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Interest Rate Movements and Inflation Risk in the Philippines

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This article examines the role of inflation risk in the determination of interest rate movements in the Philippines. The analysis proceeds by first estimating a measure of inflation risk that is analytically derived from the consumption-based capital asset pricing model (CCAPM). This inflation risk measure, the covariance of purchasing power growth and consumption growth, is estimated using a multivariate GARCH method on quarterly Philippine data from 1986 to 2005. The estimated inflation risk series is then used in a CCAPM-based interest rate model to help explain interest rate movements in the Philippines.

Keywords: inflation risk, multivariate BEKK-Garch, CCAPM

1 Introduction

This research examines the role of inflation uncertainty as a source of variation in interest rate movements in the Philippines. The Fisher hypothesis effectively says that the nominal rate should reflect the real rate of return plus some compensation to the investor for the reduction in purchasing power as a result of inflation on assets held. Hence under certainty, $i = r + \pi$, where π is the inflation rate. Implicit in this linear relation is that the covariance between the real rate and inflation is zero, $\text{cov}(r, \pi) = 0$ (Barnea, Dotan & Lakonishok, 1979).

Indeed, the Fisher hypothesis shows a well-defined linear relationship under an environment of certainty. However, it is not so when uncertainty is present. Incorporating uncertainty to the analysis inevitably leads to a nonlinear relationship and one can no longer be sure that $\text{cov}(r,\pi) = 0$.

Several studies have been made to show that the real interest rate is fairly constant and the nominal rate and expected inflation move one for one, lending support to the Fisher hypothesis (see for example, Fama, 1976). There were also several studies done that offer reasons as to why the Fisher hypothesis does not hold. For example, in the absence of uncertainty, the Mundell-Tobin effect predicts that a rise in inflationary expectations leads to a decline in real consumption and an increase in real savings that in turn leads to a decline in real interest rates. Empirical studies by Barnea, et al. (1979), Shome, Smith, and Pinkerton (1988), Kandel, Offer and Sarig (1996) and Chan (1994), using different measures of inflation risk, have shown that inflation uncertainty and volatility variables are statistically significant in their regressions, thus verifying the incompleteness of the Fisher hypothesis.

The first to show that the relation between the nominal and the real rate involves more than just an expected inflation variable was Benninga and Protopapadakis (1983). They showed that in addition to a covariance term between the real value of an asset and inflation, the price ratio also depends on purchasing power riskiness and a term due to Jensen's inequality showing inflation variability. Other theoretical analyses, that of Breeden (1986) and Cox, Ingersoll and Ross (1985) showed the importance of the inflation covariability risk in the interest rate process.

This research examines the extent to which inflation risk influences the movement of interest rates and the first step presented in this paper shows how one can derive an inflation risk series. As in Shome, et al. (1988) and Chan (1994), this study makes use of the consumption-based asset-pricing framework as a starting point of the analysis. Assuming that the individual holds pure discount bonds whose nominal cash flows are known with certainty but the real cash flows are not because of inflation uncertainty. Maximizing an intertemporal expected CRRA utility function, one obtains an asset pricing equation that shows the nominal value of the bond as a function of expected value of the product of real consumption growth (g) and purchasing power growth (π). In the case of Chan (1994), the individual holds an indexed bond maturing at time $t + j$, that pays 1 unit of real

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consumption in $t + j$. Assuming joint lognormality between g and π, one can linearize the nonlinear relation and proceed with the test of the Fisher hypothesis. The empirically implementable equation similar to Chan (1994) and Shome, et al. (1988) is of the form:

$$\ln(1+i_t) = \alpha_0 + \alpha_1 E(\ln \pi_{t+1}) + \alpha_2 E(\ln g_t) + \alpha_3 var(\ln g_{t+1}) + \alpha_4 cov(\ln g_{t+1}, \ln \pi_{t+1}) + \alpha_5 var(\ln \pi_{t+1})$$

The covariance term is the inflation risk premium. The CCAPM shows that the real rate depends on business cycle variables, namely consumption growth, $\ln g_t$, aside from inflation risk.

