Estimation and Evaluation of Asset Pricing Models with Habit Formation using Philippine Data*

ABSTRACT

This study tests the habit-formation model, an extension of the Consumption-based Capital Asset Pricing Model (C-CAPM). Using Philippine stock market data, seasonally adjusted and non-seasonally adjusted consumption data sets, the study tracks the performance of these resulting models in terms of forecast performance both in-sample and out-of sample. Several statistical measures such as the Diebold-Mariano test and the Success Ratio test are used to compare these habit models against the standard power utility/C-CAPM, the random walk with drift model, and the traditional static CAPM. Based on the criteria set by this study, only the external habit model performs better than all the other models.

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1. Introduction

The consumption capital asset pricing model (C-CAPM) is designed to price any financial asset. However several studies that test the standard C-CAPM reveal results that do not conform to observed behavior and that the C-CAPM/power utility combination cannot explain the observed asset returns.

It has been hypothesized by some researchers that the C-CAPM's failure might lie with the exclusion of trading costs (Maki and Sonoda, 2002), or with the heterogeneity of investors together with consumption adjustment costs (Tse and Zabotina, 2002). Other studies have suggested that the poor empirical performance of the C-CAPM lies with the interlocking of the elasticity of intertemporal substitution with the coefficient of risk aversion that is present in the power utility function. And one way to break this connection is to let today's consumption be influenced by past consumption and other exogenous factors.

Habit models have had modest success when used in conjunction with the C-CAPM (see Hamori and Tokunaga, 1999 and Wirjanto,1997). Now if the utility function *U(.)* is adjusted to include the habit *X* it will have the following form:

$$U(C,X) = E\left[\sum_{t=0}^{\infty} \beta^t \frac{\left(C_t / X_t\right)^{1-\gamma}}{1-\gamma}\right]$$

Research on habit formation is divided along two lines. Some propose an internal-habit model wherein a person's habit is dependent on his own past consumption decisions and habit is completely endogenous to the investor. Following Baba (2000), assume that the internal habit has the following form:

$$X_t = \left(C_{t-1}\right)^k \qquad 0 < k < 1$$

The new variable *k* can be defined as the degree of time non-separability and the analogous expression for the Stochastic Discount Factor (SDF) can be written as:

$$M = \beta \frac{u_c(C_{t+1}, X_{t+1})}{u_c(C_t, X_t)} = \beta \left(\frac{C_t}{C_{t-1}}\right)^{k(\gamma-1)} \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}$$

where u_c is the partial derivative with respect to *C.*

Other researchers propose an external habit model where habit depends on the aggregate consumption level and is not dependent on any one person. Following Abel (1999), let the external habit have the following form:

$$X_t = C_t^a C_{t-1}^b \left(G^t\right)^c \qquad G \geq 0, 0 \leq a,b,c \leq 1$$

The introduction of the exogenous term G^t allows habit to move independently of consumption. The formulation of the SDF is as follows:

$$M = \beta \frac{u_c(C_{t+1}, X_{t+1})}{u_c(C_t, X_t)} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\left[\left(\frac{C_{t+1}}{C_t}\right)^a \left(\frac{C_t}{C_{t-1}}\right)^b G^c\right]^{\gamma-1}$$

Abel (1999) suggests that additional degrees of freedom can be conserved if the following simplifications are used:

$$M = \alpha\left(\frac{C_{t+1}}{C_t}\right)^{-A}\left(\frac{C_t}{C_{t-1}}\right)^{\theta}$$

where

$$\alpha = \beta G^{c(\gamma-1)} > 0,$$

$$A = \gamma - a(\gamma - 1) > 0,$$

and $\theta = b(\gamma - 1)$

Final estimates of the variables can be derived by adding the following equations:

$$a + b + c = 1$$

$$a = 0$$

$$G = \text{sample mean of consumption growth}$$

This study's objective is to empirically evaluate the habit-formation asset pricing models as applied to the Philippine setting. To achieve this objective, the study engages in two major activities.

First, the parameters of the habit-formation models are estimated econometrically. Next, the study conducts several tests to gauge the in-sample and out-of-sample forecast performance of the models. To test their forecast evaluation accuracy, these models are then compared relative to the power utility, random walk without drift and the CAPM.

The next section details the methodology used in the paper. Section 3 presents the results of the study and Section 4 concludes.

2. Methodology

Estimation of the parameters will be done via the Generalized Method of Moments (GMM). If θ is a k-vector of parameters, the GMM procedure selects θ that will minimize the following equation:

$$J_T = m(\theta)'Wm(\theta)$$

where $m(\theta)$ is a L-vector set of moment conditions
W is a LxL positive definite weighting matrix

These moment condition restrictions can be re-stated as:

$$E[m_l(y,x,\theta)]=0 \quad \text{for } l = 1,\ldots L$$

And for each equation a sample analog can be formed for the moment conditions as:

$$m_l(y,x,\hat{\theta}) = \frac{1}{T}\sum_{t=1}^{T} m_{l,t}(y_t,x_t,\hat{\theta}) = 0$$

Aside from the usual goodness-of-fit and statistical significance of the parameters, the in-sample and out-of-sample forecast accuracy of the models is tracked.

