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DISTRIBUTION OF PRICE CHANGES AND THE MEASURE OF UNDERLYING INFLATION

By

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Abstract

It is widely accepted that the conventional consumer price index may not be the ideal indicator of underlying inflation due to noise included in the index. To remedy this problem several methods have been proposed. Based on statistical and economic criteria we develop alternative inflation measures called trimmed means. The analysis of Greek CPI data reveals that price changes on a monthly basis are widely dispersed, positively skewed, and, consequently, not normally distributed. Further analysis, based on a number of alternative measures of core inflation, concludes that trimmed means provide valuable information about underlying pressures and predict more accurately future inflation. (JEL: C82, E31)

Keywords: Underlying Inflation, Moments of distribution of price changes, limited-influence estimators.

1.0 Introduction

In recent years, a number of central banks, particularly those that have adopted explicit inflation targets have developed different measures of inflation in an attempt to identify permanent trends in inflation. These

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measures, which typically remove temporary extreme price fluctuations from the aggregate price index, are generally associated with the demand pressure component of measured inflation. Also, they are often viewed as being important for the determination of inflation expectations as well as for the reflection of the underlying inflationary trends. It is of great importance to the Central Bank to be able to distinguish between movements in price trends and noisy shocks (supply shocks) to inflation data. Policy makers should have an idea of the magnitude of these transitory effect or distortions in order first, to interpret the movements in aggregate prices and secondly to set the width of a credible target band.

Although the survey process of individual commodity prices at any given time seems to be an easy task, constructing the index for purposes related to monetary policy conduct is an extremely difficult assignment. As is well known, two problems may arise for measuring inflation. The first is the noise that is inherited in the price of commodities coming from the supply side. The second problem is associated with the well-known bias problem stemming from the weighting statistical technique. The problem of noise can have adverse effects on the volatility in the aggregate price level, if a large fluctuation in one of the price items is not at the same time matched by an opposite movement of another good's price fluctuation. Such movements in prices are not indicative of the persistent component of inflation. The randomly changes up and down are often called transitory effects or phenomena, distort the aggregate inflation rate and do not reflect persistent or generalized demand pressure in the economy. Consequently, these effects which, among other, include the effects of infrequent price adjustments (usually set directly by the government regulation like indirect taxes, excise tax on gasoline, oil prices), and, changes even in the seasonal pattern of the prices, should not affect policy makers action. To remedy the problem of noise, a number of solutions have lately been suggested. A prominent one, is the construction of alternative measures of inflation rate, that attempt to identify the permanent components of inflation, by excluding volatile items and it is based on statistical and economic criteria.

Based on the alternative measures of inflation proposed by Bryan and Pike (1991), Bryan and Cecchetti (1994), this paper tries to calculate alternative measures of underlying Greek inflation. A series of tests suggest that the most accurate estimator of tracking the inflationary pressures is the weighted-asymmetric median followed by the 17% trimmed mean. Section 2 provides a definition of underlying inflation and the calculating methodology of underlying inflation. In section 3 we discuss the distribution of the price changes and the moments of inflation. Section 4 deals with the forecasting power of the different measures of inflation and finally, section 5 contains some concluding remarks.

2.0 Core and Underlying Inflation

Researchers have long tried to develop alternative measures of inflation in order to isolate the portion of the inflation that behaves in a more predictable way. These measures are often called core or underlying inflation. According to Bryan and Cecchetti (1994) core inflation is "the long-run or persistent component of the measured price index, which is tied in some way to money growth". Quah and Vahay (1995) define core inflation as the measure of inflation that has no medium to long-run effects on output. Rogers (1997) defines core inflation the portion of the general index that excludes high price movements that distorts the movement in the aggregate price index. Broadly, there are two main methods of calculating core or underlying inflation. The first method excludes certain volatile components from the aggregate price level (and is often called core inflation) that presumed to be not representative of the price-change distribution. Often, what is excluded from the measure of inflation are ex-post, high variance components, like the food and energy items. The strategy of excluding the above two items relies basically on two arbitrary assumptions: that food and energy prices never contain information about the inflation trend and that other prices always do. But it seems that neither of these assumptions is true. The second calculation method, based on economic and statistical criteria, removes all extreme price changes on the premise, that they are not indicative of the persistent component of inflation. This method gives rise to the often-called limited-influence indicators (or trimmed means estimators). The strategy is based on that the economy is composed of two groups of price setters. The first group has flexible prices which means that they adjust their prices every period in response to changes in the economy and the second group sets prices infrequently which face high cost of readjustment.

