Sains Malaysiana 36(2)(2007): 225-232

On the Relationship between Inflation Rate and Inflation Uncertainty: An Application of the GARCH Family Models

(Hubungan antara Kadar Inflasi dan Kemeruapan Inflasi: Satu Aplikasi Model Keluarga GARCH)

ABU HASSAN SHAARI MOHD NOR, TAN YAN LING & FAUZIAH MAAROF

ABSTRACT

The main objective of this paper is to explore the varying volatility dynamic of inflation rate in Malaysia for the period from January 1980 to December 2004. The GARCH, GARCH-Mean, EGARCH and EGARCH-Mean models are used to capture the stochastic variation and asymmetries in the economic instruments. Results show that the EGARCH model gives better estimates of sub-periods volatility. Further analysis using Granger causality test shows that there is sufficient empirical evidence that higher inflation rate level will result in higher future inflation uncertainty and higher level of inflation uncertainty will lead to lower future inflation rate.

Keywords: GARCH; Granger Causality; inflation rate; volatility dynamic

ABSTRAK

Tujuan utama makalah ini adalah untuk menyajikan satu kajian empirikal tentang ciri kemeruapan dinamik kadar inflasi di Malaysia bagi tempoh Januari 1980 hingga Disember 2004. Model GARCH, GARCH-Mean, EGARCH and EGARCH-Mean digunakan untuk menganggar variansi stokastik dan asimetrik dalam pembolehubah ekonomi tersebut. Keputusan kajian menunjukkan bahawa model EGARCH memberikan keputusan penganggaran kemeruapan sub tempoh yang baik. Analisis lanjutan menggunakan ujian kausaliti Granger memberikan bukti empirikal bahawa aras inflasi yang tinggi pada masa kini berkecenderungan membawa kepada ketidakpastian inflasi yang tinggi pada masa akan datang dan aras ketidakpastian inflasi yang tinggi pada masa kini pula akan mengurangkan kadar inflasi akan datang.

Kata kunci: GARCH; kausaliti Granger; kadar inflasi; kemeruapan dinamik

INTRODUCTION

In recent years, the relationship between inflation and inflation uncertainty has been the common subject and issue of much theoretical and empirical purpose. On the theory side, Friedman (1977) in his Nobel lecture argues that a positive relationship between the level of inflation and inflation uncertainty. Friedman points out higher inflation leading to greater uncertainty, which lowers welfare and efficiency of output growth. On the other hand, Ball (1992) formalizes Friedman's hypothesis using an asymmetric information game where public faces uncertainty regarding the type of policymaker in the office. One of the policymaker is willing to tolerate a recession to reduce inflation and the other is not. During the low inflation time, both type of policymakers will attempt and try to keep it low. But, when inflation is high, only the tough type or anti-inflation policymaker will bear the economic costs of disinflation. Consequently, there is a greater uncertainty about future monetary policy during periods of high inflation because public does not know the action will be taken by policymaker. In contrast, Cukierman and Meltzer (1986) argue that the causality runs in the other direction, that greater inflation uncertainty causes higher average inflation. However, Holland (1995) provides another type of argument and he claims that greater inflation uncertainty leads to lower average inflation rate, not higher inflation rate if central bank attempts to minimize the welfare losses arising from inflation uncertainty. We have employed the Malaysian data because of considerable variation in its inflation rate as shown in Figure 1. Hence, it is easier to detect a possible relationship among inflation and inflation uncertainty although inflation rate in Malaysia is lower compared to other countries.

The main objective of this paper is to explore the varying volatility dynamic of monthly inflation rate in Malaysia over the period from January 1980 to December 2004. Exponential generalized autoregressive conditional heteroscedasticity (EGARCH) models are used to capture the stochastic variation and asymmetries in the financial instruments. The EGARCH (Nelson 1991) model is used in the empirical analysis. Besides modelling the asymmetric effect of shocks to inflation uncertainty, model EGARCH-Mean (EGARCH-M) is employed to test whether there exist any contemporeneous relationship between inflation uncertainty and inflation. The rest of the paper is organized

