Inflation, inflation uncertainty and output growth: Recent Evidence from ASEAN 5-countries

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Abstract

This paper investigates the links between inflation, its uncertainty and economic growth in five ASEAN countries over the period 1980: Q1-2011: Q3. We rely on the Exponential GARCH (EGARCH) model to explore the causal relationship among the three variables. The major findings are: (i) inflation uncertainty increases more in response to positive inflation surprises than to negative surprises in all countries; (ii) inflationary shocks affect positively inflation uncertainty as predicted by the Friedman-Ball hypothesis; (iii) there is no evidence to suggest that inflation uncertainty causes inflation, and; (iv) there is evidence that inflation affects growth negatively, both directly and indirectly (via the inflation uncertainty channel). The indirect effect is clearly stronger as it applies in all countries in the sample.

Keywords: inflation, inflation uncertainty, output growth, ASEAN

JEL classification: C22, E31, E52
1. Introduction

In his Nobel Lecture, Friedman (1977) argued that rising inflation, brought about by full employment policy objectives, creates a strong incentive to counter it, and the perception of such pressure subsequently increases uncertainty about future inflation that hinders efficient allocation of resources, and in turn leads to a decline in real output. The positive link between inflation and inflation uncertainty was later formalized by Ball (1992). In his asymmetric information model the public is unaware of the type of policy maker (pro- or anti-inflation), and uncertainty about the policymaker’s preferences only affects positively inflation uncertainty when inflation is high. Following these two papers, the Friedman-Ball hypothesis has been the subject of a large number of empirical investigations (especially for the G7 countries) because of its policy implication for the conduct of monetary policy. Indeed, if the hypothesis holds, then monetary authorities should have a strong commitment to stabilize the inflation rate when there are inflationary shocks (such as oil price shocks). This is because inflation carries a small cost if it is perfectly anticipated, but larger costs if it raises uncertainty.

Another popular theory on the inflation–inflation uncertainty link is presented in Cukierman and Meltzer (1986). The authors argue that by providing an incentive for monetary authorities to create inflation surprises in order to stimulate real activity, an increase in uncertainty about money growth and inflation will raise the optimum inflation rate. In other words, this

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1 It has been widely recognized that a moderate rate of inflation may not harmful, and at times may be beneficial, as long as inflation is not allowed to get too high (Ghosh and Phillips, 1998; Ball et al., 1988). Ghosh and Phillips (1998), for example, found that inflation and growth are positively correlated only at very low inflation rates (2-3% a year, or lower). Of course, the threshold may differ from one country to another. Khan and Senhadji (2001) found that the threshold of inflation differs between industrialized countries (1-3%) and developing countries (11-12%). On the other hand, study by Baharumshah et al. (2011) shows that inflation uncertainty has a negative effect on economic growth in ASEAN-5 economies.

2 The costs of anticipated inflation due to deadweight loss from inflation tax appear to be small. On the other hand, if inflation creates uncertainty, then there may be significant costs, such as greater risk in long-term nominal arrangements.
competing hypothesis suggests that while the monetary authority may not favor inflation, it is likely they will not pass up the opportunity to stimulate the economy with surprise inflation. The positive correlation between inflation uncertainty and inflation arising from the impact of inflation uncertainty on inflation is referred to as the Cukierman-Meltzer hypothesis. Thus, from a theoretical perspective, a positive causal relationship running from inflation uncertainty is also plausible particularly in countries where the authority focuses more on economic growth than on inflation.

As mentioned earlier, Friedman (1977) in his article emphasized on two arguments; first, he claims that the level of inflation is positively correlated with inflation uncertainty. Second, Friedman indicates that higher uncertainty distorts the information content of prices which plays an important role in the efficient allocation of resources. The combined effect is a lower ability for the economy to grow. Pindyck (1991) demonstrates that macroeconomic (e.g. inflation) uncertainty increases the uncertainty associated with the potential return of investment, and may lead to lower economic growth due to falling investment in the presence of irreversibility of investment projects. As with the effect of inflation uncertainty on inflation mentioned above, there is also little theoretical consensus on the impact inflation uncertainty has on economic performance. Dotsey and Sarte (2000), for example, show that inflation uncertainty and economic growth are positively correlated based on a precautionary savings argument. According to this view, the pool of additional savings during the uncertainty period will lead to higher investment and economic growth. It is possible that inflation causes inflation uncertainty to increase, but because of the different indirect effects of inflation on output via the inflation uncertainty channel, a common monetary policy would have asymmetric output effects. This point was forcefully argued by Fountas et al. (2004) and others in the context of an unstable economic environment.
Inflation can affect output growth both indirectly (via the inflation uncertainty channel) and directly. The direct effect is theoretically ambiguous as it could be positive, negative, or zero. Some macroeconomic theories predict that the impact of inflation on economic growth could be negative (Tobin, 1965), neutral (Sidrauski, 1967), or even positive (Stockman, 1981).