2.1 Calculating underling Inflation

Following Bryan, Cecchetti and Wiggins (1997) we try to identify underline inflation by constructing various trimmed mean indices. In constructing the χ percent trimmed mean we eliminate χ percentage points that showed the largest price changes and the same percentage points that showed the smallest price changes at any given time. The χ percent trimmed mean estimator can be described as:

$$x_{\eta} = \frac{1}{1-2(\frac{\eta}{100})} \sum_{i \in I_{\eta}} w_i \pi_{it} \quad (1)$$

where the estimator χ is computed by ordering the π_{it}, component price-change data, and their associated weights, w_I. Lastly, the averaged set of observations I, is the set of price changes where the cumulative weights, $W_i = \Sigma\, ^J_i = _I w_I x_I$ are centered between η/100 and l-η/100.

In other words we remove 20% of the upper and lower tails of the cross-sectional distribution and the rest 80% is averaged out. This approach is motivated by observations that individual price series tend to exhibit substantial skewness and kurtosis. The reason for exhibiting such statistical characteristics is not known but the distribution of such can easily occur if we mix price data with different variances. Therefore, a more robust measurement would concentrate on the central portion of the overall inflation distribution where relative prices shift the least. In constructing the weighted median, one naturally should simply take the price changes of all categories along with their weights and order them from largest to smallest. The weighted median is the price such that one half the weight is above and below it in this order.

The most appropriate estimator of the mean of a symmetric population distribution depends largely on the kurtosis of the distribution. If the population distribution is normal then the sample mean is the best linear unbiased estimator of the population mean. But if the distribution is symmetric, with higher kurtosis than the normal distribution, then the sample median is a better efficient estimator of the population mean than the sample mean. This is based on the fact that the median is less affected by the high price distortions than the mean. In addition, as more higher is the kurtosis in the distribution the more common are the extreme price movements.

But in an environment where there is persistent positive skewness, which means that more of the price changes lie on the positive tail of the distribution, the set of trimmed means will be too biased estimators of the central tendency of price changes. In other words, the trimmed mean estimators will underestimate the actual inflation and will certainly contain a negative bias. Therefore, in a situation where there is a positive skew of the distribution of the price changes, the right way to construct efficient trimmed means estimators is by removing asymmetrically a larger portion of left-hand tail of the distribution. By doing that we preserve the unbiasedness of the estimator.

3.0 Distribution of price changes

In this study we explore 39 components of the consumer price index for the period 1989-2000. The main characteristics of the disinflationary transition dynamics that account for the non-normality that exhibit the inflation rate include large swings in relative prices, increases in administered prices and indirect tax cuts. Because of the above shortcoming which, consequently makes the task of predicting inflation difficult, we develop alternative concepts of measured inflation characterized by the main feature of identifying the permanent components of inflation. In other words, temporary price fluctuations are excluded and the newly measured of inflation should not have long run effects on output, i.e. exhibit output neutrality. By using alternative measures of inflation, Central Bank which having set inflation targets can easily disentangle the transitory from the permanent movements.

