The Linkages between Inflation and Inflation Uncertainty in Selected Asian Economies: Evidence from Quantile Regression

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Abstract

Using monthly data from 1979M1 to 2019M12, this paper employs the AR(p)-EGARCH model and quantile regression to examine the linkages between inflation and inflation uncertainty in nine Asian countries. The results show that inflation positively causes inflation uncertainty in all economies regardless whether economies are inflation or non-inflation targeting. The Friedman-Ball hypothesis is thus supported. In addition, inflation uncertainty positively causes inflation in most economies. Therefore, the Cukierman-Meltzer hypothesis.is likely to be supported. The findings signal the possibility of the real cost of inflation for these economies.

Keywords: Inflation, inflation uncertainty, GARCH, quantile regression, Asian economies
JEL Classification: C22, E31

1. Introduction

The causal linkages between inflation and inflation uncertainty have been widely investigated by many researchers. The focus of empirical studies is on testing the Friedman-Ball hypothesis (Friedman, 1977, and Ball, 1992) and the Cukierman-Meltzer hypothesis (Cukierman and Meltzer, 1986). The first hypothesis posits that high inflation causes inflation uncertainty to increase while the second hypothesis postulates that increased inflation uncertainty causes inflation to increase. However, previous empirical evidence shows that there seem to have mixed results for the relationship between inflation and its uncertainty. Earlier studies have concentrated on advanced economies (e.g., Grier and Perry, 1998; Kontonikas, 2004; Fountas and Karanasos, 2007; Caporale and Kontonikas, 2009 and Chowdhury and Sarkar, 2015). Most of these studies give evidence supporting the Friedman-Ball hypothesis while some studies give evidence in favor of the Cukierman and Meltzer hypothesis. However, some studies show that there is no relationship between the two series and few studies show that inflation uncertainty lowers inflation, which is in line with the finding by Holland (1996). In addition, Albulescu et al. (2016) employ the wavelet methodology to examine the causal linkage between inflation and inflation uncertainty in the U. S. They find that the causal relationship of the two variables varies across time and frequency. Zivkov et al. (2014) use monthly data to examine the relationship between inflation and inflation uncertainty in 11 Eastern European countries. The results from quantile regression suggest that both the Friedman-Ball and the Cukierman-Meltzer hypotheses are supported for the largest countries with flexible exchange rate regime. However, the two hypotheses are not supported in smaller countries with fixed exchange rate regime.

Empirical works have been extended to the case of both advanced and developing countries (e. g., Daal et al., 2005; Chen et al., 2008 and Nasr et al., 2015). These studies provide strong evidence supporting the Friedman-Ball hypothesis mainly for developing countries. However, the results that support the Cukierman-Meltzer hypothesis are mixed. In some circumstance, inflation uncertainty has a negative impact on inflation. When inflation uncertainty lowers inflation, it implies that the central bank chooses stabilizing policy to combat inflation.

For empirical studies focused on Asian economies, Chen et al. (2008) examine the causal linkages between inflation and inflation uncertainty in Hong Kong, Singapore, South Korea and Taiwan. They find that the Cukierman-Meltzer hypothesis is supported for all four economies while the Friedman-Ball hypothesis is supported all economies, except for Hong Kong. Using monthly data, Jiranyakul and Opiela (2010) examine the two hypotheses in the ASEAN-5 countries (Indonesia, Malaysia, Philippines, and Thailand) and find that both hypotheses are supported for these five economies. Mohd et al. (2013) also examine the two hypotheses by employing quarterly data of the same five countries, but find that only the Friedman-Ball hypothesis is supported. Chowdhury (2014) finds the positive relationship between inflation and its uncertainty for India. Su et al. (2017) investigate the causal link between inflation and inflation uncertainty in China. They find that the results support the Friedman-Ball hypothesis, but evidence in favor of the Cukierman-Meltzer hypothesis is not clear.

This paper examines the relationship between inflation and inflation uncertainty in Asia using the quantile regression. Since there might be heterogeneous behavior of some series of inflation and inflation uncertainty, the quantile regression should be suitable for the estimations. This technique is robust when non-normal characteristics and outliers are present in the data. Understanding the heterogenous linkages between inflation and inflation uncertainty at different quantiles reveals more information for monetary policy frameworks by the central banks in these Asian economies such that output growth will not harmed by inflation. Therefore, this paper contributes to the existing literature in that it provides evidence on the linkages between inflation and inflation uncertainty at different quantiles. Furthermore, the quantile regression technique allows more efficient estimation than other linear regression methods.

