

The Study on Korea's Energy Dependency, Import Concentration and Energy Intensify

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ABSTRACT: Because we still lived in a world called "Era of energy" and fossil fuel remained leading role in energy consumption, energy become core issues of economic development relationship. So the situations of world energy have attracted much attention. This paper establish Three-variable model contained energy intensity, import market concentration and the dependence to study the effect relationship between import market intensity, the dependency and energy intensify. The co-integration test shows co-integration among variables based on the data between 1980 and 2013. Furthermore, Granger causality test shows that the long-term and short-term remain positive from the affection of energy import market concentration to energy intensify. And the short term are positive but long-term not from the affection of energy intensify to energy import market concentration, the same relationship with energy intensify to import market concentration and energy import dependence to import market concentration. All those results could show direction for Korea energy strategy, meanwhile, offer some experience reference and advices for China's energy strategy which own familiar energy status with Korea.

KEYWORDS: Energy intensify; Import market concentration; Import dependency; Granger causal relation test.

INTRODUCTION

After world war two, Korea government took several measures to stimulate economic development and cure the damage from the war, then became a newly industrialized country among thirty years' development. With the demand of economic, the consumption of energy increasing rapidly. So the government started to draw up a strategy to improve situation and adjust it with time changing since 1960s'. When petroleum consumption exceeds coal, the strategy took petroleum as core. All those lay a good foundation for the adjustment of energy policies and development of energy industry economic of Korea.

In 1990s', Korea government made full adjustment on energy department based on the reality of stable international petroleum price, solidify supply and demand inland system. The free competition was introduced in the field of electric power and natural gas to enhance the market function in those industries. Many scholars studied Korea's energy strategies from different angles; however, most of them based on qualitative analysis. This paper study Korea's energy policies from quantitative view by establishing three variables model, which analysis the long-term and short-term relationship among energy intensify, import market concentration and import dependency. All those results could offer advices for China's energy strategy and East-North Asia Energy Corporation.

METHODOLOGY AND DATA SOURCE

Methodology

(1) Basic model

This paper assumes that there are different reflections from energy import market import concentration and dependency to energy intensifies. So this function should be:

$$N=f(H,ID)$$

Details, N is energy intensify, H is energy import concentration and ID is energy import dependency. Based on above function, we could insert the time variable t, and make natural logarithm on both sides. A new metrology model as follow:

$$\ln(N)_t=\alpha\ln(H)_t+\beta\ln(ID)_t+\mu t$$

α and β are parameters to be estimated, μ is disequilibrium random error. It may produce false return if we made OLS directly because the time series could be non-stationary variable in model. So this paper make ADF unit root test on variables. The OLS regression remains effective only if the series stable and uniformity integrated.

(2) Co-integration regression test and error correction model

There are three variables in this model. Johansen co-integration regression test method been selected. Because Johansen co-integration regression are sensitive at lagging indicator and model form, this paper make specific assumption on them to guarantee the objectivity.

At the aspects of lagging periods of co-integration test, the paper firstly establish VAR model which contain maxim lagging period three, and confirm p as optimal lagging period of VAR model based on minimum information principle from AIC and SC. Then, the model make $p-1$ as optimal lagging period quantity for Johansen co-integrated regression test. The paper would make comprehensive judgment on the basis of LR, FPE and HQ principles if the p from AIC principle were different with SC.

On the aspects of optimal formulation of co-integration, all five possibility being tested: ① there are no intercept nor deterministic trend between series and co integration equation ② there is intercept in co-integration equation but not in series ③ there are intercept in series and co-integration ④ series have incept and co-integration have deterministic trend ⑤ there are quadratic trend in series and co-integration equation.

If eigenvalue ratio trace statistics and maximum feature root refused co-integration rank in $r=0$ under the condition of 0.01, they would exist one co-integration relationship at least among variables. However, if the possibility of model existed more than one kind, the article should make further VECM by establishing variables and make SC and AIC on every VECM unit to make sure whether optimal formulation of model contain incept and deterministic trend or not. The VECM is:

$$\Delta N_t = \lambda ECM_{t-1} + \alpha \Delta N_{t-1} + \beta \Delta ID_{t-1} + \gamma \Delta H_{t-1} + \mu_t$$

Δ is first difference method, μ is residual term, λ , α , β and γ is parameter to be solved, $ECM_{t-1} = N_{t-1} - \beta \Delta ID_{t-1} - \gamma \Delta H_{t-1}$.

