A Normative Approach to Economic Uncertainty Estimation

Pei-Tha Gan*, Siew-Yong Lim, Han Yu,
Mohd Yahya Mohd Hussin and Fidlizan Muhammad
Department of Economics, Faculty of Management and Economics,
Universiti Pendidikan Sultan Idris, Tanjong Malim, Malaysia
E-mail: gan.pt@fpe.upsi.edu.my

Abstract

A notable feature of the empirical studies on economic uncertainty index is that almost all published papers rely on the approximate form of economic uncertainty index, a method substantially used the variability measures, which is moving sample standard-deviation type. It can, therefore, not be ruled out for the refusal of economic uncertainty index precision is simply the outcome of a misspecification of a commonly used model and an elaborate data snooping process. In order to overcome these limitations, the paper considers the theoretical and practical that must be contented to construct the best economic uncertainty index, while considering Islamic rate as monetary policy instrument. Using the proposed grid search optimization procedure, the best economic uncertainty index anticipates that: (i) it can characterize the certainty of macroeconomic conditions in conformity with the expectation and (ii) it can serve as a guiding policy tool for improving certainty in macroeconomic conditions.

Keywords Grid search, optimal economic uncertainty, Islamic monetary policy

INTRODUCTION

Economic uncertainty states uncertain of future economic events. Since the seminal work on the idea of uncertainty by Knight (1921), researchers have been attempting to investigate the vagueness aversion from several methods. A prominent feature of the empirical studies on economic uncertainty index is that almost all published papers rely on the approximate form of economic uncertainty index; a method substantially used the variability measures, which is moving sample standard-deviation type. It can, therefore, not be ruled out for the refusal of economic uncertainty index precision is simply the outcome of a misspecification of a commonly used model and an elaborate data snooping process.

For instance, Hall and Noble (1987) and Thornton (1995) used such variability measures as uncertainty in testing the Friedman hypothesis. Choi and Oh (2003) provided time-varying volatility series, the measure of uncertainty by using the rolling

regression VAR model. Atta-Mensah (2004) measured the broad uncertainty through the summation of individual uncertainties, in which individual uncertainties were estimated with GARCH models. Greiber and Lemke (2005) used unobserved components model to compute a single estimate of uncertainty based on several observable indicators for the euro area. Cronin and Kennedy (2007) examined the true level of uncertainty in a "two-step" method to study the macroeconomic uncertainty in US money demand. Apergis (1999) employed ARCH modelling based on Engle's (1982) methodology to estimate the inflation uncertainty for the Greece.

Against the above background, though the performance of uncertainty measures is rarely disastrous, however, they can involve large welfare losses relatively to fully optimal uncertainty measure. According to the optimal measure, it is central bank's welfare maximization subjected to its model of the economy. It represents the minimum welfare loss given the structure of the economy and variability of the shocks hitting it (e.g. Jensen, 2002; Jondeau and Sahuc, 2008). In specific, this doctrine is a normative analysis that expresses value judgments about what the economy/goals of public policy ought to be (Caplin and Schotte, 2008).

The motivation for this paper is stimulated by the immense importance that no policy makers (hereafter central banks) have published the optimal uncertainty – best uncertainty so far – for the reason might rest on unwilling to publish it, or such an explicit formula simply does not exist. Having witnessed numbers of austerity due to outbreaks of economic since the end of 1990s, economic uncertainty has been spotted globally with its noticeable increase pace. Bernanke (2010) stressed economic engineering need to be improved in which it fine is dealt with the economic uncertainties. Moreover, it is no harm determining economic uncertainties through Islamic instrument, constitutes basis for the analysis, societal loss function is in line with a welfare maximizing policy of the central bank.[1]

The objective of the current paper is to propose the derivation of the best economic uncertainty in simple macroeconomic model. This hypothesizes that the best economic uncertainty should help (i) it can characterize the certainty of macroeconomic conditions in conformity with the expectation and (ii) it can serve as a guiding policy tool for improving certainty in macroeconomic conditions. The main innovative feature of the paper is suggesting grid search method, which consists in choosing a wide range of sets of uncertainty parameters for lastly retaining the set that gives the smallest loss value. The paper hopes when one follows this best economic uncertainty procedure, encouraging the application of grid search technique to the literature on the measurement of uncertainty.

