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Inflation forecasting and the distribution of price changes

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Abstract

This study shows that replacing the traditional measure of asymmetry that is skewness in the inflation forecasting model with an alternative asymmetry measure that captures the joint influence of both skewness and variance on inflation significantly improves the forecast at various horizons. The empirical evidence suggests that it is more appropriate to use such measure of asymmetry in inflation forecast model as it has edge over simple measure of skewness in predicting inflation. These findings are consistent with the prediction of menu cost model that the variance of cross sectional distribution of relative price changes amplifies the impact of skewness on inflation.

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1. Introduction

Large number of empirical studies have provided evidence in favor of positive association between the aggregate inflation and the skewness/variance of cross sectional distribution of relative price changes (see, e.g., Ball and Mankiw, 1995; Amano and Macklem, 1997; Aucremanne *et. al.,* 2002; Caraballo and Usabiaga, 2004; Assarsson, 2004; and Pou and Debus, 2008). Theoretically, the link between inflation and skewness is explained by models based on menu cost associated with price adjustments. In this context, Ball and Mankiw (1995) argue that in the presence of menu costs firms adjust prices only in response to large shocks and choose inaction in response to small ones. More specifically, when a firm experiences a shock to its desired price, it changes its actual price only if the required adjustment is large enough to warrant paying the menu cost. As a results, the large shocks have disproportionately a large impact on the changes in average price level. On the other hand, the positive relationship between inflation and variance of cross sectional distribution of relative price changes (commonly called relative price variability) is explained by models based on information asymmetry and misperceptions. Under information asymmetry, firms adjust quantity in response to unanticipated demand shocks if supply is price elastic and adjust prices if supply is price inelastic. Hence, unanticipated demand shocks that generate inflation tend to affect relative price variability (Lucas, 1973; Barro, 1976; Hercowitz, 1981 and Cukierman 1983). Moreover, the menu cost model of Sheshinski and Weiss (1977) also generate positive association between inflation and variance of relative price changes.

More recently, Binner *et. al.* (2010) have shown that the use of skewness of distribution relative price changes improves the inflation forecast whereas the inflation forecast is deteriorated when variance is included in the model. This result contradicts the theoretical prediction of menu cost models that the variance magnifies the effect of skewness on inflation in presence of skewed distribution of relative price changes (Ball and Mankiw, 1995).[1] Moreover, such results are also inconsistent with the anticipations of misperception models and the related large body of empirical literature which found evidence in favor of positive association between inflation and variance of relative price changes (see, Parks, 1978, Fischer, 1981; Debelle and Lament, 1996; Nath, 2004; Choi, 2010; Nautz and Scharff, 2012; Rather et. al., 2014a).

In this study, we re-estimated the inflation forecast model used by Binner *et. al.,* (2010) by using an alternative measure of asymmetry and examined the predictive power of skewness and variance of distribution of relative price changes. Unlike a simple conventional measure of skewness, the advantage of such alternative asymmetry measure is that it captures the joint influence of both variance and skewness on aggregate inflation. More importantly, the use of such asymmetry measure is motivated by the fact that in menu cost models inflation basically depends on relative density in the tails of the distribution of price changes. As Ball and Mankiw (1995) argue that "it would be more parsimonious to measure the relevant asymmetry with a single variable – one that captures both the direct effect of skewness and the magnifying effect of variance." Further, this study uses highly disaggregated commodity wise price data for the construction of various measures of asymmetry. As it is quite possible that the use of aggregated price indices may not reflect the various asymmetries in price adjustments and might result in a loss of information about the dynamics of inflation.[2]

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[1] For a detailed discussion, see Ball and Mankiw (1995)

[2] In this context, Ball and Mankiw (1995) and Balke and Wynne (2000) argue that there is asymmetric/heterogeneous response by firms when they face shocks to their desired prices.

The empirical results show that the use of an asymmetry measure that captures the joint influence of both skewness and variance has an edge over simple measure of skewness in forecasting inflation. This empirical finding is consistent with the prediction of theoretical models. In the following section 2, we discuss the methodology, in section 3 empirical results are presented and the section 4 of the paper provides concluding remarks.