The outline of this paper is as follows. The next section presents the data and estimation methods. Section 3 presents empirical results, and the last section concludes.

2. Data and Estimation Methods

Monthly data of consumer price indexes (CPIs) for nine Asian economies are retrieved from the website of the Bank of International Settlement. The period of analysis is from 1979M1 to 2019M12. This period is selected for a comparable purpose because the monthly series of Indonesia starts from 1979M1. The inflation rate for each country is the percentage change of seasonally adjusted CPI. The descriptive statistics and unit root test of all inflation rates in these Asian economies are shown in Table 1.

Table 1. Descriptive statistics and unit root test of inflation series, 1979M1-2019M12.

Country	Mean	Std. Dev.	Skewness	Kurtosis	JB	ADF
Hong Kong	0.387	0.641	0.093	6.304	224	-3.664 [5]
India	0.565	0.598	0.976	5.281	184	-8.382 [2]
Indonesia	0.746	1.099	4.758	36.586	>6000	-5.990 [3]
Japan	0.086	0.295	1.471	7.506	592	-18.514 [0]
Malaysia	0.239	0.373	1.925	20.070	>6000	-17.533 [0]
Philippines	0.650	0.942	4.132	29.233	>6000	-3.896 [6]
Singapore	0.163	0.382	0.542	6.546	281	-8.202 [2]
South Korea	0.393	0.575	2.681	13.675	2919	-3.017 [8]
Thailand	0.305	0.528	1.323	10.667	1346	-7.264 [2]

Note: JB stands for Jarque-Bera statistic for normal distribution test, the number in bracket is the optimal lag for Augmented Dickey-Fuller (ADF) test.

The countries that have high inflation rates are Indonesia, the Philippines and India, and the countries that have moderate inflation rates are South Korea, Thailand and Malaysia. Only two countries, Japan and Singapore, have low inflation rates. The descriptive statistics reveal that all inflation series are positively skewed with excess kurtosis. The Jarque-Bera statistics indicate that inflation rates are not normally distributed. The ADF test shows that the null hypothesis of unit root in each inflation series is rejected. Therefore, inflation rates in all countries are stationary. Furthermore, all inflation series are suitable for the estimation of autoregressive exponential generalized conditional heteroskedastic (AR(p)-EGARCH) model of Nelson (1991). The GARCH variance series are used to generate the series of inflation uncertainty as employed by Jiranyakul and Opiela, (2010).

This AR(p)-EGARCH(1,1) model to generate inflation uncertainty series is expressed as:

$$\pi_t = a_0 + \sum_{i=1}^{p} a_i \pi_{t-i} + \varepsilon_t \tag{1}$$

$$\log(h_t) = \alpha_0 + \alpha_1 \left| \frac{\varepsilon_{t-1}}{h_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \beta \log(h_{t-1}) \tag{2}$$

where π is the inflation rate. Eq. (1) is an autoregressive representation of the conditional mean of inflation. Eq. (2) represents the conditional variance of inflation, where h_t is the variance term and γ is the coefficient of asymmetric impact, which should be non-negative.

Two linear equations are used to examine the validity of Cukierman-Meltzer and Friedman-Ball hypotheses using quantile regression technique proposed by Koenker and Hallock (2001). They are expressed as:

$$\pi_{i,q} = \alpha_{1,q} + \beta_{1,q} u_{i,q} + e_{1i,q} \tag{3}$$

$$u_{i,q} = \alpha_{2,q} + \beta_{2,q} \pi_{i.q} + e_{2i,q} \tag{4}$$

where u is the series of inflation uncertainty, and q denotes the q^th quantile. Eqs (3) and (4) can be expressed as $Y_i = X_i^{'}\beta_q + e_i$. The quantile regression estimator for the q^th of country i will minimize the objective function:

$$Q(\beta_q) = \sum_{i:Y_i \geq X_i^{'}\beta_q}^{N} q\left|Y_i - X_i^{'}\beta_q\right| + \sum_{i:Y_i < X_i^{'}\beta_q}^{N} (1-q)\left|Y_i - X_i^{'}\beta_q\right| \quad (5)$$

where N is the number of observations.

