Modelling Seasonal Macroeconomic Consumption Behavior and Structural Breaks in Thailand

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Abstract

Consumption is the key element in the national expenditure in the Thai economy (sharing 56 percent of Gross Domestic Product (GDP)). Quarterly data during 1993-2005 show overall up ward trend of consumption. The series had a sharp drop in the second quarter of 1997 due to economic crisis. For the purpose of economic recovery, the key policy was to boost domestic consumption. Its effect took five quarters before consumption started to increase. This paper attempts to model macro consumption behavior taking into account of the structural break and seasonality. Our model based on Box-Jenkins autoregressive integrated moving average (ARIMA). The findings suggest two alternative ARMA models (without a constant and with a lag length of two). Only one of these is recommended for forecasting purpose.

KEY WORDS: Consumption, structural break and seasonality, Box-Jenkins autoregression integrated moving average

Introduction

Consumption is an important component of the gross domestic product (GDP) in the Thai economy, having contributed 55.69 per cent of total current price GDP and 54.54 per cent of total GDP at 1988 constant prices in the year 2004. As consumption is an endogenous variable in macroeconomic models, it is considerably difficult to forecast.

Consumption data for the Thai economy at constant (1988) prices are available both quarterly and annually. The quarterly data start from the first quarter of 1993. It can be seen that the series dropped sharply from the second quarter of 1997 until the third quarter of 1998, from 438.42 thousand million baht to 357.93 thousand million baht, or 18.36 per cent within five quarters, before starting to increase in the fourth quarter of 1998 and trending upward thereafter (Figure 1). As consumption had a decreasing trend for consecutive periods, it will be interesting to model the consumption behavior in the Thai economy.

This paper, the Box-Jenkins autoregressive integrated moving average (ARIMA) method is applied to forecast aggregate consumption of the Thai economy. As the data are quarterly, structural breaks and seasonality have to be considered, namely seasonal and non-seasonal unit roots, and seasonal autoregressive and moving average processes. Non-seasonal and seasonal unit root tests will be conducted; non-seasonal and seasonal autoregressive and moving average processes will be estimated to enable consumption to be forecasted using ARIMA models.

This paper is organized as organized as follows: section 2 presents methods and techniques applying in this paper; section 3 presents empirical results; and conclusion remarks are given in last section.

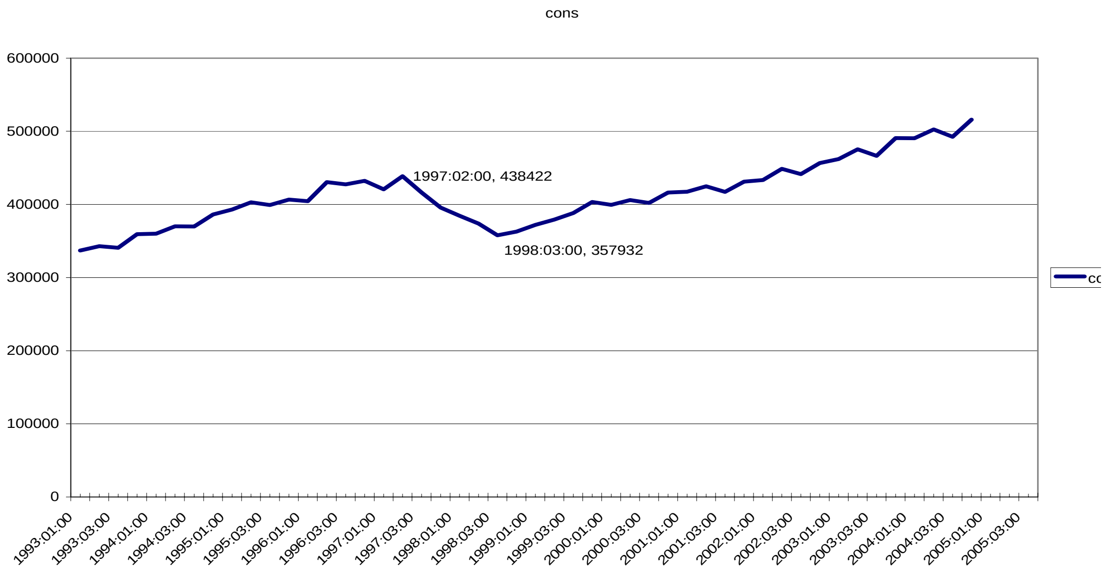

Figure 1: Quarterly consumption for the Thai economy at constant 1988 prices

Methods and techniques

The method used in this paper consists of testing for non-seasonal and seasonal unit roots and identification of the orders of the non-seasonal and seasonal autoregressive and moving average processes. Model selection criteria are then applied.