2. Methodology

Following Parks (1978), the variance of cross-sectional distribution of relative price changes (σ_t) is measured as:

$$\sigma_t = \sum_{i=1}^{N} \omega_i (\pi_{it} - \pi_t)^2$$

where, π_{it} is the i^{th} commodity inflation rate and ω_i denotes the respective weights. Also, π_t represents general inflation and is measured as the weighted average of π_{it}. Similarly, the skewness of cross sectional distribution of relative price changes (S_t) is measured as:

$$S_t = \sum_{i=1}^{N} \omega_i (\pi_{it} - \pi_t)^3$$

Following Ball and Mankiw (1995), we construct two different alternative measures of asymmetry. Firstly, we define μ_t^X for some cut off X as:

$$\mu_t^X = \sum_{i=1}^{l} \omega_i (\pi_{it} - \pi_i) D_i^- + \sum_{i=1}^{u} \omega_i (\pi_{it} - \pi_i) D_i^+ .$$

where, D_i^+ and D_i^- are dummy variables. The former (latter) takes the value one, when i^{th} industry's relative price change falls in the upper (lower) X per cent of the distribution or zero otherwise. X is the arbitrarily fixed cut off and l and u depict the number of price changes falling in upper and lower zone of the distribution. The μ_t^X gives a measure of net mass in the tails of distribution.

Note that μ_t^X is constructed by giving the full weight to the price changes which are above the cutoff X and zero weight to the remaining price changes. A variant of μ_t^X which increases the weights linearly with the size of price changes can be defined as

$$\theta_t = \sum_{i=1}^{n} \omega_i |\pi_{it} - \pi_t| (\pi_{it} - \pi_t)$$

Here, θ_t is defined as the weighted average of product of each relative price change and its own absolute value. θ_t is zero for a symmetric distribution and positive (negative) for a positively (negatively) skewed distribution. Also, its value is magnified at higher levels of variance. The advantage such asymmetry measures is that in addition of capturing the direct influence of skewness they also capture the magnifying effect of variance and which makes such measures theoretically more relevant.

Following Binner *et. al.* (2010), we constructed directly multi-period forecasts based on horizon-specific models. We estimated the following forecast equation to obtain the conditional forecasts of inflation.

$$E_t[\pi_{t+h}] = \alpha_{0ht} + \sum_{l=1}^{k} \alpha_{lht} \pi_{pt-l+1} + \sum_{l=1}^{k} \beta'_{lht} Y_{t-l+1}$$

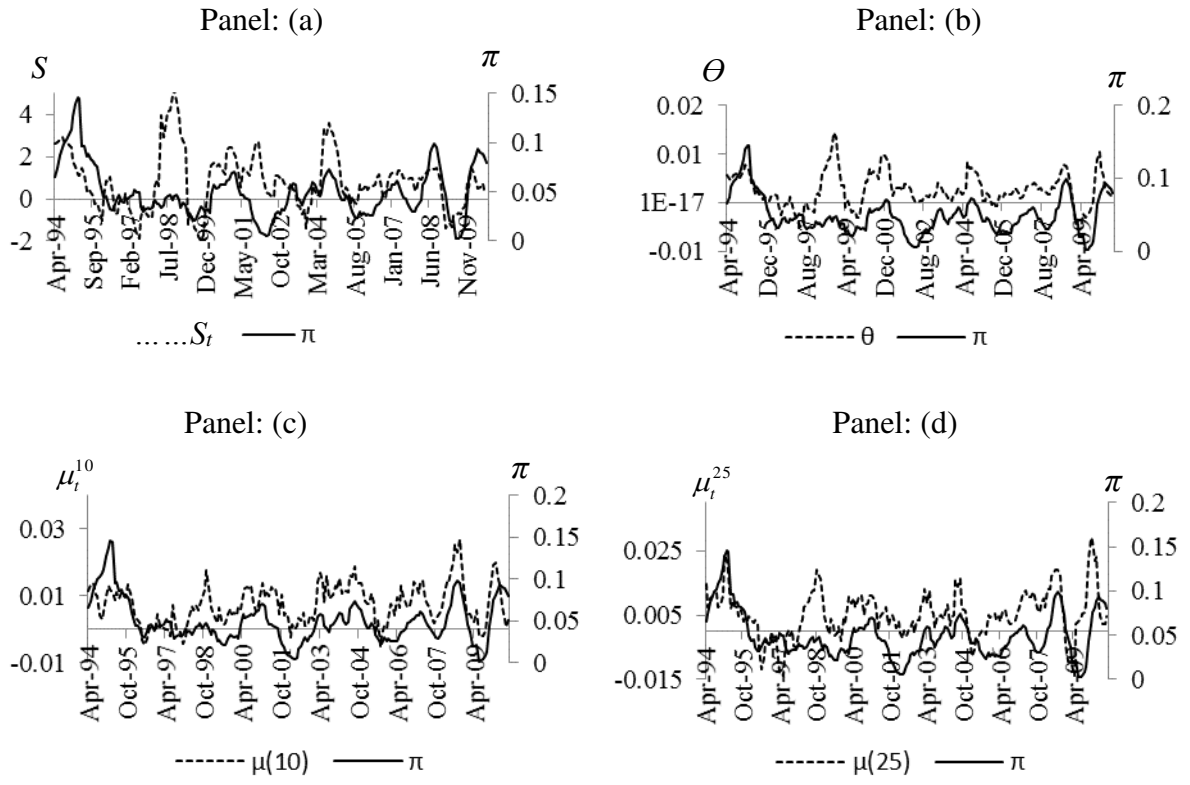
where, h is the forecast horizon, k is the number of lags and Y_t depicts the various measures of asymmetry.

