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Average labor productivity of urea-producing firms in the GCC

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Abstract

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The paper analyzes components of productivity growth of urea producers operating in Gulf Cooperation Council (GCC) region. The paper applies a model that allows for variable returns to scale. The results show that urea producers in the GCC are operating under the presence of decreasing returns to scale, and their technology is a natural gas-using technology. The paper reveals that there is a shift from labor to natural gas and from capital to labor in urea production. The paper concludes by confirming that technological change is the main contributor to productivity growth of urea producers in the GCC.

Keywords: urea producing firms; returns to scale; technological change; translog production function
JEL Code: D24; Q12

Introduction

Nitrogen fertilizer consists of ammonia and urea. Urea is an important input in agricultural production. The production process of urea starts by using natural gas to produce ammonia. Then the produced ammonia, along with additional natural gas, is used in the production of urea. Therefore, natural gas is considered as the major variable in urea production.

The purpose of this paper is to examine economies of scale of urea production in the Gulf Cooperation Council (GCC) by applying a model that allows for variable returns to scale. Furthermore, the paper aims to analyze productivity growth and its components in order to figure out the main driving force of productivity growth in the GCC nitrogen fertilizer industry. To the author's knowledge, this is the first study that empirically examines economies of scale and productivity of urea producers in the GCC.

Due to the unavailability of published papers which analyze economies of scale and productivity of urea producers worldwide, this paper will review productivity studies that were conducted on sectors with characteristics similar to the nitrogen fertilizer sector.

The induction of variable returns to scale in translog production function specification was first applied on the Canadian agricultural sector by Chan and Mountain (1983). The results show that the production function in Canadian agricultural is characterized by increasing returns to scale. The study indicated that when increasing returns to scale is considered, scale effect becomes the main driving force of average labor productivity in lieu of technical change. Mountain (1986) applies the variable returns to scale production function on Switzerland's economy. Swiss technology was characterized as labor saving and capital saving. The results showed that Switzerland economic production function exhibits increasing returns to scale. Aivazian et al. (1987) aimed to determine whether technological change or scale effect dominate productivity growth in the US natural gas transmission industry. The findings indicate that the US natural gas transmission industry is operating under the presence of increasing returns to scale and its technology is a labor-saving technology. Contrary to previous studies, technological change prevailed scale change in terms of average labor productivity. Kim (1992) improved Chan and Mountain's model by providing the correct normalization for the translog production function. The author develops the model further by using an inverse demand function, which can be adopted in the competitive and non-competitive output market. The final model consists of the translog production function and cost share equations. The model was then applied to the US manufacturing data. The results showed the existence of increasing returns to scale. Hisnanick and Kymn (1999) used the improved model to study scale economies and the components of average labor productivity on a sample of US electric power companies. The parameter of returns to scale indicates that the electric power companies are operating under the presence of increasing returns to scale. The results reveal that returns to scale played a positive role in average labor productivity. The existence of decreasing returns to scale in the Tunisian agricultural sector was found using the translog production function (Helali and Kalai, 2015). Also, evidence of decreasing returns to scale was found in off-season cucumber production in Pakistan (Qamar et al., 2017). The author indicates that decreasing returns to scale can be switched to increasing returns to scale if fertilizer and other required inputs in agricultural production are used efficiently. Alhujili et al. (2017) have analyzed productivity of nitrogen fertilizer industry in the GCC, including both ammonia and urea, using the translog stochastic frontier method. The results show the existence of decreasing returns to scale in the GCC nitrogen fertilizer industry.

Since the parameter of returns to scale in all the previous studies indicated the existence of increasing returns to scale, this study aims to examine if the improved version of Chan and Mountain's model can yield decreasing returns to scale. To the author's knowledge, all the previous studies that used Chan and Mountain's model obtained increasing returns to scale estimates through the returns to scale parameter Θ. Thus, finding a decreasing return to scale can help validate the model performance as an unbiased model to evaluate productivity.

Materials and Methods

Econometric Model

Let the production function of the GCC urea producers be represented using the following production function:

$$Q_{it} = f(X_{gt}, X_{lt}, X_{kt}, T) \quad (1)$$

where Q represents the output of the i^{th} firm in time t. In this paper, it represents the quantity produced of urea in metric tons. The inputs used in production are natural gas, labor, and capital represented by g, l, and k, respectively. T is the technical change index.

The study uses a translog production function that allows for variable returns to scale expressed as below:

$$\ln Q_{it} = \beta_0 + [\beta_T T + 0.5\beta_{TT}T^2] + \Theta[\textstyle\sum_{i=1}^{3} a_i^* \ln X_{it} + \\ + 0.5\sum_{i=1}^{3}\sum_{j=1}^{3}\beta_{ij}^* \ln X_{it} \ln X_{jt} + \sum_{i=1}^{3}\beta_{iT}^* \ln X_{it} T] \text{ for } i,j = g,l,k \quad (2)$$

where Θ is the returns to scale parameter. If $\Theta > 1$ then there is evidence of increasing returns to scale. If $\Theta = 1$ then the production function is characterized by constant returns to scale. If $\Theta < 1$ then there is evidence of decreasing returns to scale.

