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CONTRIBUTIONS TO BOOKS

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

CONFERENCE PAPERS

- Garg Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

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- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

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- Garg, Bhavet (2011): Towards a New Natural Gas Policy, Economic and Political Weekly, Viewed on July 05, 2011 http://epw.in/user/viewabstract.jsp

A MARKOV CHAIN APPROACH TO INFLATION IN INDIA SINCE 2001

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ABSTRACT

One of the most important objectives of Monetary and Fiscal Policy is to promote economic growth with price stability in the country. When price increases due to shortfall in productivity, the increase in price will powerfully decrease purchasing power and demand for commodity. This paper makes an attempt to use appropriate statistical method to predict the changes in inflation by using a well known approach called Markov Chain Model which employs a probabilistic view to analyze the price changes in India since 2001.

KEYWORDS

Consumer Price Index, Inflation, Indian Economy, Markov Chain Approach, Wholesale Price Index.

INTRODUCTION

Inflation is as violent as a mugger, as frightening as an armed robber and as deadly as a hit man", quotes the 40th US President Ronald Reagan in one of his speeches. Inflation has been a vital economic concern in almost all the developing countries. It wouldn't be incorrect to say that inflation has absorbed India into its jagged tentacles. Inflation can be defined as the rise in overall price level in the economy, i.e. rise in prices of all the goods and services. When prices rise, each rupee buys less goods and services than it had been before, consequently eroding the purchasing power of money. It is measured through inflation rate- the annualized percentage change in a general price index (Consumer Price Index and Wholesale Price Index) over time[1].

HISTORY OF INFLATION IN INDIA

Since independence, India has been plagued by the malady of inflation, though the ill effects of inflation have been prominent since 1991, post liberalization. With a quick look into the past, one could certainly state that prices have rarely dropped in our country. From the 1950s, inflation has been mostly triggered by impediments in agricultural production due to poor monsoons, with things aggravating when prices of industrial raw materials have increased. Since the 1960s, voluminous fiscal deficits with the subsequent injection of money into the economy, and the hoarding of essential commodities by speculators, have been few factors causing inflation.

Dire monsoons and harvests caused inflation in the mid-'50s; while in the mid-'60s, industrial output lost pace, agricultural production was hindered, followed the devaluation of the rupee all these triggered high inflation from 1964-65 to 1967-68. The international oil crisis of 1973 happened together raising the inflation above 16 per cent. In 1975-76 during the Emergency inflation came down to zero owing to good agricultural production and a clear out on speculation in commodities. It was only during the emergency time that the inflation was low.

The budget of 1979 stimulated price hikes by imposing higher indirect taxes on some essential commodities because of which we observe reversal in the trend again. This alleviated little in 1985-86, as the food grain production increased, which was at a record 150 million tonnes. But in the following and in subsequent years, agricultural production suffered.

Since 1990s, India witnessed very high inflation. The Balance of Payment crisis in 1991, because of deficits in government finances and devaluation of the rupee, an extremely high inflation of 13.66 per cent was seen in the Indian economy. Though it was controlled later, the average rate of inflation over post liberalisation in the 90's has been a significant value of 9.3 per cent per year. Between the fiscal year 2004-05 and 2007-2008, India had experienced an average growth rate of more than 9%, but the global crisis, the Indian economy faced severe shocks in certain sectors leading to inflationary situation. Inflation in India 2009 stood at 11.49.

SIGNIFICANCE OF THE STUDY

Inflation, by far is very vital in determining the future growth of an economy. A minimal amount of inflation encourages growth of the economy. It induces the investors to induce more because of the increase in the price level. Because the increase in price level is low, the supply won't fall much. So the market forces retain the equilibrium with a supplementary increase in the GDP and other growth indicators.

This study proposes to use statistical methods to predict the changes in inflation by using a well known approach called Markov Chain Model which employs a probabilistic approach to analyze the changes over a certain time period. An analysis of the behaviour of monthly changes in the price index would give us a clear indication of the price movements and would help us predict the future direction of prices. This would be a great advantage for policy making especially in the developing countries which concentrate on growth as well as price stability. This study could also be extended to the states to develop an understanding of growth and the primal causes of inflation using state-wise data (though we don't propose to test the data for the states in this study).