If the result of SC were different with AIC in VECM, the determinant residual should make last choice.

(3) Granger causality test

It doesn't mean Granger causality existed when co-integration relationship existed. And it could have inconformity in long-term and short-term. Actually, main purpose of this article is making examination on the short term effect and long term effects from energy import concentration and import dependency to Korea's energy intensify.

Short term relationship of granger causality test exert Wald bound on VECM lagging unit of independent variable. If the probability of χ^2 less than 0.05, the formation refuse Granger causality test and accept relevant independence variable as alternative offer for Granger causality. The error correction on VECM and Wald inspection on independence lagging unit make long-term Granger causality passed. If the probability of F unit less than 0.05, null hypothesis failed, or it could accept alternative choice.

Data source

Energy intensify means unit consumption from one GDP, energy import dependency means the ratio between import amount and locally production amount. The period of data is from 1980 to 2013. The data of energy intensify and import dependency comes from U.S. Energy Information Administration database.

Energy import concentration means the ratio between main resources import amount and whole energy import amount. The data of Korea's energy import concentration comes from UN Comtrade Database. The coding of Petroleum are 333, 334, 335 based SITC Rev.2; coding of coal are 322 and 323 based on SITC Rev.2; natural gas import code is 341 under condition of SITC Rev.2.

UNIT ROOT TEST AND CO-INTEGRATION TEST

Eviews 5 is used as tool to make quantitative analysis.

ADF unit root test

First of all, augmentation ADF unit root test to examine the stability of time series. According to ADF model, this article assume that the model exist deterministic trend and incept. The assumption would adjust when trend term failed under the condition of 0.05, then examine the model which own trend term. If all test failed, the model don't fit on addition term. Optimal lagging unit selected with AIC principle.

In table one, the result of horizontal code and difference sequence showed: under 5%, the energy import concentration passed, others are unstable series, but their difference sequence are stable. Although it would produce fault regression if OLS analysis been made directly, but co-integration test could occur in further way.

Table 1. ADF unit root test.

HORIZONTAL CODE	TEST MODE	ADF	Prob	DIFFERENCE SEQUENCE	TEST MODE	ADF	Prob	RESULT
N _t	N,N,1	-1.301	0.174	ΔN _t	N,N,0	-3.065	0.003	I (1)
ID _t	C,T,3	-3.190	0.107	ΔID _t	N,N,0	-3.066	0.003	I (1)
H _t	C,N,0	-4.091	0.003	ΔH _t	N,N,1	-3.378	0.001	I (1)

PS: test mode(C,T, k) present incept, trend term and lagging unit, it would marked with C and T if there are incept or trend term, or N. Δ present first difference; Prob are possibility of ADF.

Johansen co-integration test and error correction model

This part make Johansen co-integration test which key point is to make reasonable of zone lag and test form. Untrained VAR model shows optimal lagging unit is 2, so the zone lag of Johansen co-integration is 1. On the kind of test form, there are five possible forms which show in table two.

Trace statistic and maximum latent root shows that all variable exist one co-integration relationship at least under the condition of 1% significant level regardless of model form. For optimal model, this article establishes VECM on the basis of every five model form and compares their AIC and SC under the optimal form of minimum information selected correction model and co-integration test optimal model. As showed in table two in last two line, AIC and SC show optimal form is “series space without addition term, co-integration with incept but linear trend”. Accordingly, the co-integration formation which showed long-term equilibrium among variables as followed:

$$N_t = -1.40895 ID_{t-1} - 34.31629 H_t + 128.7675$$

$$[-1.03682] \quad [-6.64756]$$

T present time trend, [] present t statistical. The VECM based on ΔN_t as followed:

$$\Delta N_t = 0.002608 ECM_{t-1} + 0.088139 \Delta N_{t-1} + 0.142068 \Delta ID_{t-1} + 0.105678 \Delta H_{t-1}$$

$$[2.56092] \quad [0.55146] \quad [3.78759] \quad [2.35846]$$

The coefficient of ECM_{t-1} is positive, fit on adjustment system, so do ΔN_t ΔID_t and ΔH_t.

GRANGER CAUSALITY TEST

The co-integration parameter can't decide on the influence between dependent variable and independent variable. Because co-integration formation shows long-term equilibrium relationship, so there must made test on short-term and long-term respectively.