Remaining portion of the paper is organized as follow. Section 2 formally discusses a conceptual framework and theoretical model specification yielding the best economic uncertainty, and presents an empirical model to be used in the proposed grid search estimation. Methodology is discussed in Section 3. Section 4 concludes the paper.

MODEL SPESIFICATION

Conceptual Framework

The "tube in tube" design has potential as a readily means for analyzing of economic uncertainty of economic conditions, which it can be further delineated using economic modelling in the next section. An example of the optimal economic uncertainty index design with an entire macro model that has a zero uncertainty index of macroeconomic conditions (perfect form) is seen in the tube in Figure 1(*a*). In the tube, the track on each surface is the period of time over which sample data are collected; the respective surface is an entire macro model; the inner shaded tube is the optimal economic uncertainty index that crossing over time from one surface to another. The optimal economic uncertainty index can be constructed when the optimal set of its coefficients are identified.

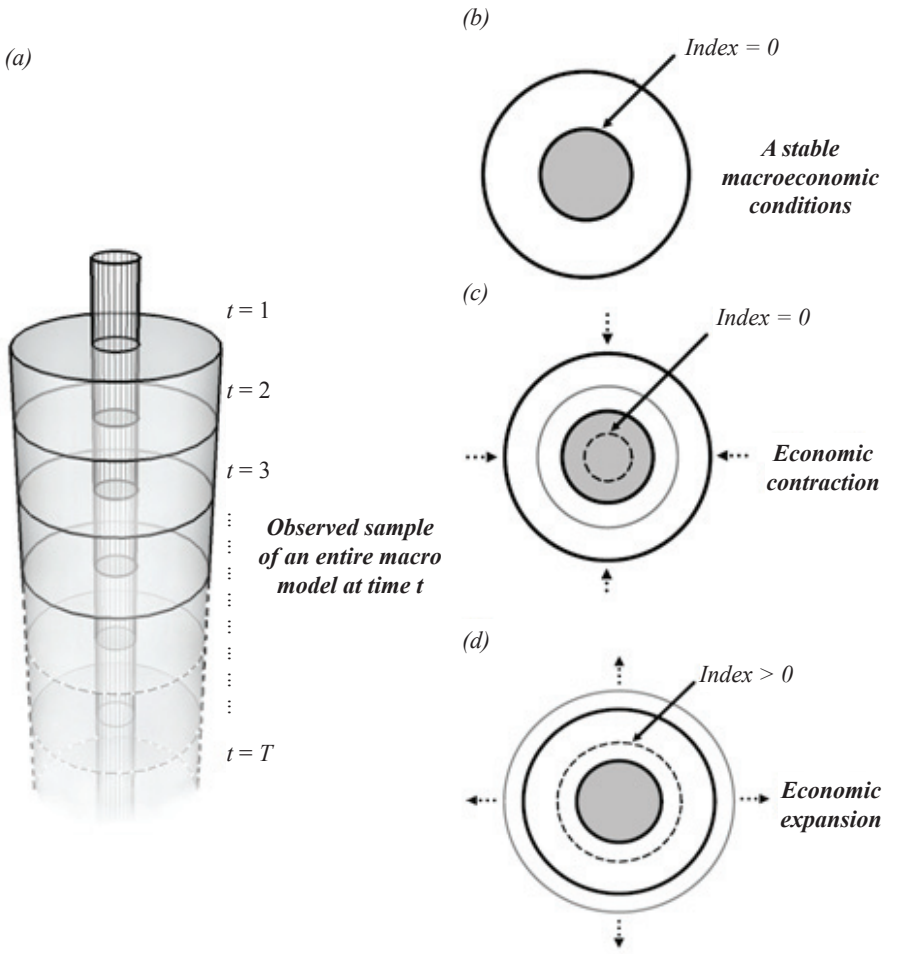

Figure 1 The view optimal economic uncertainty index of macroeconomic conditions.

Figure 1(*b*) shows a field of the perfect surface. An inner shaded circle inside the perfect surface provides the information that the optimal economic uncertainty index is zero and the welfare is maximal (loss function close to zero). However, in reality the macroeconomic conditions rarely at a zero uncertainty index (it can be an economic contraction or an economic expansion) due to unforeseen economic shocks. Thus, the surfaces in the tube like the one in Figure 1(*a*) may not be perfect, and the inner circle of surface can be placed inside (see Figure 1(*c*)) or outside (see Figure 1(*d*)) the inner shaded circle of surface in the tube (the optimal economic uncertainty index is not equal to zero and t*he flow of surface over the time is no longer a straight tube*).

