Relationships among the Oil Consumptions in China, Japan and India

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Abstract - Previous studies have focused on the analysis of energy consumption within a given country or a region. The paper aims to examine the short-run and/or long-run cross-regional relationships among the oil consumptions in China, Japan and India. These three countries are geographically close. I introduce the yearly time series of oil consumption for the 1965 to 2010 period. I tested for unit root, break date and Granger causality. I did not find any break dates in the data. I found that the oil use variables for these three countries had various unit root properties, which imply that they were impossibly co integrated. The pronounced differences of economy, politics, and population and energy sources across the countries may lead to no co integration. However, using the Toda-Yamamoto technique, I found that the oil consumption in either China or India Granger caused that of Japan. Oil consumption in India Granger caused that of China. Therefore, foreign oil consumption could be a predictive factor when one analyse China's short-run oil consumption changes.

Index Terms - oil, consumption, regional relationship

I. Introduction

Oil demand and supply have largely influenced one nation's energy consumption[1]. Therefore, literature has focused on examination of the energy consumption within given countries or regions[2]. China, Japan and India are geographically close leading countries in Asia. The oil consumption of these three nations is heavily dependent on oil imports. The oil consumption of China, Japan and India in 2011 accounted for 11.4%, 5.0% and 4.0% respectively of the world's total [3]. Hence, oil prices in international markets have similarly affected oil consumption in these three Asian countries. I assume that the oil consumptions of China, Japan and India may produce an equilibrium relationship in the long run.

China, Japan, and India are the countries with substantial economic sizes and densely populated. The Kyoto Protocol came into effect in February 2005. Hence, developed Japan must reduce its carbon dioxide emissions significantly. China and India must radically reduce the intensity of their respective carbon dioxide emissions. During a long historical period, they have exerted strong geopolitical effects on each other. Therefore, the information that China's oil use efficiency has been increasing would be quickly delivered to Japan and India. This would motivate the Japanese and Indian governments to take measures to improve their respective oil efficiency. Therefore, I suggest that changes in one country's oil consumption would exert a short-run effect on those of the other two.

The purpose of the paper is to analyze the possible short-run and/or long-run cross-regional relationships among the oil consumptions in China, Japan and India. The practical implication is that when one forecasts the oil consumption in one country, he may consider the oil consumption in geographically close countries as a leading factor.

II. Methodology

To analyze the short-run prediction and/or long-run equilibrium relationship among the economic time-series variables of interest, we can drive Granger causality and/or co integration tests[4][5]. To pre-test for the stationary of time-series variables, we can conduct the Augmented Dickey-Fuller (ADF) unit root test [6], and the structural break or break-date test utilizing the mixed innovation outlier (IO) model [7]. We estimate the t_{α}^{*} -statistics for the structural break test. Co integration requires that time-series variables of interest each contain a unit root. We can use the Johansen multivariate test to detect clues to co integration [8].Co integration implies long-run equilibrium. In such a case, we can analyze long-run elasticises, and construct an error-correction model (ECM), within which we can analyze short-run elasticises and Granger causality. However, if variables are not co integrated, it is not easy to test for Granger causality [9]. In such a case, we can analyze the Granger causality using the 'unconventional' Toda-Yamamoto test; the merit of this test is that it does not depend on the properties of unit root and co integration [10].We can conduct the vicariate test in the following lag-augmented VAR model:

$$y_t = \gamma_0 + \gamma_1 t + j_1 x_{t\ 1} + .. + j_k x_{t\ k} + j_{k+1} x_{t\ k\ 1} + .. + j_{k+d} x_{t\ k\ (d)} + \varepsilon_t$$

where the order of integration of y_t is at most two (denoted $d \leq 2$) around a linear trend t. ε_t is error term. The Waldχ^2-statistic was employed for testing the null hypothesis of no Granger causality from x_t to y_t: $H_0 : j_1 = j_2 = .. = j_k = 0$.

III. Data

Iemployedthe yearly timeseriesdata covering the period from 1965 to 2010.The three variables, *Chinaoiluse*, *Japanoiluse* and *Indiaoilus e*represent China's oil consumption, Japanese oil consumption and Indian oil consumption, respectively. I drew oil consumption series from BP [3].Oil consumption is measured in million tonnes. Date for all the testswere in natural logarithmic form.

IV. Empirical Results

ADF statistics indicated that *Chinaoiluse* did not contain a unit root. The variable *Japanoiluse* contained two unit roots. The variable *Indiaoiluse* contained a unit root (Table I).The structural break tests did not find any break dates existing in the data (Table II). Perrot provided the finite-sample critical values for $T = 70$; the critical values are -6.32, -5.59, and -5.29 at the levels of 1%, 5%, and 10% respectively[7].Therefore, we could accept the results of unit root suggested by the ADF tests. In fact, I found that the oil consumption in Japan had fluctuated dramatically and was thus criticallynonstationary with time (containing two unit roots). Therefore, these three variables were impossibly co integrated. We could directly turn to examination of their short-run relationships.