2 Framework

A consumption-based capital asset-pricing model (C-CAPM) due to Lucas (1978) is used in this study to justify the presence of inflation risk in an interest rate equation. The representative agent in this model solves a consumption/portfolio allocation problem by maximizing an intertemporal expected utility function:

$$E_t\left[\sum_{k=0}^{\infty} e^{-\rho k} u(c_{t+k})\right] \quad (1)$$

E_t is the conditional expectation operator; ρ is the subjective rate of time preference that is assumed constant; c_t is real consumption.

The standard solution to the problem is a set of Euler equations corresponding to the N assets in the portfolio:

$$1 = E_t(m_{t+1} R_{t+1}) \quad ; \quad i = 1, \dots, N \quad (2)$$

where $m_{t+1} = \frac{u'(c_{t+1})}{u'(c_t)} e^{-\rho}$ is the stochastic discount factor.

To establish the relation between inflation, interest rates and consumption using this framework, consider a one period bond and assume a CRRA utility function. With this, we can derive a pricing equation of the form:

$$q_t = E_t(\pi_{t+1} g_{t+1}^{-\alpha} e^{-\rho}) \quad (3)$$

where $\pi_{t+1} = \frac{p_t}{p_{t+1}} = \frac{1/p_{t+1}}{1/p_t}$ is the purchasing power growth, $g_{t+1} = c_{t+1}/c_t$ is real consumption growth.

To arrive at an empirically testable specification, the Euler equation in (3) is linearized by assuming that purchasing power growth and consumption growth are jointly lognormally distributed. In this case, the transformation of equation (3) follows:

$$E_t r_{t+1} = \rho + \alpha E_t \ln g_{t+1} - \frac{\alpha^2}{2} var_t(\ln g_{t+1}) - \frac{1}{2} var_t(\pi_{t+1}) + \alpha cov_t(\ln g_{t+1}, \ln \pi_{t+1}) \quad (4)$$

where $E_t r_{t+1} = -\ln q_t + E_t \ln \pi_{t+1}$ is the ex-ante real interest rate. The last three terms are second moments that describe the volatility and co-variation of consumption growth and price level changes.

Equation (4) is similar to the result derived by Breeden (1986). The covariance between purchasing power growth and consumption growth, which is the focus of this investigation, is a measure of inflation risk that may be positive or negative.

A positive covariance implies that low future consumption in times of high inflation rates (i.e., low purchasing power of money) makes the asset less attractive because it does not provide a means to smoothen fluctuations in consumption. This asset therefore has to offer a higher interest rate to induce investors to hold the asset. On the other hand, high purchasing power at low future consumption states makes the asset desirable because it can effectively even out consumption patterns. Demand for this asset is high, and as a result, the asset can command a high price and offer a lower interest rate.

3 Data and Estimation Results

3.1 Data

Quarterly data from 1986 to the fourth quarter of 2005 are used in the study. Seasonally unadjusted quarterly real consumption data were obtained from the National Statistical Coordinating Board. Data on the 91-day treasury bills rate were obtained from the *Bangko Sentral ng Pilipinas* while the consumer price index (p_t) was taken from the National Statistics Office. Before estimation, consumption was deseasonalized using the subroutine of Eviews 5.1 on the X12 method of removing seasonality.

Consumption growth is computed as the first difference of the log of real consumption. Purchasing power growth is derived as the first difference of the log of the inverse of the price level.

The first row of Figure 1 shows consumption growth and the inflation rate.[1] Shaded portions indicate the crisis periods covering the fiscal/power crises of the early 1990s and the 1997 Asian crisis. The 1990-1993 crisis were due to the following: (a) a devaluation in November 1990 that led to (b) a fiscal crisis in the following year due to high interest payments on government debt as interest rate defense of the exchange rate failed (c) the power crisis from 1992 to 1993 which crippled several industries.[2] It can be observed that consumption growth was declining in both crisis periods and the inflation rate peaked within crisis periods. In the estimation of the BEKK model, the MATLAB-based UCSD-GARCH toolbox was used.