The purpose of this study is to investigate the relationship between inflation, its uncertainty and output growth for five emerging ASEAN countries (ASEAN-5: Malaysia, Singapore, Thailand, Indonesia and the Philippines). We choose these countries because little empirical evidence on the inflation-uncertainty relationship exists in the literature for the ASEAN countries. Like the other emerging market economies, all of them were severely affected by the recent global financial crisis. Uncertainty about global economic conditions in the early 2007 poses new challenges to manage price stability, yet only few studies have looked for the relationship between inflation-growth relationships in the ASEAN countries. The coverage of the topic is inadequate and much more investigation is required using more recent data. We investigate the effects of both inflation and inflation uncertainty on growth. Using causality tests, several studies have looked at the inflation-growth nexus. Previous studies, however, have focused mainly on the major industrialized countries (US in particular). Before the crisis, most of these countries under review were able to grow well above the world’s average and enjoy low-to-moderate inflation\(^3\). The countries with the lowest and highest inflation and inflation uncertainty measured by the standard deviation are Singapore and Indonesia, respectively. CPI inflation in Indonesia rose from 6.4 in 2004 to 17.1% in 2005, following a hike in fuel price in October that year\(^4\).

\(^3\) Catão and Terronas (2003) classify all but one country (the Philippines) as low-inflation countries. The Philippines is characterized as middle inflation range.

\(^4\) The high inflationary expectations in the first quarter of 2005 was closely connected to the government effort to close the gap between the world price and the domestic fuel prices and weaker rupiah. Another historical event in Indonesia is the 1999 central bank law that allows the Bank of Indonesia both goal and instrument independence (see McLeod, 1999).
Thailand, Indonesia and the Philippines shifted to inflation targeting (IT) policy soon after the Asian financial crisis. The Bank of Indonesia formally adopted the inflation targeting regime in January 2000 while Bank of Thailand (BOT) launched the policy in July 2005. The Philippines did so in January 2002. Malaysia shifted from monetary targeting to interest rate targeting in the mid-1990s. Like the other countries, the shift took place after recognizing that the relationship between monetary aggregates and output growth had become unstable in the 1990s (Siregar and Goo, 2010). Additionally, inflation in Malaysia was at 4% for the first half of the 1990s, it increased by almost 1% in 1998 and remained fairly stable thereafter. Meanwhile, the Monetary Authority of Singapore (MAS) has been targeting its nominal exchange effective rate since early 1980s, showing the MAS’s emphasis on exchange rate movements. According to Cavoli and Rajan (2007), MAS uses its exchange rate policy to stabilize inflation (and output), at least in the short-term.

None of the ASEAN countries adopted monetary targeting during the sample period because empirical evidence on money demand in ASEAN points to instability in the relationship between monetary growth, economic activity and inflation. Other important aspects of the sample countries under review are that they differ in terms of the degree of monetary independence and price flexibility. Most of the countries under review, including Malaysia, have price controls on

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5 The IMF recommended the adoption of IT and central bank independence to a number of Asian countries after the 1997-98 crises. The details of the monetary framework vary from one country to another. A potential benefit of IT is that it can facilitate trade and investment by reducing uncertainty. But as noted by many scholars, it all depends on exchange rate stability. For an assessment of IT in emerging market economies; see Mishkin (2004) and Siregar and Goo (2010).

6 In the aftermath of the Asian financial crisis, Malaysia adopted a pegged exchange rate regime in September 1998. In July 2005, BNM replaced the peg with a managed float against a trade-basket weight of currencies.

7 Siregar and Goo (2010) examined the implementation and performance of IT in Indonesia and Thailand. In all, the evidence base on the data from 1990 to 2008 suggests a credible launching of IT in the two economies during both the stable and volatile periods.

8 We note here that the 1997/98 Asian financial crisis has affected the exchange rate as inflation in the Asian region. The degree of the impact, however, differs across the emerging market countries.
food and energy items. Focusing on fuel, the subsidies in Indonesia and Malaysia are quite high compared to the other ASEAN-5 countries. Similarly, Malaysia, Indonesia and the Philippines all have universal rather than transfer payment targeting the poor. These subsidies have been gradually removed in the recent years but there is fear among the policy makers that rising food and energy prices could spark an inflationary spiral, driving more people into poverty (especially Indonesia and the Philippines). In addition, some scholars have raised concern about the rising global food prices that started in 2000 as they are adding to inflationary pressure. This group of countries has different experienced with fiscal policy. Singapore had budget surplus for most of the sample period while the opposite is true for Malaysia and Indonesia. Additionally, the data over the past three decades reveals that fiscal variability in these countries differs from one country to another. These differences may have an impact on the relationship between inflation, inflation uncertainty and output growth.

