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Bulletin of Taras Shevchenko National University of Kyiv. Economics, 2018; 4(199): 62-66
УДК 352.07
JEL classification: G13
DOI: https://doi.org/10.17721/1728-2667.2018/199-4/8

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THE IMPACT OF THE 2008 OIL PRICE COLLAPSE ON KUWAIT GDP 2008-2012: AN ESTIMATION BASED ON STOCHASTIC LOGISTICAL METHODS

In this paper we utilize a stochastic differenced logistic process to model the annualized Kuwaiti GNPfor the year's2002 to 2012 incorporating the world oil price collapse that occurred in the third quarter of 2008 late 2009 .The fitted stochastic differenced logistic model is then used to investigate the properties and behaviour ofKuwait real GDP given the impact of the 2008 price crash on short run economic growth.The derived stochastic differenced logisticaloutput is shown to be robust in terms of goodness of fit, capturing the "jump"effect of the oil price collapse on the real GDP .This approach is unique in estimating oil price shock effects on the GDP for oil export dependent economies. Finally, the approach delivers robust estimation parameters passing standard diagnostic tests.

Keywords: Differenced logistic process, Kuwaiti GDP, Simulated process, Residual Analysis, Goodness of fit.

Background

The oil price shock of 2008/9created a severe structural break in the Kuwait GDP time series and is as such a notional Jump effect in the GDP data stream, at this time of global trade recession 2008/9. The critical dependency of the Kuwait economy on oil export revenues can be problematic for the econometric modeling using times series data. This is because the substantial income effects causedby progressiveoil price decline creates a dramatic news effect and translates rapidly into local labour and financial markets .This led to notional exchange rate devaluation in an economy where the Marshall – Lerner conditions are not favourableand concomitantly where income absorption issues are crucial. These cumulative negative mechanisms are especially acute in Kuwait, where oil revenues are greater than 60 per cent of GDP and represent an even higher proportion of government income.

Stochastic modelshave been used to study price trends of commodities, hence Aase K.K. [2, 3] used a diffusion model with shocks to evaluate fluctuations in stock prices. Furthermore, Aase KK. [4], developed the technique to model estimation issues for security prices in the presence of shock news events. For the steady and continued development of techniques in this area readers are referred to: Burbidge J. [5], Darby M. [6], Hamilton J. [7], Johnson N.[8], Jones C. [9], Karlin S. [10], Kaufman R.K. [11], Krautkraemer J.A. [12], Macmillan W. [13] and Mork K. [15]. The theory of short run dynamic price movements has evolved significantly since Muth J.F. [14], introduced the concept of rational expectations in his fundamental analysis of cobweb models and price expectations. The development of this idea in macroeconomics is well known but is focused on the classical dichotomyand relative impacts of monetary policy in the context of continuous price clearing and perfect markets. The point of departure in this paper, however, is focused on knife edge growth issues where the income effects of price bubbles and option pricing features deliver negative accelerator/multiplier income effects on real Kuwaiti GDP. The formation of expectations in the context of prices bubbles and determination of rational expectations of future price dynamics is not of direct interest.

In this paper, the trajectory of real Kuwaiti GDP for the period 2002 to 2012 is investigated in the context of the 2008 global recession and consequent oil price collapse. Figure 1 reveals that Kuwait GDP data behaved as a non-stationary processin the downward spiral.This implies that a stochastic differenced logistical process is appropriate to model Kuwaitireal GDP data given the severe price shock.

Structure of the Model

Consider the Stochastic Differenced Logistic Process {X (t): t ≥0} such that

$$\Delta X\ (t)\ =\ Z\ (t) \tag{1}$$

where Δ is the difference operator. i.e.

$$\Delta X\ (t)\ =\ X\ (t\ +\ 1)\ -\ X\ (t) \tag{2}$$

and $Z\ (t)$ is alogistic distribution with parameters α and β with probability density function and distribution function as follows

where $f(z)=\dfrac{e^{-\frac{z-\alpha}{\beta}}}{\beta\left[1+e^{-\frac{z-\alpha}{\beta}}\right]^2}$ and $F(z)=\dfrac{1}{1+e^{-\frac{z-\alpha}{\beta}}}$