General Model

In general, an economic uncertainty index is used to describe the combined effects of related macro indicators and policy indicators, and thus, captures the level of the stability – certain or uncertain – of economic activity. This index has a significant bearing on the measure of other economic variables. The general form to identify the best uncertainty reaction function can be obtained through constructing an entire macro model and a loss function for the central bank.

$$y_1 = \psi_1 x_{11} + \psi_2 x_{21} + \cdots + \psi_k x_{k1} + \omega_1$$
$$y_2 = \psi_1 x_{12} + \psi_2 x_{22} + \cdots + \psi_k x_{k2} + \omega_2$$
$$\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots$$
$$y_n = \psi_1 x_{1N} + \psi_2 x_{2N} + \cdots + \psi_k x_{kN} + \omega_N$$

$$U = \phi_1 y_1 + \phi_2 y_2 + \cdots + \phi_N y_N + \varpi_N$$

Loss function:

$$E_t \sum_{\tau=0}^{\infty} \beta^{\tau} L_{t+\tau} \qquad (1)$$

Where, y and x are the dependent variable and the independent variable; these variables are expressed in terms of the gap with their equilibrium value (i.e. the deviation of the actual value from the potential one). U , k and N are economic uncertainty index, k variables and N observations respectively. ψ and ϕ are coefficients or weights. L stands for the loss function of the central bank (Woodford, 2003); the current policy prescription is assumed to focus on the low and stable inflation. ω and ϖ are errors.

From model 1, economic uncertainty index is defined as a combination of related gap variables (i.e. y) and the gap variables can be calculated from a potential period; potential period is an equilibrium period. Given that the equation of economic uncertainty index is at constant/certainty level, $U = U^{optimal} = 0$, the economy is then close to its

long-run equilibrium (i.e. at constant level the U encompass the total effects of related macro indicators and policy indicators at optimal level). Ideally, this would provide possibility to compare any situation with the equilibrium and to conclude whether or not macroeconomic conditions in the period have positive uncertainty movements or negative uncertainty movements compared with the equilibrium. Thereby, if increases in related indicators outweigh decreases in related indicators, which indicates a higher U figure and, therefore, tighter economic policy can be materialized to mitigate positive level of U.[2] In practice, the estimation of the weights of related macro indicators and policy indicators in the U is at the heart of calculating of the U; in this context, the weight is also known as the degree of uncertainty. These weights reflect the relative impacts and changes of related indicators affected on economic uncertainty.

Regrettably, the uncertainty index is not perceivable in reality but it can be derived with the grid search procedure. The next section would augment the general form with theoretic modelling of the best economic uncertainty index; the optimal means (hereafter optimal economic uncertainty index).

Theoretic Modelling of Optimal Economic Uncertainty Index

The standard macroeconomic model used to construct the level of optimal economic uncertainty index is an extension of the small structural model of Svensson (2000). Among others, it is used by Ball (1997) and Gan and Kwek (2010a; 2010b). In line with this purpose, the contemporaneous model of economic uncertainty index is included in the small structural model. The sources of small structural model are presumed by the following equations:

$$y_{g_t} = \alpha_1 y_{g_{t-1}} - \lambda_1 r_{g_{t-1}} - \delta_1 e_{g_{t-1}} + \varepsilon_t \quad (2)$$

$$\pi_{g_t} = \alpha_2 y_{g_{t-1}} + \beta_{\pi_1} \pi_{g_{t-1}} - \delta_2 e_{g_{t-1}} + \eta_t \quad (3)$$

$$e_{g_t} = \lambda_2 r_{g_t} + v_t \quad (4)$$

$$U_t = \alpha_3 y_{g_t} + \beta_{\pi_2} \pi_{g_t} - \delta_3 e_{g_t} - \lambda_3 r_{g_t} + \varpi_t \quad (5)$$

$$r_{g_t} = \alpha_4 y_{g_{t-1}} + \beta_{\pi_3} \pi_{g_{t-1}} - \delta_4 e_{g_{t-1}} + U_{t-1} + \zeta_t \quad (6)$$

where, y_g the real output gap, π_g the inflation gap, e_g the real exchange rate gap[3], r_g the real interest rate gap (Islamic interest rate) and U the economic uncertainty index.

y_g, π_g, e_g and r_g are centred, in other words, they are expressed in terms of the gap with their equilibrium value – the deviation of the actual value from the potential one.

