Technical Efficiency, Total Factor Productivity and Technological Progress of Libyan Manufacturing Firms

Miloud Elwakshi, and Naser Tawiri

***Abstract*—**Given the importance of the manufacturing firms in any modern economy, this study uses the stochastic frontier approach to assess the growth potential of manufacturing sector in Libya. The study estimates the production function using firm level panel data of 10 manufacturing industries during the period (1996–2010). In order to reach more practical applications of this research, the estimated growth of output is decomposed into input growth and total factor productivity growth and total factor productivity growth is further decomposed into technical efficiency and technological progress.

***Keywords*—**Manufacturing firms; production function; Total factor productivity; Technical efficiency; Technological progress.

I. Introduction

THE Libyan economy depends largely on revenues from the oil sector, which contributes almost all export earnings and over half of GDP. Libya appears to be one of the less diversified oil-producing economies in the world. Manufacturing sector contributes around only 7 percent to GDP (in real terms), a share that has remained largely constant over time. However, growth in manufacturing has remained weak, and negative productivity growth has persisted in manufacturing since the mid-1990s. This reflects the impact of restrictive regulations as well as social and cultural impediments as in many others countries in the region. The main challenge for Libya is to promote growth of the non-oil sector, and stimulate diversification of its economy.

Estimates of total factor productivity TFP in Libya are much more perilous, due to the lack of reliable capital stock estimations. Some very tentative calculations based on a hypothetical capital/output ratio suggest a slightly negative growth of TFP over the 2000s. Non-oil GDP growth seems to have been mainly driven by employment growth, in line with the negative growth of labor productivity recorded during most of this period. The contribution of capital accumulation to non-oil GDP growth seems rather limited, in keeping with the relatively low investment ratios observed in the past.

Libya should embark on a strategic plan to enter the diversified economic countries by focusing on total factor productivity growth and benefit from the experience of developed countries plans. Given the importance of development strategy and the growing importance of the manufacturing sector in this strategy, there are some issues of interest. What is the source of output growth in Libyan manufacturing sector? Is it driven by productivity growth or capital accumulation? What kind of technological progress is existing?

Miloud. Elwakshi is with Misurata University, Faculty of Economics (Misurata, P.O.Box 2478 LIBYA (phone: +218913793618; fax:+218913793618; e-mail:united1515@yahoo.com).

Naser. Tawiri, is with University of Elmergeb, Faculty of Economics Alkhomos, LIBYA. (e-mail:n_sassi70@yahoo.com).

II. Model

Stochastic frontier methodology is used to estimate a production frontier model that highlights the concept of maximization. Accordingly, an industry that operates on the frontier is assumed to produce its maximum output by following the “best practice” techniques, given the technology. This concept, introduced by Farrell (1957), has paved the path for many theoretical and empirical applications of the frontier methodology.

In stochastic frontier methodology, the disturbance term, which is composed of two portions, V_i and U_i, allows inefficiency to be distinguished from the statistical noise. The random error V_i is accompanied with measurement errors, not under the control of the industry, while U_i captures technical inefficiency and is accompanied with industry-specific factors. We used Cobb–Douglas functional form with industry and time-specific dummies to estimate the stochastic production frontier model:

$$LogQ_{it} = B_0 + B_1 LogL_{it} + B_2 LogC_{it} + \sum_{t=1}^{15}\eta_t + \sum_{i=1}^{10}\phi_j - U_{it} + V_{it} \quad (1)$$

Where

i = 1, 2, . . . , 10 (no. of industries);

t = 1, 2, . . . , 15 (no. of years);

Q = output measured in 1978 prices;

C = capital measured in 1995 prices;

L = number of employees;

ϕ = manufacturing industry dummies;

η = time dummies representing each year;

U_{it} = the collective effects of non-price and organizational factors that constrain firms from achieving their maximum output from the given set of;

V_{it} = statistical random error term;

U_{it} takes the general truncated normal distribution, $U_{it} \sim N(\mu, \sigma_u^2)$.

The estimation process is carried out as following: the density function of E_{it} (where $E=U+V$) is given by:

$$f(E_{it}) = \frac{1}{\sigma(2\pi)^{1/2}}[1 - f(E_{it}/\sigma_v^2)]\exp(-1/2)[(E_{it}^2/\sigma_u)^2 - (E_{it}/\sigma_v^2)^2]$$

Where $\sigma^2 = \sigma_u^2 + \sigma_v^2$, f is the cumulative distribution function of the standard normal random variable. The density function of Q can be achieved by substituting (Q_{it}-βX_{it}) for E_{it} in the above model. The log-likelihood function can be written as:

$$f(\theta; Q_{it}) = \frac{1}{2}(N_t T_i \ln \sigma^2 + \ln 2\pi) - \frac{1}{2}[\sum (Q_{it} - \beta X_{it})'(Q_{it} - \beta X_{it})]/(1-\gamma)\sigma^2 + \sum_i^N \sum_t^T \ln[1 - f(-Z_{it})] + \frac{1}{2}\sum_i^N \sum_t^T (Z_{it}^2)$$

Where:

$\theta = (\beta, \sigma^2, \gamma)$, $\gamma = \sigma_u^2/\sigma^2$, and $Z_{it} = -\gamma(Q_{it} - \beta X_{it})/[\gamma(1-\gamma)\sigma^2]^{1/2}$

Given that U_{it} and V_{it} are independent of X_{it}, Aigner et al. (1977) have revealed that a set of equations can be formed by taking the partial derivatives of $f(\theta; Q_{it})$ with respect to θ and setting them to zero. The Davidson–Fletcher–Powell iterative algorithm is then used to estimate the solution to the set of equations and compute the maximum likelihood estimates of β, σ^2, and γ.

