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Money and uncertainty in the Philippines: A Friedmanite Perspective¹

Assad L. Baunto², Christian Bordes³, Samuel Maveyraud-Tricoire⁴ and Philippe Rous⁵

Abstract

This paper aims to provide a unified theoretical framework of the two hypotheses proposed by Friedman: (i). increased variability of money supply results in the decline of income velocity of money and (ii) high inflation leads high variability of inflation which reduces potential output growth. This paper also provides empirical investigation to validate Friedman's hypotheses using Philippine data. The Philippine economy experienced persistently higher and more variable inflation rate and weaker macroeconomic performance relative to other Asian countries, and these characteristics provide ample opportunity to evaluate Friedman's proposals at work. Utilizing original methodologies (e.g. band-pass filter), our findings validate both proposals.

Keywords: Friedman, GARCH, T-GARCH, Bai-and-Perron technique, band pass filter.

JEL classification: E31, E32, E41, E51

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1 Introduction

Traditionally, inflation in the Philippines has tended to be consistently higher and more variable than in other Asian countries. Historically this feature has often been linked to shocks or disturbances in various areas of the economy, notably the external (which relates to the balance of payments), real (which relates to output or production), and monetary sectors (sharp swings in monetary policy) [Debelle and Lim, 1998; Bangko Sentral ng Pilipinas, 2001].

This last aspect – the origins of shocks in the Philippines monetary sector and their consequences on macroeconomic performance from the mid-eighties until today – is the main subject of this paper. To analyze this question consistently, we propose a theoretical framework incorporating two fundamental relationships enounced in various contributions by Milton Friedman: the first one is relative to the origins to monetary disturbances and emphasizes the role of money supply shocks; the second one is relative to the (negative) consequences of this monetary uncertainty on economic growth. In each case, these two relationships have been the subject of a vast econometric literature where they are examined separately. For each one, while analyzing the Philippines case, we propose an original procedure to conduct an econometric test of its validity.

The paper is organized in the following way: the main stylized facts relative to the macroeconomic – inflation and growth – performances and monetary evolution in the Philippines are presented in section 1; the theoretical framework encapsulating the two main relationships relative to the links between monetary disturbances and macroeconomic performance is proposed in section 2 ; section 3 examines the origins of monetary disturbances in the Philippines by using an original procedure; section 4 do the same for their consequences on macroeconomic performance.

2 Stylized facts in the Philippines

The history of the Philippine economy beginning early 1980s is marked by episodes of instability. Over the span of nearly three decades, the economy experienced three recessions, 1984-85, 1991 and the 1998, which hampered its chances of becoming one of East Asia's miracles.

The 1980s was the most turbulent period of the economy, when annual output growth registered -7.4% in 1984 and -7.2% in 1985, the sharpest contraction ever experienced by the economy since post war. Annual inflation rates recorded double-digit figures over the period 1982-85 and in 1984 it reached an all-time high record of 49.3%.

The conduct of erratic monetary policy can be partly blamed for the large swings in output and inflation. Excessive money creation was a result of central bank's pursuit of multiple objectives including monetary aggregate targeting in conjunction with exchange rate targeting and output-growth targeting (Gochoco-Bautista, 2006).

The collapse of the peso in 1983 exacted large losses to the central bank and, eventually, added constraints to meeting its monetary aggregate targets. Central bank's accommodation of chronic public sector deficits and engagement in development financing strained its

balance sheet, which contributed to the distortions of monetary policies and restrained achievement of stable domestic price level. According to Gochoco-Bautista, the liabilities of the central bank were serviced by infusing more money in the economy but, with guidance from IMF's country programme, the central bank engaged in open market operations to tame inflationary pressures. Lamberte (2002) assessed that the central bank of the Philippines is unique among its counterparts in Asia as it had been incurring losses over the years before it was overhauled in 1993 and replaced by the Bangko Sentral ng Pilipinas. From 1983 to 1990, cumulative losses of the old central bank reached 143.7 billion pesos.

The balance-of-payment problem in the early 1980s, the political assassination of opposition leader Benigno Aquino in 1983 and the authorities' declaration of a moratorium on repayment of its debts starting 1984 helped pave way for the recession in 1984 and 1985. In response to the economic crisis, government authorities contracted money supply and imposed fiscal austerity that resulted in jacking up the domestic interest rates. The real sector was significantly affected. Restraining liquidity is not entirely a new policy strategy during economic slowdown and, in fact, meeting tight quarterly monetary targets in the 1980s became a common practice every time the economy faced deterioration of balance of payments and high inflation (Lim, 2006). These targets based on monetary base were achieved by influencing required reserve ratio and rediscount rates, and/or resorting to open market operations to buy and sell central bank bills and government securities which often times significantly affected total liquidity and credit in the financial sector.

Meanwhile, the financial scandal in 1981 when a famous businessman absconded his debts leaving several banks and financial companies on their knees, and the mounting debt crisis alerted the authorities to institute reforms in the financial sector. In 1983, the financial sector was deregulated. Expressed as a ratio of gross domestic product, monetary aggregates (M1, M2 and M3) consistently rose beginning 1986 after they were severely affected by the previous economic turmoil, and became relatively stable after the Asian financial crisis in 1998. Towards the latter part of the 1980s, the volume of M2 and M3 nearly equalized as the central bank gradually abolished deposit substitutes which originally formed part of M3.

Just as the economy saw encouraging signs of economic recovery in the second-half of 1980s with inflation rates albeit at double digits but significantly lower relative to previous levels, a mild recession occurred in 1991. Output contracted by 0.6% as the economy braced for moderate devaluation of the peso and oil price shock brought by the Gulf crisis; inflation rose to 19.3% (average inflation over the 1986-1990 period was 8.7%).

Two important events occurred in early 1990s. In 1992, the economy liberalized its foreign exchange market, which allowed domestic and foreign capital to move freely. Capital inflows rose dramatically reaching 10% of total output in 1996 compared to just 3% by end of the previous decade. But it soon dissipated when another crisis blew most economies in East Asia in 1998. In June 1993, Republic Act No. 7653, otherwise known as the "New Central Bank Act", was issued establishing the Bangko Sentral ng Pilipinas, or BSP, and transforming the old central bank into the Central Bank Board of Liquidators. Compared to the old central

bank, BSP is mandated to maintain its independence to prevent time-inconsistency problem, with price stability as its primary objective.

The economy achieved single-digit inflation rates in the mid-1990s onwards, despite high liquidity and large monetary expansion during the period until the East Asian financial crises when BSP periodically raised policy rates and the liquidity reserve ratios to stave off depreciation of the local currency.

