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Impact of shocks in domestic aggregate demand for natural gas on domestic aggregate energy consumption in China

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ABSTRACT

This paper examines the possible asymmetric transmissions from domestic aggregate demand for natural gas to domestic aggregate energy consumption in China using time series data from 1970 to 2016. The nonlinear autoregressive distributed lags (NARDL) model is employed to check the possibility of long-term asymmetric nexus among variables. The empirical findings confirm the existence of symmetric cointegration between the domestic aggregate demand for natural gas and domestic aggregate energy consumption. The results also indicate that positive shocks in domestic aggregate energy consumption lead an increase in domestic aggregate energy consumption in both short-run and long-run. While the NARDL dynamic multiplier graph suggests that the positive component of domestic aggregate demand for natural gas has deep impact on domestic aggregate energy consumption.

Keywords
Energy Consumption, Demand of Natural Gas; Natural Gas Production; China

JEL Classification
E20; Q11; Q41

1. Introduction

Natural gas (NG) is a low-carbon, clean, high-efficient energy and is a part of three mainstays of the global energy mix together with coal and oil. In 2016, NG constituted 24.13% of the world's primary energy consumption mix, and this ratio is expected to increase to 25.17% in 2035 (Zhang, Ji, & Fan, 2018). In addition to this, NG is the rapidly mounting primary energy source and is anticipated to be the fuel of choice for many developed and under developing economies (Lim & Yoo (2012). These days, the use of gas is rising due to many reasons, including fuel diversification, price, energy security, overall market growth, market deregulation and price (Yazici & Demirbas, 2001). Generally, the most important use of NG is not only generating electricity but also used in heating. Additionally, natural gas has grown in importance and therefore is one of the most important sources of clean energy for heating in domestic uses during the last several decades (Boran, 2015). Besides, in the literature of economics total energy use has drawn an immense attention than other commodities due to its economic, social, overlapping generation, political and multi-dimensions, and environmental issues (Bilgili, 2014).

China is affluent in natural resources. As stated by the Ministry of Land and Resources (MLR), China's geological conservative NG reserve potential volumes to sixty-two trillion cubic meters, and China's mineable reserve conceivable quantities are estimated to be thirty-two trillion cubic meters (Dong et al. (2017). As China has recognized the significance of uncontaminated energy resources and advances the utilization of the natural gas, the output of China's NG is gradually raising (BP statistical review of world energy, 2015). An expansion of NG in China presents a confusing picture to worried stakeholders comprises of industrial participants, academics as well as policymakers. The growing pressure to enhance air quality appears to be compelling China to aggressively take up NG as a cleaner source of energy (Li, Yin, & Wang, 2018). The domestic demand for NG has been staggering too. The use of NG has increased rapidly over the period from 2007 to 2014, expanding from 70.52 to 186.89 billion cubic meters (bcm), about an annual percentage change of 15 percent. However, in 2015 the domestic aggregate demand for NG 193.2 bcm, an increase of merely 5.7% (Natural Gas Industry, 2016).

The growth of China's domestic aggregate demand for NG was quite slow (Qian, Duan, & Wang, 2013). After 2000, China built many long-distance gas pipelines as well as branch pipelines, stimulating the fast development of the NG industry (See Figure 1). The domestic aggregate demand for NG expanded from 25.3 bcm to 185.5 bcm, with a mean annual growth rate of 15.3 percent.