3. Empirical Results

Eqs. (1) and (2) are used to generate the GARCH variance series for each country. This series is inflation uncertainty series. The estimated AR(p)-EGARCH(1,1) models are reported in Table 2.

Table 2. Estimates of AR(1)-EGARCH(1,1) model, 1979M1-2019M12.

Country	γ	$\log(h_t)$	Q(8)	Q(16)	$Q^2(8)$	$Q^2(16)$
Hong Kong	-0.134***	0.845***	2.188	4.508	4.856	16.004
			(0.975)	(0.998)	(0.773)	(0.453)
India	0.104***	0.913***	0.462	5.797	3.468	6.897
			(0.999)	(0.990)	(0.902)	(0.975)
Indonesia	0.385***	0.884***	5.124	26.176	4.728	5.609
			(0.744)	(0.052)	(0.786)	(0.992)
Japan	-0.199***	0.397**	4.519	14.180	1.219	3.628
			(0.808)	(0.585)	(0.996)	(0.999)
Malaysia	0.079	0.890***	5.247	14.736	0.776	1.524
			(0.731)	(0.544)	(0.999)	(0.999)
Philippines	-0.321***	0.809***	21.626	30.837	8.803	16.664
			(0.006)	(0.014)	(0.359)	(0.408)
Singapore	0.173***	0.645***	2.114	12.931	5.298	32.054
			(0.977)	(0.678)	(0.725)	(0.010)
South Korea	0.141***	0.937***	2.131	10.968	2.939	10.977
			(0.977)	(0.811)	(0.938)	(0.811)
Thailand	0.120***	0.954***	2.329	6.268	4.781	6.182
			(0.969)	(0.985)	(0.781)	(0.986)

Note: The coefficient γ is the asymmetry coefficient, and $\log(h_t)$ is the GARCH term. The number in parenthesis is p-value. Q(k) and $Q^2(k)$ are Ljung-Box statistics to test for serial correlation and further ARCH effect. ***, ** and * indicate significance at the 1%, 5% and 10%, respectively.

For the whole sample period, the lag order of AR(p) model is set at 12 lags for all countries. However, the lag order of 10 is enough for Malaysia to reduce the problem of serial correlation.[1] For the Philippines, increasing the lag length above 12 will not eliminate the serial correlation problem. In addition, no further ARCH effect for Singapore is shown in

[1] There are quite large AR terms in the model, but adding the moving average (MA) terms does not help in improving the estimated results. In addition, the most optimal model seems to have long memory in monthly data (see Fountas and Karanasos, 2007).

$Q^2(8)$ only.[2] It can be claimed that the model works well for most countries. As shown in Table 2, there exists asymmetry for all countries, except Malaysia. Furthermore, the size of the GARCH term, $\log(h_t)$, is less than one for all countries and thus the conditional variance or inflation uncertainty series is stationary. However, descriptive statistics and unit root test for each series are shown in Table 3.

Table 3. Descriptive statistics and unit root test of inflation uncertainty series, 1979M1-2019M12.

Country	Mean	Std. Dev.	Skewness	Kurtosis	JB	ADF
Hong Kong	0.263	0.160	3.126	16.475	4551	-9.782 [0]
India	0.028	0.125	2.768	12.696	2488	-5.211 [0]
Indonesia	1.046	3.193	11.064	156.654	>6000	-11.369 [0]
Japan	0.067	0.021	2.321	9.897	1380	-16.079 [0]
Malaysia	0.188	0.538	14.851	256.956	>6000	-12.478 [0]
Philippines	0.761	3.670	16.449	314.842	>6000	-16.267 [0]
Singapore	0.114	0.107	3.086	15.165	3714	-12.527 [0]
South Korea	0.143	0.235	6.391	51.614	>6000	-10.904 [1]
Thailand	0.184	0.172	3.404	17.752	5268	-5.756 [0]

Note: JB stands for Jarque-Bera statistic for normal distribution test, the number in bracket is the optimal lag for Augmented Dickey-Fuller (ADF) test.

The mean of inflation uncertainty are high for Indonesia and the Philippines. The rest of the countries have low mean uncertainty. All uncertainty series are positively skewed and the high values of skewness are observed for the Philippines, Malaysia and Indonesia. The large JB statistics for all countries lead to a rejection of the null hypothesis of normal distribution. Furthermore, the ADF test rejects the null hypothesis of unit root for all countries, and thus all inflation uncertainty series are stationary.

