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USING GROWTH CURVES MODEL TO ANALYSE THE PROSPECTS OF CHINA–PAKISTAN OIL AND LNG TRANSPORTATION CORRIDOR

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Abstract. In order to analysing the oil and Liquefied Natural Gas (LNG) import and consumption changing trends, the Occurrence Period (OP), Growth Period (GP) and Maturation Period (MP) of oil and LNG import and consumption in China, and studying how the oil and LNG import and consumption changing trends influence the development of China–Pakistan oil and LNG transportation corridor (CPOLTC), in this paper we apply a Growth Curve Model (GCM) based approach to solve the problems mentioned above. First, the Chinese oil and LNG import and consumption changing trends are analysed by applying the GCM. The results show that oil and LNG consumption and import belong to the GP because of the fast industrialization and urbanization development, so the oil and LNG import and consumption demand will increase fast; Then, the External Dependence (ED) is applied to describe the oil and LNG consumption dependence degree in China, the results show that import will remain high ED value, especially for the oil import (over 70%), which means the security of the energy supply chain still remains the central idea of Chin's energy policies. Finally, the challenges and key issues of CPOLTC is analysed. Challenges are: domestic political struggles and institutional defects in Pakistan make the CPOLTC projects lacking of implementation, security along the corridor, influence and competition from external forces, impacts of western project culture, the comprehensive projects establishment ability in Pakistan, etc. The key issues are: Value Engineering (VE) researches for projects, Chinese element such as project construction, management, standards and specifications, assessment of the projects' life cycle and so on.

Keywords: China–Pakistan oil and LNG transportation corridor (CPOLTC), the belt and road (B&R), energy, growth curve model (GCM), external dependence (ED), challenges, key issues.

Notations

AGED – actual LNG ED;
AIIB – Asian Infrastructure Development Bank;
AOED – actual oil ED;
B&R – the belt and road;
CPOLTC – China–Pakistan oil and LNG transportation corridor;
ED – external dependence;
FGED – fitted LNG ED;
FOED – fitted oil ED;
GCGC – LNG consumption growth curve;
GCM – growth curve model;
GIGC – LNG import growth curve;
GM – Gompertz model;
GP – growth period;
LCA – life-cycle assessment;
LM – logistics model;
LNG – liquefied natural gas;
MMFM – Morgan–Mercer–Flodin model;
MP – maturation period;
OCGC – oil consumption growth curve;
OIGC – oil import growth curve;
OP – occurrence period;
RM – Richard model;
VE – value engineering;
WM – Weibull model.

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Introduction

China currently imports oil and LNG from more than 10 regions or countries (NBS 2016). Around 83% of the China's oil and LNG supplies are sea borne, of which 80% are operated through the Strait of Malacca (NBS 2016). China considers the Strait of Malacca is a strategic weakness and may halt its socio economic and military activities in case of any unexpected events (Siddique 2014; Hilton 2013), these challenges include:

- China's territorial disputes with Japan, South Korea, Philippines and Vietnam, etc., in South and East China Sea;
- pirate attacks and armed robbery on oil supplies, near 60% of the global pirate attacks and armed robbery take place in the Strait of Malacca;
- geopolitics, the omnipresence of the US, Japanese, Australian and Indian navies in the oil and LNG shipment path raises serious security concerns for China's political leadership and policy makers;
- terrible geographical environment and crowded sea traffic in Malacca Strait, consequently, China adheres more to the reliability of the oil and LNG supply chain in its energy security policies (Leung 2011).

To deal with these challenges, China is pursuing source and transport route diversification of oil and LNG supplies around the world, which is the significant policy measures taken to ensure energy security and cut the maximum reliance on a single route. For example, the Russia–China oil and LNG pipelines, the Myanmar–China oil pipeline, CPOLTC and so on. The idea of the CPOLTC was to develop a transport and communication network consisting of rail, road, oil and LNG pipelines between the Chinese city Kashgar, and the Gwadar Port in Pakistan. The CPOLTC will meet new development opportunities because of B&R (Swaine 2015). The B&R is China's greatest international economic ambition presented by Chinese President Xi Jinping, which aims at stimulating economic development in a vast region covering sub-regions in Asia, Europe and Africa. As one of the most important B&R demonstration project, the investment projects to build the energy and transportation infrastructure in CPOLTC are worth 46 US bln $ (Bhattacharjee 2015; Du, Zhang 2018; Zhai 2018; Yu, Chang 2018; Duan et al. 2018). November 13, 2016, the COSCO "Wellington" steamship began to transfer the cargo from Kashgar to Middle East and Africa through Gwadar Port, which means the CPOLTC began to operate officially.