Assume U (t) be uniformly distributed on (0, 1). The Logistic random variates Z (t) with parametersα and β are simulated as:

$$Z(t) = \alpha - \beta \ln\left(\frac{1}{U(t)} - 1\right) \quad (3)$$

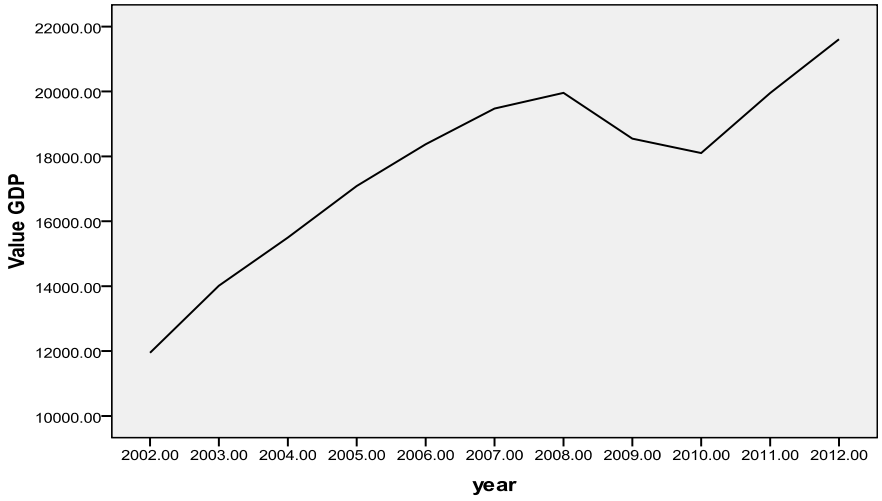
Thus, the suggested stochastic difference logistic model is then given by

$$X(t+1) = X(t) + \alpha - \beta \ln\left(\frac{1}{U(t+1)} - 1\right) \quad (4)$$

where U (t) is a uniform random variate on (0, 1).

Consider fitting the GDP data, given in figure 1 and table 1 below, using the above-mentioned stochastic model in equation (4). The Maximum Likelihood Estimates of the model parameters α and $\beta$are found to be $\hat{\alpha}$ = 0.0889 and $\hat{\beta}$ = 1.454 using the statistical package the Best Fit v.2 (Best Fit is a trademark of Palisade Corporation, USA) to the differenced data of oil prices.

Figure 1: The Original Yearly Kuwaiti GDP in Millions of KWD



*Source:*Kuwait's Ministry of Finance (2016).
The country's financial managements' final account for the year 2015/2016

Note that the 2008 financial shock is shown clearlyand this affected the behaviour of the GDPdata, causing the decline in years 2009 and 2010 and thenrising after that.

***Table*1. The Real Annual Kuwaiti GDP in Millions of KWD**

YEAR	GDP	GDP_SIM
2002	11944.5	11944.50
2003	14014	11946.04
2004	15499.1	14015.05
2005	17088.1	15502.09
2006	18372.2	17086.17
2007	19473.2	18373.81
2008	19955.9	19475.70
2009	18543.8	19957.44
2010	18104.2	18543.89
2011	19952.6	18101.25
2012	21610.2	19952.34

Source: Kuwait's Ministry of Finance (2016) [16].
The country's financial managements' final account for the year 2015/2016

Structure of the Simulation

For simulation of the process X (t) in equation (4) above, the following approximation is used: For integer value n = 0, 1, 2, 3, …, we define

$$\hat{X}(n+1) = X(n) + \hat{\alpha} - \hat{\beta} \ln\left(\frac{1}{U(n+1)} - 1\right) \quad (5)$$

where U (1), U (2),U(3),…, are independent sequence of standard uniform random variable on (0, 1). Applying the fitted model in equation (5), we get the predicted yearlyKuwaiti GDP in millions of KWD $\hat{X}(t)$, $t = 1, 2, 3, \ldots$, and $X(0)$ is the initial oil price (see table 2 below).Figure 2 shows the simulated GDPdata graphically.