3.2 Bivariate GARCH estimates of inflation risk

A bivariate BEKK[3] model is used to estimate inflation risk (the covariance term in the Equation (4)). Let ε_t be a vector composed of two (2) demeaned variables. The BEKK model can be described by the set of equations:

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} = \begin{bmatrix} r_{1t} - \bar{r}_1 \\ r_{2t} - \bar{r}_2 \end{bmatrix} \quad (5)$$

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + G'H_{t-1}G \quad (6)$$

$$C = \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix}, A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, G = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}, H_t = \begin{bmatrix} h_{11t} & h_{12t} \\ h_{21t} & h_{22t} \end{bmatrix}$$

H_t is the estimated covariance matrix; *C*, *A* and *G* are coefficient matrices; $h_{12} = h_{21}$;

Table 1 presents the parameter estimates and rows 2 and 3 of Figure 1 shows the graphs of consumption and inflation volatility and inflation covariance risk that were obtained from the BEKK estimation. The t-statistics are computed from robust standard errors.

Table 1. Bivariate BEKK parameter estimates of purchasing power growth and consumption growth volatilities

	c_{11}	c_{12}	c_{22}	a_{11}	a_{12}	a_{21}	a_{22}	g_{11}	g_{12}	g_{21}	g_{22}
Estimate	1.07	0.25	0.09	0.88	0.04	–0.54	0.67	0.47	–0.03	0.02	0.72
t-stat	5.09	1.98	0.83	9.12	2.36	–1.81	3.88	3.61	–1.37	0.09	7.65

It is seen that eight (8) out of the eleven (11) BEKK parameters are significant at the 10% level. From the graphs, it can be noted that the variables are most volatile in the late 1980s even after the 1984-85 crisis, the worst crisis experienced by the Philippines.

Inflation was not very volatile in the mid-90s up to the Asian crisis period and is consistent with the worldwide trend as inflation went down in most parts of the globe at this time. Note, however,

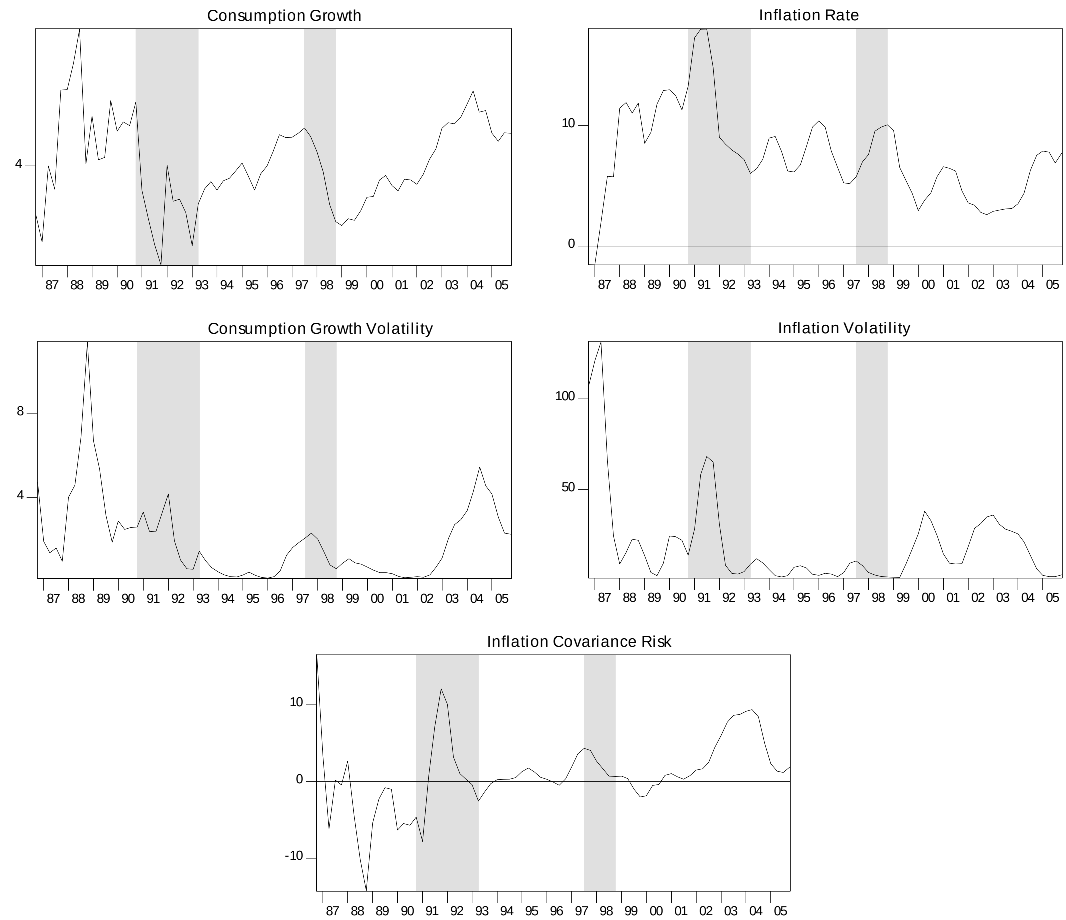
1 Note that purchasing power growth would be the mirror image of inflation.