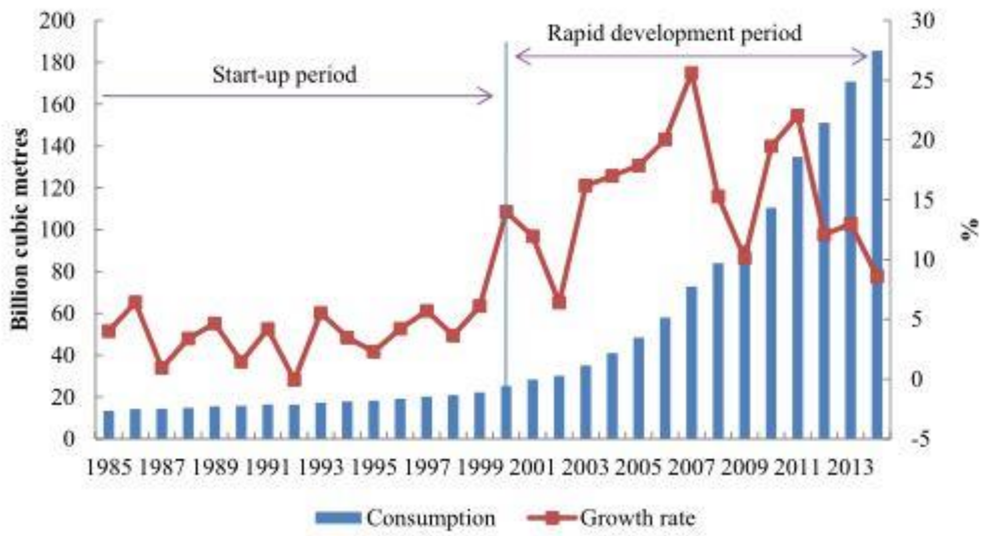

Figure 1: China's domestic aggregate demand for natural gas 1985-2014 (Source: Dong et al. (2017)

To meet the domestic demand, China started to import NG during 2006, after which the total import quantity started to swiftly grow as well, and the dependence on other country's NG has gradually expanded (Zhang, 2014). In 2014, the NG import in China reached to 58.4 billion bcm, and the degree of foreign dependence was 27.5 percent (see figure 2).

Figure 2: China's natural gas import situation (Source: Dong et al. (2017)

Due to the aforementioned major development in production, extraction, import of NG and an increase in domestic aggregate demand for NG, its impact on domestic aggregate energy consumption of China cannot be ignored. Due to the variations in demand for energy consumption, it is expected that the relationship between domestic aggregate demand for NG and domestic aggregate energy consumption will be non-linear. Thus, to capture the asymmetry arises due to shocks in domestic aggregate demand for NG, I use the non-linear ARDL to explore the long and short run relationships. The rest of this article is arranged as follows. Section 2 examines the data source and econometric methodology. Section 3 evaluates the estimated results and interpret the computed findings. Finally, the paper is wind up in part 4.

2. Research methods

This study uses secondary data on domestic aggregate energy consumption (DAEC) in kg oil equivalent, gross domestic product (GDP) in current US dollar, domestic aggregate demand for natural gas (DADNG), domestic aggregate natural gas production (DANGP) in billion cubic meters. The data series on GDP and DAEC have been gathered from World Bank Database. While the data series on DADNG and DANGP have been compiled from (BP Statistical Review of World Energy (2017). The data used in this study is from 1970-2016. All the data are transformed into a logarithm.

2.1 Empirical model

The general relationship between domestic demand for NG, gross domestic product, and aggregate domestic energy consumption can be represented in the following linear regression model:

$$DAEC_t = \varsigma_0 + \varsigma_1 GDP_t + \varsigma_2 DADNG_t + \varsigma_3 DANGP_t + \mu_t \quad (1)$$

whereas $DAEC_t$ represents domestic aggregate energy consumption in time period t, GDP_t indicates gross domestic product in time period t, $DADNG_t$ signifies domestic aggregate demand for natural gas in time period t, $DANGP$ shows domestic aggregate natural gas production, ς_0 is constant, ς_1, ς_2 and ς_3 are respective coefficients. While μ_t is error term.

To employ the ARDL method, based on Pesaran et al. (2001) ARDL framework, the following equation is employed.

$$\begin{aligned}\Delta DAEC_t = \chi_0 &+ \sum_{k=0}^{p} \chi_1 \, \Delta DAEC_{t-k} + \sum_{k=0}^{p} \chi_2 \, \Delta GDP_{t-k} + \sum_{k=0}^{p} \chi_3 \, \Delta DADNG_{t-k} \\ &+ \sum_{k=1}^{p} \chi_4 \, \Delta DANGP_{t-k} + \vartheta_0 DAEC_{t-1} + \vartheta_1 GDP_{t-1} + \vartheta_2 DADNG_{t-1} \\ &+ \vartheta_3 DANGP_{t-1} + \Theta_t \quad (2)\end{aligned}$$

whereas $\Delta DAEC_t$ indicates the first difference of domestic aggregate energy consumption in time period t, ΔGDP_{t-k} shows the first difference of gross domestic product in time period t and lagged value k, $\Delta DADNG_{t-k}$ signifies the first difference of domestic aggregate demand for natural gas in time period t and with lagged value k, $\Delta DANGP_{t-k}$ is the first difference of domestic aggregate natural gas production with lagged value $t-k$. Whereas $\chi_1 \to \chi_4$ are short run coefficients, $\vartheta_0 \to \vartheta_3$ are long run coefficients and Θ_t is error correction term. In equation (2), the possible existence of long-term co-integrating association among sample variables is found out by testing the joint significance of lagged levels employing the standard F-test. Specifically, the null hypothesis of $\vartheta_0 = \vartheta_1 = \vartheta_2 = 0$ or no long run association among sample variables is tested. The typical critical values of F-statistics cannot be utilized because it does not follow the standard normal F-distribution. To deal with this problem, the Pesaran et al. (2001) developed two different critical values that take into consideration the integrating characteristics of variables. The null hypothesis is rejected only if the estimated value of F-statistic is more than the upper (lower) critical values. If the sample variables provide an evidence of co-integration, then equation (2) is estimated to produce both short-term and long-term dynamics responses of China's domestic aggregate energy consumption to changes in gross domestic product, domestic aggregate demand for natural gas and domestic natural gas production.