Since inflation and inflation uncertainty series are stationary, the next step is to estimate Eqs. (3) and (4) by the ordinary least squares (OLS) method to see how inflation and inflation uncertainty affect each other. Even though the OLS method might not be efficient and may produce errorneous results when heteroskedasticity, skewness and some outliers are present, this method can be helpful in giving preliminary results concerning the Friedman-Ball and Cukierman-Meltzer hypotheses. The results are reported in Table 4.

Table 4. Least squares estimates of the relationship between inflation and inflation uncertainty, 1979M1-2019M12.

Country	β_1	BPG test	β_2	BPG test
Hong Kong	0.584***	35.403	0.038***	24.245
		(0.000)		(0.000)
India	1.171***	34.517	0.060***	6.032
		(0.000)		(0.014)
Indonesia	0.010***	50.571	0.861***	1.407
		(0.000)		(0.236)
Japan	2.229***	8.621	0.012***	9.543
		(0.003)		(0.000)
Malaysia	0.027	0.642	-0.506	0.362
		(0.423)		(0.124)
Philippines	0.136***	9.309	2.151***	108.904

[2] Other forms of AR(p)-GARCH models might not be applicable to the case of the Philippines.

		(0.002)		(0.000)
Singapore	0.275*	73.484	0.023*	0.001
		(0.000)		(0.985)
South Korea	1.236***	130.960	-0.003***	20.329
		(0.000)		(0.000)
Thailand	1.110***	30.676	0.144***	10.611
		(0.000)		(0.000)

Note: The coefficients, β_1 and β_2, are the slope coefficients of Eqs. (3) and (4) without quantiles. BPG test stands for Breusch-Pagan-Godfrey test for heteroskedasticity. ***, ** and * indicate significance at the 1%, 5% and 10% respectively. The number in parenthesis is p-value.

The results from OLS method indicate strong evidence in support for both the Friedman-Ball and Cukierman-Meltzer hypotheses. For the first hypothesis, the sizes of the estimated slope coefficients vary across countries, e.g., Japan has the highest coefficient followed by South Korea, India and Thailand. The rest of the countries have the slope coefficients of less than one. For the second hypothesis, most of the countries have slope coefficients of less than one, and some have a negative slope. The Cukierman-Meltzer hypothesis is supported for the majority of the countries, except Malaysia, Singapore and South Korea. In the case of South Korea, inflation causes inflation uncertainty to decrease.

The Breusch-Pagan-Godfrey (BPG) tests for heteroskedasticity of Eqs. (3) and (4) without quantiles suggest that there might be heterogenous impacts of inflation uncertainty on inflation for most countries. Similarly, there might be heterogenous impacts of inflation on inflation uncertainty in most cases. It should be noted that for Singapore and Malaysia, there are high values of skewness in inflation uncertainty series. The results provide the justification to examine the linkages in different quantiles. Table 5 reports the results of quantile regression of Eq. (3) for testing the Friedman-Ball hypothesis.

Table 5. Quantile regression for testing the Friedman-Ball hypothesis, 1979M1-2019M12. Dependent variable: Inflation

Country	0.1th	0.25th	05th	0.75th	0.9th
Hong Kong	-0.623	-0.132	-0.016	0.143	1.696***
India	-0.252	0.881***	1.439***	2.200***	2.229***
Indonesia	-0.021*	0.015**	0.125	0.358***	0.462***
Japan	-0.797	-0.450	2.003*	4.408***	5.877***
Malaysia	-0.056	0.111	0.071***	0.054***	0.608
Philippines	0.037	0.073	0.122***	0.196	0.772***
Singapore	-0.185***	0.069	0.382	1.125***	2.428***
South Korea	0.462***	0.430***	1.686***	1.779***	2.579***
Thailand	0.089	0.913***	1.222**	1.696***	2.010***

Note: ***, ** and * indicates significance at the 1%, 5% and 10%, respectively.