Equation (2) is IS curve. Output gap depends positively on its own past value; negatively on the real interest rate gap and the real exchange rate gap. In addition, ε_t is a demand shock.

Equation (3) is Phillips curve. The change in inflation depends positively on the

level of activity (output gap); negatively on the real exchange rate gap.

Equation (4) posits a positive link between the interest rate and exchange rate. The shock v_t captures other influences on the exchange rate.

Equation (5) is a contemporaneous economic uncertainty function. The positive signs on y_g and π_g indicate that the output gap mitigation and the inflation reduction could reduce economic uncertainty. The negative signs on e_g and r_g specify that central bank could reduce economic uncertainty by appreciating exchange rate and rising interest rate.

Equation (6) represents the Islamic monetary policy. The positive signs on y_g, π_g and U point out that the monetary authority has to stabilize the output gap, inflation gap and economic uncertainty by raising the short-term interest rates. The negative sign on e_g shows that monetary authority stabilizes the real exchange rate gap by reducing the short-term Islamic interest rate.

In this section, the derivation of theoretic modelling of the optimal economic uncertainty index assumes the central bank chooses a sequence of inflation, output gap and interest rates to minimize the discounted expected loss subject to the small structural model above (equation two to six). The central bank's loss function is assumed to be quadratic in inflation gap, output gap and interest rate gap; the period loss function is modelled as

$$L_t = \mu_{y_g} V_{y_g} + \mu_{\pi_g} V_{\pi_g} + \gamma_{r_g} V_{r_g} \qquad (7)$$

where μ_{y_g}, μ_{π_g} and γ_{r_g} denote weights attached to the stabilization of the output gap, the inflation gap and the interest rate gap, respectively. Here, V_{y_g} and V_{π_g} respectively stands for the unconditional variance of the output gap and the inflation gap. The variance of the interest rate gap, V_{r_g}, here is mainly functioned to avoid unrealistic situation of the high interest rate volatility. Finally, the optimal economic uncertainty index is then expressed as equation (8), which minimizes L, given the weights of μ_{y_g}, μ_{π_g} and γ_{r_g} (to be discussed in the next section).

$$U_t^{optimal} = \alpha_3^{optimal} y_{g_t} + \beta_{\pi_2}^{optimal} \pi_{g_t} - \delta_3^{optimal} e_{g_t} - \lambda_3^{optimal} r_{g_t} + \varpi_t \qquad (8)$$

METHODOLOGY

This section explains the method applied in estimating the optimal economic uncertainty index, the small structural model from Section 2(c) would provide the basis for formulating the optimal economic uncertainty index.

The Grid Search Method: Finding the Optimal Economic Uncertainty Index

Grid search method is a direct search algorithm for solving nonlinear optimization. This method is departure from the works of Gan (2013). To apply this technique, supposing the small structural model can be written as a general matrix system, $X_t = BX_{t-1} + K_t$. One should modify the matrix system when the small structural model contents some contemporaneous components. Given this, the small structural model (i.e. equation from two to six) in Section 2(c) is inscribed as equation 9 to define the following state-space form model,

$$A_1 X_t = A_2 X_{t-1} + Z_t \tag{9}$$

thereby,

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & -\lambda_2 & 0 \\ -\alpha_3 & -\beta_{\pi_2} & \delta_3 & 1 & \lambda_3 & 0 \\ 0 & 0 & 0 & -1 & 1 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} y_{g_t} \\ \pi_{g_t} \\ e_{g_t} \\ U_t \\ r_{g_t} \\ \Delta r_{g_t} \end{bmatrix} = \begin{bmatrix} \alpha_1 & 0 & -\delta_1 & 0 & -\lambda_1 & 0 \\ \alpha_2 & \beta_{\pi_1} & -\delta_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ \alpha_4 & \beta_{\pi_3} & -\delta_4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 \end{bmatrix} \begin{bmatrix} y_{g_{t-1}} \\ \pi_{g_{t-1}} \\ e_{g_{t-1}} \\ U_{t-1} \\ r_{t-1} \\ p_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ \eta_t \\ \nu_t \\ \varpi_t \\ \zeta_t \\ 0 \end{bmatrix}$$