The paper contributes to the literature in two additional ways: first, unlike most of the earlier studies, we rely on the Exponential GARCH (EGARCH) model to construct the conditional variance of inflation series. In contrast, most research assumes a symmetric GARCH process governing conditional inflation volatility. Our analysis is based on a sample of quarterly data ending in 2011 and, therefore, including the recent global financial crisis and the euro debt crisis. Uncertainties about the global economic environment and sharp price increases in major commodities in the last few years pose new challenges for managing price stability. Second, the paper adopts the approach suggested by Toda and Yamamoto (1995) to test for the two competing hypotheses on the inflation-inflation uncertainty nexus and the effects of inflation and inflation

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9 The range of measures to smooth the social impact of higher inflation due to rising international food and commodity prices in 2011 varies from one country to another. In Singapore, one-off cash transfer and personal income tax rebates were announced to buffer household income from inflation. Thailand, delayed plans to reduce subsidies on fuel and palm oil imports.
uncertainty on growth. As discussed latter, this method does not require the series to be of the same order of integration, and hence it avoids the concern about pretesting issues regarding the variables in the model as raised in the past literature.

The rest of the paper is structured as follows. In the next section, we provide a brief review on the empirical literature. Section 3 presents the EGARCH model and its use in constructing inflation uncertainty. Section 4 provides a brief description of the data and reports the empirical findings, and Section 5 concludes.

2. A Brief Review of the Literature

We first review the literature on the inflation-inflation uncertainty nexus. A review of many of the earlier empirical studies by Davis and Kanago (2000) reveals that the evidence on the Friedman-Ball hypothesis is inconclusive, partly reflecting the group of countries studied and empirical methodologies employed, including the representation of inflation uncertainty (see also Grier and Perry, 1998). More recent studies, such as Grier and Perry (1998), Fountas (2001), Hwang (2001) and Thornton (2007, 2008), to name a few, addressed the concern by using the generalized autoregressive conditional heteroskedasticity (GARCH) type specification. Specifically, Grier and Perry (1998) for G7 countries, Fountas (2001) for the UK, Fountas et al. (2004) for eurozone countries, Thornton (2007) for 12 emerging market economies, Jiranyakul and Opiela (2010) for the ASEAN-5, and Jiranyakul and Opiela (2011) for Thailand, have endorsed the Friedman-Ball hypothesis10. By contrast, Hwang (2001) found no such evidence rejecting the notion that an inflationary period is associated with high inflation uncertainty using long series of monthly US inflation data. Meanwhile, the empirical evidence on the

10 Thornton (2008) constructed inflation uncertainty using Argentina’s data for the period 1810-2005 and finds supportive evidence for the Friedman-Ball hypothesis.
Cukierman-Meltzer hypothesis is mixed: Apergis (2004) and Jiranyakul and Opiela (2010) find supporting evidence for the G7 and the ASEAN-5, respectively. In contrast, Hwang (2001) and Baillie et al. (1996) obtain no supporting evidence. Others, as in Grier and Perry (1998) and Narayan et al. (2009), have found evidence that uncertainty about future inflation has a negative rather than a positive impact on inflation, the so-called Holland hypothesis.\(^\text{11}\) Mixed evidence is also obtained by Fountas et al. (2004) for eurozone countries and Bredin et al. (2009) for five Asian countries. In summary, the empirical evidence on the Cukierman-Meltzer hypothesis is not robust across countries, a rather plausible result given the influence of the degree of central bank independence on the direction of this effect (Fountas et al., 2004).

We now present a review of the evidence on the relationship between inflation (nominal) uncertainty and output growth. Empirical studies on the relationship between inflation uncertainty and real economic activity have produced a mixed outcome in terms of the sign of the effect. The empirical evidence found in Grier and Perry (2000), Apergis (2004) and Grier et al. (2004) supports the negative effect of inflation uncertainty on economic growth. However, Fountas et al. (2004) find evidence against the negative effect of inflation uncertainty on growth in the eurozone countries. Fountas et al. (2006) find mixed evidence for the G7. Similarly, Fountas (2010), using historical data that cover over a century on 22 industrial countries, shows evidence against the detrimental effect of inflation uncertainty on growth in the majority of countries. Regarding the evidence in Asian countries, Narayan et al. (2009) find the hypothesis holds for China, Jiranyakul and Opiela (2011) find that it holds for Thailand, while Bredin et al. (2009) find no evidence for the hypothesis in India, South Korea, Singapore, Malaysia and the Philippines. Instead, Bredin et

\(^{11}\) Narayan et al. (2009) employed the EGARCH model to show that inflation uncertainty lowers average inflation in China for the period 1987-2006. They noted that most price controls in China were abolished by the early 1990s. They also found that inflation uncertainty reduces economic growth over the same period. Support of the hypothesis is more like to hold in developed countries with high degree of central bank independence.
al. (2009) find evidence for the Dotsey and Sarte (2000) hypothesis in two Asian countries. They also find that real (output) uncertainty is more important than nominal (inflation) uncertainty at least for the sample period ending in the mid-2000s. The latter result is also consistent with a recent study by Jiranyakul and Opiela (2011) for the case of Thailand. The study by Malik and Chowdhury (2001) in four South Asian countries find a reverse causality running form economic growth to inflation. Their results reveal that economic growth has a significant positive impact on inflation. For critical review on the inflation-growth nexus see also Temple (2000).

