issues of Marine Fisheries; A Case Study of Kerala State, India,* February, 2000.

W.P. 298 **D. NARAYANA, K. K. HARI KURUP,** *Decentralisation of the Health Care Sector in Kerala : Some Issues,* January, 2000.

W.P. 297 **K.C. ZACHARIAH, E. T. MATHEW, S. IRUDAYA RAJAN** *Impact of Migration on Kerala's Economy and Society,* July, 1999.

W.P. 296 **P.K. MICHAEL THARAKAN , K. NAVANEETHAM** *Population Projection and Policy Implications for Education:A Discussion with Reference to Kerala,* July, 1999.

W.P. 295 **N. SHANTA, J. DENNIS RAJA KUMAR** *Corporate Statistics: The Missing Numbers,* May, 1999.

W.P. 294 **K. P. KANNAN** *Poverty Alleviation as Advancing Basic Human Capabilities: Kerala's Achievements Compared,* May, 1999.

W.P. 293 **MRIDUL EAPEN** *Economic Diversification In Kerala : A Spatial Analysis,* April, 1999.

W.P. 292 **PRADEEP KUMAR PANDA** *Poverty and young Women's Employment: Linkages in Kerala,* February, 1999.

W.P. 291 **P. K. MICHAEL THARAKAN** *Coffee, Tea or Pepper? Factors Affecting Choice of Crops by Agro-Entrepreneurs in Nineteenth Century South-West India,* November 1998

W.P. 290 **CHRISTOPHE Z. GUILMOTO, S. IRUDAYA RAJAN** *Regional Heterogeneity and Fertility Behaviour in India,* November 1998.

W.P. 289 **JOHN KURIEN** *Small Scale Fisheries in the Context of Globalisation,* October 1998.

W.P. 288 **S. SUDHA, S. IRUDAYA RAJAN** *Intensifying Masculinity of Sex Ratios in India : New Evidence 1981-1991,* May 1998.

W.P. 287 **K. PUSHPANGADAN, G. MURUGAN** *Pricing with Changing Welfare Criterion: An Application of Ramsey- Wilson Model to Urban Water Supply,* March 1998.

W.P. 286 **ACHIN CHAKRABORTY** *The Irrelevance of Methodology and the Art of the Possible : Reading Sen and Hirschman,* February 1998.

W.P. 285 **V. SANTHAKUMAR** *Inefficiency and Institutional Issues in the Provision of Merit Goods,* February 1998.

W.P. 284 **K. P. KANNAN** *Political Economy of Labour and Development in Kerala,* January 1998.

W.P. 283 **INDRANI CHAKRABORTY** *Living Standard and Economic Growth: A fresh Look at the Relationship Through the Non- Parametric Approach,* October 1997.

W.P. 282 **S. IRUDAYA RAJAN, K. C. ZACHARIAH** *Long Term Implications of Low Fertility in Kerala,* October 1997.

W.P. 281 **SUNIL MANI** *Government Intervention in Industrial R & D, Some Lessons from the International Experience for India,* August 1997.

W.P. 280 **PRADEEP KUMAR PANDA** *Female Headship, Poverty and Child Welfare : A Study of Rural Orissa, India,* August 1997.

W.P. 279 **U.S. MISRA, MALA RAMANATHAN, S. IRUDAYA RAJAN** Induced Abortion Potential Among Indian Women, August 1997.

W. P. 278 **PRADEEP KUMAR PANDA** *The Effects of Safe Drinking Water and Sanitation on Diarrhoeal Diseases Among Children in Rural Orissa,* May 1997.

W. P. 277 **PRADEEP KUMAR PANDA** *Living Arrangements of the Elderly in Rural Orissa,* May 1997.

W. P. 276 **V. SANTHAKUMAR** *Institutional Lock-in in Natural Resource Management: The Case of Water Resources in Kerala,* April 1997.

W.P. 275 **G. OMKARNATH** *Capabilities and the process of Development* March 1997.

W.P. 274 **K. PUSHPANGADAN, G. MURUGAN** *User Financing & Collective action: Relevance sustainable Rural water supply in India.* March 1997.

W.P. 273 **ROBERT E. EVENSON, K.J. JOSEPH** *Foreign Technology Licensing in Indian Industry : An econometric analysis of the choice of partners, terms of contract and the effect on licensees' performance* March 1997.

W.P. 272 **SUNIL MANI** *Divestment and Public Sector Enterprise Reforms, Indian Experience Since 1991* February 1997.

W.P. 271 **SRIJIT MISHRA** *Production and Grain Drain in two inland Regions of Orissa* December 1996.

W.P. 270 **ACHIN CHAKRABORTY** *On the Possibility of a Weighting System for Functionings* December 1996.

BOOKS PUBLISHED BY THE CDS

Biodiversity, Sustainable Development and Economic Analysis
J. Hans B. Opschoor
CDS, 2004, Rs. 100/$11

Plight of the Power Sector in India: Inefficiency, Reform and Political Economy
K.P. Kannan and N. Vijayamohanan Pillai
CDS, 2002, Rs. 400/$40

Kerala's Gulf Connection: **CDS Studies on International Labour Migration from Kerala State in India**
K.C. Zachariah, K. P. Kannan, S. Irudaya Rajan (eds)
CDS, 2002, pp 232, Hardcover, Rs. 250/$25

Performance of Industrial Clusters: A Comparative Study of Pump Manufacturing Cluster in Coimbatore (Tamil Nadu) & Rubber Footwear Cluster in Kottayam (Kerala)
P. Mohanan Pillai
CDS, 2001, pp 158, Paperback, Rs. 175/$18

Poverty, Unemployment and Development Policy : A Case Study of Selected Issues With Reference to Kerala
United Nations, 2000 (reprint), pp 235
(available for sale in India only), Rs. 275