3. Data and empirical results

This study uses monthly data on prices of 418 commodities, which constitutes 96 percent of the commodity basket used in the construction of Wholesale Price Index in India. The sample period ranges from April 1993 to November 2010. The time series data on price indices and the corresponding weights are collected from the website of the Office of the Economic Advisor, Ministry of Commerce and Industry, Government of India (www.eaindustry.nic.in).

Before proceeding to forecasting analysis, we examined the time series properties of inflation, skewness, variance and various measures of asymmetry using the traditional Augmented Dickey-Fuller and Phillips-Perron unit root tests. The results suggest that the null of unit root is rejected at 1% significance for all the variables (results not presented here).

Figure1. Inflation, skewness and alternative measures of asymmetry



Note: The expressions μ_t^{10}, μ_t^{25} denotes that the cut off X for μ_t^X is fixed at 10% and 25%, respectively.

In Figure 1, we plotted inflation against the skewness and other alternative asymmetry measures to visualize the relationship between inflation and various moments of distribution

of price changes. The plots in Figure 1 display that the basic empirical prediction of the underlying theoretical models is apparent in data. It can be seen from the graph of panel (a) that inflation *(π)* closely follows the trajectory of skewness of the cross sectional distribution of relative price changes (S_t). However, this association is much clear when inflation is plotted against various alterative measures of asymmetry (see, graphs in panel (b), (c) and (d)). This implies that the variance magnifies the influence of the skewness on inflation.

The forecasting performance of skewness and the alternative asymmetry measures is examined using out-of-sample forecast. The forecasting analysis is carried out by estimating each model recursively, beginning with the period and incorporating successively a new data point to the sample. In the first stage, we obtained inflation forecasts by using a simple AR(1) model, which serves as a bench mark. Then, the inflation forecasts were obtained by augmenting the bench mark model with the simple measure of skewness (S_t). In the next stage, we replaced the skewness measure (S_t) with the alternative measures of asymmetry (i.e., θ_t, μ_t^{10} and μ_t^{25}) alternatively and re-estimated the model.[3] In order to evaluate the forecasting performance of these models, the *h* period ahead forecast made at each stage is compared with the corresponding actual observation. For this purpose, we compared the estimates of mean square error (MSE) and mean absolute error (MAE) obtained from the each model.

We used Diebold–Mariano (1995) test statistic (DM) to examine whether the estimates of MSE (and MAE) obtained from the competing models with different asymmetry measures are significantly different from the estimates of MSE (MAE) obtained from the bench mark model. The DM statistics based on MSE and the associated p-values are presented in Table 1. The rows of the table provide the lag structure (*l*) and the forecast horizon (*h*) is given in the columns of the table for each model. In the table, corresponding to each lag the first row provides the results from model where S_t is used and the second row provides the results from the model wherein θ_t is used. The results indicate that the estimates of MSE obtained from the models wherein θ_t is used are found to be significantly lower than MSE obtained from the bench mark model, for each lag structure. The p-values associated with *bold* DM statistics suggest that we reject the null hypothesis that the inflation forecasts obtained from the given two competing models are equal at the conventional level of significance. However, the estimates of MSE obtained from the model wherein S_t is used are not found to be significantly different from the MSE obtained from the benchmark model for any lag structure *(l)* or the forecast horizon *(h)*. Also, the results obtained from the models wherein alternative asymmetry measures { μ_t^{10} and μ_t^{25} } were used are presented in rows four and five corresponding to each lag. These results indicate that the asymmetry measure μ_t^{25} performs better in comparison to the asymmetry measure μ_t^{10}; thereby implying that large shocks have disproportionate impact on aggregate inflation. Overall, these results confirm that the forecasting model, wherein an asymmetry measure (θ_t) is used, outperforms the model where a simple measure of skewness is used.[4]