Tests of non-seasonal and seasonal unit roots

The standard test for unit roots in the regular and seasonal polynomials is that of Hylleberg, *et al*. (1990) (or HEGY), which is discussed briefly below:

Definition:

(i) first difference operator: $\Delta \equiv 1 - L;$

(ii) seasonal difference operator: $\Delta_s \equiv 1 - L^s;$

(iii) the summation operator of order s: $S_s(L) \equiv 1 + L + L^2 + ... + L^{s-1}$.

The following relationship holds between these operators:

$$\begin{aligned} 1 - L^s &= (1 - L)(1 + L + L^2 + ... + L^{s-1}) \\ &= (1 - L)S_s(L) \end{aligned} \qquad [1]$$

as

$$1 - L^s = (1 - L)(1 + L + L^2 + L^3),$$

$$(1 + L + L^2 + L^3) = (1 + L)(1 + L^2),$$

and

$$(1 + L^2) = (1 + iL)(1 + iL),$$

where i is the imaginary root, or $(-1)^{0.5}$, so that $i^2 = -1$ and $-i^2 = 1$. Using these results gives:

$$\begin{aligned} (1 - L^4) &= (1 - L)(1 + L + L^2 + L^3) \\ &= (1 - L)(1 + L)(1 + iL)(1 + iL), \end{aligned}$$

so that the roots are +1, -1, +i, -i. These roots have the following interpretation: +1 denotes a long run with no cycles (namely, the standard unit root), -1 denotes a semi-annual frequency of two cycles per year, and +i and –i denote one cycle per year. HEGY use $I_\theta(d)$ to denote the series is integrated of order d at the θ frequency (Patterson, 2000, pp.274-5), while Osborn, Chui, Smith and

Birchenall (1988) use I(d, D), where d denotes one-period differences and D the number of seasonal differences for stationarity.

A polynomial, $\phi^{+}(L)$, may be expanded about its roots with a remainder $\varphi^{*}(L)(1-L^{4})$, as follows:

$$\varphi^{+}(L) = -\gamma_1 L(1+L+L^2+L^3) - \gamma_2(-L)(1-L+L^2-L^3) - (\gamma_3 L+\gamma_4)(-L)(1-L^2) + \varphi^{*}(L)(1-L^4). \qquad [2]$$

Substituting for $\varphi^{+}(L)$ in the model $\varphi(L)^{+} Y_t = \varepsilon_t$ gives:

$$\begin{aligned}\varphi^{*}(L)\ \Delta_4 Y_t &= \gamma_1 L(1+L+L^2+L^3)Y_t \\ &\quad + \gamma_2(-L)(1-L+L^2-L^3)Y_t \\ &\quad + (\gamma_3 L+\gamma_4)(-L)x(1-L^2)Y_t + \varepsilon_t \\ &= \gamma_1 Y_{1t} + \gamma_2 Y_{2t-1} + \gamma_3 Y_{3t-2} + \gamma_4 Y_{3t-1}, \qquad [3]\end{aligned}$$

where

$$\begin{aligned}Y_{1t} &= (1+L+L^2+L^3)Y_t \\ Y_{2t} &= -(1-L+L^2-L^3)Y_t \\ Y_{3t} &= -(1-L^2)Y_t\end{aligned}$$

(see Hylleberg et al. (1990) and Patterson (2000, p.275))

The following augmented regression model may be conducted:

$$\Delta_4 Y_t = \mu_t + \gamma_1 Y_{1t-1} + \gamma_2 Y_{2t-1} + \gamma_3 Y_{3t-2} + \gamma_4 Y_{3t-1} + \sum_{i=1}^{p} \varphi_i \Delta_4 Y_{t-i} + \varepsilon_t, \qquad [4]$$

for which implications and critical values for testing seasonal unit roots are given in Table 1.