TABLE I The Augmented Dickey-Fuller (ADF) Unit Root Tests

Variable		*k*	ADF	p-value
Chinaoiluse	L[a]	2[b]	-5.07[c]	0.00
	FD	-	-	-
Japanoiluse	L	2	-2.83	0.19
	FD	5	-3.75	0.03
	SD	2	-4.76	0.00
Indiaoiluse	L	2	-3.03	0.14
	FD	2	-3.55	0.05

a. L, LD and SD denote level, first difference and second difference, respectively. b. I selectedkusing modified AIC; however, I preset k between 2 and 9 [11]. c. All tests includedthe intercept and the trend.

TABLE II The Structural Break Tests

Variable	Regressor	*k*	Estimates (p-values)	t_{α}^{*}	*t*-statistic	$\hat{T}_b$
Chinaoiluse	y_{t-1}[a]	8[b]	0.35(0.00)	3.18	1.64[c]	24[d]
Japanoiluse		6	0.74(0.00)	5.04	1.63	17
Indiaoiluse		3	0.15(0.40)	0.85	2.46	32

a. Estimates were only for α on the term yt-1. I selected the lag orders k using a general-to-specifictechnique (Perron, 1997).b. I presetk between 1 and 8. λ=0.3. c. The t-statistic (≥1.6) represents that for the coefficient of the kth lagged term. d. $\hat{T}_b$ is the possible structural break dates detected.

I tested for Granger causality using the Toda-Yamamoto technique (Table III). The test procedures were: First, the lag length was selected by reducing AIC to the extent possible while maintaining multivariate joint normality. Subsequently, the maximal possible order of integration d contained in the data was assumed to be two; therefore, I estimated the VAR(k+2) systems. I found three Granger-causal relationships. Variable Indiaoiluse Granger caused Chinaoiluse as well as Japanoiluse. The variable Chinaoiluse Granger caused Japanoiluse. However, Japanoiluse did not Granger cause any variable of interest.

TABLE III The Toda-Yamamoto Granger Causality Tests

Dependent variable	Independent variable	Wald-χ^{2a}	DF[b]	*k*+ *d*	F	Adj. R^2	AIC	ARCH[c]	Ramsey[d]
Chinaoiluse	*Japanoiluse*	14.7	9(0.10)[e]	12	353.43	1.00	-0.38	1.42 (0.23)	6.11(0.04)
	Indiaoiluse	90.7	11(0.00)	13	1589	0.99	-5.7	1.01(0.32)	0.17(0.70)
Japanoiluse	*Chinaoiluse*	326	12(0.00)	14	171.86	0.99	-7.9	3.67(0.06)	1.02(0.50)
	Indiaoiluse	54.3	12(0.00)	14	25.44	0.96	-0.60	3.41 (0.06)	16.6(0.15)
Indiaoiluse	*Chinaoiluse*	7.48	12(0.82)	14	202.67	0.99	-4.67	3.03(0.08)	0.32(0.67)
	Japanoiluse	13.1	12(0.36)	14	369.07	0.99	-5.27	2.76(0.10)	0.03(0.96)

a. Wald χ2(k)-statistic was used in order to test for H0 (no Granger causality). b. DF denotes the degree of freedom. c. ARCH is the LM statistic for no ARCH. d. Ramsey denotes the Ramsey RESET F-statistic for constancy in the VAR model. e. The figures in parentheses are p-values.

V. Discussions and Conclusions

Previous studies have focused on the analysis of energy consumption within a country or region. China, Japan, and India are the three leading countries in Asia. They all hold considerable economic sizes and are densely populated. Oil consumption in these three countries is heavily dependent on imports. They are geographically close. Hence, oil consumption among them may establish a long-run cross-regional equilibrium. In addition, there have existed long-run and close geopolitical relationships among these countries. The information of oil consumption in one country may effuse promptly to either of the other two countries and thereby producing short-run effects on the latter's oil consumption. Therefore, the paper aims to analyze the short-run and/or long-run cross-regional relationships among the oil consumptions in China, Japan and India using the co integration and/or Granger causality tests.

The oil consumption of the three countries held distinct unit root properties. The variables were not co integrated. That is, they did not contain equilibrium. The growth of oil consumption in these three countries exhibited different trends. Japanese oil consumption has fluctuated considerably with time; it trended upward quickly before the late 1970s, but steadily or even downward thereafter. Oil consumption in either China or India has trended upward; however, the oil consumption in China has grown faster than India's. In addition, the three countries differ noticeably in terms of governmental efficiency, energy efficiency, economic levels, economic growth, and energy resource sources. Therefore, the co integration or long-run equilibrium was rarely established. Despite this, using the Toda-Yamamoto technique, I found three short-run Granger-causal relationships. China has been a rapidly emerging country; hence, it could make quick responses to the short-run changes in India's oil consumption. However, it seems that China has not responded to short-run changes in Japanese oil consumption. Both China's and Japan's oil consumption could not affect Indian oil consumption in the short run. Both China's and India's oil consumption could produce a short-run effect on Japan's oil consumption. Japan is a highly developed society and thereby holding an extremely experienced management, where as it is in much short supply of energy. I attribute this to the quick responses of changes in Japanese oil consumption to the change in oil consumption in China and India.

Therefore, one could consider Indian oil consumption as a short-run international factor when he predicts China's oil consumption. In order to improve China's oil use efficiency, the Chinese government must pay sufficient attention to, and have quick and appropriate responses to, the short-run change in Japanese oil consumption.

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