Figure 2: The Original and Simulated Yearly Kuwaiti GDP in Millions of KWD

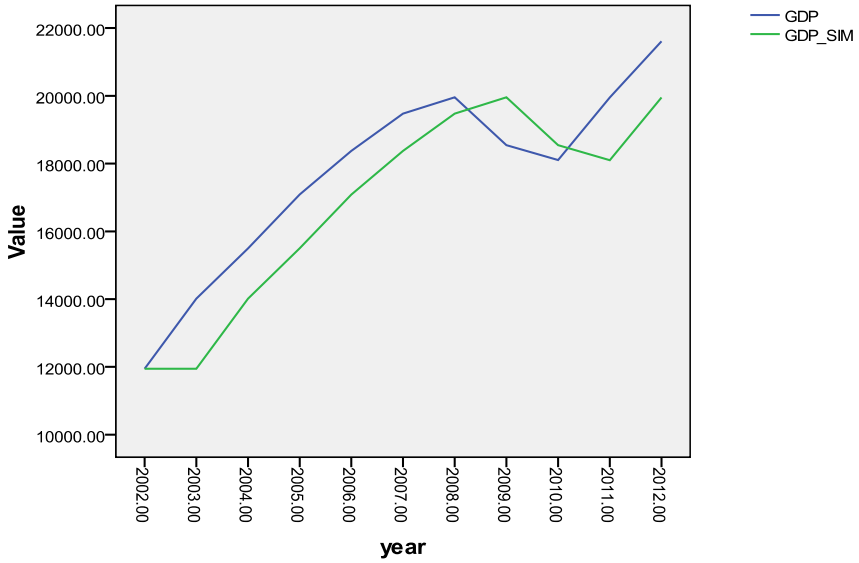


Figure 2 shows that the fitted stochastic differenced logistic model is very close to the behaviour of the original GDP data.

Source: output statistical package the Best Fit v.2 (Best Fit Palisade Corporation, USA)

This model is reliable,promising and efficient in capturing the decline and the eventual rise in the real GDP flow accurately.

Residual Analysis

To assess the goodness of the fit in derived model we use a test based on the sample autocorrelation function ACF of the residuals W (n) where:

$$W(n) = X(n) - \hat{X}(n) \qquad (6)$$

If the fitted model is appropriate, then the residuals {W (n)} should be independent and distributed with mean zero and constant variance. We verify this property by plotting the sample ACF of {W (n)} and check for compatibility with independence using the bounds $\pm 1.96 / \sqrt{n}$. Wecompare the sample ACF with bounds $\pm 1.96 / \sqrt{n}$ to see if { W(n) } are independent. We reject if there are values very far outside the bounds or more than 5% of the values lie outside the bounds.

For this application the sample ACF of {W (n)} is shown in figure 3 below which implies that the residuals are compatible with independence and the Gaussian stochastic model for the Kuwaiti GDP data passesthis particular test. Figure 4 of partial ACF of W(n) strongly supports the goodness of our fit criterion of the model.

Figure 3: The ACF of Residuals W(n)

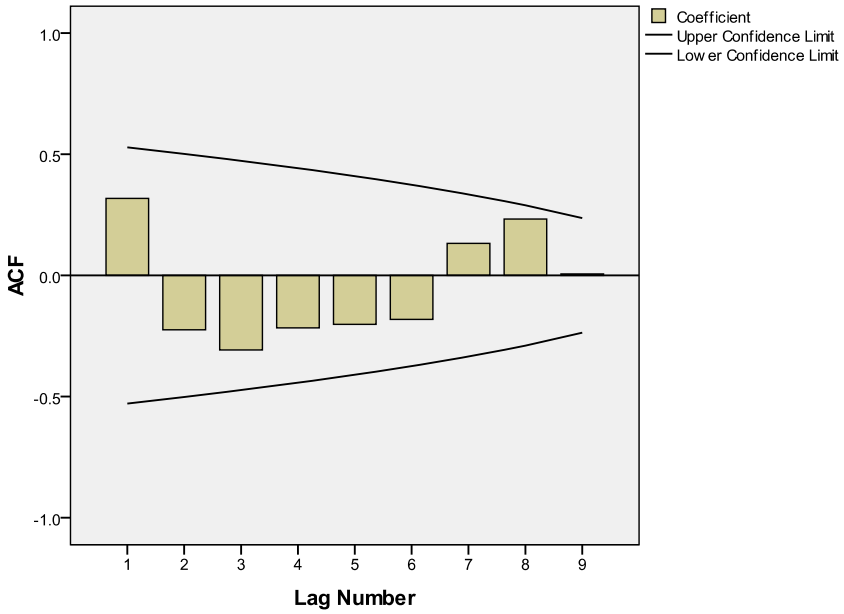
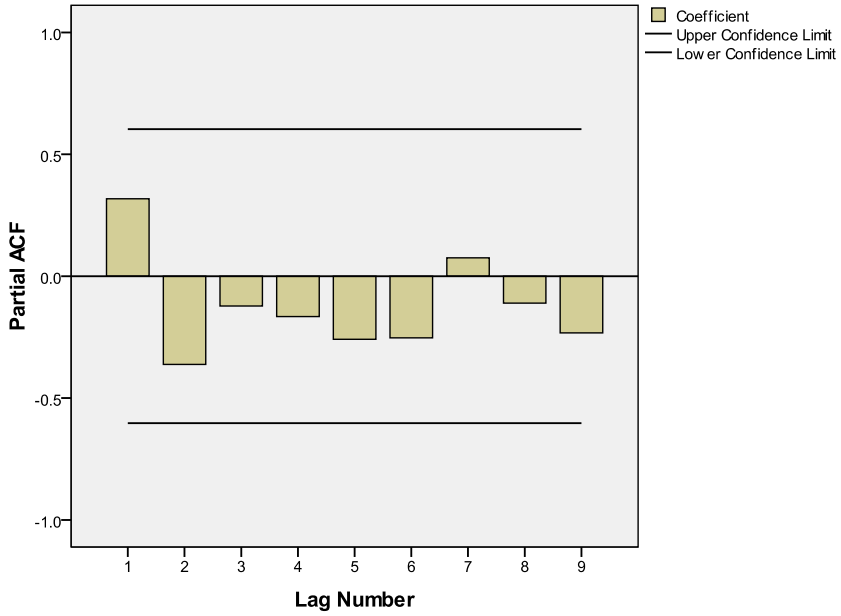