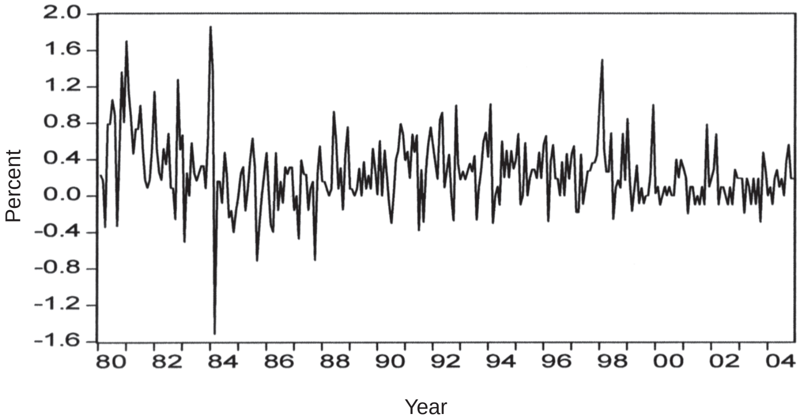

FIGURE 1. Monthly inflation rate, 1980 - 2004

as follows. The next section discusses the literature review. Section 3 presents an overview on data and methodology. Section 4 contains the empirical results. Finally, section 5 provides the conclusion

LITERATURE REVIEW

A number of previous studies have used the conditional error variance as a measure of inflation uncertainty. Kontonikas (2004) analyze the relationship between inflation and inflation uncertainty in the United Kingdom from 1973 to 2003 with monthly and quarterly data. Different types of GARCH-Mean-Level (GARCH-M-L) models that allow for simultaneous feedback between the conditional mean and variance of inflation are used to test the relationship and they find positive relationship between inflation and inflation uncertainty, in line with Friedman-Ball causal link. Similarly, Karanasos et al. (2004) apply the same method in the US inflation rate using monthly data for the period January 1960 to February 1999. They find strong bidirectional relationship between inflation and inflation uncertainty as predicted by Friedman and Cukierman and Meltzer's hypothesis. On the other hand, Fountas et al. (2004) use quarterly data from first quarter of 1960 to second quarter of 1999 in six European Union countries. Fernandez Valdovinos (2001) applies monthly data covering period of January 1965 to December 1999 in Paraguay with two-step approach to estimate inflation uncertainty. Once the measure of inflation uncertainty is obtained, they use Granger causality methods to test whether higher average inflation causes inflation uncertainty or vice versa. They found strong evidence supporting Friedman's hypothesis in all the European countries except for Germany and less robust evidence to support Cukierman and Meltzer and Holland's hypothesis. Fernandez Valdovinos (2001) shows that in Paraguay, higher levels of inflation have been accompanied by more inflation uncertainty. Berument et al. (2001) use an EGARCH method to model inflation uncertainty in Turkey from January 1986 to December 2000. They point out that the effect of positive shocks in inflation uncertainty to inflation are greater than negative shocks to inflation. In contrast, Nas and Perry (2000) employ the two-step approach to investigate the link between inflation and inflation uncertainty in Turkey from January 1960 to March 1998. The results show strong statistical support that inflation significantly raised inflation uncertainty over the full sample period. However, the evidence on the causal of inflation uncertainty on average inflation is rather mixed.

DATA AND METHODOLOGY

DATA

Inflation (π) is measured as the first difference of consumer price index (CPI) : $\pi_t = \log(CPI_t / CPI_{t-1})*100$, using monthly data in order to examine the relationship between inflation and inflation uncertainty. The sample data set covers the period from January 1980 to December 2004 which includes 300 monthly observations. The data are obtained from CD Rom International Financial Statistics, International Monetary Fund.

THE VOLATILITY MODELS

Early researchers measured inflation uncertainty as the moving standard deviation of inflation rate. This kind of measure only shows the variation of inflation and does not capture the type of uncertainty (Fernandez Valdovinos 2001; Nas & Perry 2000). ARCH model indicates that the conditional error variance varies overtime, not constant overtime as measured by moving standard deviation. Therefore, if we take this conditional variance as a proxy of inflation uncertainty, it means that ARCH model inflation uncertainty is a time-varying process. Following Eagle's (1983) idea for ARCH model, several class family of ARCH models have been introduced in the literature such as generalized ARCH (GARCH), integrated GARCH (IGARCH), GARCH-Mean (GARCH-M), exponential GARCH (EGARCH), component GARCH (CGARCH), threshold ARCH (TARCH) and others.