Hence, analysing the oil and LNG import and consumption changing trends, the OP, GP and MP of oil and LNG import and consumption in China, and studying how the oil and LNG import and consumption changing trends influence the development of CPOLTC are important. In this paper, we try to solve the problems mentioned above by using GCM. The remainder of this paper is organized as follows: in section 1, we analyse the Chinese oil and LNG import and consumption changing trends by applying the GCM, first we will introduce the basic concept of GCM and the initial data need to collect, next we will present the Chinese oil and LNG changing trends results. Section 2 is devoted to prospects discussion and suggestions of the CPOLTC according to the analysis results, includes using ED to analyse the CPOLTC's influence on energy import, the strategic challenges and key issues of CPOLTC. Finally, the last section presents the major conclusions and gives an outline of future research tasks.

1. Oil and LNG import and consumption changing trends analysis

The import and consumption changing trends of oil and LNG are influenced by many factors, such as:

- the development of regional economic;
- the total population and the total urbanization population;
- the change of the industrial structure makes energy consumption intensity changing;
- energy consumption structure reflects the proportion of the total energy consumption;
- the development of the science and technology also influences the energy import and consumption;
- the improvement of residents living consumption level.

These years, China's industrialization and urbanization development are fast, meanwhile, the energy consumption will increase fast, the oil and LNG import and consumption demand will also increase fast until China enters post-industrialization stage. So how should we describe China's oil and LNG import and consumption changing trends in the future? What about the OP, GP and MP of oil and LNG import and consumption in China? How the oil and LNG import and consumption changing trends influence the development of CPOLTC? Next we will apply the GCM to answer the questions mentioned above.

1.1. The GCM

The GCM is originally introduced by Potthoff and Roy (1964), and subsequently studied by many authors, such as Szczepańska (2013), Song, Wang (2014), Song, Chang (2016), etc. GCM has been applied in many fields, such as block design (Szczepańska 2013), eco-efficiency assessment (Egilmez et al. 2016), unbiased estimators (Song, Wang 2014), equalities proof of various estimators in GCM (Song, Chang 2016) and so on. The GCM belongs to a biological changing based curve model, which is always applied to describe the variation of the variables with time changing. The curve shows three stages during the whole life cycle, including OP, GP and MP (Panik 2013). Most of the growth curves are *S*-shaped, includes two growth forms: single and continuous (Figure 1).

When applied the GCM to fit the initial data, we usually choose m, $m \geq 2$ alternative GCM models, and try to match the curve characteristics of the alternative model

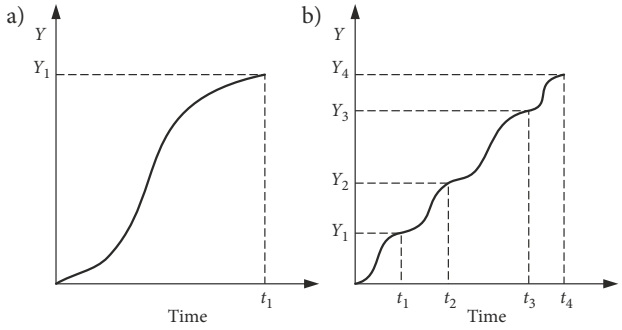

Figure 1. Two growth forms: a – single; b – continuous (Panik 2013)

with the actual curve growth characteristics. In this paper all the alternative GCM models must satisfy the monotonic growth characteristics, and the curves will be separated into two parts at the inflection point $I_m\left(t_{\inf}^m, Y_{\inf}^m\right)$, before the inflection point the curve belongs to rapid growth stage, after the inflection point the curve belongs to slow growth stage, finally limited to a finite value (usually we called it saturation value). The inflection points of the alternative GCM models are different from each other because of different model function expression and parameters setting, which means, the rapid growth stage and slow growth stage are also different. In this paper we will choose five kinds of alternative basic GCM models to fit the initial data of the oil and LNG import and consumption in China, including LM, GM, RM, WM and the MMFM (Song, Chang 2016; Panik 2013). In addition, we will choose the model with the highest goodness of fit to formulate the oil and LNG import and consumption changing trends. Now we introduce the basic function expression, inflection point as well as the applicable conditions about the five models mentioned above. The parameters used in this paper are presented in Table 1.

Table 1. The parameters

$Y(t)$	dependent variable of the model
t	independent variable of the model, usually represent time
I_m	inflection point of the m model
$Y_{\inf}^m$	dependent variable value at the inflection point
$t_{\inf}^m$	independent variable value at the inflection point
Y_∞	parameter to be estimated, which is related to the asymptote of curve, the asymptote for all model is $Y(t)=Y_\infty$
α	parameter to be estimated, which is related to intercept value of the dependent variable
β	parameter to be estimated, which is related to the change rate of the dependent variable
γ	parameter to be estimated, which represents the flexibility of the model, $\gamma > 1$