The advent of financial deregulation and liberalization allowed the BSP to rethink the usefulness of its existing monetary framework. Under the monetary targeting framework, BSP uses M3 as its intermediate target for monetary policy and base money as its operating target. Whether the BSP can actually achieve the ultimate target of monetary policy—which are inflation, growth and employment—crucially depends on the predictability and stability governing the relationship between these variables and money, and the ability of the BSP to control broader monetary aggregates.

Recognizing the possible impacts of rapid financial innovations introduced in the economy, the BSP carefully assessed its position and modified its approach to monetary policy in 1995 putting greater emphasis on price stability over rigidly observing targets set for monetary aggregates. With hybrid approach (combination of both monetary targeting and inflation targeting) to conducting monetary policy, the BSP closely monitored movements of a wide range of key variables including interest rates, exchange rates, domestic credit and equity prices and a set of demand and supply and external economic indicators. In January 2000, the BSP approved the principle of inflation targeting and officially adopted inflation targeting as its main monetary framework two years hence.

To operationalise inflation targeting, the BSP underscored the following important elements: 1). setting up inflation range targets, with two-year target horizon, using the rate of change of 'headline' consumer price index, 2). making use of sophisticated forward-looking macroeconomic inflation-forecasting model to project future inflation, 3). relying on various monetary policy instruments, e.g. policy rates, to achieve inflation targets, 4). holding periodic meetings—every six weeks—of the Monetary Board, the policy-making body of the BSP to assess macroeconomic conditions and discuss future monetary policy stance, 5). publishing quarterly reports to explain BSP's policy stance and progress in meeting inflation targets, and 6). remaining accountable to the public in case actual inflation deviates from the targets (BSP, 2006).

Average inflation over 2002-06 was 5.3%. According to the official report by the BSP, inflation rates for the first-two years after the official adoption of inflation targeting are below their targets while from 2004 onwards actual inflation rates are slightly above their targets. Supply side factors are blamed for the deviations. Average output growth over the period was 5.2%.

3 Money and uncertainty: Two Friedmanite proposals

The past two decades and the current one have witnessed a literal flood of econometric literature dealing with main Friedman's proposals on the links between money, inflation and real growth. Expressed in broad terms, the literature has dealt with the two following overlapping proposals:

- Money Supply Volatility Hypothesis: "An exceptional volatility of monetary growth increases the degree of perceive uncertainty an thereby increases the demand for money" [Friedman, 1984]; and
- Inflation Variability and Growth Hypothesis: "Inflation, particularly highly variable inflation, interferes with growth by (a) introducing static into the messages transmitted by the price system, increasing the uncertainty facing individuals and business enterprises, which encourages them to divert attention from productive to protective activities, and (b) inducing governments to adopt such counterproductive false cures as price controls and incomes policy. These adverse effects have sometimes been more than offset by other forces, so that high inflation has not prevented rapid growth". [Friedman, 1980, pp. 55-6]

The first hypothesis was a subject of much debate across academic and policy circles when a decline of income velocity of money, derived from the Quantity Theory of Money equation, was observed. Milton Friedman (1983, 1984) argued that the decline in M1 velocity that began in the United States in 1982 was due to an increase of the variability of the growth rate of money supply. An increase of money supply implies a rise of uncertainty, which leads to a rise of money demand for precautionary reasons and hence to a diminution of investment (as the increase of money demand implies a diminution of demand of financial assets). *Ceteris paribus*, income velocity should decrease. Hence, an active monetary policy is not accurate as its effects on activity are uncertain and may even be harmful⁶.

Earlier accounts supporting Friedman's hypothesis includes Hall and Noble's (1987) who suggested that money growth volatility in the US, proxied by eight-quarter lagged moving standard deviation of money, causes changes in velocity, in Granger sense. Other studies questioned the robustness of the specification of the model used by Hall and Noble and proposed, instead, that there may be other causal influences on velocity due, perhaps, to structural change in the short-run (Brocato and Smith, 1989) including financial deregulation (Mehra, 1987 and 1989), financial innovation (Thornton and Molyneux, 1995) and disinflation. The instability of the relationship implies that there exists a shift in the process generating velocity rather than mere variability in the determinants of income velocity (McMillin, 1991). A more recent assessment of this configuration points to the determinants of velocity driving the instability (Chowdhury and Wheeler, 1999).

Attempts that lend support to the hypothesis were found in both developed economies (Chowdhury, 1988; Lynch and Ewing, 1995; McCornac, 1994) and emerging economies (Baliamoune-Lutz and Haughton, 2004). In Malaysia, for instance, the hypothesis is found to be robust for M1 and M2 such that much of the volatility of money growth was attributed to the financial liberalisation process (Choong, et. al. 2004). But, still others argue in favour of "little general applicability" of the

⁶ From a theoretical point of view, the Friedman's hypothesis is based on the fact that the income effect is higher than the substitution effect. The substitution effect occurs when an increase of the variability of money growth rate implies a rise of demand for foreign currency, considered as a perfect substitute of money. When substitution effect dominates, income velocity increases.

hypothesis (Bordes, 1990; Thornton, 1995; Payne, 1992) or no causal relationship at all (Arize, 1993), at least for the major industrialised economies. Finally, Friedman's hypothesis appears to be moot for narrower definitions of money, for example in UK (Thornton, 1991) and Egypt (Balioune-Lutz and Haughton, 2004). In the Philippines, no known work has been done yet on this topic and this motivates the paper.

This study employs a traditional Granger-causality test. However, this paper is different from previous literature, with the exception of Serletis and Shahmoradi (2005), as the variability of money growth is computed using a Generalised Autoregressive Conditional Heteroskedasticity, or GARCH, set up (Bollerslev, 1986). One particular novelty of the model is that it avoids the *ad hoc* nature of calculating variability of money growth traditionally used in the literature that is based on moving standard deviation of the series. Instead, the GARCH model generates a stochastic volatility process of money (M1) growth, after controlling for other covariates that have potential influence on the money growth variability, e.g. output growth and interest rate rates (see also Serletis and Shahmoradi, 2005). Its great degree of flexibility allowed this paper to structure the conditional variance to accommodate the effect of high money growth translating into high money growth variability (see figures 1 and 2). Moreover, structural breaks of income velocity of M1 are taken into account as these shifts can imply non-stationarity of the series. If found stationary, after accounting for the breaks in detrending the series, cointegration techniques are not relevant and a simple Granger causality test can be implemented.