In-sample statistics to be computed are the Mean-Square Error (MSE), Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC).

Out-of-sample forecast accuracy of the competing models is assessed by the following tests. The Mean Squared Predicted Error (MSPE) is complemented by the Diebold-Mariano (DM) test. This test is used to assess the quality of forecasts of the models against that of a model that forecasted prices/returns using the simple random walk, without drift model (RW) and against that forecasted using the capital asset pricing model (CAPM). The DM test is designed to detect whether or not the errors of the models generated would be statistically different from those of the random walk and CAPM. To arrive at a useful test, the null hypothesis is written to be a loss differential *d*:

$$d_t = E\left[L\left(e_{t+h}^{A}\right)\right] - E\left[L\left(e_{t+h}^{\text{RW or CAPM}}\right)\right]$$

where *L(.)* is the loss function (error term) from time *t* to *t+h* of models A and RW or CAPM respectively.

Diebold and Mariano (1995) show that if d_t is covariance stationary then for a one period forecast and large samples the following distribution holds:

$$DM = \frac{\bar{d}}{\sqrt{f}} \sim N(0,1)$$

where $\bar{d}$ and *f* are the sale and variance of the loss differential respectively.

Furthermore the success ratio test will be used to test the frequency that the forecasts get the correct sign for the return of the month. Since excess stock returns tend to be centered on zero, correctly predicting positive or negative returns is essential. If SR denotes the number of correctly predicted signs, then it can be formulated using indicator functions in the following manner:

$$SR = \frac{1}{m}\sum_{j=1}^{m} I_j \left[r_{n+j}\,\hat{r}_{n+j} > 0 \right]$$

Pesaran and Timmerman (1992) propose a Success Ratio of Independence test that detects whether the SR differs from a SR that had independent returns. The test has the following form:

$$SRI = P\hat{P} + (1-P)(1-\hat{P})$$

where

$$P = \frac{1}{m}\sum_{j=1}^{m} I_j \left[r_{n+j} > 0 \right]$$

$$\hat{P} = \frac{1}{m}\sum_{j=1}^{m} I_j \left[r_{n+j}\,\hat{r}_{n+j} > 0 \right]$$

From which the following Directional Accuracy test can be used:

$$DA = \frac{SR - SRI}{\sqrt{Var(SR) - Var(SRI)}} \sim N(0,1)$$

where

$$Var(SRI) = \frac{1}{m}[(2\hat{P} - 1)^2 P(1-P) + (2P-1)^2 \hat{P}(1-\hat{P}) + \frac{4}{m} P \hat{P}(1-P)(1-\hat{P})]$$

$$Var(SR) = \frac{1}{m} SRI(1-SRI)$$

In the tables to be presented later, columns under the headings of AIC, SIC, MSE and MSPE compute the mean values for all assets forecasted. While the columns under the headings of DM and SR, tally the frequency that the forecast's DM and SR reject their respective null hypothesis at the five percent significance level.

3. Data and Estimation Results

The sample period of this study is from the first quarter of 1990 (1990:1) until the second quarter of 2003 (2003:2). Estimation and in-sample testing of the models is done using the data for the time period of 1990:1 to 2001:4. While the remaining sample, 2002:1 to 2003:2, is used for the out-of-sample testing.

Ooms and Franses (1997) and Ghysels (1997), argue that there might be additional information attained if consumption is seasonally adjusted. Hence, the Quarterly Real Personal Consumption Expenditure series obtained from the National Statistical Coordinating Board is seasonally adjusted using the X-11 procedure. This paper presents results using both the not seasonally adjusted consumption (CONS) and seasonally adjusted consumption (DCONS) data sets.

The source data on market indices, common stocks and accompanying dividends is the Philippine Stock Exchange and Bloomberg Information services. The study will focus on the market portfolio which is the return on investing an equally valued portfolio of the market index.

The representative returns on bonds are the yields of the 91-day Treasury bills (Tbills) rate. These data were obtained from the Bangko Sentral ng Pilipinas. To convert this data into quarterly rates, the equation used is $(1 + Yield)^{1/4}$.

Table 1 presents the results for power, internal and external models. Also in Table 1 are the implied estimates such as the implied discount rate *r* and the solved values for the external habit model.

One model was eliminated because it violated the underlying economic theory. In particular, model 4 uses the internal habit form yet at the same time its degree of time non-separability, *k,* is greater than the allowed range of zero to one.