3.1 The moments of inflation

Before proceeding with the calculation of the trimmed mean estimators we first calculate the moments of the actual inflation process. Table 1 presents a summary of the moments statistics of the monthly changes for the overall period and some sub periods. As can be seen, the mean fell significantly, the last years of the sample, along with some extreme mean price changes. Also, standard deviation is large demonstrating the significant dispersion of monthly price changes and indicating the high degree of noise in the data. The plot of the coefficient of skewness in the fourth panel of figure 1 illustrates that in most months the distribution of price changes is skewed and on average is skewed to the right. Over the entire period the skew was 0.79. However, the use of more disaggregated data should give a higher number for skewness. Also, for the entire period, the skew was positive for 102 times and only 41 negative. This implies that the mean and median diverge, with the median lying below the mean.

TABLE 1

Summary of price change moments (CPI)

Period	Mean	Std.Dev.	Skew	Kurtosis
Overall	0.85%	3.43%	0.79	11.13
Dec. 1989	1.96%	4.30%	2.68	10.32
Dec. 1993	0.62%	2.60%	0.89	9.19
Dec. 1997	0.54%	1.79%	1.01	6.25
Dec. 2000	0.02%	1.97%	-1.36	4.67
1989-1995	1.18%	3.81%	1.04	11.29
1996-2000	0.41%	2.91%	0.45	10.92

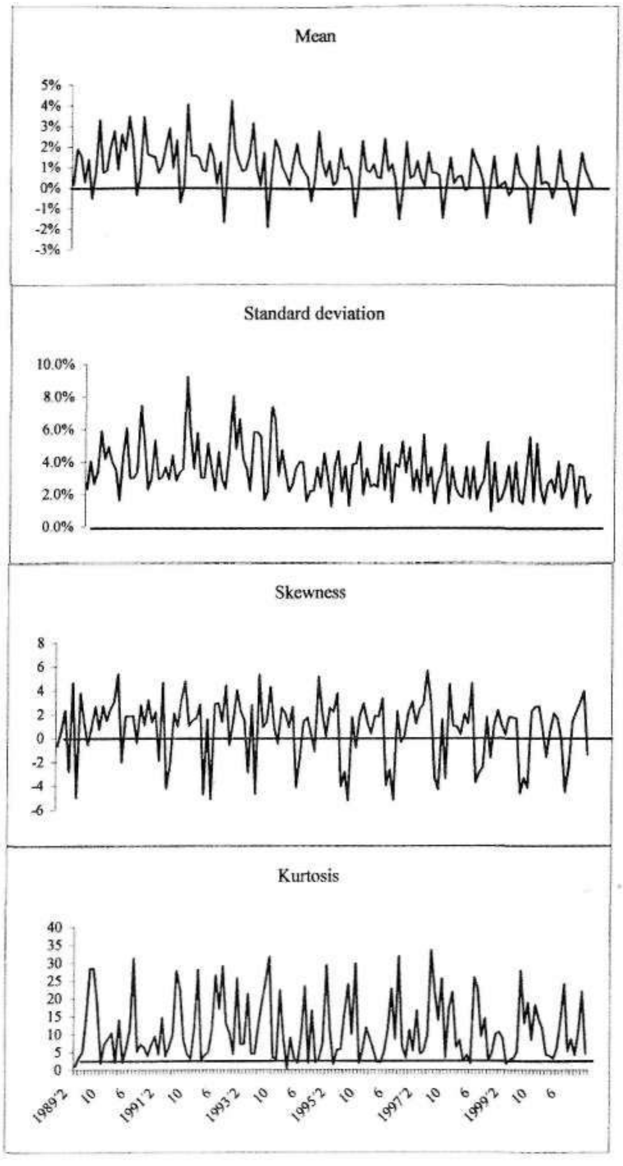
Next, we turn on the kurtosis of the price change distribution. The kurtosis coefficient, which is shown in figure 1 panel 4 most of the times is larger than 3. Over the entire period the average degree of kurtosis in the distribution of monthly price changes was 11.13 indicating excess kurtosis compared to normal distribution. This indicates that the distribution of price changes has considerably fatter tails than the normal distribution. In a normal distribution, the mean is the most efficient unbiased measure but in a distribution exhibiting leptocurtic signs, the mean may no longer be the most efficient measure of central tendency. On individual basis, the degree of kurtosis ranges from 0.33 for the period 1994:01 to 33.43 for the period 1997:05. Such a price change distribution with fat tails compared to normal distribution, appears to be common across a broad range of countries. This characteristic can occur if we mix price data exhibiting different variances.