The second hypothesis was also carefully scrutinized and related econometric studies undertaken can be classified into the following three surrounding issues. The first one relates to whether high inflation rates might result in more variable inflation and to, subsequently, create more unpredictability in future inflation. However, there appears contradictory evidence of the causal relationship between inflation levels and inflation uncertainty and this leaves macroeconomists uneasy whether the Friedman-Ball (Friedman, 1977 and Ball, 1992) hypothesis really holds (see Davis and Kanago, 2000; Fountas, 2001; Fountas et al., 2002; Grier et al., 2004; Aspergis, 2004; Kontonikas, 2004; and Thornton, 2006).

The second issue relates to the welfare loss associated with inflation so that unpredictable future inflation tends to distort the efficient allocation of resources through the price mechanism and, hence, to lower total output. Studies that tested the link between the inflation variability and the output growth include Grier and Perry (2000), Hayford (2000), Fountas et al. (2002), Aspergis (2004) and Grier et al. (2004). Unfortunately, the results found in these studies are not unanimous.

And finally, the last issue investigates the link between the level and the variability of both inflation and growth (refer to Wilson and Culver, 1999; Grier et al., 2004; Wilson, 2006; and Fountas and Karanasos, 2007), which basically addresses the simultaneous feedback between the variables of interest. The results derived are also mixed and depend on the samples and econometric methodologies employed.

In all previous studies that use GARCH models, they appear to support Friedman's second hypothesis. In our case, we attempt to replicate GARCH model but we allow the asymmetric effects of good news and bad news, i.e. Threshold-GARCH or T-GARCH. We also attempt to employ band-pass filter to extract potential real output from its business-cycle component and short-term shocks.

It would be interesting then to examine whether our results that employs T-GARCH square with the findings of these studies.

4 An unified theoretical framework

The foregoing analysis of the paper is based on the following theoretical framework⁷:

$$\begin{aligned}
(1) \quad & y_t \equiv y_t^p + z_t + \varepsilon_t \\
(2) \quad & y_t^p = y_{t-1}^p + \mu_{t-1} + \xi_\pi \sigma_\pi^2 \\
(3) \quad & z_t = -\phi(L)(i_{t-1} - E_{t-1}\pi_t) + \theta(L)z_{t-1} + g_t \\
(4) \quad & \pi_t = \kappa_m + \phi(L)\pi_t + \lambda(L)z_t + \varepsilon_t \quad \varepsilon_t | \Omega_{t-1} \rightarrow N(0, \sigma_t^2) \\
& \text{with } \sigma_{\pi,t}^2 = \omega + \alpha(L)\varepsilon_t^2 + \beta(L)\sigma_{\pi,t}^2 \\
& \text{and } \kappa_m = (\Delta m_t^{MTLR} - \Delta m_t^{d,MTLR}) \\
& \alpha(L) = \sum_{i=1}^q \alpha_i L^i, \quad \beta(L) = \sum_{i=1}^p \beta_i L^i, \quad \phi(L) = \sum_{i=1}^v \phi_i L^i, \quad \lambda(L) = \sum_{i=1}^v \lambda_i L^i \\
(5) \quad & \alpha = r^* + \pi^* \\
(6) \quad & i_t^* = \alpha + \gamma_\pi [E_t \pi_{t+k} - \pi^*] + \gamma_z [E_t z_{t+l}] + \gamma_M [\Delta m_t^{MTLR} - \Delta m^*] \\
(6') \quad & i_t = \rho i_{t-1} + (1 - \rho)i_t^* + v_t \\
(7) \quad & m_t - p_t = \kappa_y y_t - \kappa_i i_t + w_t \\
(8) \quad & \kappa_y = \kappa_0 + \kappa_1(L)\sigma_{m,t-1}
\end{aligned}$$

where: y is the actual value of real GDP; z_t is the output gap; y_t^p is the potential value of real GDP; i_t is the nominal interest rate; E_t is the conditional expectation calculated at date t ; π_t is the inflation rate; g_t denotes a goods demand-side shock; ε_t denotes a supply-side shock; p_t is the price level; m_t denotes the money supply; w_t denotes a money demand shock (all of the variables, except for the interest rate, are expressed as logarithms); Δm_t^{MTLR} and $\Delta m_t^{d,MTLR}$ denote, respectively, the medium-term/long run (MTLR) components of money supply and money demand growth. Δm^* summarizes the excess of MTLR nominal money growth over MTLR real money demand growth

⁷ This is an extension of the model proposed by Bordes and Clerc (2007).

Equation (3) is an IS curve, where the output gap depends on the real interest rate and of its past values.

Equation (4) is a « two-pillar » Phillips curve (Gerlach, 2004). It is a standard backward-looking Phillips curve, but with the intercept (κ_m) depending on the medium term /long run (MTLR) component of money supply growth relative to the MTLR component of real money demand growth.

Equations (6) and (6') represent the central bank's behaviour. Equation (7) indicates that the desired value of the nominal interest rate for the current period (i^*) is determined by monetary authorities according to an Ireland's rule [Ireland, 2004]. Like an inflation target, this rule calls for the Central bank to adjust the short-term nominal interest rate in reaction to deviations of expected inflation and output from their steady-state levels to assure monetary stability in the short-run to medium term. However, this rule also calls for the Central bank to adjust the short-term interest rate to deviations of actual money growth from its medium-term to long run reference value corresponding to the steady state level of nominal money demand. In the case where γ_π , the interest rate is determined according to the Friedman's k-percent money supply rule.

Equation (7) is a Friedman-Meltzer type specification of the demand for money (Nelson, 2002) where it depends negatively on the return rate on its substitutes - equities, bonds, physical capital - and positively on the interest rate on monetary assets.

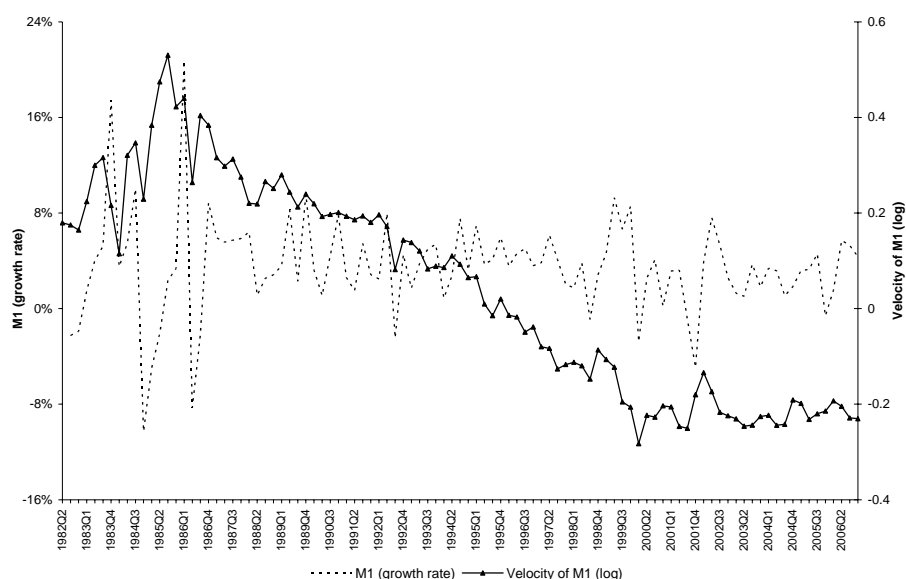
The model encapsulates the two proposals we are interested in here. First, according to equation (7), the income-elasticity of the money demand depends positively on the money supply variability. Second, according to equation (2), inflation uncertainty, due mainly to monetary disturbances, impacts negatively on economic growth as represented by the evolution in the level of potential output. Each of these two proposals is the subject of each of the following sections where the Philippines case is analyzed.