1.1.1. The LM

The LM is suitable to describe the curves with the approximate same length of rapid GP and slow GP, LM has many expression forms, shown as the following Equations (1)–(6), but all forms have the same inflection point (Panik 2013), shown as the following Equation (7):

$$Y(t)_{LM_1} = \frac{Y_\infty + \left(Y_0 - Y_\infty\right)}{\left(1+\frac{t}{\alpha}\right)^\beta},\ t \geq 0; \tag{1}$$

$$Y(t)_{LM_2} = \frac{Y_\infty}{1+\alpha\cdot e^{-\beta\cdot t}},\ t \geq 0; \tag{2}$$

$$Y(t)_{LM_3} = \frac{Y_\infty}{1+e^{\alpha-\beta\cdot t}},\ t \geq 0; \tag{3}$$

$$Y(t)_{LM_4} = \frac{Y_\infty}{1+\beta\cdot t\cdot e^{\alpha}},\ t \geq 0; \tag{4}$$

$$Y(t)_{LM_5} = \frac{1}{Y_\infty+\alpha\cdot e^{-\beta\cdot t}},\ t \geq 0; \tag{5}$$

$$Y(t)_{LM_6} = \frac{1}{Y_\infty+\alpha\cdot \beta^{t}},\ t \geq 0; \tag{6}$$

$$I_{LM}\left(t_{\inf}^{LM}, Y_{\inf}^{LM}\right) = \left(\frac{\ln\alpha}{\beta}, \frac{Y_\infty}{2}\right). \tag{7}$$

1.1.2. The GM

The GM has the same applicable condition with LM, which is suitable to describe the curves with the approximate same length of rapid GP, slow GP and the same inflection point (Panik 2013). GM includes four kinds of forms, shown as the following Equations (8)–(11), all forms have the same inflection point, shown as the Equation (12):

$$Y(t)_{GM_1} = Y_\infty\cdot\exp\left(-\alpha\cdot\exp\left(-\beta\cdot t\right)\right),\ t \geq 0; \tag{8}$$

$$Y(t)_{GM_2} = Y_\infty\cdot\exp\left(-\exp\left(\alpha-\beta\cdot t\right)\right),\ t \geq 0; \tag{9}$$

$$Y(t)_{GM_3} = \exp\left(Y_\infty-\alpha\cdot\beta^{t}\right),\ t \geq 0; \tag{10}$$

$$Y(t)_{GM_4} = Y_\infty\cdot\alpha^{\beta^t},\ t \geq 0; \tag{11}$$

$$I_{GM}\left(t_{\inf}^{GM}, Y_{\inf}^{GM}\right) = \left(\ln\frac{\alpha}{\beta}, 0.36788\cdot Y_\infty\right). \tag{12}$$

1.1.3. The RM

The RM is suitable to describe the curves with longer length of rapid GP, and shorter slow GP (Panik 2013), the detail formula is presented as Equation (13), Equation (14) shows how to calculate its inflection point:

$$Y(t)_{RM} = \frac{Y_\infty}{\left(1+\exp\left(\alpha-\beta\cdot t\right)\right)^{\frac{1}{\gamma}}},\ t \geq 0; \tag{13}$$

$$I_{RM}\left(t_{\inf}^{RM}, Y_{\inf}^{RM}\right) = \left(\frac{\alpha-\ln\gamma}{\beta}, \frac{Y_\infty}{\left(1+\gamma\right)^{\frac{1}{\gamma}}}\right). \tag{14}$$

1.1.4. The WM

With the opposite applicable condition of RM, the WM is suitable to describe the curves with shorter length of rapid GP, and longer slow GP (Song, Chang 2016), WM and its inflection point calculation equation are presented as following Equations (15) and (16), respectively:

$$Y(t)_{WM} = Y_\infty - \alpha \cdot \exp\left(-\beta \cdot t^\gamma\right),\ t \geq 0; \quad (15)$$

$$I_{WM}\left(t_{\inf}^{WM}, Y_{\inf}^{WM}\right) = \left(\left(\frac{\gamma-1}{\beta\cdot\gamma}\right)^{1/\gamma}, Y_\infty - \alpha\cdot\exp\left(-\frac{\gamma-1}{\gamma}\right)\right). \quad (16)$$

1.1.5. The MMFM

MMFM (Song, Chang 2016) has the same applicable condition with WM, which can be well fit to describe the curves with shorter length of rapid GP, and longer slow GP. MMFM and its inflection point calculation equation are presented as following Equations (17) and (18), respectively:

$$Y(t)_{MMFM} = \frac{\alpha\cdot\beta + Y_\infty \cdot t^\gamma}{\beta + t^\gamma},\ t \geq 0; \quad (17)$$

$$I_{MMFM}\left(t_{\inf}^{MMFM}, Y_{\inf}^{MMFM}\right) = \left(\left(\frac{\beta\cdot\gamma-\beta}{1+\gamma}\right)^{1/\gamma}, \frac{\alpha - Y_\infty + (\alpha + Y_0)\cdot\gamma}{2\cdot\gamma}\right). \quad (18)$$

All the *S*-shaped curves formulas mentioned above start from a low value, if the curves formulate the oil and LNG import and consumption as a completely new matter, then the value of the curve begins at zero; otherwise the value of the curve is greater than zero if the oil and LNG import and consumption had undergone a previous growth cycle. Then, the curves start an exponential related increase until flattening out into near linear growth through the cycle's inflection point, after that the curves follow an exponential related decrease in growth until reaching a high level. For each model mentioned above, we calculate the determination coefficient R^2, and choose the model with highest R^2 value to analyse Chinese oil and LNG import and consumption changing trends.