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[3] The expressions μ_t^{10} and μ_t^{25} denote that the cut off X for μ_t^X is fixed at 10% and 25%, respectively.

[4] Moreover, the results suggest that inflation forecasts are worsened when we include the variance and skewness together in the model. This finding is consistent with the theoretical prediction that variance does not have independent impact on inflation (Ball and Mankiw, 1995).

Similar inferences can be drawn when we compare the estimates of MAE obtained from the given competing models, as presented in the Table 2. The results indicate that the forecasting performance of the model augmented with θ_t improves for the longer forecast horizons.

Table 1: DM statistics based on MSE

l / h	Model	1	2	3	4
1	θ_t	**4.67 (0.00)**	**4.84 (0.00)**	**4.05 (0.00)**	**3.57 (0.00)**
	S_t	1.43(0.15)	1.29(0.20)	1.09(0.27)	0.91(0.36)
	AS10	-1.26(0.20)	-1.40(0.16)	-0.97(0.33)	-0.70(0.48)
	AS25	**2.20(0.03)**	**2.30(0.02)**	**2.30(0.02)**	**2.21(0.03)**
2	θ_t	**2.08 (0.04)**	**1.96 (0.05)**	1.56 (0.12)	1.42 (0.15)
	S_t	1.19(0.23)	1.06(0.29)	0.93(0.35)	0.95(0.34)
	AS10	**2.20(0.03)**	1.90(0.06)	1.86(0.06)	1.23(0.22)
	AS25	1.78(0.08)	1.73(0.08)	1.45(0.15)	1.32(0.18)

Note: In parenthesis are p-values. The bold values indicate that we reject the null hypothesis that the inflation forecasts obtained from the given models are equal at the conventional level of significance using a one-sided Diebold–Mariano test.

Table 2: DM statistics based on MAE

l / h	Model	1	2	3	4
1	θ_t	**3.36(0.00)**	**3.68(0.00)**	**3.58(0.00)**	**3.24(0.00)**
	S_t	0.89(0.37)	0.87(0.38)	0.82(0.41)	0.70(0.48)
	AS10	-0.14(0.89)	-0.13(0.90)	0.12(0.90)	0.06(0.95)
	AS25	**2.18(0.03)**	**2.31(0.02)**	**2.40(0.02)**	2.37(0.08)
2	θ_t	**2.67(0.01)**	**2.37(0.02)**	**2.26(0.02)**	**2.34(0.02)**
	S_t	1.55(0.12)	1.48(0.14)	1.44(0.15)	1.44(0.15)
	AS10	1.63(0.10)	1.34(0.18)	1.11(0.27)	0.75(0.45)
	AS25	**2.34(0.02)**	**2.29(0.02)**	**2.10(0.04)**	**2.03(0.04)**

Note: In parenthesis are p-values. Here also, the bold values indicate that we reject the null hypothesis that the inflation forecasts obtained from the given models are equal at the conventional level of significance using a one-sided Diebold–Mariano test.

Over all, the results indicate that an asymmetry measure (θ_t), which captures the joint influence of skewness and variance has an edge over simple measure of skewness in predicting inflation. These results corroborate the theoretical prediction of menu cost models that the variance magnifies the impact of skewness on the inflation.

4. Conclusion

This study examines the performance of skewness and variance of the cross sectional distribution of relative price changes in forecasting inflation. To this end, we constructed the alternative measures of asymmetry that capture the joint influence of both skewness and variance on inflation. The empirical evidence suggest that the inflation forecast models augmented with such asymmetry measures have an edge over the model wherein simple classical measure of skewness is used in predicting the inflation. These empirical findings are consistent with the theoretical predictions of menu cost models.

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