2 For more details on the events that transpired during crisis years in the Philippines, see Bautista (2003).

3 After Baba, Engle, Kraft and Kroner; See Engle and Kroner (1995) for more details of the technique or Bauwens, Laurent and Rombauts (2006) for a review of multivariate GARCH models.

that consumption uncertainty was rising prior to the 1997 Asian Crisis. Volatility in both variables began to rise at around the beginning of the 2000 decade. A possible explanation was the increase in worldwide inflation and the US recession in early 2000 that affected other economies.

Figure 1



As result, it can be seen that inflation risk was (a) highest during the fiscal and power crisis period (ignoring decade 1980); (b) not very high during the Asian crisis although it did rise from previous levels; and (c) is higher in the years 2003-2004 than in 1997, when the world-wide low inflation period ended.

3.3 GMM estimates of a CCAPM-based interest rate equation

Prior to estimation, the variables are subjected to unit root tests which are shown in Table 2 to determine if they are stationary.

These variables include the fitted variance and covariance series obtained from the BEKK estimates in the previous section and the three interest rate variables used. As can be seen above, ADF tests reject most of the unit root hypothesis and hence, variables are stationary but there are fewer rejections of the hypothesis using the ADF test with GLS detrending.

Table 3 presents the results of GMM estimates. The instruments used are three lags each of the interest rate, consumption growth, variance of inflation, variance of consumption growth and covariance of inflation and consumption growth, a constant and a time trend.

Table 2. Unit root test

	ADF (p-values)		DFGLS (t-stats)	
With:	**constant**	**trend**	**constant**	**trend**
Inflation covariance risk	0.03	0.01	−0.22	−1.89
Discount rate	0.00	0.01	−1.06	−2.28
Inflation rate	0.32*	0.03	−1.73	−3.63*
Consumption growth	0.00	0.00	−1.42	−2.92*
Money market rate	0.00	0.00	−2.14*	−3.50*
Treasury bills rate	0.95*	0.00	−0.50	−1.26
Inflation volatility	0.03	0.11	0.12	−1.48
Consumption volatility	0.05	0.50*	−2.48*	−2.87*
Sig levels for DFGLS				
1%			−2.60	−3.67
5%			−1.95	−3.10
10%			−1.61	−2.81

**cannot reject unit root hypothesis*

It is clear from the results that inflation covariance risk is a significant factor in the determination of interest rates. Consumption growth is significant but incorrectly signed in two (2) out of three (3) estimates and is correctly signed but insignificant in one. The J-stat shows that the over-identifying restrictions cannot be rejected, hence, validating the reasonableness of the specification.

Table 3. GMM estimates of CCAPM-based interest rate model for three (3) different rates

	Discount rate		Money market rate		91-day treasury bills rate	
	coef	**t-stat**	**coef**	**t-stat**	**coef**	**t-stat**
constant	6.72	6.65	6.45	4.37	0.06	0.04
consumption growth	−1.45	−5.56	−0.88	−2.27	0.49	1.03
inflation variance	0.06	8.86	0.08	4.60	0.01	0.75
consumption growth variance	−0.02	−0.18	−0.03	−0.17	3.45	4.70
Inflation covariance risk	−0.07	−1.80	0.16	1.86	0.35	2.87
J-stat	0.11		0.11		0.11	

4 Conclusion

This paper has demonstrated how the inflation risk definition derived from the CCAPM can be estimated using multivariate GARCH. It should be noted that these estimates are preliminary and for convenience, the actual inflation rate was used instead of a measure of expected inflation (or equivalently future purchasing power growth). Using quarterly data from 1986 to 2005, a CCAPM-based interest rate model was estimated with inflation risk as one of its determinants. The empirical results show that inflation covariance risk significantly influences the interest rate process.

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