5 Empirical analysis

5.1 Variability of M1 and velocity in the Philippines

Data series used in the foregoing analysis comes from the CEIC database. The money measure employed is M1, consisting of domestic currency in circulation and domestic money banks demand deposits, which is a good proxy of money as medium of exchange. The choice of M1 as our reference of analysis is driven by our curiosity whether there is really cogent evidence in favour of the collapse of Friedman's volatility hypothesis for narrow definitions of money as some previous studies claim. Our full-sample consists of quarterly series from 1982:Q2 to 2006:Q4. Data for M1, nominal and real GDP, and income velocity are adjusted for seasonality using multiplicative moving average.

Figure 1. M1 growth rate and Income velocity



We conducted a series of stationarity test for our data. The model rests upon the stationarity of the series. Where a series is not stationary, the relationships derived in the estimation procedures are spurious (Granger and Newbold, 1974). Two criteria to test for non-stationarity are employed: KPSS and DF-GLS. KPSS (Kwiatkowski, *et. al.*, 1992) tests for the null hypothesis of stationary series against the alternative of non-stationarity while the Dickey-Fuller with GLS de-trending (Eliot, *et. al.*, 1996) tests for the null hypothesis of non-stationarity against the alternative of stationarity. Careful inspection of our data series suggests that, in order to correctly specify our tests, only the drift term should be included in the null and alternative hypotheses for growth rate of M1. On the other hand, both the drift and time trend should be included for the income velocity (log) series. Table 1 displays the results. M1 growth rate is a stationary series using KPSS and DF-GLS criteria. Income velocity is non-stationary using KPSS and DF-GLS.

Table 1. KPSS and DF-GLS unit root tests

Variables	KPSS	DF-GL
Income velocity of M1 (log)		
With drift and time trend	0.149**	-2.502
With drift but no time trend	1.237***	-0.638
M1 growth rate		
With drift and time trend	0.056	-7.929***
With drift but no time trend	0.087	-1.700*
Interest rate differentials		
With drift and time trend	0.035	-6.710***
With drift but no time trend	0.047	-6.623***
Output growth		
With drift and time trend	0.117	-2.606
With drift but no time trend	0.412*	-0.819
Income velocity of M1 (log)		
With drift and time trend	0.149**	-2.502
With drift but no time trend		

Note: ***, **, * respectively indicates rejection of the null at 1%, 5% and 10% significance levels.

The non-stationarity of log of income velocity of M1 implies that innovations have persistent effects. However, it is also possible that the trend is not correctly specified. In particular, the persistence of a time series is influenced by infrequent permanent shocks due to rare economic events. Ignoring these shifts in the M1 income velocity generating mechanism may at best distort conventional unit-root tests. It may be fitting then to isolate these rare occurrences, or structural breaks, that significantly altered the behaviour of the time series permanently (Perron, 1989).

Bordes et al. (2007) show that the velocity of money in the euro area is affected by structural breaks both in the intercept and trend. For example, structural change in the financial system seems to explain the breakdown of money holdings in industrial countries (Tucker, 2006; Ferrero, Nobili and Passiglia, 2007).

Recent technique that endogenously determines multiple structural breaks and corresponding estimates of the break dates was developed by Bai and Peron (1998, 2003). The BP technique considers a partial structural change model such that not all parameters of the model are subject to shifts and, hence, avoids the penalty of losing the number of degrees of freedom, a conventional pitfall of pure structural change model especially when more than one break exist. It is implemented using a sequential algorithm for estimating models with unknown number of structural breaks and yields consistent estimates of the breakpoints. We consider five as the maximum number of break points (k^{\max}). Given k^{\max} , the detection of breaks consists of estimating their position for each $k_i \leq k^{\max}$, $i = 1; \dots, 5$. Then we determine the location of the breaks by computing the global minimum of the sum-of-squared residuals. We identify the optimal number of breaks both through the Akaike Information and Schwarz (BIC) criteria. The amount of trimming is specified as $T \in [0.10T; 0.90T]$.

Table 2: Bai-Perron Results for M1 velocity structural change model (1982Q2-2006Q4)

	Number of breaks	Suggested breaks	SupFT test	UDmax/WDmax tests
Velocity of M1	BIC: 3	1985Q1	SupFT (1) = 0.00	UDmax= 4761499**
	LWZ: 2	1988Q2	SupFT (2) = 46622**	WDmax= 7810403**
		1999Q2	SupFT (3) = 668177**	

Note: Break dates are based on minimised sum of squares. ** (*) indicates significance at 1% (resp. 5%) level.

The following is the interpretation for M1 income velocity with constant and trend, where q stands for the number of regressors which can change overtime:

The supF test for 0 versus 1.0000 breaks (scaled by q) is: 0.0000

The supF test for 0 versus 2.0000 breaks (scaled by q) is: 46622.4172

The supF test for 0 versus 3.0000 breaks (scaled by q) is: 668177.2922

Table 2 suggests that significant breaks occurred around 1985, 1988 and 1999⁸ and this likely supports earlier findings on instability of income velocity of money in the economy that led to Bangko Sentral ng Pilipinas' adoption of inflation targeting in place of monetary targeting in 2000 (Guinigundo, 2005) and a breakdown of equilibrium relationship between logs of M1 and price level as a result of the Asian financial crisis (Gochoco-Bautista, 2006).