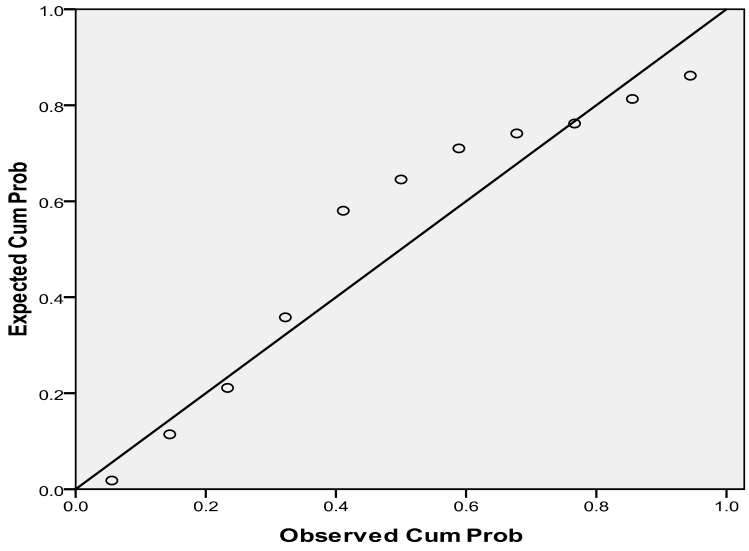
Figure 4: The Partial ACF of Residuals W(n)



Source: tables 3 and 4 Output statistical package the Best Fit v.2 (Best Fit is a trademark of Palisade Corporation, USA)

Finally,figure 5 below shows the normal probability plot for the residuals, these too, indicate the normality of the residuals.

Figure 5: The Normal P-P Plot of Residuals W(n)



Source: table 5 Output statistical package the Best Fit v.2 (Best Fit is a trademark of Palisade Corporation, USA)

Discussion:

The significance of the estimation should be seen from viewpoint of natural resource rich nations where a high proportion of GDP is accounted for by export sales revenues. The impact of a dramatic fall in export sales as seen in the referenced period 2008-9 is difficult to capture using traditional econometric time series analysis given the massive structural break in the exports data that occurred.So, the impact of the collapse in the oil trade 2008-9 for oil producers requires a different perspective. Despite the vast literature on the impact of oil crises that exists this material is largely focused on potential or, actual effects on the oil importers. By contrast, there has been scant-attention in this academic literature focused on the impact of a collapse in oil prices on the macroeconomic income effects on oil producers. The bibliography shows that most of the analysis using logistical methods in the literature refers to share/ option pricing. The paper then represents a new departure in modeling GDP where shock- jump effects are discernible and where the fall in export revenues affects a large fraction of GDP creating dramatic structural breaks in the data time series.The shock to Kuwait GDP modeled in this paper captures the process mechanisms widely discussed in syntheses of the elasticity and income absorption approaches to trade balance. In Kuwait, the Marshall – Lerner conditions do not hold,so that a collapse in oil prices deliver severe income effects where concomitant liquidity effects create huge negative impacts on State budgets and GDP. This is difficult to capture using

linear regression techniques because a new growth trend arises. The results in this paper offer a robust alternative perspective to capture and translate nonlinear /price income effects. The residual analysis shows that these are robust and meet accepted tests. Essentially in developing countries where the Marshall – Lerner conditions are reversed income shocks via price crashes spiral, creating massive pressure on government budgets and rapid GDP downturns.