Many studies have developed different econometric models to predict inflation. These models have been developed based on certain assumptions and have been tested only for a particular set of data. Testing the empirical relevance of a model developed is utmost important when we want to employ it for future predictions of price movements. Through this study we intend to test the empirical relevance of the Markov Chain Model of Inflation.

OBJECTIVES OF THE STUDY

The study is basically an extension of Dr. Vijayamohanan Pillai's paper where the Markov Chain Model was used to test the predicted series of price changes with the actual, over the period 1980-2000 i.e., for 240 months.

- The study proposes to test whether the price rise is cumulative and hence inflationary.
- Whether the Markov Chain Model can be used to predict inflation in the immediate future.

DATA SOURCES AND PERIOD OF STUDY

Whole Price Index (WPI) monthly data from 2001-2010, with base year as 1993-94 has been obtained from Office of the Economic Adviser to the Government of India, Ministry of Commerce and Industry.

Authenticity of data is not at stake as the same data is also available in the Handbook of Statistics of the Indian Economy, published by the Reserve Bank of India (RBI).

HYPOTHESIS

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).

STATISTICAL TOOLS AND METHODOLOGY

Markov Chain Probability Estimates are the basic building blocks of the Model. We use simple hypothesis testing using Chi-Squared and Normal Distribution. We use statistical regression and probabilistic tools of SPSS software to analyze the data.

The Markov Chain Model adopted by Dr. Vijayamohanan Pillai, in his study "A Markov Chain Model for Inflation in India" is used. The WPI values of Inflation are considered for the analysis, where the price inflation in percent (%) over the previous month is calculated.

We describe a Markov chain as follows: We have a set of states, S = {s1, s2 .... sr}. The process starts in one of these states and moves successively from one state to another. Each move is called a step. If the chain is currently in state **si**, then it moves to state **sj** at the next step with a probability denoted by **pij**, and this probability does not depend upon which states the chain was in before the current state. The probabilities **pij** are called transition probabilities. The process can remain in the state it is in, and this occurs with probability **pii**. An initial probability distribution defined on S, specifies the starting state. Usually this is done by specifying a particular state as the starting state. [2] **pij** is conditional probability.

The analysis can be done using 2 states as well as 3 states. We consider the former case for study in this paper. When we define 3 states we have a positive state, a zero state and a negative state; and when 2 states are defined we have a positive and a non-positive state.

FIGURE: FREQUENCY DISTRIBUTIONS OF TRANSITIONS FROM THE PREVIOUS STATE I TO THE PRESENT STATE J

	Current State								
		1	2	..	..	j	..	..	m	Total
Previous State	1	n11	n12			n1j			n1m	n1
	2	n21	n22			n2j			n2m	n2
	i	ni1	ni2			nij			nim	ni
	m	nm1	nm2			nmj			nmm	nm
TOTAL		n.1	n.2			n.j			n.m	N

Using Maximum Likelihood Estimates we can calculate the values of **pij** wich is the probability of transition from the current state to the next state.

$$P(j|i) = \frac{P(i,j)}{P(i)} = \frac{n_{ij}/N}{n_{i\bullet}/N} = \frac{n_{ij}}{n_{i\bullet}} = P_{ij}.$$

= corresponding row sum

Also, we have

$$P_{ij} = n_{ij} / \sum_{j=1}^{m} n_{ij} = n_{ij} / n_{i\bullet},$$

---------- **(1)**

LIMITATIONS OF THE STUDY

The global economic crisis of 2007 had an impact on inflation, so predictions of the model during the crisis period could be faulty though it might not be the case. Also we are considering all commodityprices rather than individual prices, so we won't be able to predict which commodity are the main the cause of inflation.

Sometimes while using Markov chains though there is sufficient data, there might not be enough number of transition states to give a closed set of transient data. It could be due to various factors like a sudden recession or a rare climatic event.