The previous two equations are based on the assumption that domestic aggregate demand for natural gas has symmetric impacts on domestic aggregate energy consumption. As our primary objective is to test whether or not aggregate domestic demand for natural gas has symmetric or asymmetric affect on domestic aggregate energy consumption. Thus, to capture the asymmetric effects in the model, following Shin et al. (2013) methodology, domestic aggregate demand for natural gas is decomposed into two new variables where one variable captures merely positive shocks in domestic aggregate demand for natural gas ($DADNG_t^+$) and the other variable merely captures the negative shocks in domestic aggregate demand for natural gas ($DADNG_t^-$) as follows:

$$DADNG_t^+ = \sum_{j=1}^{t} \Delta DADNG_j^+ = \sum_{j=1}^{t} max\left(\Delta DADNG_j^+, 0\right) \tag{3}$$

$$DADNG_t^- = \sum_{j=1}^{t} \Delta DADNG_j^- = \sum_{j=1}^{t} min\left(\Delta DADNG_j^-, 0\right) \tag{4}$$

To get the full version of nonlinear ARDL model, I substitute $DADNG_t$ with $DADNG_t^+$ and $DADNG_t^-$ in equation (2):

$$\begin{aligned}\Delta DAEC_t = \grave{\chi}_0 &+ \sum_{k=0}^{p} \grave{\chi}_1 \, \Delta DAEC_{t-k} + \sum_{k=0}^{p} \grave{\chi}_2 \, \Delta GDP_{t-k} + \sum_{k=0}^{p} \grave{\chi}_3 \, \Delta DADNG_t^+ \\ &+ \sum_{k=0}^{p} \grave{\chi}_4 \, \Delta DADNG_t^+ + \sum_{k=1}^{p} \grave{\chi}_5 \, \Delta DANGP_{t-k} + \vartheta_0 DAEC_{t-1} + \vartheta_1 GDP_{t-1} \\ &+ \vartheta_2 DADNG_{t-1}^+ + \vartheta_3 DADNG_{t-1}^- + \vartheta_4 DANGP_{t-1} \\ &+ \Theta_t \end{aligned} \tag{5}$$

After estimating equation (5), the Wald test is carried out to identify asymmetry effects of domestic aggregate demand for natural gas on China's domestic aggregate energy consumption as follows: (1) short-run asymmetrical effects is recognized if the null hypothesis of $-{}^{\grave{\chi}_3}/_{\grave{\chi}_1} = -{}^{\grave{\chi}_4}/_{\grave{\chi}_1}$ or, no short run symmetrical affects is rejected; and (2) long-term symmetrical affects is found out if the null hypothesis of $-{}^{\vartheta_2}/_{\vartheta_0} = -{}^{\vartheta_3}/_{\vartheta_0}$, or no long-term asymmetrical affects is rejected.

3. Empirical results and discussion

To identify the order of integration among the main variables, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test have been employed. The findings of the unit root tests are depicted in Table 1. The outcome validates that all the main variable series are non-stationary at the level but become stationary at first difference. In addition to this, none of the variables is integrated of order two. So, we can carry out NARDL in our study.

Table 1: ADF and PP unit root test

Variables	Level		First Difference	
	ADF	PP	ADF	PP
DAEC	0.643031	1.338733	-3.565457**	-3.568900**
GDP	1.658236	1.649734	-5.275870***	-5.344616***
DADNG	-0.984485	-0.424803	2.981044**	-3.872180**
DANGP	-0.386355	-1.149038.	-2.788603**	-2.724029**

Note: *** and ** represent 1% and 5% significance level, respectively

The estimated short-term and long-term findings are reported in Table 2. As our central theme of this paper is to identify the asymmetrical effects, thus first we focus on estimated positive and negative components of DADNG. The short-term outcomes reveal that both coefficients of positive and negative components of DADNG are positive. For instance, the computed elasticities of DADNG increases (decreases) with respect to DAEC are 0.24 (0.05), pointing that a one percent increase (decrease) in DADNG is expected to increase (decrease) DAEC by 0.24% (0.05%). From table 2, it is clear that the coefficient of the positive component of DADNG is highly statistically significant. On the other hand, the coefficient of the negative component of DADNG is statistically insignificant. Based on the different statistical significance and magnitude of the computed elasticities, DADNG changes appear to have an asymmetric effect on China DAEC in the short run. In contrast, the result of Wald test (see Table 3) divulges that the null hypothesis of no asymmetrical effects, in short, is accepted, providing a strong evidence of short-term symmetric effects of DSDNG changes.