The closest study to ours is Jiranyakul and Opiela (2010) that also focuses on the ASEAN-5, and Jiranyakul and Opiela (2011) that focuses on Thailand. However, the present study differs from Jiranyakul and Opiela (2010) as it includes output growth in the analysis and examines the direct and indirect effect (via inflation uncertainty) of inflation on growth. It also differs from Jiranyakul and Opiela (2011) as it includes four more countries, it allows for asymmetries in the GARCH specification, and it examines also the direct effects of inflation on growth.

3. The Volatility Model

As mentioned earlier, to model the time-varying volatility in macroeconomic variables, a large fraction of this literature has relied on the popular autoregressive conditional heteroscedasticity or ARCH (Engle, 1982) and generalized ARCH (Bollerslev, 1986) or GARCH models. These models assume that current volatility is a function of past conditional variances and past shocks to the inflation series. In the GARCH (1,1) specification, the variance expected at any given time is a combination of the long-run variance and the variance expected for the last period, adjusted to take into account the size of last period’s observed shock.

Recently, several authors have expressed their concern on the appropriateness of using the
conditional variance obtained from a simple GARCH model to measure uncertainty (Brunner and Hess, 1993; Fountas, et al., 2004; Daal et al., 2005; Grier and Grier, 2006; Thornton, 2007). They point out that the standard GARCH specification imposes a symmetric restriction on the conditional variance. Additionally, as Brunner and Hess (1993, p. 187) put it, ‘The essence of Friedman’s hypothesis is inconsistent with such symmetric restriction, since new information suggesting that inflation is lower should reduce, rather than raise, uncertainty about future inflation’. Using the asymmetric power GARCH (PGARCH) model, Daal et al. (2005) construct the conditional variance of inflation rate in the G-7 countries and the emerging markets for Asian, Latin America and Middle Eastern countries. The authors find supportive evidence to suggest that inflationary shocks have a strong (positive) impact on inflationary uncertainty in many Latin American (Argentina, Colombia, Mexico and Venezuela), Asian (India, Korea, Pakistan, Sri Lanka and Thailand) and the Middle Eastern (Bahrain, Egypt, Morocco and Turkey) countries. All in all, the evidence is supportive of the Friedman-Ball hypothesis in both the developed and emerging countries, but the evidence of the Cukierman and Meltzer (1986) hypothesis is at best mixed.

In this study, we employ the EGARCH model suggested by Nelson (1991) which is widely used in measuring volatility in stock returns. The model has flexibility to allow for the asymmetric (sign) effects as well as the magnitude (size) effects of shocks to the inflation rate. That is, in addition to a larger shock of any sign having a larger effect, positive and negative shocks are allowed to have a different effect on inflation volatility. An EGARCH (1,1) representation of the conditional variance of inflation is described by the system below:

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12 In this study, the authors found that the parameter measuring the asymmetric effects for five countries (India, the UK, Colombia, Peru and Morocco) was shown to be negative and statistically significant at the usual significant levels, implying that positive shocks result in stronger effects on inflation uncertainty.
\[ \pi_t = \beta_0 + \sum_{i=1}^{n} \beta_i \pi_{t-i} + \varepsilon_t, \quad \varepsilon_t \sim N(0, h_t) \] (1)

\[ \log h_t = \omega + \alpha |\eta_{t-1}| + \gamma \eta_{t-1} + \beta \log h_{t-1}, \quad |\beta| < 1 \] (2)