The empirical analysis is divided into two parts. The first part provides the estimation of distribution of inflation rate, including the first and second moments statistics as well as the measures of skewness and kurtosis. Furthermore, the inflation rate is tested for unit root using the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests. The second part of the analysis gives the characteristics of the volatility dynamics. In this paper the GARCH(1,1), GARCH(1,1)-M, EGARCH(1,1) and EGARCH(1,1)-M models are used. The EGARCH(1,1) model is able to accommodate for the asymmetric or leverage effect of the financial variables (Nelson 1991), while the EGARCH-M model can give an additional measure on the relationship between inflation and inflation uncertainty. The following family of GARCH-type models are employed in the empirical analysis on the Malaysian inflation rate.

a. The AR(p)-GARCH(1,1) Model

$$\pi_t = \alpha_o + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{i=1}^{2} \delta_i d_{t-i} + \varepsilon_t \quad (1)$$

$$\varepsilon_t = e_t \sigma_t \quad (2)$$

$$\sigma_t^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 \quad (3)$$

where $\beta_0 > 0$, $\beta_1 \geq 0$, $\beta_2 \geq 0$, and $\beta_1 + \beta_2 < 1$, π_t is the inflation rate, d_t is the monthly seasonal dummy variable, ε_t is the disturbance term $\sim$ NID$(0, \sigma_t^2)$, e_t is the sequence of independent and identically distributed (*iid*) random variables with mean zero and variance one.

The equation in (1) is a standard time series model of autoregressive, AR(p) process. Inflation at time t is a function of past values of inflation (AR terms) and the term $\delta_i d_{t-i}$ accounts for monthly seasonal effects. The equation in (2) is a GARCH(1,1) process that represents the conditional variance of inflation at time t. The model is selected based on information criterion (Akaike Information Criterion, AIC and Schwarz Criterion, SC) and diagnostic tests (Ljung-Box Q-statistics on standardized residuals and Ljung-Box Q^2-statistics on standardized squared residuals). For example, model A is said to be better than model B if model A has smaller value of AIC and SC plus standardized residuals and standardized squared residuals are free from serial correlations and conditional heteroscedasticity.

b. The AR(p)-GARCH(1,1)-M Model

$$\pi_t = \alpha_o + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{i=1}^{2} \delta_i d_{t-i} + \xi \sigma_t^2 + \varepsilon_t \quad (4)$$

$$\sigma_t^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 \quad (3)$$

In order to investigate the contemporaneous relationship between inflation uncertainty and inflation level which is represented by the parameter ξ, model AR(p)-GARCH(1,1)-M as shown in equations (4) and (3) are used. In the above GARCH models, it is assumed that negative shocks and positive shocks have the same effects (symmetric) on the conditional variance (volatility). The following models are used to study the asymmetric behavior of the inflation rate in Malaysia.

c. The AR(p)-EGARCH(1,1) Model

$$\pi_t = \alpha_o + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{i=1}^{2} \delta_i d_{t-i} + \varepsilon_t \quad (1)$$

$$\log \sigma_t^2 = \beta_0 + \beta_1 \left|\varepsilon_{t-1} / \sigma_{t-1}\right| + \beta_2(\varepsilon_{t-1} / \sigma_{t-1}) + \beta_B \log \sigma_{t-1}^2 \quad (5)$$

where the terms $|\varepsilon_{t-1}/\sigma_{t-1}|$, $\varepsilon_{t-1}/\sigma_{t-1}$ and $\log^2_{t-1}$ are used to explain the behavior of the conditional variance in equations (5).