Conclusion

It is clear from the graph in figure 3 of the sample ACF, and in figure 4 of sample partial ACF as well asthose in figure 5 of the normal probability plot for the residuals from the fitted model pass the tests for independence, lending support to the goodness of fit of the developed stochastic differenced logistic process for annualized Kuwaiti GDP during for the period from 2002 to 2012. The net foreign trade multiplier is large in Kuwait. This is also coupled to a substantial government expenditure multiplier linked with a high aggregate capital output coefficient. [AL – Sayegh-2018] For Kuwait this means that a typical growth trajectory embodies a Harrod Razor Edge scenario given potentially large accelerator /multiplier interactions for oil price collapses or, bubbles.Actual growth of GDP in Kuwait can be at the Harrod Warranted Rate for oil price inflation and conversely for price collapses. The estimation procedure outlined in this paper captures the nature of Razor Edge GDP growth in the Harrod growth model literature. So the impact of the collapse in the oil trade 2008-9 for oil exporters requires a different methodology. The bibliography shows that most of the analysis using logistical methods in the literature links toto share/ option pricing.The methodology used in this paper represents a new departure in modeling GDP growth trends where shock-jump effects are apparent and where the shock in export revenues impacts negatively via –multiplier-accelerator processes on GDP.

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Received: 10/05/2018
1st Revision: 09/06/2018
Accepted: 15/07/2018

Author's declaration on the sources of funding of research presented in the scientific article or of the preparation of the scientific article: budget of university's scientific project

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ВПЛИВ КРИЗИ ЦІН НА НАФТУ В 2008 РОЦІ НА ВВП КУВЕЙТУ ПРОТЯГОМ 2008-2012 РОКІВ: ОЦІНКА НА ОСНОВІ СТОХАСТИЧНИХ ЛОГІСТИЧНИХ МЕТОДІВ

У даній роботі ми використовуємо стохастичний диференційований логістичний процес, щоб моделювати річний ВВП Кувейту за 2008-2012 роки. Ми включаємо до моделі світовий колапс цін на нафту, який відбувся в третьому кварталі 2008 року – наприкінці 2009 року. Застосовуємо пристосовану стохастичну диференційовану логістичну модель для дослідження властивості та поведінки реального ВВП Кувейту з урахуванням впливу цінової кризи 2008 р. на економічне зростання у короткостроковій перспективі. Отриманий стохастичний логістичний прогноз показав, що він є надійним з точки зору придатності, фіксує ефект "стрибка" на реальний ВВП від розпаду цін на нафту. Цей підхід є унікальним при оцінці впливу шоків цін на нафту на ВВП для економік, залежних від нафти. Нарешті, підхід забезпечує надійні параметри оцінки, що проходять стандартні діагностичні тести.

Ключові слова: різницевий логістичний процес, ВВП Кувейту, імітований процес, аналіз залишків, добробут придатності.

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ВЛИЯНИЕ КРИЗИСА ЦЕН НА НЕФТЬ В 2008 ГОДУ НА ВВП КУВЕЙТ В ТЕЧЕНИЕ 2008-2012 ГОДОВ: ОЦЕНКА НА ОСНОВЕ СТОХАСТИЧЕСКИХ ЛОГИСТИЧЕСКИХ МЕТОДОВ

В данной работе мы используем стохастический дифференцированный логистический процесс, чтобы моделировать годовой ВВП Кувейта за 2008-2012 годы. Мы включаем в модели мировой коллапс цен на нефть, который состоялся в третьем квартале 2008 года – в конце 2009 года. Применяем приспособленную стохастической дифференцированную логистическую модель для исследования свойств и поведения реального ВВП Кувейта с учетом влияния ценового кризиса 2008г. на экономический рост в краткосрочной перспективе. Полученный стохастический логистический прогноз показал, что он является надежным с точки зрения пригодности, фиксирует эффект "скачка" на реальный ВВП от распада цен на нефть. Этот подход является уникальным при оценке влияния шоков цен на нефть на ВВП для экономик, зависимых от нефти. Наконец, подход обеспечивает надежные параметры оценки, которые проходят стандартные диагностические тесты.

Ключевые слова: разностный логистический процесс, ВВП Кувейта, имитированный процесс, анализ остатков, благосостояние годности.