The long-term outcomes also reveal that the positive component as a well negative component of DADNG are positive. For an instant, the elasticity of DADNG rises (decreases) with respect to DAEC is 0.47 (0.11), inferring that one percent rise (decrease) in DSDND is anticipated to increase (decrease) DAEC by 0.47% (0.10%). From table 2, it is clear that the coefficient of the positive component of DADNG is statistical significance at one percent level. On the other side, the long-term coefficient of the negative component of DADNG is statistically insignificant. Based on the different statistical significance and magnitude of the computed elasticities, DADNG changes seem to have an asymmetric effect on China DAEC in the long-run. However, the outcome of Wald test (see Table 3) indicates that the null hypothesis of no asymmetrical effects in long-run is accepted, providing a strong support of long-term symmetric effects of DADNG changes.

Table 2: Results of short-run and long-run nonlinear ARDL equation (2, 0, 1, 0)

Variable	Short run Coefficient	Std. Error	t-Statistic
C	0.6596664***	0.212307	3.107116
D(DAEC(-1))	0.494879***	0.128730	3.844327
$DADNG^{+}$	0.235091***	0.062274	3.775113
$DADNG^{-}$	0.052579	0.091964	0.571732
GDP(-1)	0.059466**	0.021805	2.727163
GP(-1)	-0.094435	0.060277	-1.566679
D(GDP)	0.191420***	0.045569	4.200699
D(DANGP)	0.011761	0.105387	0.111600
ECT(-1)	-0.500258***	0.091981	-5.438691
Variable	**Long run Coefficient**	**Std. Error**	**t-Statistic**
$DADNG^{+}$	0.469940***	0.088145	5.331415
$DADNG^{-}$	0.105104	0.182473	0.575997
GDP	0.118870***	0.035743	3.325670
DANGP	-0.188772	0.115850	-1.629458
C	1.328648***	0.342256	3.852816
NARDL Bound test			
$\mathrm{F-statistic\ (HYP1)} = 4.281223$ $[\mathrm{LB} = 2.2, \mathrm{UB} = 3.09 \text{ at } 10\%]$ $[\mathrm{LB} = 2.56, \mathrm{UB} = 3.49 \text{ at } 5\%]$ $[\mathrm{LB} = 2.88, \mathrm{UB} = 3.87 \text{ at } 2.5\%]$			

Note: *** and ** represent 1% and 5% significance level, respectively.

The short-run coefficient of GDP is not only positive but also significant at one percent level. Accordingly, one percent increase in GDP leads an increase DAEC by 0.19% in the short run. While the short-run coefficient of DNGP is positive and statistically insignificant. The long-run coefficient of GDP is positive as well as statistically significant at one percent level. This means that GDP increases China's domestic aggregate energy consumption in the long run; for instance, when GDP increases by one percent, DAEC increase by about 0.12% in the long-run. While the long-run coefficient of DANGP is statistically insignificant.

Table 3: Testing hypothesis of an asymmetrical effect

Null Hypothesis	Alternative Hypothesis	F-Statistic	Decision
$-\vartheta_2/\vartheta_0 = -\vartheta_3/\vartheta_0$	$-\vartheta_2/\vartheta_0 \neq -\vartheta_3/\vartheta_0$	0.884	Long run symmetry
$-\grave{\chi}_3/\grave{\chi}_1 = -\grave{\chi}_4/\grave{\chi}_1$	$-\grave{\chi}_3/\grave{\chi}_1 \neq -\grave{\chi}_4/\grave{\chi}_1$	0.659	Short run symmetry