d. The AR(p)-EGARCH(1,1)-M Model

$$\pi_t = \alpha_o + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \sum_{i=1}^{2} \delta_i d_{t-i} + \xi \sigma_t^2 + \varepsilon_t \quad (4)$$

$$\log \sigma_t^2 = \beta_0 + \beta_1 \left|\varepsilon_{t-1} / \sigma_{t-1}\right| + \beta_2(\varepsilon_{t-1} / \sigma_{t-1}) + \beta_B \log \sigma_{t-1}^2 \quad (5)$$

According to Berument et al. (2001) and Kontonikas (2004), EGARCH model is more powerful and more advantageous than both ARCH and GARCH models to measure inflation uncertainty for the following reasons. First, EGARCH model allows the asymmetry in the responsiveness of inflation uncertainty to the sign of shocks from inflation. Second, EGARCH model does not impose the non-negativity constraints on the parameters, unlike GARCH which requires that all of the estimated parameters are positive. Third, modeling inflation and inflation uncertainty in logarithms form hampers the effects of outliers on the estimation results. Hence, the EGARCH model is more appropriate for modeling most of economics and financial time series data since negative shocks and positive shocks have different effects on the conditional variance (volatility). In general, the symmetrical (GARCH) versus asymmetrical (EGARCH) effects of positive and negative shocks on the volatility can be seen in Figure 2. The quasi-maximum likelihood estimation (QMLE) method is employed in the GARCH(1,1), GARCH(1,1)-M, EGARCH(1,1) and EGARCH(1,1)-M models. In general the quasi-maximum likelihood estimators are robust as they can produce consistent estimates of the parameters of a correctly specified conditional mean, even if the distribution is incorrectly specified (Wooldridge 2003).

GRANGER CAUSALITY TESTS

In this paper, the two-step approach is used to test the effect of higher lagged inflation uncertainty on inflation and vice versa. In the first step, the conditional variance for inflation

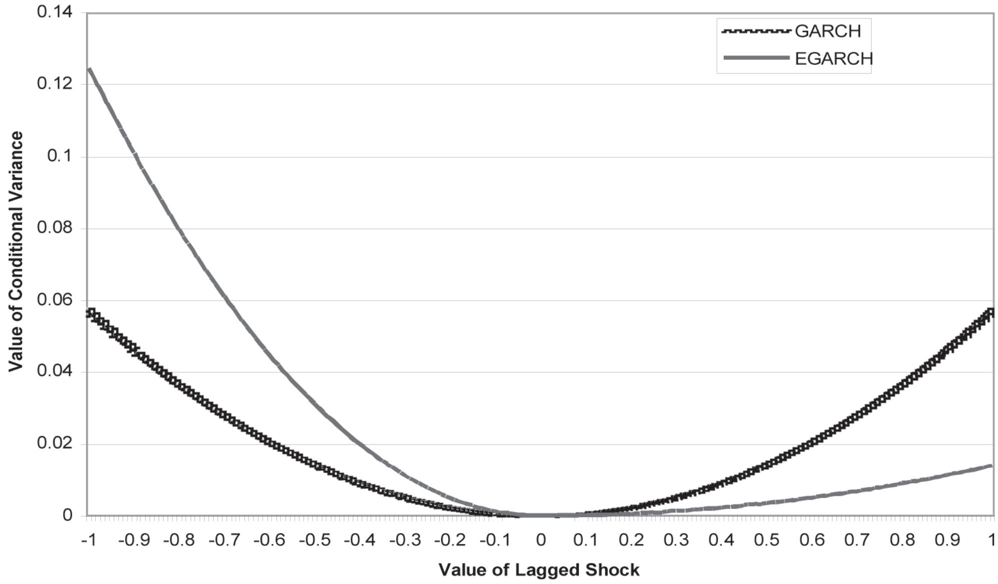

FIGURE 2. Effect of negative and positive shocks on volatility (asset return)

rate is estimated by employing equations (1)-(5). The second step involves the application of the estimated volatility of inflation in the Granger causality tests, as given below.

$$INF_t = \alpha_0 + \sum_{i=1}^{k} \gamma_i INF_{t-i} + \sum_{i=1}^{k} \lambda_i INFUNC_{t-i} + v_t \quad (6)$$

$$INFUNC_t = \alpha_0 + \sum_{i=1}^{k} \gamma_i INF_{t-i} + \sum_{i=1}^{k} \lambda_i INFUNC_{t-i} + u_t \quad (7)$$

where INF_t is the inflation rate at time t and $INFUNC_t$ is the inflation uncertainty at time t

Finally, the information criterion is used to achieve optimal lag lengths in equations (6) and (7).