Moreover, $a_i^* = \frac{a_i}{\Theta}$, $\beta_{ij}^* = \frac{\beta_{ij}}{\Theta}$, $\beta_{iT}^* = \frac{\beta_{iT}}{\Theta}$.

Since the sample consists of four firms, the intercept will be expressed as below to take into account efficiency differences across the four firms (Aivazian et al., 1987):

$$\beta_0 = a_0 + \sum_{i=2}^{4} a_i D_{i.}$$

Furthermore, the input share equation is expressed as below:

$$S_{it} = a_i^* + \textstyle\sum_{i=1}^{3}\beta_{ij}^* \ln X_{jt} + \beta_{iT}^* T, \text{ for } i,j = g,l,k \quad (3)$$

where $S_{it} = P_{it}X_{it} / \sum_{i=1}^{3} P_{it}X_{it}$, for $i = g,l,k$

The model's parametric restrictions are:

$$\textstyle\sum_{i=1}^{3} a_i^* = 1, \beta_{ij}^* = \beta_{ij}^*, \sum_{i=1}^{3}\beta_{ij}^* = \sum_{i=1}^{3}\beta_{ij}^* = 0, \sum_{i=1}^{3}\beta_{iT}^* = 0, \quad (4)$$

We can obtain the rate of technological change (TC) from the translog production function (2) as follows:

$$TC = \frac{\partial \ln Q_{it}}{\partial T} = \beta_T + \beta_{TT}T + \beta_{iT}^* \ln X_{it}, \text{ for all } i = g,l,k \quad (5)$$

To determine if the translog model (2) is correctly specified, the model is tested against alternative competing models. The alternative models that will be considered are as follows:

1. Cobb-Douglas production function ($\beta_{ij}^* = 0$, $\beta_T = 0$, $\beta_{TT}^* \beta_{iT}^* = 0$) for all i,j
2. Translog and no technological change ($\beta_T = 0$, $\beta_{TT}^* \beta_{iT}^* = = 0$) for all i,j
3. Hicks neutrality ($\beta_{iT}^* = 0$) for all i,j
4. Constant returns to scale ($\Theta = 1$)

Data

Since not all urea producers in the GCC region disclose their financial and production information, the sample of this study will consist of Saudi Arabia Fertilizer Company (SAFCO), Qatar Fertilizer Company (QAFCO), Gulf Petrochemical Industries Company (GPIC), and Petrochemical

Industries Company (PIC). The data is a balanced panel data from 2001 to 2013. Thus, the total number of observations in this study is 53. The main variables used in this study are quantity produced of urea in metric tons, quantity of labor, quantity of natural gas in one million British thermal units (MMBTU), capital expenditure, and lending rates as a proxy for the price of capital (Hisnanick and Kymn, 1999). The data used in this paper comes from the annual and sustainability reports of the selected companies as a sample of this study: a Kuwait official paper presented at the Arabic Energy Conference in 2006 and 2010, Saudi Arabia Monterey Agency, World Bank, Kuwait and Qatar annual statistical abstract, and Bahrain data portal.

Results and Discussion

Hypothesis tests concerning the model's functional form are presented in Table 1. Based on the likelihood ratio test, the null hypothesis of the Cobb-Douglas production function, no technological change, Hicks neutrality, and constant returns to scale are rejected. Therefore, the selected model is the preferred model for the urea producers in the GCC.

The translog model (2) along with the share equation (3) was estimated using the iterative seemingly unrelated regression (ITSUR) method. The capital share equation was dropped to avoid singularity in the variance-covariance matrix. The results of the estimated parameters are presented in Table 2.

The main parameter of interest is the returns to scale parameter . Its value is less than one and significant at the one percent level, which indicates that the urea producers in the GCC are operating under the presence of decreasing returns to scale. This result shows that the model is a valid model to yield decreasing returns to scale. Moreover, the technology of urea producers in the GCC is characterized as natural gas-using, labor and capital-saving technology.

One of the most widely used measures of productivity is the average labor productivity ($A\dot{P}L$) It divides productivity into three elements. One element represents movement from labor to other factors of production, the second element represents the rate of technological change (TC), and the third element represents scale effect (Aivazian et al., 1987; Chan and Mountain, 1998; Hisnanick and Kymn, 1999).