The evidence for log of M1 income velocity (v_t) as an integrated process with broken trends shows a strong non-reversible tendency of the series. It seems therefore appropriate to remove the

⁸ Following Wang (2006), the BIC criterion is preferred to the AIC criterion.

deterministic component of the variable prior to investigating the stochastic nature it reveals. In detrending the series, the choice of the specification of deterministic trend is crucial since the deterministic component can distort test results for stationarity. Including a single linear trend can impose severe penalty as this assumes a constant growth rate of the series. Hence, we allow the deterministic component of the series to be driven by a simple linear time trend (*trend*) and we introduce time dummy variables (D_i) that correspond to the three structural breaks identified earlier using the BP procedure and their possible interaction with the time trend:

$$v_t = \alpha_o + \sum_{i=1}^q \alpha_i D_i + \beta_o trend + \sum_{i=1}^q \beta_i (D_i \times trend) + e_t,$$

where $D_i = \begin{cases} 1, & \text{when } t \in T = \{1985Q1, 1988Q2 \text{ and } 1999Q2\} \\ 0, & \text{otherwise} \end{cases}$

Eqn (1)

Estimating equation 1 using ordinary least squares permits us to generate a detrended series for log of M1 income velocity (\hat{v}_t). Further, the detrended series appears to be stationary (test results not presented here) which allows using it as a valid regressor to analyse Friedman's volatility hypothesis later in this section.

Results in table 3 suggest that the three structural breaks significantly affected both the constant and the velocity trend. Notably, the declining trend velocity which is exhibited by negative effect of the dummy on the slope during the period 1985Q1-1988Q1 reflects growing monetization of the economy (Gochoco-Bautista, 2006). The full impact of financial deepening in the economy on velocity, which introduced financial and technological innovations to enhance transactions including Automated Teller Machines or ATM and IT, towards the latter part of the 1980s may have been offset by relatively high degree of currency substitution (Yap, 2001) as the economy embraced foreign exchange and capital liberalisation in the early 1990s to attract untapped capital from abroad⁹. Interestingly, currency substitution came into force when the Uniform Currency Act, that recognises the domestic currency or peso as the only legal tender in settling contractual obligations, was abolished in June 1996. It comes as no surprise that structural break in 1988 pulled down only the intercept term and not the slope of trend during the period 1988Q2-1999Q1, probably due to the dominating effect of currency substitution in increasing income velocity of M1. Finally, the effect of the Asian financial crisis in 1998 and the worldwide IT bubble in the early part of 2000s to create temporary supply shocks in the economy may have restrained income velocity to depress the constant by a relatively large amount but not enough to sufficiently reverse the sign of the slope of trend velocity during 1999Q2-2006Q4.

⁹ Currency substitution may also arise when the economy is plagued by high and variable inflation rate to discourage the use of domestic currency as a medium of exchange. But, according to Yap (2001), given stable macroeconomic conditions in the economy, currency substitution in the Philippines is brought by institutional change, e.g. capital liberalisation. Either way, currency substitution is likely to increase income velocity of money.

Table 3. Coefficient estimates (detrending)

Variables	Coefficient
Constant	0.1737***
Dummy1985Q1 (D_1)	0.5799***
Dummy1988Q2 (D_2)	-0.2122**
Dummy1999Q2 (D_3)	-0.7572***
Time trend (<i>trend</i>)	0.0134***
$D_1 \times trend$	-0.0358***
$D_2 \times trend$	0.0123***
$D_3 \times trend$	0.0100***

Note: ***, **, * respectively indicates rejection of the null at 1%, 5% and 10% significance levels.

To calculate the variability of money growth, a GARCH (p,q) model is used. The model assumes that the persistence in the dynamics comes from the conditional second moment of the series. Consider a univariate regression with GARCH (p,q) effects:

$$\begin{aligned}
 m_t &= \gamma_0 + \gamma(L)m_t + X\beta + \varepsilon_t \quad \varepsilon_t | \Omega_{t-1} \sim N(0, \sigma_t^2) \\
 \sigma_t^2 &= \omega_0 + \alpha(L)\varepsilon_t^2 + \delta(L)\sigma_t^2 + \omega_1 m_t \\
 \alpha(L) &= \sum_{i=1}^q \alpha_i L^i, \quad \delta(L) = \sum_{i=1}^p \delta_i L^i, \quad \gamma(L) = \sum_{i=1}^v \gamma_i L^i
 \end{aligned}
 \tag{Eq 2}$$

where m_t is money (M1) supply growth; X is a vector of covariates that may have influence on m_t such as short-run nominal interest rate and output growth; ε_t , error term; Ω_{t-1} , available information set in period $t-1$; σ_t^2 , conditional variance which depends linearly on past squared-error terms and past variances; and $\omega_0 > 0, \alpha_i \geq 0, \delta_i \geq 0; \gamma_0, \gamma_i, \beta_i, \omega_1 \forall i$ are parameters to be estimated. Lack of complete data series on T-bill rate (90 days) covering our full sample period confined this research to use weighted average of lending rate of ten Philippine commercial banks as a proxy for short-term nominal interest rate. The use of weighted average of lending rate of ten commercial banks may cast doubts if it really reflects the opportunity cost of holding money. Previous literature points to the existence of undue concentration of banking industry dominated by big players in the market, especially in commercial banking, during the 1970s and 1980s (Tan, 1991 and Milo, 2000). Nevertheless, given this limitation in the model, the interest rate variable used in this paper and the T-bill rate exhibit high and positive correlation where data availability permits. Initial unit-root tests show that interest is a non-stationary process and, hence, the first order difference (which is stationary) is used to control its influence on M1 growth, which is a stationary series. While table 1 cannot ascertain whether real GDP growth rate is a stationary process, equation 2 is implemented by including the level of real GDP growth rate.

The optimal number of lags is obtained by using the Schwarz criterion and, in this case, it is one. Mean equation in equation 2 thus follows an AR(1) process. The conditional variance is determined by a GARCH(1,1) model as a standard model of volatility in the literature and includes contemporaneous M1 growth as one of its regressors, following Thornton (2006).

Table 4. GARCH(1,1) model of M1 growth volatility

Variables	Coefficient
<i>I. Mean Equation</i>	
Constant	0.0297***
Interest rate (1 st difference)	0.0044
Output growth	0.1596*
M1 growth (-1)	0.0471
<i>II. Conditional Variance Equation</i>	
Constant	0.0005**
Residual (-1) or ε^2_{t-1}	0.5317**
GARCH (-1) or σ^2_{t-1}	-0.0530
M1 growth	0.0097***

Note: ***, **, * respectively indicates rejection of the null at 1%, 5% and 10% significance levels.