Table 1: Implications and Availability of Critical Values for Testing Seasonal Unit Roots

Null	Implications Implication	Alternative	Implication	Test statistic
$\gamma_1 = 0:$	$I_0(1)$	$\gamma_1 < 0:$	$I_0(0)$	$\hat{\tau}$ type
$\gamma_2 = 0:$	$I_{\frac{1}{2}}(1)$	$\gamma_2 < 0:$	$I_{\frac{1}{2}}(0)$	$\hat{\tau}$ type
$\gamma_3 = \gamma_4 = 0:$	$I_{\frac{1}{4}}(1)$	$\gamma_3 \neq 0$ and/or $\gamma_4 \neq 0$	$I_{\frac{1}{4}}(0)$	F type

Alternative strategy to test the null $I_{\frac{1}{4}}(1)$

(i) $\gamma_4 = 0$ against $\gamma_4 \neq 0$ use $\hat{\tau}$ type test statistic.

If null not rejected continue with:

(ii) $\gamma_3 = 0$ against $\gamma_3 < 0$, use $\hat{\tau}$ type test statistic and, if $\gamma_4 = 0$ and $\gamma_3 = 0$, do not reject $I_{\frac{1}{4}}(1)$

No seasonal unit roots are present if: $\gamma_2 \neq 0$ and either γ_3 or $\gamma_4 \neq 0: I_{\frac{1}{2}}(0)$ and $I_{\frac{1}{4}}(0)$;

No standard unit root is present if $\gamma_1 < 0 : I_0(0)$.

Source: Patterson (2000).

Model selection criteria

Criteria for model selection used in this study are Akaike's Information Criterion (AIC) (Akaike, 1973) and Schwarz's Bayesian Information Criterion (alternatively, BIC or SBC), which are given as:

$$AIC = \log \hat{\sigma}^2 + 2\frac{p+q}{T}$$

and

$$BIC = \log \hat{\sigma}^2 + 2\frac{p+q}{T}\log T ,$$

where $\hat{\sigma}^2$ is the estimated error variance at time t, p and q are the orders of the ARMA (p,q) process, and T is the number of observations.

Data for the study were obtained from quarterly consumption data for the Thai economy at constant 1988 prices. In our analysis of this series, the sample period ran from 1998.1 to 2005.3.

Empirical results

The results presented in Table 2 shows estimates of augmented regression of equation (4). Five models were tested including five augmented regressions: with a constant, without a constant, with a constant and seasonal dummies, with a constant and trend, and with a constant, seasonal dummies and trend. The empirical results suggested that the model with a constant show that the appropriate lag length for the dependent variable is two as the estimated equation gives the Durbin-Watson statistic nearest to two and the lowest AIC and BIC (Table 2, Model 1). However, as the constant term in this model is not significant, re-estimating it without a constant gives lower AIC and BIC values and a Durbin-Watson statistic nearer to two (Table 2, Model 2). Therefore, the model without a constant is selected, with a lag length of two.

Table 2: Estimates of the Augmented Regression, Equation (4)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
			Coefficient		
C	7668.36	-	10964.10	38282.28	39541.49
Y_{1t-1}	-0.0034	0.0013	-0.0027	-0.027	-0.025
Y_{2t-2}	-0.012	-0.013	-0.32	-0.015	-0.32
Y_{3t-2}	-0.28	-0.28	-0.37^{*}	-0.23	-0.33
Y_{3t-1}	0.52^{***}	0.52^{***}	0.55^{***}	0.48^{***}	0.51^{***}
$\Delta_4 Y_{t-1}$	0.91^{***}	0.91^{***}	0.59^{**}	0.86^{***}	0.56^{**}
$\Delta_4 Y_{t-2}$	-0.47^{***}	-0.48^{***}	-0.36^{**}	-0.36^{***}	-0.26
D1	-	-	-6359.29	-	-6660.080
D2	-	-	654.86	-	607.46
D3	-	-	-12156.00	-	-11897.09
TREND	-	-	-	308.59	286.79
Akaike info criterion	21.19773	21.15520	21.22294	21.17018	21.19822
Schwarz criterion	21.48735	21.40344	21.63667	21.50117	21.65332
Durbin-Watson stat	1.996860	2.016686	32.25499	42.02781	30.46466

Source: Calculation.
Note: Included observations: 42 after adjusted end points.
Model 1: with a constant
Model 2: without a constant
Model 3: with a constant and seasonal dummies
Model 4: with a constant and trend
Model 5: with a constant, seasonal dummies and trend
Significant level * at 90 per cent level of significance
** at 95 per cent level of significance
*** at 99 per cent level of significance.