1.2. The needed data

We should collect the oil import and consumption value during 1995 to 2015, and the LNG import and consumption value during 2002 to 2015 (NEA 2016; NBS 2016) as the inputs of the model. The oil data was presented in Table 2, the LNG data was presented in Table 3.

China began to import LNG in 2007, before that, LNG was an export product for China, so the LNG import values before 2007 were negative. From the above Table 2 and Table 3 we could find that the oil was still a more important kind of import product than the LNG. The data would be applied to fit the oil and LNG import and consumption changing trends.

Table 2. China's oil import and consumption value during 1995–2015 [mln t]

Year	Import	Consumption
1995	3673.2	16064.9
1996	4536.9	17436.2
1997	6787.0	19691.7
1998	5738.7	19817.8
1999	6483.3	21072.9
2000	9748.5	22439.3
2001	9118.2	22838.3
2002	10269.3	24779.8
2003	13189.6	27126.1
2004	17291.3	31699.9
2005	17163.2	32535.4
2006	19453.3	34875.9
2007	21139.4	36570.1
2008	23015.5	37302.8
2009	25642.4	38384.5
2010	29437.2	44101.0
2011	31593.6	45378.5
2012	33088.8	47797.3
2013	34264.8	49970.6
2014	36179.6	51861.8
2015	38245.8	53266.4

Table 3. China's LNG import and consumption value during 2002–2015 [bln m^3]

Year	Import	Consumption
2002	–35	292
2003	–11	339
2004	–18	397
2005	–25	468
2006	–25	561
2007	3	695
2008	4	807
2009	23	875
2010	127	1075
2011	282	1313
2012	399	1471
2013	457	1650
2014	486	1786
2015	595	1940

1.3. The fitting results

After comparing the 13 GCM models mentioned above, we chose the LM_6 as the fitting model because the model has the highest R^2 when fit the data (over 0.88). We fitted four growth curves in this paper, including OIGC, OCGC, GIGC and GCGC. Figure 2a shows the initial oil import data based fitting curve, Figure 2b is the complete fitting

OIGC, Figure 2c is the initial oil consumption data based fitting curve, Figure 2d is the complete fitting OCGC. Figure 3a shows the initial LNG import data based fitting curve, Figure 3b is the complete fitting GIGC, Figure 3c is the initial LNG consumption data based fitting curve, Figure 3d is the complete fitting GCGC. Abscissas in Figure 2 and Figure 3 show the time (year). All initial fitting year is 1995 in Figure 2. The initial year in Figure 3a and 3b is 2007, initial year in Figure 3c and Figure 3d is 2002, China began to import LNG in 2007, before that, LNG was an export product for China (from 2002 to 2007). Ordinate in Figure 2 shows the oil fitting value, unit is [mln t]. Ordinate in Figure 3 shows the LNG fitting value, unit is [bln m^3].

Table 4 presents each curve's goodness of fit R^2 based on LM_6, formula and the inflection points. Table 5 presents China's oil import and consumption fitting value from 1995 to 2030, Table 6 shows the LNG import and consumption fitting value. LNG import value is from 2007 to 2030 because all GCM data must be positive, consumption value is from 2002 to 2030.

From the calculation results we can find:

»» the R^2 of each growth curve is very close to 1, shows that the LM_6 is suitable to describe China's oil and LNG import and consumption value;
»» the R^2 of GIGC is lower than the other three curves because of the rapid growth of LNG consumption and the sudden increase of LNG imports;
»» the oil import development cycle and consumption development cycle are quite close: before 2000 belongs to OP, GP from 2001 to 2019, and MP after 2019, which means after 2019 the oil import and consumption will almost remain unchanged;
»» the LNG import development cycle is different from the LNG consumption development cycle: the OP for LNG import is from 2007 to 2011, the GP is from 2012 to 2022, after 2022 is the MP; the OP for LNG consumption is from 2002 to 2007, the GP is from 2008 to 2027, after 2027 is the MP;
»» now, China's oil and LNG consumption and import belong to the GP, these years China's industrialization and urbanization development are fast, so the oil and LNG import and consumption demand will also increase fast.