RESULTS

It is necessary to check the order of integration for inflation rate series before we continue to model the inflation uncertainty. We test for the stationary properties of inflation data using ADF and PP tests. The results are reported in Table 1. Both unit root tests reject the null hypothesis of a unit root at the 0.05 significance level and we can concluded that inflation rate is stationary I(0) over the 1980-2004 period.

TABLE 1. Unit root tests

	Unit Root Tests	
	ADF	PP
Test statistics	-4.7924	-13.6574
Critical value : 5%	-2.8712	-2.8710
Lags	5	5

DESCRIPTIVE STATISTICS

The result in Table 2 reports the descriptive statistics for inflation rate in Malaysia. From the table, we can make the following observations. (a) inflation rate tend to have high excess kurtosis, indicating that the distributions appear to be leptokurtic and skewed to the right, (b) the Jarque-Bera test is statistically significant at 0.01 level and thus inflation rate has a non-normal distribution.

TABLE 2. Descriptive statistics for inflation rate

Descriptive statistics	
Mean	0.2535
Median	0.1957
Maximum	1.8617
Minimum	-1.5147
Standard deviation	0.3833
Skewness	0.4768
Kurtosis	5.8787
Jarque-Bera	114.5747
p value	0.0000
N	300

ESTIMATION RESULTS

The results in Table 3 panel (A) show the robust ordinary least square (OLS) results that include two lags (first lag and sixth lag) of inflation and two monthly seasonal dummies (February and March). Ljung-Box *Q*-statistics indicate that the residuals are serially uncorrelated and insignificant at all lags. However, Ljung-Box *Q*-statistics on the squared residuals are significant at the 0.01 level of significant for lag 6 and lag 12. Hence, it means that the error variance of inflation rate is not constant but time varying.

TABLE 3. OLS estimates, AR(6)-GARCH(1,1) and AR(6)-GARCH(1,1)-M models

		(A) OLS		(B) AR(6)-GARCH(1,1)		(C) AR(6)-GARCH(1,1)-M	
Variable		Coefficient	*p* value	Coefficient	*p* value	Coefficient	*p* value
constant	α_0	0.2499***	0.0000	0.2087***	0.0000	0.2194***	0.0000
π_{t-1}	α_1	0.1768**	0.0174	0.1398**	0.0209	0.1406**	0.0181
π_{t-6}	α_6	-0.2118***	0.0039	-0.1833***	0.0031	-0.1782***	0.0034
d_2	δ_2	0.2120***	0.0003	0.1542**	0.0444	0.1549**	0.0252
d_3	δ_3	0.1876***	0.0009	0.1584***	0.0002	0.1534***	0.0003
σ^2_t	ξ					-0.1347	0.7185
constant	β_0			0.0563***	0.0096	0.0600***	0.0016
ε^2_{t-1}	β_1			0.3676**	0.0210	0.4057**	0.0143
σ^2_{t-1}	β_2			0.2128	0.2700	0.1581	0.3191
AIC		0.7783		0.7036		0.7101	
SC		0.8411		0.8041		0.8231	
Log LL		-109.0187		-95.0792		-95.0283	
$Q(6)$		5.1214	0.2750	4.5159	0.3410	4.6716	0.3230
$Q(12)$			9.3560	0.4990	17.0470*	0.0730	17.9280*
0.0560							
$Q^2(6)$		32.0860***	0.0000	2.6473	0.6180	2.0075	0.7340
$Q^2(12)$		34.1220***	0.0000	4.8857	0.8990	4.2729	0.9340

Notes : *** , ** and * indicate significance at the 0.01, 0.05 and 0.10 levels respectively