From table 4, output growth has the expected positive and significant effect on M1 growth, although only at 10% significance level. Despite interest rate not having the expected sign, it turns out that it is insignificant. While not all of the parameters in the conditional variance are positive, the GARCH component is nevertheless insignificant. Significance of M1 growth in the conditional variance equation implies positive relationship between money growth rate and money growth volatility. We proceed to calculating M1 growth volatility as the estimated conditional variability defined in equation 2. Unit root test is applied to the estimated conditional variability (results not presented here) and confirms that, indeed, it is stationary using DF-GLS criterion.

Using the detrended series of log of M1 income velocity (given by equation 1) and M1 growth volatility (given by equation 2) which are each integrated of order naught, $I(0)$, an ordinary least square can be performed to test whether the parameter has the expected sign (see figure 2). Passing the standard diagnostic tests for normality, autocorrelation and heteroskedasticity, result in table 5 confirms the significantly negative relationship between income velocity and money growth volatility.

Figure 2. Conditional variability of M1 growth and income velocity (log, detrended)

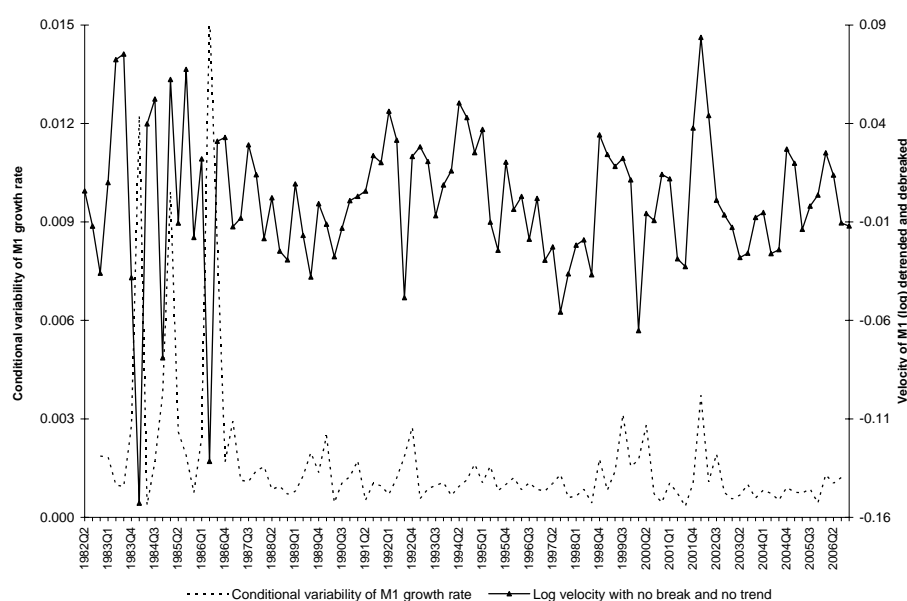


Table 5. OLS for M1 income velocity (detrended)

Variables	Coefficient
Constant	0.0099**
M1 growth volatility	-5.7842***
Adjusted R ²	0.1122
F-stat	13.0129***
Jarque-Bera	4.7287*
Breusch-Godfrey	0.9546
White	39.9240***

Note: ***, **, * respectively indicates rejection of the null at 1%, 5% and 10% significance levels.

Finally, before Friedman's hypothesis can be ascertained true in the Philippines, the direction of causality needs to be formally tested. Granger and Sim's tests (Granger, 1969; Sims, 1972) are employed to determine the causality in the Granger sense. If volatility of M1 growth Granger-causes income velocity, it means that, conditional on information in lagged income velocity, lagged volatility of money growth does help to forecast contemporaneous income velocity. Of course, the opposite direction is also possible in which case the validity of Friedman's volatility hypothesis is questioned. Our Granger causality test is driven by the Schwarz criterion to determine the optimal number of lags as rejection of the null hypothesis is very sensitive to the number of lags included in the process.

With lag of two quarters, the null hypothesis that velocity does not Granger-cause M1 growth volatility is not rejected at 5% significance (see table 6). On the other hand, with optimal lag of six quarters, the null hypothesis that M1 growth volatility does not Granger-cause income velocity is rejected at 5%. Hence, the Friedman's hypothesis is verified.

Table 6. Granger-causality test

Variables	Optimal number of lags	Likelihood ratio	H0 at a 5% level
Log velocity (detrended and debreaked) Granger causes variability of M1	2	0.13	No reject
Variability of M1 Granger causes log velocity (detrended)	6	29.95	Reject

Note: The optimal number of lags is determined by using the Schwarz (BIC) criterion

5.2 Inflation, uncertainty and output growth

Following the theoretical model, the real GDP can be decomposed in a cyclical, a non-cyclical component and an error term:

$$Y_t \equiv Y_t^p + Z_t + \varepsilon_t$$

where Y_t^p the non-cyclical component, Z_t the cyclical component and ε_t the error term.

Econometric techniques offer the possibility of extracting cycles that move in given frequency bands (Cf. Hodrick and Prescott, 1997; Baxter and King, 1999; and Christiano and Fitzgerald, 2003).

Broadly, these methods consider that Y_t can be estimated in the frequency domain by minimizing the conditional expected mean-squared error:

$$\text{Min} : E \left[(Y_t - \hat{Y}_t)^2 | Z \right], Z \equiv [Z_1, \dots, Z_T] \quad (2)$$

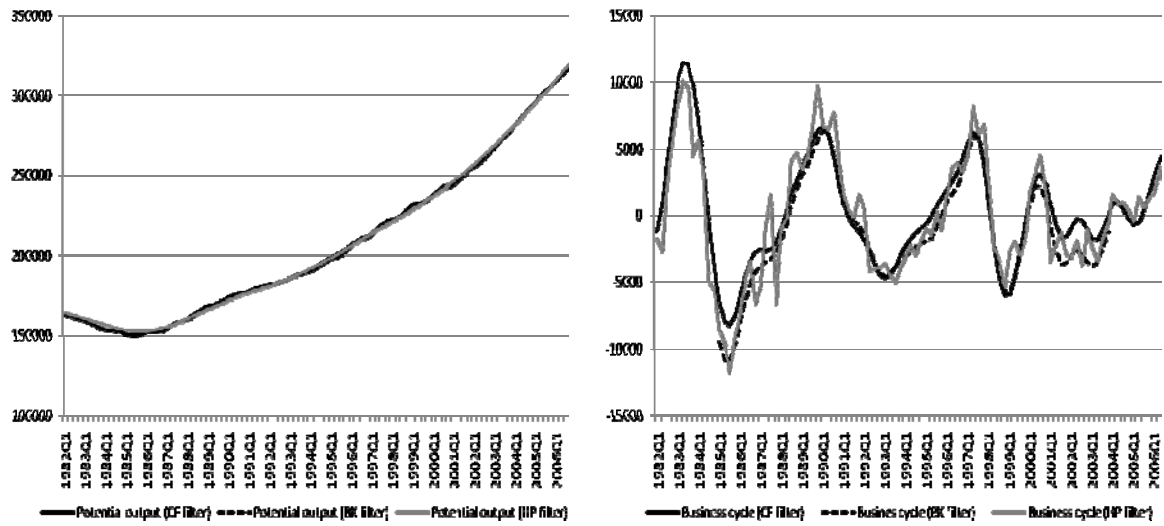
\hat{Y}_t is the linear projection of Y_t onto every element in the data set, Z_t is the component allowed to pass through the filter.