REVIEW OF LITERATURE

Dr. Vijaymohanan Pillai (2002) in his paper "A Markov Chain Model of Inflation in India" tests the Markov model for price movements on WPI and other price indices. The analysis was done for a period of 1981-2001 in 2 phases i.e. pre-liberalisation and post liberalisation. The transition probabilities and steady state probabilities were calculated and the results showed that the probability that there is inflation in the economy is high which led to the conclusion that the price rise is inflationary.

Christian Ahlin and Mototsugu Shintani (2007) studied the high inflation and low inflation bands for the optimal pricing of goods and commodities, where the low inflation band was assumed to be contained within the high inflation band. There were 2 states represented by (s,S) contained within the inflation band region. Markov techniques were used to variance of inflation. The position of the states within the band region gives us the price dispersion and inflation. The conclusions drawn were that optimal pricing could pilot inflation because it leads to clustering of prices.

John Simon (1996) use similar Markov techniques to describe inflation in Australia. It also incorporates switching techniques to explicitly allow for structural changes. The paper was helps in understanding the shifts in the inflationary expectations of the public. The conclusions drawn from the paper were discussed at the Reserve Bank of Australia, for new policy decisions which had a positive impact on the economy.

Thams, Andreas (2007) in his paper "Inflation Transmission in the EMU: A Markov-Switching VECM Analysis" analyzes the transmission of inflation across the five largest economies in the European Monetary Union, i.e. France, Germany, Italy, Netherlands and Spain. The main objectives of the paper were to analyze the changes in the inflation using Markov Switching Techniques. Monthly CPI data over the period of 1970-2006 was considered for the analysis. The findings were from the early 1970s upto the mid 1980s there was inflation every time a government switched. Later on there was a stable transmission mechanism adopted leading to low degree of inflation in short and long run.

Ramesh Chand (2010) examined the nature and the causes of food inflation in India in recent past. The study finds that the main reason for increase in food prices is the supply shock due to the drought in 2009 and the carry over effect of the low food production in 2008-2009. This study also emphasises that the major cause of increase in food prices in 2008 was due the influence of exports led by high prices. This study also forecasted that the frequency of these shocks are expected to rise in future and to deal with it India need to have an effective food management strategy. It suggests that timely release of cereals stock held by FCI could reduce prices substantially. It also highlights the importance of increasing storage facilities for various types of food and reducing exports to increase domestic stabilisation stock.

There is a large scope of research on inflation in India which could be done by using Markov Process and other analytical approaches like the Bayesian Approach which could help in predicting inflation.

This study proposes to use statistical methods to predict the changes in inflation by using a well known approach called Markov Chain Model which employs a probabilistic approach to analyze the changes over a certain time period.