Short-term affection

In table three, some χ² statistics be showed after Wald test on VECM variables. All those result could be reasons for short term of Granger causality relationship.

Table 2. JOHANSEN co-integration test result.

SERIES SPACE	WITHOUT ADDITIONAL	WITHOUT ADDITIONAL	WIHTOUT ADDITONAL	LINEAR TREND	QUADRATIC TREND
CO-INTEGRATION FORMATION	WIHTOUT INTERCEPT	WITH INTERCEPE	WITH INTERCEPT	WITH INTERCEPT	WITH INTERCEPT
	WIHTOUT LINEAR TREND	WITHOUT LINEAR TREND	WITHOUT LINEAR TREND	WITH LINEAR TREND	WITH LINEAR TREND
TRACE STATISTICS	0	1	1	1	2
MAXMIUM ROOT UNIT	0	1	1	2	2
AIC	-9.218	-9.856	-9.770	-9.713	-9.623
SC	-8.518	-9.109	-8.930	-8.826	-8.642

ps:1)The co-integration relationship confirmed based on Mack innon-Haug-Michelis;2)AIC and SC is a statistics which diagnose on whole error correction formation.

Table 3. Short-term granger causality test based on error correction model.

TARGET	ΔN_{t-1}		ΔID_{t-1}		ΔH_{t-1}	
	χ^2	AFFECTION	χ^2	AFFECTION	χ^2	AFFECTION
ΔN_{t-1}			0.066 (0.797)		0.432 (0.512)	
ΔID_{t-1}	14.346 (0.0002)	+			3.043 (0.081)	
ΔH_{t-1}	5.562 (0.018)	+	1.579 (0.209)			

PS:1)(present possibility of χ^2 statistics; 2) affection marked as+ or – to present difference lagging coefficient of dependency variation.

Energy import dependency and concentration is the reasons of Korea's energy intensify in short term of Granger. In specific, the increasing of import dependency and concentration could enhance energy intensify in short term. Korea have very high dependency for its bare content of energy in homeland, especially on import of petroleum and natural gas. In general, energy utilization could be effective if one country have low energy intensify. And intensify own high relationship with technical ability, but the ability couldn't change in short time, so it could be seen as invariant. According to the statistics from U.S. Energy Information Administration, Korea's energy intensify in 2012 is 11.520, and 20.306 for Japan, 105.882 for China. Government increased energy import to get rid of financial crisis in 2008. If one country relied more on energy import, it would have low homeland security coefficient. But, Korea sacrificed some national energy security for economic development. So, Korea's energy import dependency enhanced energy intensifies.

Long-term Affection

(1) Direct affection in long-term

Table 4. Direct affection test in long-term based on co-integration.

Independency Variable	N _t		ID _t		H _t	
	Variable		Variable		Variable	
N _t	_____		-0.714	[-0.120]	-0.029	[-0.096]
ID _t	-1.401	[-1.037]	_____			[0.756]
H _t	-34.316	[-6.646]	24.496	[6.081]	_____	
C			-91.918		-3.752	
Adj R ²	0.543		0.227		0.488	

ps: 1)T present trend amount, C present intercept; 2)[] present related T statistics.

Direct affection in long term is described by co-integration formation. Table four shows estimation results under different variables. All coefficient remains non-significant under 0.05 exclude the energy import concentration in Ht and Dt. In formation N, energy import concentration has negative correlations with energy intensify. In formation ID, energy import concentration has positive correlations with energy intensify.

Compared with table three, some differences could be found: the energy import concentration have negative correlations between long-term and short-term in formation N. Although Korea's energy intensify have positive correlation with import concentration in short time, but Korea would decrease energy intensify and make good use of energy with higher energy concentration when development of economic and technology cause higher energy risks. All those fit reasonable expectation. And this shows many positive effect sacrificed by positive effect in short time.

(2) Comprehensive affection in long term

This part takes attention on the amount of long-term affection in dependency variable. Table five show results of two meaningful long term test. The last line in table five shows the t statistic and possibility in ECM_{t-1} from five VECMs. Under the condition of 0.05, error correction show negative in ΔN and ΔH. Those could be seen as: long term equilibrium co-integration is the reason of Korea's energy intensify and energy import concentration, but this relationship doesn't have conspicuous long term affection.