Forecast Accuracy

Aside from the market index and Treasury bill returns, the returns of the stocks comprising the market index will be used in this exercise. After performing the diagnostic tests detailed in the methodology section, the best models in each sub-group are models 2, 3, and 6. One last comparison is made between these models and the CAPM. Using the published betas found in the 2002 Philippine Corporate Handbook, the forecasted returns of the companies comprising the market index were computed. After which the same sequence of in-sample and out-of-sample testing procedures done for the C-CAPM are performed for the CAPM. Table 2 summarizes the results of these tests. Note however that the DM test shown in the last column of Table 2 presents the frequency that the null hypothesis of the DM test between the C-CAPM and CAPM is rejected at α=5 percent.

In Model 2, $\beta=0.9850$ and $\gamma=5.0350$ and this translates to an annualized implied discount rate of 6.2%. Model 2 uses seasonally adjusted consumption and in terms of forecasting accuracy, this power utility variant shows considerable improvement over the CAPM.

In Model 3, the parameter vector gives an annualized implied discount rate of 82.9%, a coefficient of relative risk aversion of 4.9099 and a degree of time-separability of 0.9099. Clearly the value derived for the subjective discount rate is on the high side. These results also imply that habit is highly persistent and that present consumption is almost equal to last year's consumption. Furthermore, in almost all of the statistics computed, Model 3 is the only variant that fared more poorly than the CAPM.

Finally model 6's parameter vector gives an annualized implied discount factor of 10.8%. Like model 2, this variant also uses seasonally adjusted consumption sets. Compared to the internal habit model, this habit is less conditioned to last period's consumption and is greatly influenced by an exogenous factor as represented by the large exponent of *G*. And among the competing asset pricing models, this external habit model has the best performance in terms of in and out of sample forecasting tests.

4. Conclusion

Using the external habit formation model together with the Consumption Capital Asset Pricing model shows promise in the Philippine setting. The in-sample and out-of-sample tests show that the external habit model is superior to all other asset pricing models and its fit of the financial data is a big improvement compared to that of the internal habit model and CAPM. The external model also marginally outperforms the power utility/C-CAPM model combination.

However the results of the econometric exercises also show that the internal habit model gives inferior in-sample and out-of-sample forecasts when compared to the external habit model, to the power utility model and to the CAPM. One explanation for the poor performance of the internal habit model is that by construction, the habit of the internal model in this paper is constrained to be dependent only on the previous period's consumption and nothing else. It might be the case that habit is more complex than this and needs to be modeled using other explanatory factors.

Finally it is interesting to note that from a purely econometric standpoint, when seasonally adjusted consumption data sets are applied to all three variants of the C-CAPM (power utility, internal and external habit) the resulting models have better fit than those that used not seasonally adjusted consumption data sets. It is quite possible that seasonally adjusted consumption is more compatible with the C-CAPM in explaining asset returns. This is another area of research that can be explored in the future.

Table 1: Estimation Results

	Power Utility		Internal Habit		External Habit	
	MODEL 1	**MODEL 2**	**MODEL 3**	**MODEL 4**	**MODEL 5**	**MODEL 6**
Consumption Data	CONS	DCONS	CONS	DCONS	CONS	DCONS
Parameter Estimates [P-Values]	β=0.8940, γ=4.9440 [0, 0]	β=0.9850, γ=5.0350 [0, 0]	β=0.8599, γ=4.9099, k=0.9099 [0, 0, 0]	β=0.9861, γ=5.0361, k=1.0361 [0, 0, 0]	α=0.9722, A=0.9222, θ=-0.0278 [0, 0, 1.3921e-20]	α=0.9746, A=0.9246, θ=-0.0254 [0, 0, 1.8757e039]
J-Stat [P-Value]	5.6422 [0.3426]	0.0144 [0.9046]	5.8022 [0.3259]	4.6601 [0.4588]	6.6673 [0.2466]	5.8748 [0.3186]
Implied Estimates	r =56.5%	r =6.2%	r =82.9%	r =5.8%,	r =11.8% a =0, b =0.3573, c =0.6427, G =1.0079	r =10.8% a =0, b =0.3369, c =0.6631, G =1.0035

Note: All models use the first lags of the market index and Tbills as well as a constant for its instrumental variables

Table 2: Summary of Statistics for Models 1 – 6 and CAPM

Model	Mean AIC	Mean SIC	Mean MSE	Mean MSPE	%SR vs. RW	%DM vs. RW	%DM vs. CAPM
1 – Power utility	125.1317	128.2414	48485.58	17584.46	10%	61%	
2 – Power utility	-84.8157	-81.7053	187.5331	75.4769	61%	94%	59%
3 – Internal Habit	169.2491	173.9134	145946.7	51325.73	10%	32%	7%
5 – External Habit	-9.43456	-4.7701	1336.606	565.3744	26%	90%	
6 – External Habit	-97.0745	-92.41	130.075	50.05464	74%	94%	59%
CAPM	1.960828	3.494517	1241.563	0.151563	0%	62%	

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