Figure 2 shows the evolution of the percentile of the monthly price change distribution corresponding to the sample mean over the period 1989-2000. It clearly demonstrates that the mean inflation rate usually has a percentile ranking greater than 50, indicating again, that the mean inflation is greater than the median. In fact, 96 out of 143 period distributions the mean is above the 50th percentile and on average the mean is contained in the 63rd percentile. From this can be easily concluded that the series are highly volatile on the monthly basis, providing an indication of how unrepresentative the mean rate of inflation is.

An issue, which is interesting to investigate, is the relationship of the different moments of inflation, and in particular, the correlations of the

FIGURE 1

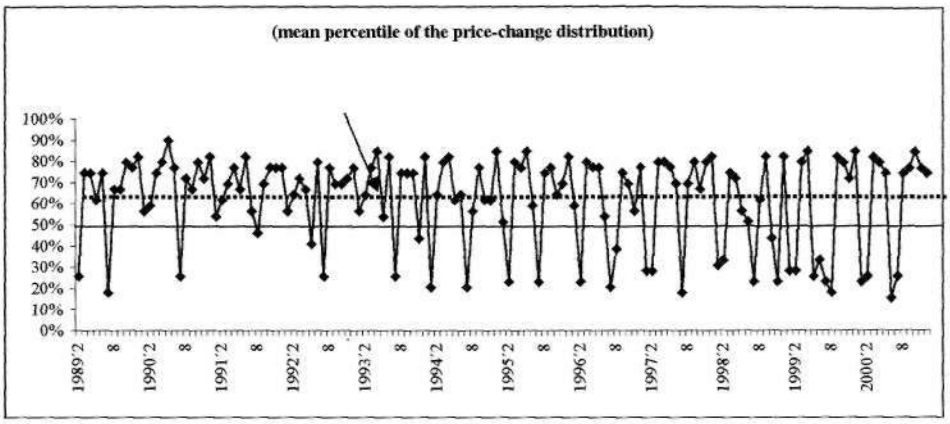
Moments of Greek Inflation



A normal distribution has a zero mean, a standard deviation of one, skewness of zero and kurtosis close to three.

FIGURE 2

Greek Price Asymmetry



moments. Table 2 presents the correlations of the moments for the overall sample. First, the mean appears to be positive correlated with the skewness of the distribution. This is consistent with the findings of other researchers (Bryan and Cecchetti, 1997, Meyler, 1999) and it can be explained by Ball and Mankiw's (1995) model of menu costs and Balke and Wynne (1996) asymmetric input-output relationships between sectors[1]. Particularly, in Ball and Mankiw's model, menu costs generates positive correlation between the rate of inflation and the skewness of the price change distribution. On the other hand, Balke and Wynne using a dynamic equilibrium model with flexible prices, show the existence of a positive relationship between the mean and the skewness of the distribution in an environment of asymmetric input-output relationships between sectors. Secondly, there is a positive correlation between the standard deviation of the series and the kurtosis, which means that some of the components experienced extreme price changes. As a result, when the data is generated by fat-tail distributions, the measure of aggregate price change using the weighted mean is very likely to be inefficient. By trimming the tails of the distribution we can improve the statistical efficiency of the aggregate statistics.

1. Ball and Mankiw (1995) and Balke and Wynne (1996) models with sticky and flexible price models respectively can give an economic structural explanation for the presence of fat-tailed price-change distributions.