with Ω as the covariance matrix associated to Z, the system can be written like $X_t = BX_{t-1} + K_t$ but now with:

$$B \equiv A_1^{-1} A_2 \tag{10}$$

$$K \equiv A_1^{-1} Z_t \tag{11}$$

It is followed by the Σ – the covariances matrix associated with the error terms K can be given by $\Sigma = E\left[KK'\right] = E\left[(A_1^{-1}Z_t)(A_1^{-1}Z_t)'\right] = A_1^{-1}\Omega(A_1^{-1})'$

Given that the objective of the central bank is to minimize the standard quadratic loss function (L), it is then can be subjected to the model of the economy as follows:

$$\begin{cases} \underset{\{\beta_{y_g},\beta_{\pi_g},r_g\}}{Min} & L = \mu_{y_g} V_{y_g} + \mu_{\pi_g} V_{\pi_g} + \gamma_{r_g} V_{r_g} \\ s.t. & A_1 X_t = A_2 X_{t-1} + Z_t \end{cases}$$

with $\alpha_3, \beta_{\pi_2}, \delta_3, \text{and } \lambda_3$ the parameters of the economic uncertainty index; μ_{y_g}, μ_{π_g} and γ_{r_g} are respective weights on output gap, inflation gap and interest rate gap, these weights reflect the central bank's preference parameters; V_y and V_π respectively the unconditional variance of the output gap and inflation gap. As the fact that central banks are likely to move their instrument (i.e. interest rate) in moderate steps, it is necessary to add an identity formula, $\Delta r_{g_t} = r_{g_t} - r_{g_{t-1}}$, in the. The optimal economic uncertainty index is then the combination of optimal economic uncertainty reaction coefficients $(\alpha_3^{optimal}, \beta_{\pi_2}^{optimal}, \delta_3^{optimal}, \lambda_3^{optimal})$ which minimizes L, given the weights of μ_{y_g}, μ_{π_g} and γ_{r_g}. Following Svensson (2000), the unconditional contemporaneous covariance matrix of X, devoted V, can be given in vector form by:

$$Vec(V) = \left[I - B \otimes B\right]^{-1} Vec(\Sigma) \qquad (12)$$

In this method, V_{y_g}, V_{π_g} and V_{r_g} are then can be given by the 1st, the 8th and 36th element of $VecV$. Given the combination $(\alpha_3, \beta_{\pi_2}, \delta_3, \lambda_3)$ in solving this sequence, the method consists then can be displayed as below,

$$(\alpha_3, \beta_{\pi_2}, \delta_3, \lambda_3) \Rightarrow B, S \text{ and } \Sigma \Rightarrow VecV \Rightarrow L \qquad (13)$$

The grid search procedure explained above can be exercised with a help of various computer programming software.

CONCLUSIONS

The objective of the current paper is to propose the derivation of the best economic uncertainty in simple macroeconomic model. The results anticipated from the estimated best economic uncertainty index using grid search optimization procedure would strongly accept the hypothesis that best economic uncertainty should help (i) a good summative information tool to characterize the certainty of macroeconomic conditions and (ii) a guiding policy tool for improving certainty in macroeconomic conditions.

In terms of the policy implication, by examining the best economic uncertainty index reaction process and its forecasting performance, the paper expects that the central bank did care about both inflation and the output. The paper also expects that

Islamic interest rate continues to be an important policy instrument of the central bank (Gan and Kwek, 2010a); central bank should take into account exchange rate as a tool of the central bank. The used of exchange rate and interest rate as central bank's tools not only can assign as a framework to attain low and/or stable inflation but the exchange rate alone can serve as independent operating target would certain stability in the foreign capital market. Despite the usefulness of the optimal economic uncertainty, a caveat remains that the optimal economic uncertainty estimation is not an economic turbulence stop policy but it would make the crisis less likely to happen and mitigate the effect of the crisis if any economic and financial tragedy emerged.

ACKNOWLEDGEMENTS

I would like to thank to Research Management Centre, Universiti Pendidikan Sultan Idris and Ministry of Higher Education Malaysia through the funds of FRGS support to produce this research.