The second meaning of long term affection is that specific dependence variable effect other variable by long term co-integration relationship then has indirectly effect on independence variable. In specific, the article establishes impulse response function based on VECM. All IRF curve changing then converge in a constant after the thirtieth impulse. This shows this model is stable and could have affection on thirtieth convergence value to judge long term affection. If long term affection passed Wald test in 0.05, the convergence of generalized impulse response function should be reported in convergence value. In this paper, the difference between short term and long term is not only time, but also the variable of other factors

Table 5. Comprehensive affection in long term based on correction model.

Subject	ΔN _{t-1}		ΔID _{t-1}		ΔH _{t-1}	
	F	Convergence Value	F	Convergence Value	F	Convergence Value
ECM _{t-1} , ΔN _{t-1}	_____		0.161		12.609	-0.001
			(0.852)		(0.0001)	
ECM _{t-1} , ΔID _{t-1}	8.868	0.030	_____		9.867	-0.008
	(0.001)				(0.0006)	

ECM _{t-1} , ΔH_{t-1}	5.170 (0.017)	-0.028	1.105 (0.346)	_____
ECM _{t-1}	2.561 (0.017)		-0.566 (0.576)	4.352 (0.0002)

ps: 1)() present possibility of F statistic under Wald test; 2)"convergence value" is information impulse in standard difference on

specific dependence variable;3)all generalize impulse response function converge on content.

Firstly, the reason of long term Granger of Korea's energy intensifies is energy import dependency and import concentration. But in long-term affection, energy import dependency is positive, and import concentration is negative. Under the pressure of energy risk and growth of technology, Korea would improve the efficiency of energy utility, optimize energy consumption construction, lower the index of energy intensify and generalize energy conservation to establish an environment friendly society.

Second, energy intensify and import dependency is the reason of Granger causality about Korea's import concentration in long term, which makes them negative. And energy intensify have Granger causality with energy import concentration mutually. All those relationship fit with reality. With higher import dependency, Korea impel energy diplomacy on the basis of bilateral cooperation to reduce the risk of energy risk. Korea signed several contract and project to reinforce the energy cooperation with Russia, Kazakhstan, Sudan, Nigeria and Angola. There are effective negotiation pattern between Korea with energy countries. All their cooperation could help Korea reduce its risk of energy import concentration.

Third, all variable weren't reason of Granger causality in long term, which means that Korea's energy import dependency is a exogenous variable in further place. There is nearly 80% energy counting on import for its scarce reserve of resources. This make Korea have very high import dependency which would remained in long time.

CONCLUSION

Even though only three variables in this model, but are there not very obvious relationship among those variables. So it is need to settle them in the core of energy intensify N.

Firstly, there are Granger causality between energy import dependency, energy import concentration and energy intensify. And there are no relations between energy intensify, import concentration and energy import dependency.

Secondly, in long term, there is Granger causality between energy import concentration and energy intensify, energy import concentration and import dependency at the same time. Compared the pm between long term and short term, it could find that there is inversion phenomenon from energy import concentration to energy intensify. For finiteness of resources, the key point of Korea's energy strategy is energy exploration and energy diplomacy.

As same as Korea, China has a serious situation of imbalance between supply and demand. In 2003, the consumption amount of energy and petroleum had exceeded Japan and become the second place. There were 4.26 billion coal consumption amounts in China until 2014. It already became national security strategy. World Energy Outlook 2014 pointed out that it was urgent to adjust China's energy demand on the basis of China's industrial policy and energy policy. On account of conclusion from the relationship of Korea's energy import concentration and dependency, paper thinks that there are two directions for China to improve:

- ① Set up scientific consciousness of energy security, developing on a green road.

As not only a large country needing energy, but also a large country producing energy, China need to optimize energy structure, exploit positively shell gas, control the consumption of coal and make more use of natural gas, enhance the utilization of wind power and hydro energy on the basis of national circumstances. Let energy development strategy become energy conservation strategy. Meanwhile, China should reinforce the scientific research to reduce energy intensify and take full advantage of resources to protect environment.

- ② Develop energy diplomat to reduce energy import dependency

China should reinforce its import country relationship with Middle East, Africa, Latin-American, and make fully corporation with Russia, Saudi Arabia and so on. Some mechanism for energy information communication should be established by using of “one belt and one road” to set up novelty conversation strategy. It is important to broaden petroleum import channel, build multilateral energy corporation mechanism to reduce the dependency on middle-east and protect transportation safety.

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