Table 2. Parameters estimate

Variable	Coefficient	Variable	Coefficient
a_0	0.932 (0.930)	β^*_{gl}	0.0008** (0.004)
a_2	0.141** (0.067)	β^*_{lk}	-0.042*** (0.006)
a_3	-0.407** (0.152)	β^*_T	-0.019 (0.036)
a_4	-0.430*** (0.136)	β^*_{TT}	0.001 (0.003)
a^*_g	0.860*** (0.080)	β^*_{Tg}	0.009** (0.004)
a^*_l	0.181*** (0.063)	β^*_{Tl}	-0.005* (0.003)
a^*_k	-0.042 (0.098)	β^*_{Tk}	-0.004* (0.002)
β^*_{gg}	-0.036*** (0.008)	Θ	0.667*** (0.064)
β^*_{ll}	-0.003 (0.004)		
β^*_{kk}	0.050*** (0.004)		
β^*_{gk}	0.152* (0.082)		

Note: * p > 0.05; ** p > 0.01; *** p > 0.001; Standard errors are in brackets

$$A\dot{P}L = S_G(\dot{X}_G - \dot{X}_L) + S_K(\dot{X}_K - \dot{X}_L) + \text{TC} + + (\Theta - 1)(S_G\dot{X}_G + S_K\dot{X}_K + S_L\dot{X}_L) \quad (6)$$

The first two terms in (6) represent natural gas deepening and capital deepening. The term after TC represents the scale effect. Table 3 shows the results of $A\dot{P}L$ for urea producers in the GCC.

It can be seen that technical change played a major role in productivity growth. This result is consistent with Aivazian et al. (1987), which concluded that technical change explained productivity more than scale effect in the US natural gas transmission industry. The agreement between this paper and Aivazian's paper is not surprising since natural gas is the main input in urea production. Thus, the main driver of productivity growth in the GCC urea industry is the technological change. On average, natural gas deepening shows that there is a shift from labor to natural gas. However, capital depending reveals that there is a shift from capital to labor. The shift from capital to

Table 1. Model specifications test

Model	χ^2 Statistics	Pr > χ^2	Decision
Cobb-Douglas production function	24.11	0.0002	Reject H_0
Translog with no technological change	23.54	<.0001	Reject H_0
Hicks neutrality	6.43	0.0401	Reject H_0
Constant returns to scale	15.33	0.0001	Reject H_0

Table 3. Average labor productivity ($A\dot{P}L$) and its components

Corporate	Natural gas deepening	Capital deepening	TC	Scale effect	$A\dot{P}L$
SAFCO	-0.004	-0.003	0.027	-0.004	0.017
QAFCO	-0.011	0.007	0.030	-0.046	-0.020
GPIC	0.004	-0.016	0.032	-0.004	0.017
PIC	0.035	-0.007	0.020	-0.007	0.041
Average	0.006	-0.004	0.027	-0.015	0.014

labor took place in all the firms, except QAFCO. Furthermore, it can be seen that QAFCO scored the lowest average scale effect compared to its peers. This is due to the fact that QAFCO, during the time-frame of this study, had negative scale effect in all the observations of this study, which ultimately affected its average scale effect. This is attributed to the mega extension projects that QAFCO implemented during the time frame of this study, and some of these projects have not achieved their full production capacity. Finally, the most productive company in the sample is PIC and the least productive one is QAFCO.

Conclusion

The study aimed at applying Chan and Mountain's variable returns to the scale model to examine returns to scale and productivity growth of the GCC's urea producing firms. The results show that urea producers in the GCC are operating under the presence of decreasing returns to scale. In addition, the technology of urea producers in the GCC is characterized as natural gas-using, labor and capital-saving. On average, the results of average labor productivity and its explanatory factors show a shift from labor to natural gas and from capital to labor. Moreover, the papers showed that productivity growth was mainly driven by technological change rather than scale effect. The paper concluded that technological change is the main driving force of productivity growth in the GCC urea industry.

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References

Aivazian, V. A., Callen, J. L., Chan, M. L., & Mountain, D. C. (1987). Economies of scale versus technological change in the natural gas transmission industry. *The Review of Economics and Statistics*, *69*(3), 556-561.

Alhujili, A., Al-Mahish, M., & Elmulatham, N. (2017). Productivity analysis of the GCC nitrogen fertilizer industry. *The Emperical Economics Letters,* pp. 1125-1133.

Chan, M. L., & Mountain, D. C. (1983). Economies of scale and the Tornqvist discrete measure of productivity growth. *The Review of Economics and Statistics*, 663-667.

Hisnanick, J. J., & Kymn, K. O. (1999). Modeling economies of scale: the case of US electric power companies. *Energy Economics*, *21*(3), 225-237.

Helali, K., & Kalai, M. (2015). Estimate of the Elasticities of Substitution of the CES and Translog Production Functions in Tunisia. *International Journal of Economics and Business Research*, *9*(3), 245-253.

Kim, H. Y. (1992). The translog production function and variable returns to scale. *The Review of Economics and Statistics*, 546-552.

Mountain, D. C. (1986). Economics of Scale Versus Technological Change: An Aggregate Product Function for Switzerland. *The Review of Economics and Statistics*, 707-711.

Qamar, A., Ashfaq, M., & Khan, M. T. I. (2017). Resource use efficiency and return to scale analysis in off-season cucumber production in Punjab, Pakistan. *Sarhad Journal of Agriculture*, *33*(1), 47-52.