REFERENCES

Apergis, N. (1999). Inflation uncertainty and money demand: Evidence from a monetary regime change and the case of Greece. *International Economic Journal*, *13*(2), 21–30.

Atta-Mensah, J. (2004). Money demand and economic uncertainty. Bank of Canada Working Paper No. 2004-25. Ottawa: Bank of Canada.

Ball, L. (1997). Efficient rules for monetary policy. NBER Working Paper No. 5952. National Bureau of Economic Research.

Bernanke, B. S. (2010). On the implications of the financial crisis for economics. Speech Presented at the Conference, Center for Economic Policy Studies and the Bendheim Center for Finance, Princeton, New Jersey, September 24, website: http://www.federalreserve.gov/newsevents/speech/bernanke20100924a.htm.

Choi, W. G. & Oh, S. (2003). A money demand function with output uncertainty, monetary uncertainty, and financial innovations. *Journal of Money, Credit and Banking*, *35*(5), 685–709.

Cronin, D. & Kennedy, B. (2007). *Does uncertainty impact money growth? A multivariate GARCH analysis*, Research Technical Paper 6/RT/07. Dublin: Central Bank & Financial Services Authority of Ireland.

Engle, R. F. (1982). Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation. *Econometrica*, *50*(4), 987–1007.

Gan, P.T. (2013). The optimal economic uncertainty index: A grid search application. Computational Economics. DOI10.1007/s10614-013-9366-y.

Gan, P. T. & Kwek, K. T. (2010a). Optimal monetary policy for Malaysia: Islamic rule versus conventional rule, *Review of Islamic Economics, 14*(2), 47-68.

Gan, P. T. & Kwek, K. T. (2010b). The monetary policy reaction function: Evidence from ASEAN-3. *Asian Academy of Management Journal of Accounting and Finance*, *6*(1), 1-23.

Greiber, C. & Lemke, W. (2005). *Money demand and macroeconomic uncertainty*. Deutsche Bundesbank Discussion Paper 26/2005. Frankfurt: Deutsche Bundesbank.

Hall, T. & Noble, N. (1987). Velocity and the variability of money growth: Evidence from Granger causality tests. *Journal of Money, Credit and Banking*, *19*(1), 112–116.

Jensen, H. (2002). Targeting nominal income growth or inflation?. *American Economic review*, 92(4), 928–956.

Jondeau, E. & Sahuc, J-G. (2008). Optimal monetary policy in an estimated DSGE model of the Euro Area with cross-country heterogeneity. *International Journal of Central Banking*, 4, 23-72.

Knight, F. H. (1921). *Risk, Uncertainty, and Profit*. Boston. MA: Hart, Schaffner and Marx; Houghton Mifflin Company.

Svensson, L. (2000). Open-economy inflation targeting. *Journal of International Economics*, 50, 155-183.

Taylor, J. B. (2009). The financial crisis and the policy responses: An empirical analysis of what went wrong. NBER Working Paper No. 14631. National Bureau of Economic Research.

Thornton, J. (1995). Friedman's money supply volatility hypothesis: Some international evidence. *Journal of Money, Credit and Banking*, *27*(1), 288-292.

Woodford, M. (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton: Princeton University Press.

(Endnotes)

[1] Islamic instrument is superior to the conventional instrument because the former generated greater welfare gain compared to the latter one (cf. Gan and Kwek, 2010a).

[2] One may softer economic policy to mitigate negative level of economic uncertainty index if the above process is the other way round.

[3] An increase in real effective exchange rate (REER) represents a real appreciation while a decrease represents a real depreciation of the domestic currency relative to its trading partners.

Subscription rates:

RM25.00 per issue, payable in advance (not including postage, packing and handling) for subscribers in Malaysia. For subscribers elsewhere, US$25.00 covering air delivery charges.

Subscription correspondence should be addressed to:

Editor-in-Chief
Journal of Contemporary Issues and Thought
Faculty of Management and Economics
Universiti Pendidikan Sultan Idris
35900 Tanjong Malim, Perak, Malaysia.
e-mail: gan.pt@fpe.upsi.edu.my
Fax: +6015-4811 7295

Change of address: Subscribers are requested to notify the Editor-in-Chief of the Journal in advance of change, giving both new and old addresses. Please allow four weeks for changes.