The decomposition of real GDP (RGDP) in potential output, business cycle and short run shocks appears to be particularly accurate to test Friedman's hypothesis. Indeed, as presented in the section 4, the inflation rate is linked to the output gap (and less to potential output). Besides, according to Friedman, the uncertainty due to high inflation may affect potential output (whatever the phase of the business cycle).

Through these common characteristics, each filter—that are the Hodrick-Prescott filter (1997) (Hereafter the HP filter), the Baxter-King filter (1999) (hereafter the BK filter)) and the CF filter—presents singular features. Contrary to the HP filter, the BK and CF filters can be applied as well for business cycles (between 1.5 years to 8 years) than for higher frequencies (short run shocks) and lower frequencies (the long run or potential output). Compared to the BK filter, the CF filter uses all observations of a series while the BK filter does not (Cf. Shelley and Wallace, 2005).

In what follows, in order to appreciate the robustness of our results, we implement all of these filters to our data. We proceed as follows. First, we isolate the business cycle from the potential output. For that, the HP filter is implemented by fixing the value of the smoothing parameter to 1600. For the BK and CF filters, the frequency domain of the business cycle is considered to lie between 6 quarters (1.5 years) to 32 quarters (8 years). The number of lags and leads is equal to 12 for the BK filter. At this stage, the series of RDGP is decomposed as the sum of the cyclical series including the business cycle (and the noise (short run shocks) in the case of the HP filter) and the noncyclical series including the trend (and the noise when using the BK and CF filters). Second, only for the BK and CF filters, we implement a filter to the non-cyclical series with a frequency domain that lies between 2 quarters to 5 quarters in order to dissociate the short run shocks from the potential output. The series obtained using this methodology are presented in Figure 3.

Figure 3: Potential output and business cycle



After having extracting the business cycle, the short run shocks series and the potential RGDP, we use a GARCH(p,q) model. The model assumes that the persistence in the dynamics comes from the conditional second moment of the series. Although the GARCH(p,q) conditional variance model is widely used, there are other alternatives to represent the conditional variance of the inflation rate. In the standard GARCH(p,q) model, positive and negative residuals have a symmetric impact on the conditional variance. However it seems relevant to incorporate a threshold element and introduces a *Threshold-GARCH* (p,q) model, hereafter, TGARCH, that allows for negative residuals to have a different impact on the conditional variance than do positive residuals (Glosten, et. al. 1993):

$$\begin{aligned}
 \pi_t &= \gamma_0 + \gamma_1(L)\pi_t + \gamma_2(L)\frac{Z_t}{Y_t^p} + \varepsilon_t \quad \varepsilon_t | \Omega_{t-1} \rightarrow N(0, \sigma_t^2) \\
 \sigma_{\pi,t}^2 &= \omega + \alpha(L)\varepsilon_t^2 + \beta(L)\sigma_{\pi,t}^2 + \delta(\varepsilon_{t-1}^2 \times I_{t-1}) \\
 \alpha(L) &= \sum_{i=1}^q \alpha_i L^i, \quad \beta(L) = \sum_{i=1}^p \beta_i L^i, \quad \gamma(L) = \sum_{i=1}^v \gamma_i L^i, \\
 I_{t-1} &= \begin{cases} 1, & \text{if } \varepsilon_{t-1} < 0 \\ 0, & \text{otherwise} \end{cases}
 \end{aligned} \tag{3}$$

where π_t is the inflation rate; $\frac{Z_t}{Y_t^P}$ is the business cycle component on potential output, ε_t , error term; Ω_{t-1} , available information set in period t-1; L stand for the lag operator, $\sigma_{\pi,t}^2$, the conditional variance of inflation which depends linearly on past squared-error terms, past variances and on the negative shocks of $\gamma_0, \gamma_i, \omega > 0, \alpha_i \geq 0, \beta_i \geq 0, \forall i$ are parameters to be estimated.

$I_{t-1} = 1$ if $\varepsilon_{t-1} < 0$ and $I_{t-1} = 0$ otherwise. If the asymmetry parameter δ is negative then negative inflationary shocks result in the reduction of inflation uncertainty.

We use quarterly data of inflation obtained from CEIC database. Our analysis covers the period 1982Q2-2006Q4. Real GDP is seasonally adjusted using the Census X12 method.

As the series $\sigma_{\pi,t}^2$ is built from estimated coefficients, the question of the robustness of the results relating to the Granger causality test arises. One can test robustness using the following protocol (repeated 1000 times):

First, with the estimated vectors of coefficients (CV) and the standard deviations vectors of these coefficients (SDV), we build a new vector of coefficients (BVC) as:

$$BVC(i) = CV(i) + RSDV(i)$$

Where $CV(i)$ is the i^{th} component of CV. $RSDV(i)$ is obtained by multiplying the i^{th} component of SDV by a uniform random number (that lies between -2 and 2).

Second, BVC is used to calculate a new series of the conditional variances of inflation.

Third, with this new series, we implement a Granger causality test¹⁰ on the variables of inflation, conditional variances of inflation and on potential output growth.

The results of the TGARCH models (Table 7) show that the mean equations of inflation rate is quite similar whatever filter is used for extracting the series of business cycle: in all cases, lag inflation rate and lag output gap are both highly significant and positive¹¹. Hence, as-expected, a positive output gap is correlated with an increase of inflation. The conditional variance equation of inflation rate (that is the uncertainty of inflation) gives less clear results. When using the CF and BK filters, negative inflationary shocks significantly result in the reduction of inflation uncertainty, which appears to confirm Friedman's hypothesis. However, even if the coefficient related to the impact of negative inflationary shocks is negative with business cycle derived from the HP filter, the coefficient is not significant at a 10% level.

¹⁰ The number of lags is equal to 2. This procedure was also implemented with respectively 4 and 6 lags. As results are not really different, they are not presented in this paper but are available on request.

¹¹ The number of lags is determined by an analysis of cross correlations.