TABLE 4. AR(6)-EGARCH(1,1) and AR(6)-EGARCH(1,1)-M Models

		(A) AR(6)-EGARCH(1,1)		(B) AR(6)-EGARCH(1,1)-M	
Variable		Coefficient	*p* value	Coefficient	*p* value
constant	α_0	0.2335***	0.0000	0.4661**	0.0289
π_{t-1}	α_1	0.1563***	0.0103	0.1493**	0.0136
π_{t-6}	α_6	-0.1623**	0.0130	-0.1851***	0.0045
d_2	δ_2	0.1539**	0.0281	0.1032	0.1295
d_3	δ_3	0.1807***	0.0001	0.1733***	0.0001
$\log\alpha^2_t$	ξ			0.0969	0.2896
constant	β_0	-1.2687**	0.0369	-1.1064**	0.0249
$\lvert\varepsilon_{t-1} / \sigma^2_{t-1}\rvert$	β_1	0.3104*	0.0580	0.2713*	0.0791
$\varepsilon_{t-1} / \sigma^2_{t-1}$	β_2	0.2262**	0.0452	0.2269**	0.0359
$\log \sigma^2_{t-1}$	β_3	0.5356**	0.0438	0.5954***	0.0051
AIC			0.6912		0.6939
SC			0.8042		0.8195
Log LL			-92.2576		-91.6542
$Q(6)$		5.1910	0.2680	4.8449	0.3040
$Q(12)$		15.5280	0.1140	13.5810	0.1930
$Q^2(6)$		2.4359	0.6560	1.5042	0.8260
$Q^2(12)$		5.2868	0.8710	5.5933	0.8480

Notes : *** , ** and * indicate significance at the 0.01, 0.05 and 0.10 levels respectively

Based on the information criteria and significance test on the parameters, the results in Table 3 panel (B) and (C) show that in general the GARCH and GARCH-M models are not the best model for modeling the dynamic volatility behavior of inflation rate in Malaysia. Hence, we proceed to present the results of a more robust model for the estimation of inflation rate volatility by using the EGARCH models.

Table 4 panel (A) and (B) report the estimates of EGARCH(1,1) and EGARCH(1,1)-M models. The Ljung-Box *Q*-statistics on both standardized residuals and standardized squared residuals show that the residuals are free from serial correlations and conditional heteroscedasticity. However, AR(6)-EGARCH(1,1) model has smaller values of AIC and SC as compared to AR(6)-EGARCH(1,1)-M model.

Thus, AR(6)-EGARCH(1,1) model seems adequate for estimating both the conditional mean and conditional variance of Malaysia's inflation rate. However, in this paper the focus of our discussion is on the conditional variance (volatility) estimation. The coefficients of β_2 and β_3 measure the asymmetric effect and persistency of inflation uncertainty (volatility), respectively. The results show that both parameters are statistically significant at the 0.05 level. In this study, the positive and significant value of β_3 coefficient implies that positive shocks have greater impact on inflation uncertainty as compared to negative shocks. The insignificant result of the parameter ξ in Table 4 panel (B) shows that there is no contemporaneous relationship between inflation uncertainty and inflation.

Sub-periods analysis on average inflation and inflation volatility give some evidence on the relationship inflation and inflation uncertainty. The graph in Figure 3 gives clear indication that during the global recession in the early 1980s, the average inflation rate and average inflation uncertainty in Malaysia is high. However, during the periods from 1985 to the period before the financial crisis the average inflation uncertainty is quite low. Except during the financial crisis period, in general it is observed that the average inflation uncertainty has dropped during the recent

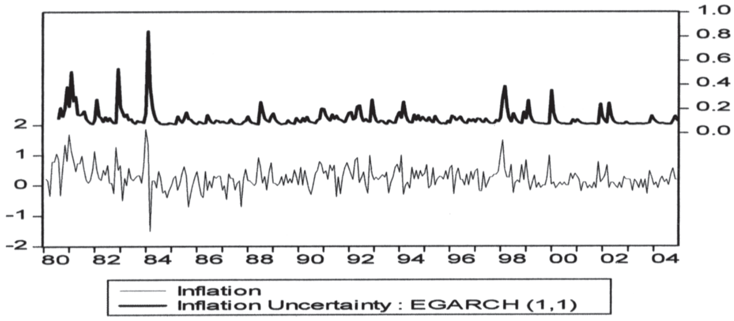

FIGURE 3. Inflation and inflation uncertainty, 1980 – 2004

TABLE 5. Sub-period analysis on inflation and inflation uncertainty: EGARCH(1,1)