The mean equation is defined as in equation (1) and represents an autoregressive model where \( \pi_t \) denotes the inflation and \( \varepsilon_t \) is conditionally normal with mean zero and variance, \( h_t \), whilst the structure of the conditional variance is presented in equation (2). \( \eta_t \) shows the standardized standard errors. Since equation (2) is a model of the logarithm of the conditional variance (\( h_t \)), no restrictions on the parameters are required to ensure the conditional variance is positive. Nelson (1991) demonstrated that the restriction \( |\beta| < 1 \) ensures stationarity and ergodicity for the EGARCH (1,1) specification. The parameters \( \alpha \) and \( \gamma \) in the model represent the magnitude and sign effects of the conditional (or standardized) shocks, respectively, on the conditional variance. If \( \gamma > 0 \), then inflation uncertainty will rise more in response to positive shocks than to negative inflation shocks. On the other hand, if \( \gamma < 0 \), then inflation uncertainty (\( h_t \)) will rise more in response to negative shocks than to positive shocks. It is also possible that the estimated value of \( \gamma \) is not significantly different from zero, implying that a positive shock to inflation has the same effect on uncertainty as a negative shock of the same magnitude (i.e., absence of asymmetric effect). In other words, the direction of change in inflation does not influence the path of inflation uncertainty in the country under investigation. To sum up, the EGARCH model differs from the standard symmetric GARCH model in two important aspects. First, the EGARCH model allows positive and negative shocks to have different impact on volatility. Second, the model allows large inflationary shocks to have a greater impact on volatility than the GARCH model does.
3.1 Granger-causality Toda-Yamamoto approach

We use the methodology developed by Toda and Yamamoto (1995) to test for the causal relationship between inflation ($\pi_t$) and its uncertainty ($h_t$). To briefly demonstrate the application of Toda-Yamamoto Granger causality test, consider the following bivariate autoregressive model having $k$ lags as,

\[
\begin{bmatrix}
\pi_t \\
h_t
\end{bmatrix}
= \begin{bmatrix}
\beta_{\pi} \\
\beta_h
\end{bmatrix} + \sum_{l=1}^{k} \begin{bmatrix}
a_{\pi,\pi,l} \\
a_{h,\pi,l}
\end{bmatrix} \begin{bmatrix}
\pi_{t-l} \\
h_{t-l}
\end{bmatrix} + \begin{bmatrix}
\nu_{\pi} \\
\nu_h
\end{bmatrix},
\]

(3)

The test of whether $\pi_t(h_t)$ Granger causes $h_t(\pi_t)$ is simply a test of the joint restriction where all the $a_{\pi,\pi,h}(a_{h,\pi,h}) = 0$ $(1,\ldots,k)$. Unlike the ordinary difference vector autoregressive (VAR), the above formulation involves variables appearing in their level. As shown by the authors, the advantage of this method is that it does not require prior knowledge of the cointegration properties of the system. It has a normal limiting chi-square distribution, and the standard lag selection procedure to the system can be applied even if there is no cointegration and (or) the stability and rank conditions are not satisfied “so long as the order of integration of the process does not exceed the true lag length the model” (Toda and Yamamoto, 1995, p. 225). The test is performed in two steps. In the first step, the optimum lag length is determined using either the Akaike information criterion (AIC) or the Schwartz (SIC) information criterion. In the second step, a VAR of order $k^*=k+d_{\text{max}}$ is estimated, where $d_{\text{max}}$ is the maximal anticipated order of integration. The MWALD statistic is valid whether the series is $I(1)$, $I(0)$ or $I(2)$, noncointegrated or cointegrated of an arbitrary order.

Pagan (1984) pointed out the simultaneous estimation of the conditional mean and variance (e.g., EGARCH-in-mean) is more efficient than the two-step produce as done in this paper. Grier and Perry (1998), however, argued that the simultaneous approach has a limitation as it does not allow for possible lagged effects of inflation uncertainty on inflation. For this reason, we adopt the two-step procedure in our analysis.
(Rambaldi and Doran, 1996). In essence, the procedure circumvents some pre-testing biases that researchers may confront with the standard unit root and cointegration tests.

4. Empirical Results

Quarterly frequency data on the consumer price index (CPI) were used to construct the inflation rates for five ASEAN countries for the period 1980:Q2 to 2011:Q3. Output growth rates are constructed using the percentage change in the logarithm of the quarterly industrial production index (IPI). For the IPI series, the data for Malaysia started in 1988: Q2, Thailand in 1992: Q2, Singapore in 1984: Q4, Indonesia, 1990: Q2 and the Philippines in 1981: Q2. The data were compiled from the International Monetary Fund’s *International Financial Statistics*. Indonesia, the largest ASEAN country in terms of both population and income, recorded the highest average annual inflation rate (11%) followed by Thailand (8%).