TABLE 2

Correlations of moments

	Mean	Std.Dev.	Skew	Kurtosis
Mean	-			
S.D.	0.24	-		
Skew	0.59	0.07	-	
Kurtosis	-0.26	0.20	-0.11	-

Monthly estimates of two alternative measures of underline inflation are presented in table 3 , namely the 17% trimmed mean and the median. In calculating the 17% trimmed mean, we trim the tails of the price-change distribution such that 63% of every percentage point is trimmed off the lower tail of distribution relative to 37% of the upper tail of the distribution. In other words, 10.7% is trimmed off the bottom tail of the distribution and 6.3% off the upper tail of the distribution. For all two alternative measures, the mean and standard deviation are lower than the overall measure of monthly change inflation. The median measure shows less volatility (in terms of absolute standard deviation) by almost 37%, while the 17% trimmed mean by 35% in terms of volatility relative to its own mean. Also, the 17% trimmed mean exhibits the highest degree of correlation with movements in the overall CPI. Specifically, the correlation between 17% trimmed mean and overall CPI is .852, between median and CPI is .73 and the 17% trimmed men and median is .87.

TABLE 3

Comparison of different measures of inflation

	Mean	Std.Dev.
CPI	0.9%	3.4%
17% trimmed mean	0.6%	0.7%
Median measure	0.5%	0.8%

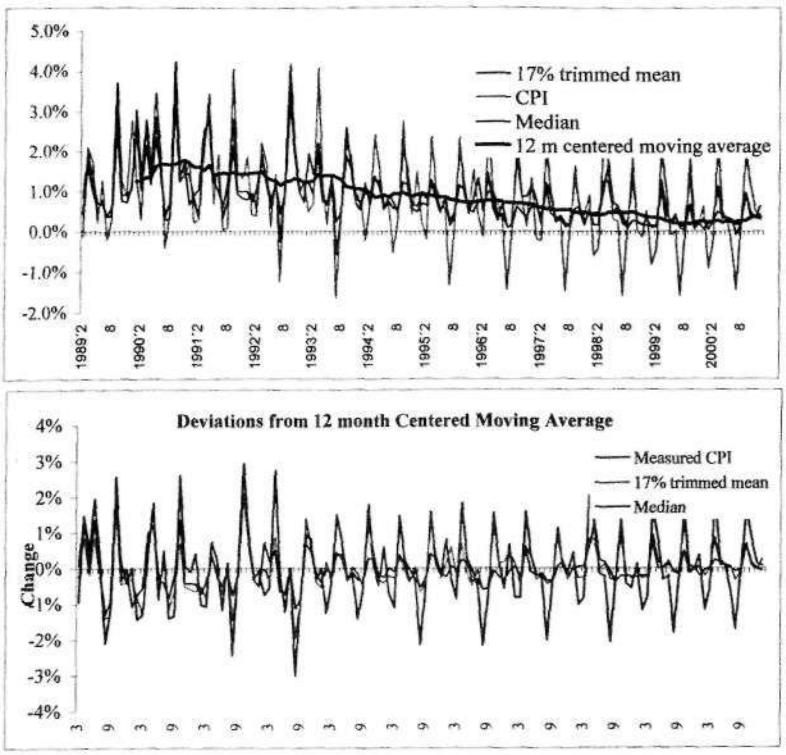
Correlations			
	CPI	17% Trimmed	Median
CPI	**1.00**		
17% trimmed	0.85	**1.00**	
Median	0.73	0.87	**1.00**

2. Although we examine other trimmed mean estimators such as the 50% and 75% trimmed means, we find that these do not significantly differ from the 17% and median calculations. Therefore, we use only the above two measures for simplicity purposes.