The estimation of testing for unit roots to indicate the integration level of dependent variable and independent variables are presented in Table 3. The testing with no constant, no seasonal dummies and no trend brings in unit roots at the zero and $\frac{1}{2}$ cycles frequency per quarter. Therefore, in order to render the data stationary, the variable is written in the form $(1-L)(1-L^2)Y_t$, so that an ARMA (p,q) of $(1-L)(1-L^2)Y_t$ has to be investigated.

Table 3: Testing for Seasonal Unit Roots for Aggregate Consumption in Thailand

Augmented Regression Model					
$\Delta_4 Y_t = \mu_t + \gamma_1 Y_{1t-1} + \gamma_2 Y_{2t-1} + \gamma_3 Y_{3t-2} + \gamma_4 Y_{3t-1} + \varphi_2^* \Delta_4 Y_{t-2} + \varepsilon_t$					
Null hypothesis	$\gamma_1 = 0$	$\gamma_2 = 0$	$\gamma_3 = 0$	$\gamma_4 = 0$	$\gamma_3 = \gamma_4 = 0$
Frequency	zero	semi-annual	quarterly	quarterly	quarterly
Deterministic component, μ_1					
None	.00 (-1.95)	-.01 (-1.95)	-.28 (-1.93)	.52 (2.05)	15.53 (3.26)
I	-.00 (-2.96)	-.01 (-1.95)	-.28 (-1.90)	.52 (2.04)	5.54 (3.04)
I, SD	-.00 (-3.08)	-.31 (-3.04)	-.37 (-3.61)	.55 (2.35)	6.43 (7.68)
I, Tr	-.03 (-3.56)	-.02 (-1.91)	-.23 (-1.92)	.47 (1.96)	4.62 (2.95)
I, SD, Tr	-.02 (-3.71)	-.32 (-3.08)	-.33 (-3.66)	.51 (2.34)	5.30 (6.55)

Source: (1) Calculation (2) 5% critical values (in parentheses) are from Hylleberg *et al*. (1990), Table 1A, and Table 1B in Patterson (2000).

Two alternative estimated autoregressive moving average (ARMA) models in Table 4 are estimated. Table 4 shows the Maximum likelihood estimates of $(1-L)(1-L^2)Y_t$. The model in Table 8 gives lower AIC and BIC values compared with that in Table 9. However, the backcast from the model in Table 8 cannot be obtained because the roots of the moving average (MA) process are too large, whereas the backcast of the model in Table 9 can be calculated. Hence the model in Table 8 is recommended for purposes of forecasting. While the model in Table 9 is recommended for purposes of backcasting.

Table 4: Estimated ARMA Models

Variable	Model 1	Model 1
	Coefficient	
C	-240.1240**	70.42511
AR(2)	-0.862806***	-
MA(1)	0.884653***	0.266057**
MA(2)	-	-0.678252***
MA(5)	-0.841682***	-
MA(8)	-0.760726***	-
MA(6)	-1.226851***	-
MA(4)	-1.213550***	-
SMA(2)	-0.572434***	-
Akaike info criterion	20.34920	21.20007
Schwarz criterion	20.67686	21.32052
Durbin-Watson stat	2.221393	1.791432

Note: Included observations: 43 after adjusting endpoints
Significant level
* at 90 per cent level of significance
** at 95 per cent level of significance
*** at 99 per cent level of significance.

Concluding remarks

In this paper, consumption behavior model in Thailand are examined using quarterly consumption data during 1993-2005. This paper endeavors to model macro consumption behavior taking into account of the structural break and seasonality. Our model bases, on Box-Jenkins autoregressive integrated moving average (ARIMA). The properties of stationary time series can be summarized in terms of the autocorrelations of the process. The empirical results of the testing for unit root with no constant, no seasonal dummies and no trend yields unit roots at the zero and $\frac{1}{2}$ cycles frequency per quarter. Therefore, in order to render the data stationary, the variable is written in the form $(1-L)(1-L^2)Y_t$, so that an ARMA (p,q) of $(1-L)(1-L^2)Y_t$ are examined.

From given parameters of the ARMA model, future values of the time series can be forecasted from past values. The findings indicate two alternative ARMA models (without a constant and with a lag length of two). Only one of these is recommended for purposes of forecasting.

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