The ASEAN countries have recorded remarkable growth rates over the sample period, except during the 1997-98 Asian financial crisis. Three of the ASEAN economies, namely, Thailand, Indonesia and the Philippines, have adopted inflation as nominal anchor for their monetary policy. Singapore adopted exchange rate targeting while Malaysia interest rate targeting. Table 1 provides a statistical summary of the inflation rates for all the countries under investigation. The descriptive statistics also show that the distribution of the inflation rates series is characterized by a long-tailed distribution with large skewness and kurtosis. Singapore exhibited the lowest inflation rate and the lowest standard deviation. Additionally, the Jarque-Bera normality test reveals that all data series are characterized by a non-normal distribution. This finding of skewness and excess kurtosis is consistent with the fact that the distribution of inflation rates, like other financial variables, is nonnormal. Furthermore, the reported LM statistics in Table 1 provide evidence for the existence of ARCH effects in the inflation series. Figure 1 provides the time plot
of output growth rates, inflation and inflation volatility, with the gray area to mark the Asian financial crisis. A glance at the figures indicates that the inflation and volatility series vary across these countries and we are unable to draw conclusion regarding the relationship between the three variables. The formal targets launched by the IT countries do not bring additional benefits in terms of lower uncertainty. [Insert Table 1 and Fig. 1]

We therefore, proceed with the estimation of an EGARCH model. The estimated EGARCH model parameters for all countries are reported in Table 2. Several observations are worth noting. First, we find that the EGARCH (1,1) specification is adequate to model inflation uncertainty in all the countries. All the $\beta$ estimates are significant and less than one in absolute value. In some cases (Thailand, Singapore, the Philippines), evidence for significant persistence in conditional variances applies as the size of the $\beta$ coefficient is quite large. Second, the positive (negative) sign on parameter $\alpha$ for Thailand, Indonesia, the Philippines, Malaysia and Singapore (Indonesia) indicates that larger shocks have bigger (smaller) impact on the conditional variances. Third, the asymmetry coefficient, $\gamma$ is positive and highly statistically significant in all countries, except Singapore, where significance applies at 10% only. This carries the interpretation that positive shocks to inflation tend to increase inflation uncertainty more than negative shocks. Comparing our results with Fountas et al. (2004), we note that these authors found positive estimated asymmetry coefficients for France, Italy, Netherlands and Spain and a negative coefficient for Germany, a country that has traditionally placed strong emphasis on price stability. [Insert Table 2]

Fourth, based on the estimated coefficient of $\alpha$ and $\gamma$ parameters, it can be concluded that the magnitude (or size) effects have a larger impact than sign effects of the conditional shocks on the conditional variances for all countries but Indonesia and Thailand. Table 2 also reports some
diagnostics on the residuals of the EGARCH model. The Ljung-Box Q test statistics for the standardized residuals and the squared standardized residuals are lower than the 5% critical values (sole exception $Q^2(4)$ for Malaysia), thus indicating no further first or second-order serial dependence in the data. Finally, the p-values of the ARCH LM statistics show no further evidence for GARCH effects.

Next, the empirical results of the Toda-Yamamoto causality test between inflation, its conditional variance and output growth are presented in Table 3\textsuperscript{14}. Note that the optimum lag length $(k+1)$ is based on the popular AIC. Here, the $(k+1)$ order VAR was estimated with restrictions performed on lagged terms up to the $k$-th lag. Notice that the optimum lag for Thailand is five, for the Philippines is four, for Indonesia and Malaysia is three, and for Singapore is two. We also use extended lags to test whether our results are robust for different lag lengths\textsuperscript{15}.

We obtain some interesting results. Our first finding relates to the causal effect of inflation on inflation uncertainty. In all countries, we provide strong evidence for the Friedman-Ball hypothesis that predicts a positive effect of inflation on inflation uncertainty. Our second finding refers to the opposite type of causality from inflation uncertainty on inflation. In all the countries, we find no evidence of a significant positive (the Cukierman-Meltzer hypothesis) or negative (the Holland hypothesis) effect of inflation uncertainty on inflation. Our results concur with the recent evidence summarized in Daal et al. (2005) for the Asian economies (that include Thailand and Indonesia), Thornton (2007) for 12 emerging market economies (that include Malaysia, Thailand, Indonesia), and Kontonikas (2004) for UK, in the sense that no consistent evidence for the Cukierman-Meltzer hypothesis applies. It is worth noting that Thornton (2007) finds evidence consistent with the Cukierman-Meltzer hypothesis for Indonesia. Third, higher inflation has a

\textsuperscript{14} The sample period varies from country to country, depending on the availability of the IPI data.

\textsuperscript{15} To conserve space, the results are not reported here. These results are available from the authors upon request.
negative (direct) impact on economic growth in Thailand, Indonesia and the Philippines. It is worth noting that all three countries have adopted inflation targeting in the aftermath of the Asian financial crisis. However, there is no evidence of such view for Malaysia (interest rate targeting) and Singapore (exchange rate targeting), implying that inflation has no direct real effect. In the context of the ASEAN countries, we find a rise in inflation either adversely affect growth or no impact of growth. Finally, there is a strong support for the finding that higher inflation uncertainty reduces output growth in all the ASEAN countries in support of the Friedman hypothesis\textsuperscript{16}. This result is consistent with Jiranyakul and Opiela (2011) who show that there are real costs associated with inflation uncertainty in the case of Thailand. In contrast, Bredin et al. (2009) obtained results that are supportive of a positive and significant effect of inflation uncertainty on growth for Singapore and South Korea (as the Dotsey and Sarte (2000) argument suggests). However, their estimation was based on a symmetric GARCH and their sample period ended in 2005. [Insert Table 3]