Figure 3 shows various measures of inflation compared with the 12-month centered moving average. The first panel shows, on a monthly basis, the median measure of inflation, the 17% trimmed mean, and the actual CPI inflation compared with the 12 month centered moving average. All alternative measures of inflation exhibit lower peaks than actual inflation and high persistence. The alternative measures of inflation did not reflect the changes in the actual mean of inflation. The second panel shows the comparison between the alternative measures of inflation and the CPI, on a yearly basis. However, while the cyclical movements have been similar, over the sample period, the trimmed measures lie above the CPI inflation for the periods 1989-1990, 1992-1993 and 1997-1999. It appears that for those periods the trimmed means calculations capture inflationary pressures that are not

FIGURE 3

12-m centered moving average vs. Different measures of inflation, 1989-2000

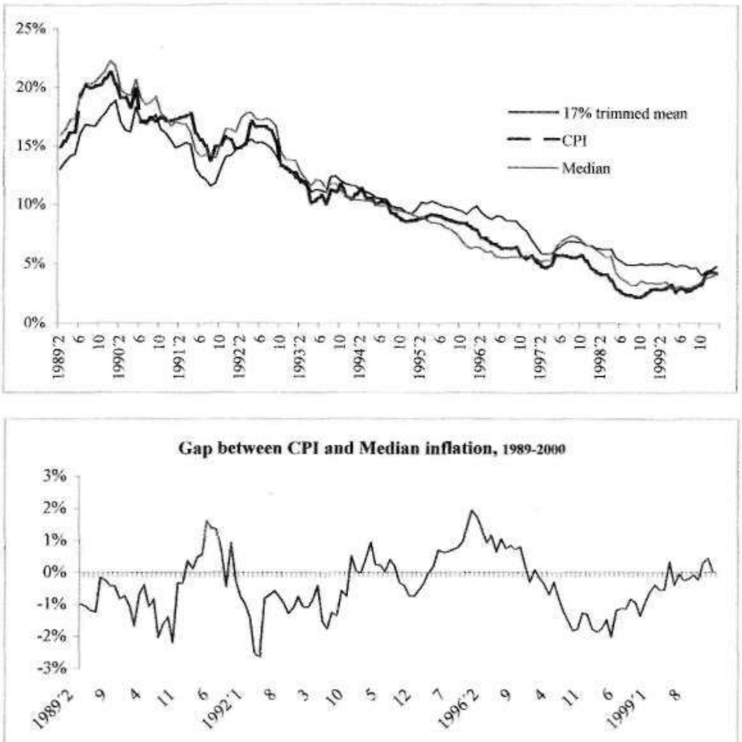


so evident in the CPI inflation rate. Mostly the trimmed mean calculations have smoother paths than the actual inflation rate.

Lastly, figure 4 exhibits the difference between the median calculation and the actual measure of inflation. It gives the impression that in the later part of the sample, and specifically for the last year of the sample, when extreme changes are limited and low and stable rates are prevailed, both measures tend to move together. But which size can be prescribed as the optimal one? In order to answer the above equation we use the 12-month centered moving average as a benchmark for comparing the range of trimmed means[3]. Figure 5 shows the RMSE against the 12-month centered moving average for each of the alternative measures of inflation, over the period 1989-2000. The actual measure of inflation, which is the zero per cent

FIGURE 4

Measures of Inflations (% yoy)