TABLE 1: GENERAL PRICE INFLATION (%) OVER THE PREVIOUS MONTH AND THE CORRESPONDING STATES

		WPI	Monthly Inflation		State of the Nature	
			Present	Previous	Present	Previous
					St	St-1
2001	January	158.6				
	February	158.6	0			
	March	159.1	0.315	0	1	0
	April	159.9	0.503	0.315	1	1
	May	160.3	0.25	0.503	1	1
	June	160.8	0.312	0.25	1	1
	July	161.1	0.187	0.312	1	1
	August	161.7	0.372	0.187	1	1
	September	161.7	0	0.372	0	1
	October	162.5	0.495	0	1	0
	November	162.3	-0.123	0.495	0	1
	December	161.8	-0.308	-0.123	0	0
2002	January	161	-0.494	-0.308	0	0
	February	160.8	-0.124	-0.494	0	0
	March	161.9	0.684	-0.124	1	0
	April	162.3	0.247	0.684	1	1
	May	162.8	0.308	0.247	1	1
	June	164.7	1.167	0.308	1	1
	July	165.6	0.546	1.167	1	1
	August	167.1	0.906	0.546	1	1
	September	167.4	0.18	0.906	1	1
	October	167.5	0.06	0.18	1	1
	November	167.8	0.179	0.06	1	1
	December	167.2	-0.358	0.179	0	1
2003	January	167.8	0.359	-0.358	1	0
	February	169.4	0.954	0.359	1	1
	March	171.6	1.299	0.954	1	1
	April	173.1	0.874	1.299	1	1
	May	173.4	0.173	0.874	1	1
	June	173.5	0.058	0.173	1	1
	July	173.4	-0.058	0.058	0	1
	August	173.7	0.173	-0.058	1	0
	September	175.6	1.094	0.173	1	1
	October	176.1	0.285	1.094	1	1
	November	176.9	0.454	0.285	1	1
	December	176.8	-0.057	0.454	0	1
2004	January	178.7	1.075	-0.057	1	0
	February	179.8	0.616	1.075	1	1
	March	179.8	0	0.616	0	1
	April	180.9	0.612	0	1	0
	May	182.1	0.663	0.612	1	1
	June	185.2	1.702	0.663	1	1
	July	186.6	0.756	1.702	1	1
	August	188.4	0.965	0.756	1	1
	September	189.4	0.531	0.965	1	1
	October	188.9	-0.264	0.531	0	1
	November	190.2	0.688	-0.264	1	0
	December	188.8	-0.736	0.688	0	1
2005	January	188.6	-0.106	-0.736	0	0
	February	188.8	0.106	-0.106	1	0
	March	189.4	0.318	0.106	1	1
	April	191.6	1.162	0.318	1	1
	May	192.1	0.261	1.162	1	1
	June	193.2	0.573	0.261	1	1
	July	194.6	0.725	0.573	1	1
	August	195.3	0.36	0.725	1	1
	September	197.2	0.973	0.36	1	1
	October	197.8	0.304	0.973	1	1
	November	198.2	0.202	0.304	1	1
	December	197.2	-0.505	0.202	0	1
2006	January	196.3	-0.456	-0.505	0	0
	February	196.4	0.051	-0.456	1	0
	March	196.8	0.204	0.051	1	1
	April	199	1.118	0.204	1	1

	May	201.3	1.156	1.118	1	1
	June	203.1	0.894	1.156	1	1
	July	204	0.443	0.894	1	1
	August	205.3	0.637	0.443	1	1
	September	207.8	1.218	0.637	1	1
	October	208.7	0.433	1.218	1	1
	November	209.1	0.192	0.433	1	1
	December	208.4	-0.335	0.192	0	1
2007	January	208.8	0.192	-0.335	1	0
	February	208.9	0.048	0.192	1	1
	March	209.8	0.431	0.048	1	1
	April	211.5	0.81	0.431	1	1
	May	212.3	0.378	0.81	1	1
	June	212.3	0	0.378	0	1
	July	213.6	0.612	0	1	0
	August	213.8	0.094	0.612	1	1
	September	215.1	0.608	0.094	1	1
	October	215.2	0.046	0.608	1	1
	November	215.9	0.325	0.046	1	1
	December	216.4	0.232	0.325	1	1
2008	January	218.1	0.786	0.232	1	1
	February	219.9	0.825	0.786	1	1
	March	225.5	2.547	0.825	1	1
	April	228.5	1.33	2.547	1	1
	May	231.1	1.138	1.33	1	1
	June	237.4	2.726	1.138	1	1
	July	240	1.095	2.726	1	1
	August	241.2	0.5	1.095	1	1
	September	241.5	0.124	0.5	1	1
	October	239	-1.035	0.124	0	1
	November	234.2	-2.008	-1.035	0	0
	December	229.7	-1.921	-2.008	0	0
2009	January	228.9	-0.348	-1.921	0	0
	February	227.6	-0.568	-0.348	0	0
	March	228.2	0.264	-0.568	1	0
	April	231.5	1.446	0.264	1	1
	May	234.3	1.21	1.446	1	1
	June	235	0.299	1.21	1	1
	July	238.7	1.574	0.299	1	1
	August	240.8	0.88	1.574	1	1
	September	242.6	0.748	0.88	1	1
	October	242.5	-0.041	0.748	0	1
	November	247.2	1.938	-0.041	1	0
	December	248.3	0.445	1.938	1	1
2010	January	250.5	0.886	0.445	1	1
	February	250.5	0	0.886	0	1
	March	253.4	1.158	0	1	0
	April	257.5	1.618	1.158	1	1
	May	260.4	1.126	1.618	1	1
	June	261	0.23	1.126	1	1
	July	263.3	0.881	0.23	1	1
	August	263.8	0.19	0.575	1	1

Source: Handbook of Statistics on the Indian Economy & Computed

Price inflation in % of WPI (all commodities) is estimated over the previous month in the above table.