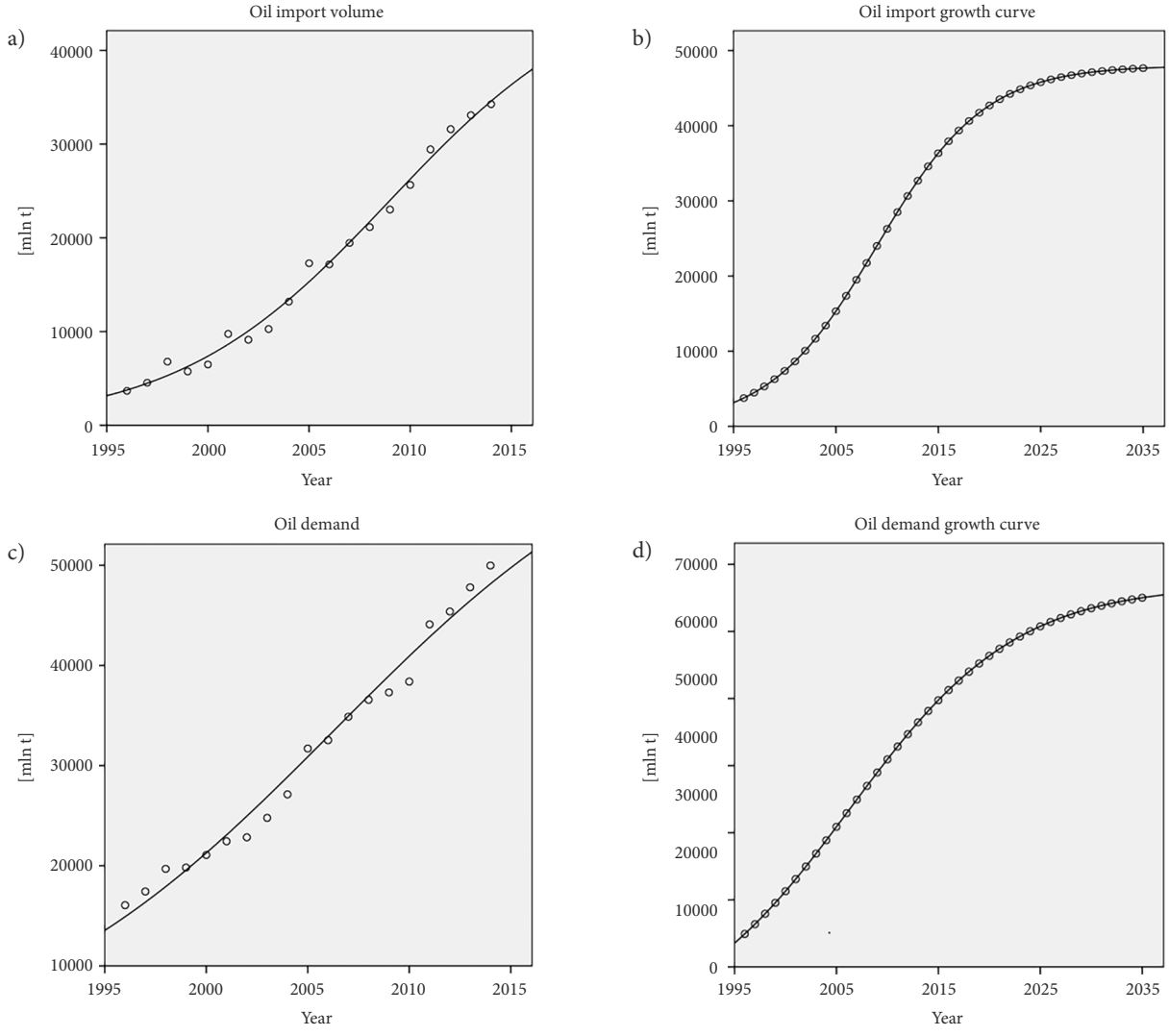

Figure 2. OIGC and OCGC based on LM_6

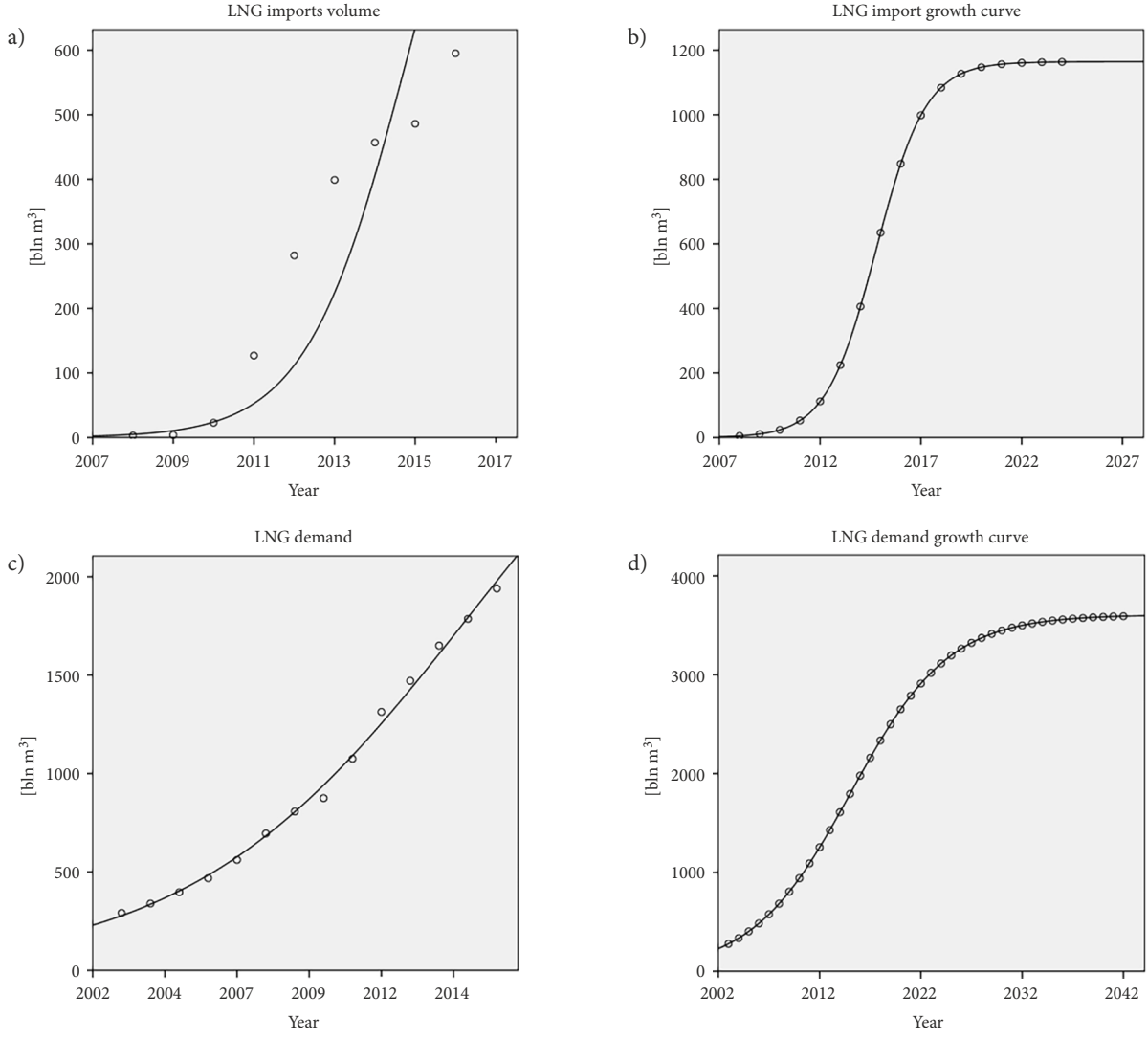

Figure 3. GIGC and GCGC based on LM_6

Table 4. The statistical data of the four growth curves based on LM_6

	R^2	Formula of the curve	Inflection point
OIGC	0.988	$Y(t)=\frac{1}{2.08\cdot10^{-5}+\ 2.9\cdot10^{-4}\cdot0.83^{t}}$	$t_1=5.795,\ t_2=23.553$
OCGC	0.981	$Y(t)=\frac{1}{1.49\cdot10^{-5}+\ 5.89\cdot10^{-5}\cdot0.89^{t}}$	$t_1=4.769,\ t_2=24.271$
GIGC	0.883	$Y(t)=\frac{1}{8.6\cdot10^{-4}\ +0.46\cdot0.45^{t}}$	$t_1=4.171,\ t_2=10.797$
GCGC	0.997	$Y(t)=\frac{1}{2.8\cdot10^{-4}+4.1\cdot10^{-3}\cdot0.81^{t}}$	$t_1=5.508,\ t_2=19.466$

Table 5. China's oil import and consumption fitting value based on LM_6 [mln t]

Year	Import	Consumption
1995	3766.64	14910.96
1996	4479.22	16367.63
1997	5310.41	17917.65
1998	6273.61	19557.75
1999	7381.32	21282.88
2000	8644.08	23086.14
2001	10069.33	24958.77
2002	11659.94	26890.28
2003	13412.97	28868.63
2004	15318.46	30880.47
2005	17358.79	32911.51
2006	19508.65	34946.88
2007	21735.90	36971.60
2008	24003.21	38971.01
2009	26270.46	40931.15
2010	28497.54	42839.21
2011	30647.14	44683.74
2012	32687.12	46455.00
2013	34592.20	48144.99
2014	36344.78	49747.59
2015	37934.93	51258.52
2016	39359.71	52675.22
2017	40622.02	53996.77
2018	41729.30	55223.65
2007	21735.90	36971.60
2008	24003.21	38971.01
2009	26270.46	40931.15
2010	28497.54	42839.21
2011	30647.14	44683.74
2012	32687.12	46455.00
2013	34592.20	48144.99
2014	36344.78	49747.59
2015	37934.93	51258.52
2016	39359.71	52675.22
2017	40622.02	53996.77
2018	41729.30	55223.65

China is adjusting the industrial structure, as well as the energy consumption structure there years, meanwhile the residents living consumption level, science and technology develop and change very fast, so when China enters post-industrialization stage, the oil and LNG import and consumption will remain unchanged or even decline.