	Full Sample: 1980M01-2004M12	
Descriptive statistics	Inflation	Inflation uncertainty
Mean	0.2535	0.1213
Sample size	299	293

	1980M01-1983M12		1984M01-1987M12	
Descriptive statistics	Inflation	Inflation uncertainty	Inflation	Inflation uncertainty
Mean	0.4795	0.1655	0.0948	0.1219
Sample size	47	41	48	48

	1988M01-1991M12		1992M01-1993M12	
Descriptive statistics	Inflation	Inflation uncertainty	Inflation	Inflation uncertainty
Mean	0.2703	0.1140	0.3386	0.1267
Sample size	48	48	24	24

	1994M01-1997M06		1997M07-1998M12		1999M01-2004M12	
Descriptive statistics	Inflation	Inflation uncertainty	Inflation	Inflation uncertainty	Inflation	Inflation uncertainty
Mean	0.2598	0.1129	0.3870	0.1387	0.1350	0.0993
Sample size	42	42	18	18	72	72

years (see Table 5). One of the possible reasons is that in 1998, monetary policy was implemented in order to stabilize the economy due to the adverse impact from the financial crisis. A tight monetary policy (high interest rate) was implemented at the beginning of 1998 in order to contain high inflation rate due to the depreciation of the Malaysian ringgit.

In terms of predicting the level of inflation, the result in Figure 4 gives an indication that when inflation is high (1980 until late 1984) the level of predictability is low (confidence bound is wide). Hence, this result provides additional information for authorities in charge of monetary policymaking when future inflation rate is to be estimated.

Table 6 gives the results on the dynamic relationship between inflation and inflation uncertainty using Granger causality tests. We test the first null hypothesis that inflation does not Granger caused inflation uncertainty, using lag lengths 4, 8 and 12. While the second hypothesis test the null hypothesis that inflation uncertainty does not Granger caused inflation. Over the sample period studied, the null hypothesis that inflation does not Granger caused inflation uncertainty is rejected at the 0.01, level for all lags. Moreover, the sum of the coefficients is positive, indicating that higher inflation level causes greater inflation uncertainty as mentioned by Friedman's hypothesis.

The null hypothesis that inflation uncertainty does not Granger-caused inflation is also rejected. However, the sum of the coefficients on lagged inflation uncertainty is negative and this is in line with the result stated in Holland's hypothesis. Finally, we summarize that there exits a bi-directional causal relationship between inflation and inflation uncertainty in Malaysia.

CONCLUSION

The empirical exercise on modeling and finding relationship between inflation and inflation uncertainty has been done for the period 1980-2004. The GARCH and EGARCH models were used to generate a measure of inflation uncertainty. The empirical results show that there is significant asymmetric effect of inflation shocks to inflation uncertainty. However, the result from EGARCH(1,1)-M model shows that there is no contemporaneous relationship between inflation uncertainty and inflation. Based on the results from the EGARCH model and the Granger causality tests, there is