5. Conclusions

In this paper we attempt to examine the bidirectional causality between inflation and inflation uncertainty in five ASEAN countries. Alternatively, our primary focus is on two well-known hypotheses: the Friedman-Ball hypothesis and the Cukierman-Meltzer hypothesis. We also test for the direct and indirect (via inflation uncertainty) effects of inflation on output growth. We employed an EGARCH (1,1) model to measure inflation uncertainty and to shed light on the relationship between inflation and its uncertainty. Like the GARCH model, the EGARCH model yields a time-varying measure of inflation uncertainty that responds to the magnitude (size) of inflation shocks. However, the main advantage of the EGARCH model is in its ability to capture

\textsuperscript{16} This inflation uncertainty-output growth channel was added in response to a referee’s suggestion. We thank the journal referee for bringing this issue to our attention.
asymmetric behavior in the conditional variance in contrast to the GARCH model – thus permitting the measure of uncertainty to respond not only to the size of inflation shocks but also to the signs of inflation shocks. We find that the EGARCH (1,1) model fits fairly adequately with the data from the ASEAN-5 countries.

We obtain four main results: first, inflation creates greater inflation uncertainty in all the countries. This result overwhelmingly supports the Friedman-Ball hypothesis that inflation is a primary determinant of inflation uncertainty. Second, we find no evidence for a significant effect of inflation uncertainty on inflation. Hence, no support is provided for the Cukierman-Meltzer or the Holland hypothesis. Third, positive shocks to inflation seem to affect inflation uncertainty more than negative shocks in all countries, thus supporting the asymmetric GARCH specification. Fourth, inflation is a negative determinant of output growth, both directly and indirectly (via its impact on inflation uncertainty). However, the indirect effect seems stronger than the direct effect, as it applies in all countries in our sample. The policy implication of this finding is that monetary authorities should try to minimize the costs of uncertainty on the economy due to the recent oil price shocks, by applying monetary policy aiming at low average inflation rates. Our results seem to differ from those obtained for industrialized countries where inflation uncertainty does not seem to be detrimental to economic growth. However, for industrialized countries, inflation does have an adverse direct effect on growth. Like the industrialized countries, the ASEAN countries have prioritized price stability (McCauley, 2001). Some of these countries (e.g. Indonesia and Thailand) have returned to higher inflation regime in the absence of effort to manage inflation expectation. The use of a monetary framework, such as inflation targeting, to anchor inflationary expectations and to keep inflation at moderate level may be warranted.

It should be noted that there is also a number of studies that have looked at the fiscal
deficit-inflation relationship. Rother (2004), for example, presented empirical evidence suggesting that volatility in discretionary fiscal policies has contributed to inflation volatility in the OECD countries. If a positive relationship between fiscal deficit and inflation holds in the ASEAN countries, then discretionary policy launched in the recent years could have a destabilizing effect on the economy through the inflation uncertainty-growth channel. Of course, this issue needs further investigation as other factors are at play in the region’s inflationary trends. Finally, the analysis also could be extended by considering Markov regime switching model. Such a modeling strategy may be fruitful area for future research to uncover the nonlinear effects of inflation and its uncertainty on economic growth.

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Sydney: Reserve bank of Australia.
Table 1: Descriptive Statistics

<table>
<thead>
<tr>
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<th>MH</th>
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<th>IN</th>
<th>PH</th>
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<tr>
<td>Mean</td>
<td>0.7450</td>
<td>0.9790</td>
<td>0.5039</td>
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<td>Median</td>
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<td>0.8778</td>
<td>0.4748</td>
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<tr>
<td>Maximum</td>
<td>4.0302</td>
<td>6.0966</td>
<td>3.4209</td>
<td>18.2854</td>
<td>15.8905</td>
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<td>Minimum</td>
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<td>-3.5058</td>
<td>-1.1579</td>
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<td>Std. Dev.</td>
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Table 2: The Estimated AR($p$)-EGARCH(1,1) Model