Table 5 presents the quantile regression results of the slope coefficient in Eq. (3) for testing the Friedman-Ball hypothesis. The results appear to differ from those of the OLS estimates reported in Table 4. The results seem to lend moderate and strong supports for the Friedman-Ball hypothesis. For the higher estimated quantiles, the Friedman-Ball hypothesis is strongly supported in the cases of Japan, Indonesia, Singapore, the Philippines and Hong Kong. This implies that inflation uncertainty positively causes inflation when the inflation rate is high. For South Korea, the hypothesis holds for all estimated quantiles. In addition, the results are similar for India and Thailand, i.e., the hypothesis does not hold only in the lowest quantile.[3] In the case of Malaysia, the hypothesis holds in the median and one quantile above the median.

Table 6 presents the quantile regression results of the slope coefficient in Eq. (4) for testing the Cukierman-Meltzer hypothesis. Again, the results support the hypothesis for most countries.

Table 6. Quantile regression for testing the Cukierman-Meltzer hypothesis, 1979M1-2019M12.

Dependent variable: Inflation uncertainty

Country	0.1th	0.25th	05th	0.75th	0.9th
Hong Kong	0.001	-0.009	-0.001	0.033**	0.037*
India	0.016**	0.023**	0.045***	0.060***	0.084***
Indonesia	0.084**	0.162***	0.322***	0.496***	1.294
Japan	0.002	0.003	0.006**	0.020***	0.018***
Malaysia	0.018	0.011	0.001	0.012	0.048
Philippines	0.063***	0.099**	0.273***	0.609***	1.131***
Singapore	0.010	0.016	0.039***	0.044***	2.351***
South Korea	0.051***	0.056***	0.085***	0.164***	0.318***
Thailand	0.044**	0.065***	0.103***	0.129***	0.128***

Note: ***, ** and * indicates significance at the 1%, 5% and 10%, respectively.

The slope coefficients are positively significant for all estimated quantiles for the Philippines, South Korea, Thailand and India. Furthermore, the sizes of the slope coefficient seem to become larger from lower to upper quantiles. Therefore, the Cukierman-Meltzer hypothesis is strongly supported for these four economies. For the two low-inflation countries, namely Japan and Singapore, the slope coefficients are positively significant from the median to upper quantiles. This also indicates that inflation uncertainty causes inflation to increase when inflation uncertainty is high enough. For Hong Kong, the slope coefficients change the sign from negative to positive when moving from lower to upper quantiles. In addition, only one quantile above the median is significant at the 5% level. The hypothesis is completely rejected only in the case of Malaysia. The findings in this paper seem to be in line with the findings by Chen et al. (2008), Jiranyakul and Opiela (2010) and Chowdhury (2014). However, the finding for the ASEAN-5 economies is not in line with Mohd et al. (2013) regarding the Cukierman-Meltzer hypothesis.

After the 1997 Asian financial crisis, some of these Asian economies, namely South Korea, Indonesia, the Philippines and Thailand, have adopted explicit inflation targeting scheme as monetary policy frameworks by the central banks. India has formally adopted flexible inflation targeting since February 2015 by the Bank of India. The remaining Asian countries, Hong Kong, Japan, Malaysia and Singapore are non-inflation targeting economies.[4] Nevertheless, inflation causes inflation uncertainty to increase regardless of inflation targeting scheme. In addition, inflation uncertainty can cause inflation rate to

[3] It should be noted that the sizes of the slope coefficient increase from lower to upper quantiles in many cases.

[4] Gerlach and Tillman (2012) find that inflation targeting has perform well in Asia because inflation persistence decline after adopting inflation targeting.

increase, except for Malaysia. Therefore, most of these countries will still face the real cost of inflation and its uncertaitnty if the inflation rate is not effectively controlled.

4. Conclusion

Due to the heterogenous behavior of most series of inflation and inflation uncertainty in the data, this paper examines the relationship between inflation and inflation uncertainty in nine Asian countries by the quantile regression technique. The inflation uncertainty series are created by the AR(p)-EGARCH(1,1) model with long memory. When heteroskedasticity is present in the OLS estimates and some inflation and inflation uncertainty series have large skewness, the results from OLS estimates are not reliable. The results from the quantile regression estimates point to the existence of the Friedman-Ball hypothesis for all economies. Also, the Cukierman-Meltzer hypothesis is supported, except for Malaysia. The findings do not depend on whether the economies have adopted inflation targeting as monetary policy frameworks by the central banks or not. The results also indicate that these economies cannot avoid the real cost of inflation if the inflation rates are not in check.

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