State=1 for positive change and State=0 for a non-positive change.

Now, a cross table of the current Vs previous price inflation states is found which is basically a 2X2 table. It confirms that $n_{.j} = n_{i.}$ for i=j and $n_{10} = n_{01}$ where n_{10} is the total number of times the event $\{S_t=0 \mid S_{t-1}=1\}$ occur and n_{01} for that of $\{S_t=1 \mid S_{t-1}=0\}$. This result is observed because n_{10} and n_{01} are closely associated.

TABLE 2: FREQUENCY DISTRIBUTION OF INFLATION STATES

		Current Month Price Changes		
		Positive	**Non-Positive**	**Total**
Previous Month Price Changes	**Positive**	76	15	91
	Non-Positive	15	9	24
	Total	91	24	115

The above table is called the transition matrix which would help us determine the long run probabilities of inflation and also the nature of inflation. We use the maximum likelihood estimator which could be used as the long run estimator for predicting future inflation. When we consider more states we will have more variables, which will give us clear picture as to where the cumulative effects were high and would aid in the reasons for those effects. In the long run, we need to figure out ways to maintain low and steady inflation through suitable policy implementations.

$$P(j) = n_{\bullet j}/N,$$

$$P(0) = P_{10}/(P_{10} + P_{01}), \text{ and} \qquad \text{---------- (2)}$$

gives the long run probability for any state j=1,2 m.
For j=2, there exist only 2 steady state probabilities for the '0' and '1'states denoted by

$$P(1) = P_{01}/(P_{10} + P_{01}), \qquad |1 - P_{10} - P_{01}| < 1 \qquad \text{---------- (3)}$$

The ML estimator of P_{10} is $n_{10}/n_{1.}$ and that of P_{01} is $n_{01}/n_{0.}$. Substituting these values we compute the values P(0) and P(1).
P(0) = 24/115 = 0.21
P(1) = 91/115 = 0.79
P(0) + P(1) = 1

OBSERVATIONS
From the above analysis we observe the following
1. **P(1) > P(0),**
2. **$n_{01} = n_{10}$**

CONCLUSIONS AND POLICY RECOMMENDATIONS

From the above observations, it is evident that the inflation exists in the economy and it has been cumulative over the years. The fact that P(1)> P(0) leads to the conclusion that Inflation is highly dependent on the previous state, i.e., it is cumulative in nature. So one can conclude that price rise has been increasing over the years.
While predicting the inflation of the next period we need to consider parameters like the previous state and the prevailing price level. When these parameters have been extrapolated it seems like in the short run, we could witness a slight shift in the price level while in the long run, the cumulative effects could be more pronounced leading to high inflation.
Developing countries like India need to focus on the ever increasing inflation in the short run periods. Most of the economy is Agrarian, so inflation in the short run could affect production and total output. Policy suggestions could be made after a detailed Markov analysis on every commodity included in the WPI calculations. But with the analysis conducted policy decisions should be such that the prices so as to stabilise inflation or maintain a 4-5% inflation. With hands set on the growth path, the government has been injecting more and more money into the economy for developmental and growth activities. Though the rate of injection of money is lower than that of inflation, it is advisable to follow a very strict monetary policy to anchor inflation.

FUTURE SCOPE OF THE STUDY

In this paper we have analyzed inflation in India addressing inflation using only 2 states. We could extend the study to more states higher accuracy. Also, analysis on individual items contained in the WPI would aid in the formulation of accurate policy decisions for anchoring high inflation.

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