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<tr>
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<td>Mean Equation</td>
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<td>$\pi_{-1}$</td>
<td>0.3801 0.2709 0.5509 0.5890 0.3763</td>
<td>[0.0000] [0.0088] [0.0000] [0.0000] [0.0013]</td>
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<tr>
<td>$\pi_{-2}$</td>
<td>0.1117 0.0032 -0.0698 0.5187 0.5187</td>
<td>[0.0070] [0.9710] [0.0224] [0.0011]</td>
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<td>$\pi_{-3}$</td>
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<tr>
<td>$\pi_{-4}$</td>
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<td>[0.0002] [0.0015] [0.8617]</td>
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<tr>
<td>$\pi_{-5}$</td>
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<td>Constant</td>
<td>0.3779 0.5119 0.2088 1.2198 0.6429</td>
<td>[0.0000] [0.0000] [0.0001] [0.0006]</td>
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</table>

| Variance Equation |       |       |       |       |       |
| log $h_t = \omega + \alpha |\eta_{t-1} | + \gamma \eta_{t-1} + \beta log h_{t-1}$, $|\beta| < 1$ |       |       |       |       |
| $\omega$ | -3.3056 -0.1610 -0.3743 1.8466 -0.3936 | [0.0000] [0.0308] [0.0151] [0.0000] [0.0041] |
| $\alpha$ | 1.1565 0.1298 -0.3397 -1.1937 0.7019 | [0.0000] [0.0788] [0.0154] [0.0000] [0.0001] |
| $\gamma$ | 0.2263 0.3421 0.1543 1.8074 0.4039 | [0.0085] [0.0001] [0.0809] [0.0001] [0.0004] |
| $\beta$ | -0.6411 0.8680 0.9054 0.2575 0.7003 | [0.0000] [0.0000] [0.0000] [0.0431] [0.0000] |

| Residual Tests |       |       |       |       |       |
| Q(4) | 1.0062 1.9226 2.6569 2.5082 | [0.9090] [0.8790] [0.6170] [0.6430] [0.2220] |
| Q(8) | 2.4667 8.2254 11.1190 8.8268 | [0.9630] [0.4120] [0.0190] [0.3570] [0.3880] |
| Q(12) | 7.4152 13.4700 14.6750 9.8513 | [0.8290] [0.3360] [0.2600] [0.6290] [0.2340] |
| Q'(4) | 8.8776 0.8483 1.9237 2.9095 | [0.0640] [0.9320] [0.7500] [0.5730] [0.6300] |
| Q'(8) | 12.190 0.1917 10.8580 8.0115 | [0.1430] [0.9970] [0.2100] [0.4320] [0.8420] |
| Q'(12) | 16.8110 2.3872 11.3560 8.5514 | [0.1400] [0.9990] [0.4990] [0.7410] [0.9190] |
| ARCH(5) | 1.6250 0.7450 6.1953 0.7493 | [0.1632] [0.9804] [0.2877] [0.5909] [0.5747] |

| LL | -60.8849 -143.8875 -100.2497 -123.6047 -204.9527 | [0.0000] [0.0000] [0.0000] [0.0000] [0.0000] |
| AIC | 1.6154 2.5064 1.7000 | [0.0000] [0.0000] [0.0000] [0.0000] [0.0000] |
| SC | 1.9230 2.7132 1.8358 | [0.0000] [0.0000] [0.0000] [0.0000] [0.0000] |

Notes: MS, TH, SP, PH and IN represents Malaysia, Thailand, Singapore, the Philippines and Indonesia, respectively. Figures in bracket [ ] are $p$-values. $\pi_{-1}$ in the mean equation denotes the rate of inflation. AR ($p$) is an autoregressive process at lag $p$. A Dummy variable is included in the model for Malaysia: Dum=1 for the period 2007:Q1-2009:Q4 and zero otherwise. Q ($p$) and $Q'$ ($q$) represent the $p$th-order test statistics for correlation in residuals and squared residuals, respectively. LL, AIC and SC represents the likelihood statistic, Akaike info criterion statistic and Schwarz criterion statistic, respectively. ARCH ($m$) is a $m$th order test for autoregressive conditional heteroscedasticity.
<table>
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<tr>
<th>Country</th>
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<th>$h_\pi / \rightarrow \pi_t$</th>
<th>$OG_t / \rightarrow \pi_t$</th>
<th>$\pi_t / \rightarrow OG_t$</th>
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</table>

Notes: MS, TH, SP, IN and PH represents Malaysia, Thailand, Singapore, Indonesia and the Philippines, respectively. $\pi_t / \rightarrow h_\pi$: inflation does not Granger-cause inflation uncertainty, $h_\pi / \rightarrow \pi_t$: inflation uncertainty does not Granger-cause inflation while $OG_t / \rightarrow \pi_t$: output growth does not Granger-cause inflation, $\pi_t / \rightarrow OG_t$: inflation does not Granger-cause output growth and $h_\pi / \rightarrow OG_t$: inflation uncertainty does not Granger-cause output growth. Figures reported are MWALD statistics ($p$-values in brackets). The lag order is based on the AIC.
Notes: MS, TH, SP, IN and PH represents Malaysia, Thailand, Singapore, Indonesia and the Philippines, respectively. Left axis refers to inflation series and output growth series while the right axis refers to inflation uncertainty series.