2. The related discussion and suggestions

2.1. CPOLTC's influence on energy import

ED is a basic index to describe the oil and LNG consumption dependence degree for a country (Greene, Liu 2015), we used the ratio of import value I_i from other countries and consumption value C_i to formulate the ED_i during the i year:

$$ED_i = \frac{I_i}{C_i} \cdot 100\% . \tag{19}$$

Table 6. China's LNG import and consumption fitting value based on LM_6 [bln m^3]

Year	Import	Consumption
2002	–	277.73
2003	–	335.38
2004	–	403.54
2005	–	483.52
2006	–	576.49
2007	4.90	683.42
2008	10.93	804.91
2009	24.20	941.05
2010	52.86	1091.24
2011	112.13	1254.11
2012	224.42	1427.49
2013	405.80	1608.43
2014	634.73	1793.43
2015	848.31	1978.61
2016	998.22	2160.12
2017	1083.68	2334.38
2018	1126.73	2498.38
2019	1147.07	2649.88
2020	1156.38	2787.43
2021	1160.59	2910.36
2012	224.42	1427.49
2013	405.80	1608.43
2014	634.73	1793.43
2015	848.31	1978.61
2016	998.22	2160.12
2017	1083.68	2334.38
2018	1126.73	2498.38
2019	1147.07	2649.88
2020	1156.38	2787.43
2021	1160.59	2910.36

In this paper we used the data in Table 2 to calculate the AOED, used the data in Table 5 to calculate the FOED. Applied the data in Table 3 to calculate the AGED, applied the data in Table 6 to calculate the FGED. AOED, AGED, FOED and FGED are shown in Figure 4. We can find that China's oil and LNG import ED will remain increasing in the near future, especially for the oil imports. When territorial clashes, pirate attacks, geopolitical conflict, ship collision, hit the rocks and stranded happened, the Strait of Malacca will become an energy transport bottleneck easily. The successful operation of CPOLTC will offer China a more powerful and safe energy transport artery, especially for the strategic energy transport. The oil and LNG imported from the Middle East and Afri-

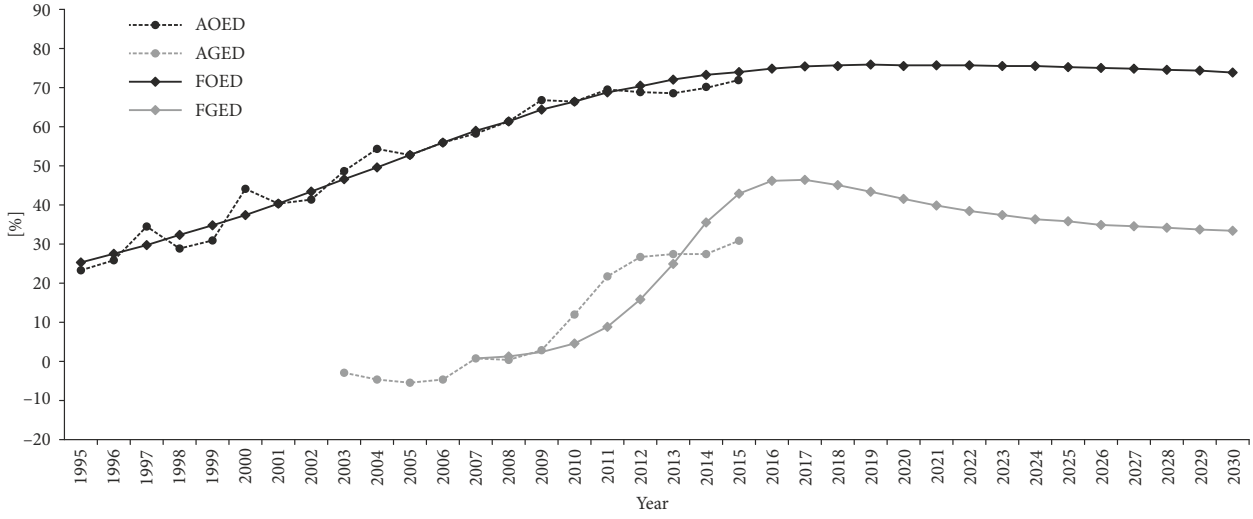

Figure 4. The AOED, AGED, FOED and FGED changing trends

ca will be transported through Gwadar Port, arrived at Kashgar. Compared with the 15000 km length of Malacca and Taiwan Straits sea transportation line, the CPOLTC will reduce the transport distance by half, and reduce the transportation time and cost. Moreover, Russia is worried about China's peaceful rise, especially hesitant and wavering in China's oil and LNG export projects. The CPOLTC provides more powerful negotiations conditions in the oil and LNG cooperation with Russia and other countries.