PREDICTION OF INFLATION RATE IN THE RRESENCE OF EGARCH EFFECT

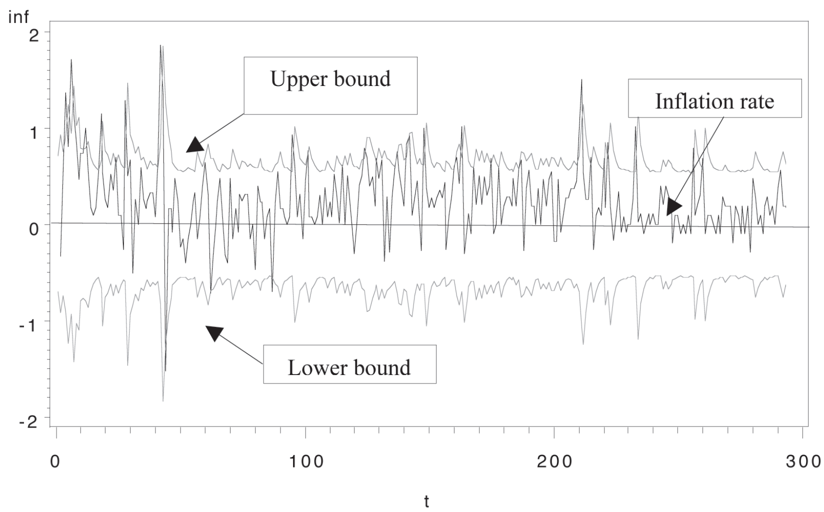

FIGURE 4. Inflation rate and 95% prediction interval (lower and upper bounds) using time-varying conditional standard deviation of inflation

TABLE 6. Granger Causality test

Lag	H_0 : Inflation does not Granger caused inflation uncertainty		H_0 : Inflation uncertainty does not Granger caused inflation	
	F-statistic	*p* value	*F*-statistic	*p* value
4	69.3461***(+)	0.0000	3.2560**(-)	0.0124
8	29.4787***(+)	0.0000	3.1865***(-)	0.0018
12	18.5976***(+)	0.0000	2.4559***(-)	0.0048

Notes : *** and ** indicate significance at the 0.01 and 0.05 levels sufficient evidence that higher inflation rate tends to lead to higher future inflation uncertainty. On the other hand, higher level of inflation uncertainty tends to lead to lower future inflation rate.

REFERENCES

Ball, L. 1992. Why does inflation raise inflation uncertainty? *Journal of Monetary Economics* 29(3) : 371-388.

Berument, H., Metin-Ozcan., K. & Neyapti, B. 2001. Modelling inflation uncertainty using EGARCH: An application to Turkey. *Federal Reserve Bank of Louis Review* 66: 15-26.

Cukierman, A & Meltzer, A. 1986. A theory of ambiguity, credibility, and inflation under discretion and asymmetric information. *Econometrica* 54: 1099-1128.

Eagle, R. 1983. Estimates of the variance of US inflation based upon the ARCH model. *Journal of Money, Credit and Banking* 15: 286-301.

Fernandez Valdovinos, C. 2001. Further evidence Friedman's hypothesis: The case of Paraguay. *Cuadernos de economia* V38 N115.

Friedman, M. 1977. Nobel lecture: Inflation and unemployment. *Journal of Political Economy* 85: 451-472.

Fountas, S., Ioannidis, A. & Karanasos, M. 2004. Inflation, inflation uncertainty, and a common European monetary policy. *The Manchester School*. 72: 221-242.

Holland, S. 1995. Inflation and uncertainty: Tests for temporal ordering. *Journal of Money, Credit, and Banking* 27: 827-837.

Karanasos, M., Karanassou, M. & Fountas, S. 2004. Analyzing US inflation by a GARCH model with simultaneous feedback. *WSEAS Transactions on Information Science and Applications* 1: 767-772.

Kontonikas, A. 2004. Inflation and inflation uncertainty in the United Kingdom, evidence GARCH modelling. *Economic Modelling* 21: 525-543.

Nas, T. F. & Perry, M. J. 2000. Inflation, inflation uncertainty, and monetary policy in Turkey: 1960–1998. *Contemporary Economic Policy* 18: 170–80.

Nelson, D.B. 1991. Conditional Heteroskedasticity in Asset Returns: A New Approach. *Econometrica* 59: 347–370.

Wooldridge, J.M. 2003. *Introductory Econometrics*. (2nd al.) USA: Thomson South-Western. 2 Edition.

Abu Hassan Shaari Mohd Nor, Tan Yan Ling,
Pusat Pengajian Ekonomi
Fakulti Ekonomi dan Perniagaan
UKM, Bangi 43600 Selangor D.E.
Malaysia

Fauziah Maarof
Jabatan Matematik, Fakulti Sains
Universiti Putra Malaysia
43400, Serdang, Selangor D. E.
Malaysia

Received: 10 December 2006
Accepted: 25 February 2007