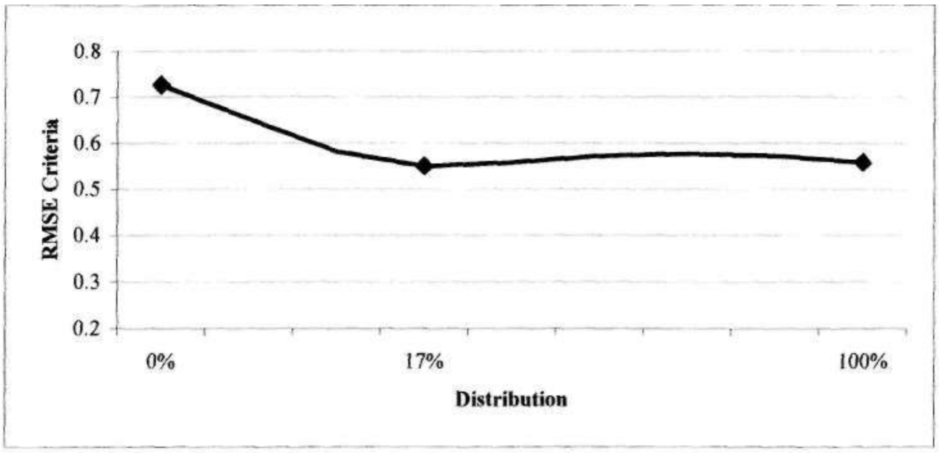
trimmed mean, had a RMSE of .724 percent compared to the benchmark measure of underlying inflation. The 17% trimmed mean measure had the lowest RMSE, equal to .548 percent, while the median measure (or alternative the 63 percentile median) had .557 percent. Both the 17% trimmed mean and the median estimators represent a 24.3 percent and 23 percent improvement on the regular (zero trim) mean. It can be seen from the diagram that large efficiency gains could achieve from relatively small trims of the data.

4.0 Forecasting using the alternative measure of inflation

Our next task is to show how these alternative measures of inflation can be put to use in order to provide more accurate forecasting information to the monetary authorities. In this section we compare the forecasting performance of the alternative measures of inflation to the forecasting performance using noisy measured inflation data. As is well known, the inflation-forecast exercise is not an easy thing to do. Nevertheless, our task

FIGURE 5

Asymmetric Mean Estimators



3. Other researchers use the Hodrick-Prescott filter of the monthly mean inflation as the proxy of the trend component of inflation. This particular filter has the advantage that for relative large smoothness parameters, it will be affected less by a one-off shock to mean inflation rate.

here is to identify the measure of inflation that does better (relative to the other measures) in a short medium-run horizon, by examining the marginal forecasting power of alternative measures of inflation. Table 4 presents forecast statistics, using out-of-sample data, for measured actual inflation, 17% trimmed mean and median inflation. The RMSE for forecasts of actual inflation (0.66 per cent), is considerably higher than that of 17% trimmed mean (0.31 per cent), and median inflation (0.21 per cent). This would imply tighter confidence intervals for the two alternative measures of inflation (i.e. 17% trimmed mean and median)[4].

TABLE 4

Forecast statistics for AR(6) models (1998-2000:12)*

	MAE	RMSE	Theil U
CPI	0.627	0.656	0.420
17% Trimmed	0.291	0.312	0.291
Median	0.207	0.223	0.267

* The above numbers are averages and out of sample forecasts. MAE=mean absolute error, RMSE=root mean square error.

5.0 Conclusion

In this paper, we try to identify different measures of inflation that better capture the permanent component of the inflation rate. We found that price change distributions are highly leptokurtic, and the conventional use of inflation i.e. the sample mean is inefficient estimator of the population mean. The extreme price changes in the tails of the distribution are considered to be unrepresentative of the permanent component of inflation because they disproportionaly impact the mean rate of inflation. As a result, the mean rate of inflation is not considered as a good indicator of persistent inflation and consequently is not a good indicator for policy-makers. For this purpose, we examined alternative measures of inflation and conclude that some of them are policy-relevant. There are significantly gains for trimming small portions of the tails of the distribution and rise, as the trim

4. The Theil statistics for the 17% trimmed and median models are less than the statistics of the actual model and are consistently below unity, indicating that the selected model outperforms the naive model. But note that a straight-line model could also outperform the naive model.

gets bigger. The weighted median measure can be considered as the best-trimmed measure of inflation. Also, due to the fact that distribution of the CPI component price changes is systematically positively skewed, trimmed means should be centered on a percentile higher than the 50%, and more specifically close to the 63%. These findings help understand better the distribution of the price changes and realize the best measure in capturing underlying inflationary pressures.

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