III. DATA

Annual data on output, capital and labor for 10 manufacturing industries were compiled for the period 1995–2010 from the annual profit and loss (income) statements and balance sheets of 1200 manufacturing firms. For capital, following Kaynak and Pagan (2003), Wadud (2004), and Coelli (2005), net fixed capital stocks was used. With labor, the number of workers employed was used due to the lack of data on man hours.

IV. RESULTS

Table 1demonstrates the estimates obtained from the stochastic frontier model. At the beginning, the result of the Ramsey Reset test indicates that there is no functional misspecification in Eq (1).The explanatory magnitude of the model specified by the value of γ at 0.85 is statistically significant at the 1% level. This shows that the inclusion of the industry-specific efficiency associated variable U_{it} in Eq. (1) is essential to explain the variation in the output of the manufacturing firms.

TABLE I
ESTIMATES OF THE STOCHASTIC FRONTIER MODEL

Variable	Model estimates
β_0	1.54 (0.750)
β_1	0.24 (0.127)
β_2	0.76 (0.413)
η	All 15 time dummies were significant
φ	All 10 Industry dummies were significant

The input parameters are statistically significant and the sum of the input parameters is almost equal to one, and consequently the null hypothesis of constant returns to scale could not be rejected, giving support to the implemented Cobb–Douglas functional form. The estimations also did not suffer from any diagnostic deficiencies like heteroscedasticity and serial correlation and the significance of the time and industry dummies show the importance of including them to get precise estimates.

Given the substantial dependence on capital in the manufacturing industries, the capital share of 0.76 and the labor share of 0.24 are not unexpected. Through using the estimated labor and capital shares, using the framework set out in Kaynak and Pagan (2003), TFP growth and output growth are then decomposed for the manufacturing sector in the Table 2.

TABLE II
DECOMPOSITION OF OUTPUT GROWTH AND TFP GROWTH

Period	Input growth	Output growth	TFP growth	Technological progress	Change in technical efficiency
1996-2000	1.48(84.5%)	1.59	0.10(6.3%)	0.07	0.03
2001-2005	1.98(125%)	1.55	-0.43	-1.62	1.15
2006-2010	1.86(185%)	0.85	-0.85	0.35	-1.45

As was found in many other studies, output growth in Libyan manufacturing sector is input driven. The contribution of input growth has improved over time. TFP growth for the manufacturing sector in 1996–2000 was small at 0.10% (resulting of small improvements in both technical efficiency and technological progress). On the other hand, TFP growth has not only become negative in the late 1990s but furthermore has declined even further in the 2000s.

What caused the low TFP growth since 2001? It can be realized that the causes of low TFP growth in the manufacturing sector for the periods 2001–2005 and 2006–2010 were varied. In 2001–2005, while the adjustment in technical efficiency was positive, the negative technological progress triggered negative TFP growth. In 2006–2010, technological progress was positive, but the large deterioration in technical efficiency resulted in negative TFP growth. Therefore, with further experience and better knowledge over time, it was possible for the manufacturing firms to be better utilizing capital and labor such that there was some progress in technical efficiency.

For the period of 2006–2010, technological progress was positive while the adjustment in technical efficiency was negative. This period indicates some improvement with the use of better and more advanced technology because adequate training might have been delivered to employees to qualify them to use the better equipment over time, so enabling manufacturing firms to enjoy some achievements from technological progress.

Then, what policy implications can be drawn for the Libyan manufacturing sector? The study suggests that increasing skilled labor by providing training and allowing/encouraging skilled worker entry into Libya should be given first priority. This would not only increase technical efficiency of manufacturing firms but also offer the incentive for foreign direct investment (FDI) to involve into skill intensive industries. Such FDI would carry along better and additional advanced technology to Libya, and consequently enable the country to get rapid gains from technological progress.

V. Conclusion

The stochastic frontier methodology used in this study is revealed to be suitable in decomposing TFP growth to classify the sources of TFP growth unlike the growth accounting methodology represented in the non-parametric approach. This study paves the pathway for future exploration, whereby regression examination can be undertaken to analyze the factors that affect technical efficiency and technological progress in Libyan manufacturing industries to make specific policy implications.

Empirical evidence indicates that Libyan manufacturing sector growth is greatly dependent on input growth that is positively biased in the direction of skilled labor. This would boost capital deepening (such as the use of better and more advanced technology) by FDI and domestic investments in the manufacturing sector. Therefore, government involvement in the labor market is essential to increase the quality of the labor force in addition to the provision of investment incentives, a good financial system, efficient infrastructure, a good macroeconomic atmosphere with political stability, and so forth.

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