Table 7: TGARCH equations

Variables	CF coefficients	BK coefficients	HP coefficients
<i>I. Mean Equation (π)</i>			
Constant (γ_0)	3.62***	6.11***	4.70***
$\pi(-1)$	0.52***	0.32***	0.46***
$z(-2)$	0.60**	0.78***	0.91***
<i>II. Conditional Variance Equation (σ_π)</i>			
Constant (ω)	18.29**	15.82*	16.23***
ε_{t-1}^2	0.51	0.08	0.28
$\sigma_{\pi, t-1}^2$	0.38***	0.40	0.47**
$\varepsilon_{t-1}^2 \times I_{t-1}$	-0.77*	-0.59***	-0.68

Note: ***, **, * respectively indicates rejection of the null at 1%, 5% and 10% significance levels.

In order to implement Granger causality tests, we build a VAR model for each potential output corresponding to the use of a particular filter (Table 8). Whatever filter used to estimate potential output, the lag inflation rate is positively and highly significantly linked with the uncertainty of inflation rate (calculating as the conditional variance of the TGARCH model) in accordance with the Friedman's hypothesis. Furthermore, in all cases, we obtain a negative link between inflation rate and potential output growth. One reason of this negative link is that an increase of productivity diminishes costs of production and at the same time increases potential output. Contrary to the Friedman's hypothesis, the link between the uncertainty of inflation and the potential output is not significant and even positive when using the HP filter.

Table 8: VAR models

	CF filter			BK filter			HP filter		
	$\sigma_{\pi, t-1}^2$	Π	γ^p	$\sigma_{\pi, t-1}^2$	Π	γ^p	$\sigma_{\pi, t-1}^2$	Π	γ^p
$\sigma_{\pi, t-1}^2$	0.27*** (0.11)	-0.01 (0.01)	-0.002 (0.002)	0.36*** (0.12)	0.08 (0.16)	-0.003 (0.02)	0.26 (0.11)	-0.003 (0.03)	-0.000003 (0.00008)
$\sigma_{\pi, t-2}^2$	0.13*** -0.05	-0.02*** -0.01	-0.001 (0.001)	0.03 (0.07)	-0.08 (0.09)	-0.01 (0.01)	0.13 (0.05)	-0.04 (0.01)	0.00006 (0.00004)
$\pi(-1)$	11.34*** (0.74)	0.31*** (0.10)	-0.01 (0.01)	1.42*** (0.12)	0.24 (0.15)	-0.002 (0.02)	6.46*** (0.39)	0.29*** (0.10)	0.0002 (0.0003)
$\pi(-2)$	-2.70 (1.45)	0.55*** (0.20)	0.00 (0.03)	-0.97*** (0.20)	0.16 (0.26)	-0.01 (0.03)	-1.11 (0.80)	0.35 (0.20)	0.0005 (0.0006)
$\gamma^p(-1)$	4.98 (4.36)	-1.50*** (0.59)	1.26*** (0.09)	0.52 (0.67)	-1.69** (0.86)	1.05*** (0.09)	84.82*** (24.92)	-11.54** (6.30)	1.94*** (0.02)
$\gamma^p(-2)$	-3.00 (4.32)	0.29 (0.59)	-0.59*** (0.09)	-1.26* (0.65)	1.10 (0.83)	-0.79*** (0.09)	-82.53** (24.24)	9.53 (6.13)	-0.95*** (0.02)
C	-44.63*** (14.15)	7.06*** (1.92)	1.22*** (0.28)	11.01*** (3.03)	7.20* (3.90)	2.82*** (0.43)	-33.01*** (9.76)	11.81*** (2.47)	0.01** (0.01)
Adjusted R-squared	0.84	0.48	0.79	0.78	0.12	0.73	0.81	0.34	0.99

Note: under brackets stand standard deviations. ***, **, * respectively indicates rejection of the null at 1%, 5% and 10% significance levels.

The Granger causality tests show that, for whatever filter used, there is a causality between inflation and uncertainty of inflation. According to the VAR results, this link is positive, which coincides Friedman's second hypothesis (Table 9). More precisely, there is bi-causality when the CF filter is used and to a less extent the HP filter (as unidirectional causality running from inflation rate to inflation uncertainty is obtained in 34.5% of the cases). But, when the BK filter is used, a unidirectional causality from inflation rate to uncertainty is obtained.

Surprisingly, even if the coefficients linking inflation uncertainty and potential output growth in the VAR equations are not significant (but negative as the Friedman's theory suggests), bi-causality between inflation uncertainty and potential output growth, in Granger sense, is obtained when the CF and HP filters are employed. With the BK filter, however, there is no significant causality between these two aggregates. Since the main difference between the BK filter and the other ones is that the first 12 lags and last 12 leads are not taken into account, we can presume that these results are due to the tails of the sample. In particular, the period between 1982 and 1985, omitted by the BK filter, was the period of high inflation; hence, as Friedman suggested, the periods of high inflation seem to significantly and negatively influence potential output growth.

Table 9: Granger causality tests

CF filter					
	σ_π Granger causes π	σ_π does not Granger cause π		y^p Granger causes σ_π	y^p does not Granger cause σ_π
π Granger causes σ_π	88.50%	11.50%	σ_π Granger causes y^p	93.50%	5.40%
π does not Granger cause σ_π	0%	0%	σ_π does not Granger cause y^p	0.00%	1.10%
BK filter					
	σ_π Granger causes π	σ_π does not Granger cause π		y^p Granger causes σ_π	y^p does not Granger cause σ_π
π Granger causes σ_π	6.80%	85.70%	σ_π Granger causes y^p	0.20%	8.30%
π does not Granger cause σ_π	0%	0%	σ_π does not Granger cause y^p	0.30%	85.10%
HP filter					
	σ_π Granger causes π	σ_π does not Granger cause π		y^p Granger causes σ_π	y^p does not Granger cause σ_π
π Granger causes σ_π	65.5 %	34.5 %	σ_π Granger causes y^p	79.4 %	3.3 %
π does not Granger cause σ_π	0 %	0 %	σ_π does not Granger cause y^p	11.3 %	6 %

6 Conclusion

Using data from the Philippines, this paper provides strong evidence in favor of Friedman's proposals on uncertainties in money supply and inflation, and economic growth. Taking into account possible structural breaks in velocity, our study shows that high variability of money growth is linked with a diminution in the income velocity of narrow definitions of money. Moreover, high level of inflation

Granger causes a higher variability of inflation, which, to a certain extent, Granger causes a diminution of the potential output.

Hence, the higher level of inflation that characterized the Philippines relative to other East Asian economies seems to be one of the main explanations of shocks in the 1980's and the 1990's. This further explains the weaker macroeconomic performance of the economy during this period.

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