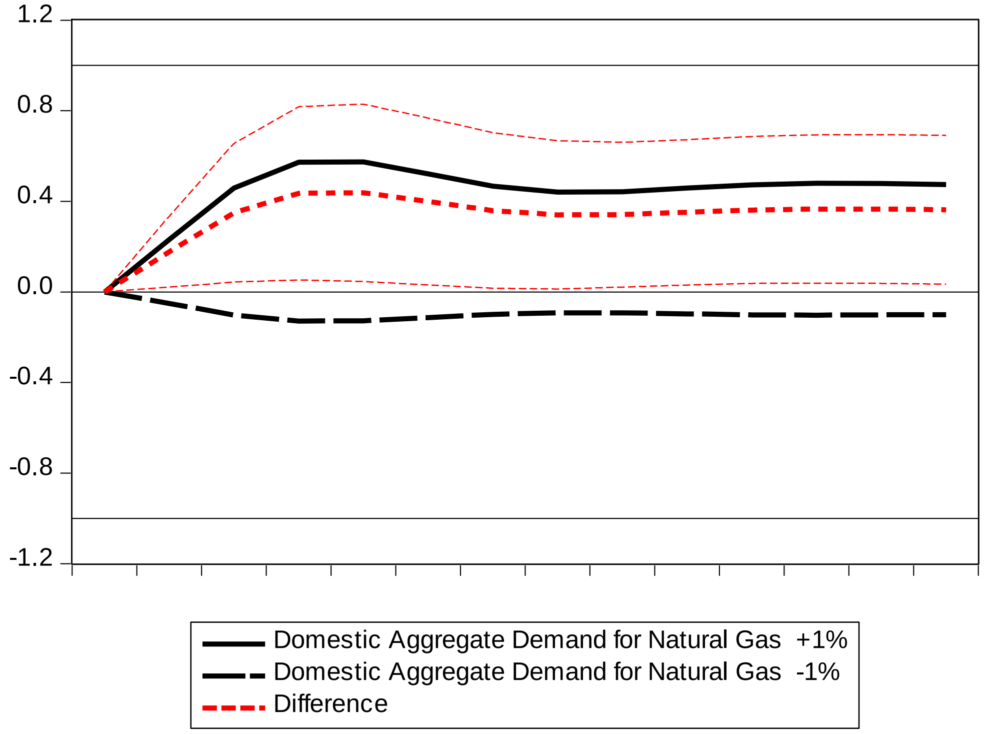

Figure 3: Dynamic Multiplier Graph

It is north worthy to mention that the short-run and long-run estimated coefficients in equation (5) are important. We test for cointegration among the variables and we compare the computed F-statistic with the upper critical values with the tabulated values of Pesaran et al. (2001). When we carry out this test, the obtained F-statistic is 4.28 and 5% (2.5%) upper critical value is 3.49 (3.87). Hence, we strongly reject the hypothesis of no co-integration among variables. Another method of conforming cointegration among variables is that the equilibrium occurs when the error correction coefficient is not only negative but also statistically significant (Shin, Baek, & Heo, 2018). As a matter of fact, we obtained the negative coefficient of ECT (-1) (-0.50), and this is statistically significant at one percent levels. Hence, there is strong evidence supporting long-run association among sample variables.

In order to evaluate the asymmetric adjustment of negative and positive shocks in the prevailing long-run equilibrium with respect to the newfangled long run equilibrium a NARDL's dynamic multiplier graph has been plotted (see figure 3). In summary, the result of dynamic multiplier graph infers that negative DADNG shock has less or no impact than the positive DAEC shocks.

Table 4 Validation Test

Test	Test-Statistic	Probability
ARCH	1.662586	0.1973
LM Test	3.99755	0.1374
Ramsay Reset test	0.003244	0.9549

Ultimately, to validate our model selection, we carry out different diagnostic tests for the residuals of our data (see Table 4). The Lagrange multiplier (LM) statistic of residual serial correlation is LM = 3.99. Hence, there is no indication of the serial correlation in our model. The ARCH statistic of residual serial correlation is ARCH = 1.66, which confirmed that our model is free of the heteroscedasticity problem. The Ramsey's Reset statistic is LM = 0.003, supporting a correctly specified optimum model.

4. Conclusion

The current explored the linkages between gross domestic demand (GDP), domestic aggregate demand for natural gas (DADNG), domestic aggregate natural gas production (DANGP) and domestic aggregate energy consumption (DAEC) by utilizing the methodology of non-linear ARDL over the period of 1970-2016 for China. The ADF and PP unit root tests are employed to check the variables for an order of integrations. The results of both unit root tests indicated that all the variables are I(1). The NARDL bound test showed that there exists a long-run association among sample variables. While Wald test confirmed that there exist both short-run and long-run symmetric linkage between DADNG and DAEC. The findings also inferred that GDP is an important factor of DAEC in both long-run and short-run.

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