Land Relations and Agrarian Development in India:A Comparative Historical Study of Regional Variations
Sakti Padhi
CDS,1999. pp 335, Hardcover, Rs. 425/$48

Agrarian Transition Under Colonialism: Study of A Semi Arid Region of Andhra, C.1860-1900
GN Rao
CDS,1999. pp 133, Paperback, Rs. 170/ $19

Property Rights, Resource Management & Governance: Crafting An Institutional Framework for Global Marine Fisheries
John Kurien
CDS & SIFFS, 1998. pp 56, Paperback, Rs. 50/ $10

Health, Inequality and Welfare Economics
Amartya Sen
CDS. 1996. pp 26, Paperback, Rs. 70/ $ 10

Industrialisation in Kerala: Status of Current Research and Future Issues
P Mohanan Pillai & N Shanta
CDS. 1997. pp 74, Paperback, Rs. 110/ $ 12

CDS M.Phil Theses (1990/91-1993/94): A Review Vol.II
T T Sreekumar
CDS. 1996. pp 99, Paperback, Rs. 120/$ 14

Trends In Agricultural Wages in Kerala 1960-1990
A A Baby
CDS. 1996. pp 83, Paperback, Rs. 105/ $ 12

CDS M.Phil Theses (1975/76-1989/90): A Review Vol.1
G N Rao
CDS. 1996. pp 162, Paperback, Rs. 155/ $ 18

Growth of Education in Andhra - A Long Run View
C Upendranath
CDS. 1994. pp 158, Paperback, Rs. 135/ $ 15

Growth of Market Towns in Andhra: A Study of the Rayalseema Region C 1900-C.1945
Namerta
CDS. 1994. pp 186, Paperback, Rs.125/ $ 14

Floods and Flood Control Policies: an Analysis With Reference to the Mahanadi Delta in Orissa
Sadhana Satapathy
CDS. 1993 pp 98, Paperback, Rs. 110/$ 12

Growth of Firms in Indian Manufacturing Industry
N Shanta
CDS. 1994. pp 228, Hardcover, Rs. 250/ $ 28

Demographic Transition in Kerala in the 1980s
K C Zachariah, S Irudaya Rajan, P S Sarma, K Navaneetham,
P S Gopinathan Nair & U S Mishra,
CDS. 1999 (2nd Edition) pp 305, Paperback, Rs.250/ $ 28

Impact of External Transfers on the Regional Economy of Kerala
P R Gopinathan Nair & P Mohanan Pillai
CDS 1994. pp 36, Paperback, Rs.30/ $ 10

Urban Process in Kerala 1900-1981
T T Sreekumar
CDS. 1993. pp 86, Paperback, Rs.100/ $ 11

Peasant Economy and The Sugar Cooperative: A Study Of The Aska Region in Orissa
Keshabananda Das
CDS. 1993. pp 146, Paperback, Rs.140/ $ 16

Industrial Concentration and Economic Behaviour: Case Study of Indian Tyre Industry
Sunil Mani
CDS. 1993. pp 311, Hardcover, Rs. 300/ $ 34

Limits To Kerala Model of Development: An Analysis of Fiscal Crisis and Its Implications.
K K George
CDS. 1999 (2nd edition) pp 128, Paperback, Rs. 160/ $ 18

Indian Industrialization: Structure and Policy Issues. (No Stock)
Arun Ghosh, K K Subrahmanian, Mridul Eapen & Haseeb A Drabu (EDs).
OUP. 1992. pp 364, Hardcover, Rs.350/ $ 40

Rural Household Savings and Investment: A Study of Some Selected Villages
P G K Panikar, P Mohanan Pillai & T K Sundari
CDS. 1992. pp 144, Paperback, Rs. 50/ $ 10

International Environment, Multinational Corporations and Drug Policy
P G K Panikar, P Mohanan Pillai & T K Sundari
CDS. 1992. pp 77, Paperback, Rs.40/ $ 10

Trends in Private Corporate Savings
N Shanta
CDS. 1991. pp 90, Paperback, Rs. 25/ $ 10

Coconut Development in Kerala: Ex-post Evaluation
D Narayana, K N Nair, P Sivanandan, N Shanta and
G N Rao
CDS. 1991. pp 139, Paperback, Rs.40/ $ 10

Caste and The Agrarian Structure
T K Sundari
Oxford & IBH. 1991. pp 175, Paperback, Rs.125/ $ 14

Livestock Economy of Kerala
P S George and K N Nair
CDS. 1990. pp 189, Hardcover, Rs. 95/ $ 10

The Pepper Economy of India (No Stock)
P S George, K N Nair and K Pushpangadan
Oxford & IBH. 1989. pp 88, Paperback, Rs. 65/ $ 10

The Motor Vehicle Industry in India
(Growth within a Regulatory Environment)
D Narayana
Oxford & IBH. 1989. pp 99, Paperback, Rs. 75/ $ 10

Ecology or Economics in Cardamom Development
(No Stock)
K N Nair, D Narayana and P Sivanandan
Oxford & IBH. 1989. pp 99, Paperback, Rs. 75/ $ 10

Land Transfers and Family Partitioning
D Rajasekhar
Oxford and IBH. 1988. pp 90, Hardcover, Rs. 66/ $ 10

Essays in Federal Financial Relations
I S Gulati and K K George
Oxford and IBH. 1988. pp 172, Hardcover, Rs. 82/ $ 10

Bovine Economy in India
A Vaidyanathan
Oxford & IBH. 1988. pp 209, Hardcover, Rs. 96/ $ 11

Health Status of Kerala
P G K Panikar and C R Soman
CDS. 1984. pp 159, Hardcover , Rs.100/ $ 11 & Paperback, Rs. 75/ $ 10

—