2.2. The strategic challenges and key issues of CPOLTC

We think there are five strategic challenges existing during the establishment process of CPOLTC:

- »» domestic political struggles and institutional defects in Pakistan make the CPOLTC projects lacking of implementation. For example, obstruction from the domestic opposition parties; intense interest competition among the central governments, provincial governments and local tribes; interest and power competition among different departments and their leaders, etc.;
- »» security along the CPOLTC. Gwadar is located in Balochistan Province, some extremist elements used reactionary public opinions to incite riots, or attacked Chinese staffs;
- »» influence and competition from external forces. Some countries (e.g., the US, Japan, etc.) still have Cold War mentality, they treated the CPOLTC as a geopolitical strategic competition problem, not a geopolitical economic cooperation problem;
- »» impacts of western project culture. Some middle classes in Pakistan with highly-educated or Western-educated, and some government departments (except the military and foreign ministry) admire western project culture, they think the western project culture is better than the Chinese project culture. Even worse, some people became agents of western project culture;
- »» the comprehensive projects establishment ability in Pakistan. CPOLTC will pass through Karakorum Mountain, Hindu Kush Mountain, Pamirs Plateau and Himalayas Mountain. Huge construction difficulties test the comprehensive projects establishment ability of Pakistan.

The B&R as well as the AIIB offer the CPOLTC necessary funds, policies and strategic support, but there are some key issues of the CPOLTC need to be treated seriously:

- »» VE researches for CPOLTC. VE is one of the proven management techniques in the construction industry, which is applied to improve the function and eliminate unnecessary costs, deal with the core competencies of projects, usually it is handled with secrecy (Heralova 2016);
- »» Chinese element in CPOLTC. For example, Chinese project construction, management, standards and specifications. How to apply the Chinese standards into the engineering is one of the critical issues for CPOLTC;
- »» assessment of the CPOLTC's life cycle. LCA is an evaluation of the environmental load and energy consumption of goods and services during their total life cycle. LCA has been applied in assessing construction costs, and has become an important technique for improving construction sustainability (Egilmez et al. 2016).

Conclusions and future research tasks

In this paper we focus on analysing the prospects of CPOLTC based on the GCM, we tried to answer three questions: how can we describe the oil and LNG import and consumption changing trends in the future? What about the OP, GP and MP of oil and LNG import and consumption in China? How the oil and LNG import and consumption changing trends influence the development of CPOLTC?

For oil import development cycle and consumption development cycle, the fitted results show that: before 2000 belongs to OP, GP is from 2001 to 2019, and MP is after 2019, which means after 2019 the oil import and consumption will almost remain unchanged. For LNG import development cycle and consumption development cycle, the fitted results show that: the OP for LNG import is from 2007 to 2011, the GP is from 2012 to 2022, after 2022 is the MP; the OP for LNG consumption is from 2002 to 2007, the GP is from 2008 to 2027, after 2027 is the MP. Now China's oil and LNG consumption and import belong to the GP because of fast industrialization and urbanization development, so the oil and LNG import and consumption demand will also increase fast. Then we applied the ED to describe the oil and LNG consumption dependence degree in China, the results show that China's oil and LNG import will remain high ED value, especially for the oil import (over 70%), the security of the energy supply chain still remains the central idea of China's energy policies. The successful operation of CPOLTC will provide China a more powerful, safe, cost-saving and time-saving energy transport artery, provide more powerful negotiations conditions in the oil and LNG cooperation with Russia and other countries. Finally, we analysed the challenges and key issues of CPOLTC including: domestic political struggles and institutional defects in Pakistan make the CPOLTC projects lacking of implementation; Security along the corridor; Influence and competition from external forces; Impacts of western project culture; The comprehensive projects establishment ability in Pakistan, etc. The key issues of the CPOLTC including: VE researches for projects; Chinese element, such as project construction, management, standards and specifications; Assessment of the projects' life cycle.

In the future, we will provide some estimates of the cost comparison between constructing CPOLTC and continuing to use supertankers; we will discuss the benefits of CPOLTC to reduction congestion in Malacca straights, shipping pollution, etc.; we will discuss China's policies to deal with the challenges mentioned above, and the approaches to solve the key issues; furthermore, we will study the oil and LNG transportation sharing rate by the CPOLTC route, as well as the detail transportation organization problems.

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