Similarities and Dissimilarities Among Egyptian Public Sector Manufacturing Firms: A Comparative Study

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This paper investigates reasons behind variances in efficiency scores within public manufacturing units and causes of their low scores relative to similar private units. The efficiency is estimated using six-years pooled data for 10 industries covering major Egyptian public manufacturing firms via stochastic frontier analysis (SFA) technique for Cobb-Douglas production function. Results exhibit great variability for factors of production coefficients within industries. Results also show that the average technical efficiency (TE) is varied across industries and for firms within the same industry. Some industries are labor-intensive and others are capital-intensive. Moreover, results reveal major differences in industry's characteristics, regions, and utilized technique of production. Results illustrate that all industries are inefficient with different rates. Consequently, efficiency scores are regressed against size, age, infrastructure conditions (INC), exchange rate (EXR), and access to finance (ATF) variables to examine their influence on efficiency scores in which fixed effects technique is supported in some industries and random effects technique is preferred in other industries. Regression results show that the impact of such variables on efficiency scores is clear in some industries and trivial in others. But, the common characteristic for all public firms is that all of them are suffering from deliberate governmental ignorance.

Keywords: public manufacturing sector, industries, technical efficiency, maximum likelihood estimates (MLEs), efficiency scores, fixed and random effects

Introduction

In 1927, Talaat Harb established the first serious phase of national industry with an accurate methodical base. Misr El-Mahalla Company was the start followed by a sequence of firms cover constructions, yarn, and textiles activities. In a parallel way, state capitalists set the grounds for further industries, which were considered as the cornerstone for modern Egyptian manufacturing sector.

During the 1950s, the government established a series of firms in different activities. In 1954, the Egyptian iron and steel company was founded followed by fertilizers, chemicals, oil refining, and pharmaceutical firms. In July 1961, large private entities were nationalized and regulated under the power and supervision of holding companies. During this era, public entities conferred fund by the government and played major role as a guide for industrial sector. Commonly, the public manufacturing sector was affected by prevalent social thoughts aimed at satisfying low-income needs at uniform prices.

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The protectionism policy was approved until beginning of the 1990s where economic reform policies were adopted to shift toward privatization. Policies involve gradual prices liberalization and structural adjustments and sustain the role of private ownership. Unfortunately, the privatization program was operated and managed incorrectly in which the government started to get rid of profitable units and stopped restructuring instable ones. Outcomes of such wrong policies—stop injecting new investments, stop upgrading machinery and equipment, and getting rid of skilled labor—have driven the sector to productivity slowdown.

Egyptian public manufacturing sector has its own characteristics wherein firms are spread across the country mainly in 10 industries where each industry has its notable socioeconomic and infrastructural features. Moreover, all industries are only concentrated in three governorates whereas some of them are distributed in specific governorates, due to their closeness to raw materials or labor force. Easy access to factors of production and other infrastructural facilities is not evenly distributed over country. Regions differ widely due to variances in available stocks of physical and human capital and other characteristics, such as type of machinery, labor force, industry's concentration, climate, etc. Social and economic infrastructure, such as access to markets, doing business indicators, and variations in infrastructure services, should affect production process.

Measuring performance via efficiency would not be the paper's final goal, since rivalry quite relies on a wide range of external or internal factors, such as exchange rates (EXR), operating costs, interest rate costs, inventory turnover, time, quality, value adding capabilities, logistics, etc. Also, firms vary in sizes, age, access to finance (ATC) and infrastructure conditions (INC), which may affect efficiency scores. So, the paper aims to examine the role of some of these factors on efficiency scores. The remainder of the paper is organized as follows: Section II covers the literature review; section III covers the employed model; section IV gives a brief description of each industry and collected data; section V covers obtained and analysis of empirical results; section VI displays conclusions; and finally, section VII shows references.

Literature Review

Literature has developed based on the assumption that public managers have greater freedom to follow their own objectives, at the expense of conventional objectives. Alessi (1974) viewed public managers as preferring capital-intensive budget and Lindsay (1976) stated public managers as preferring visible variables. These hypotheses propose that measured performance is lower in the public sector than in the private sector. Empirical tests of the public-private performance differential hypothesis are numerous. Many of the comparisons have been conducted using regulated utility data, since most of public activities are focused in utilities and services. Due to the global trend of public utilities' privatization, besides regularity in collecting and providing data in such organizations, Jamasb and Pollitt (2003) surveyed the empirical evidence for electricity distribution.

Education and health care are two additional areas in which several public-private performance comparisons have been conducted. For any public-private performance comparison, the problem is how to measure their performance. Pestieau (2009) offered a forceful defense of a narrow focus on technical efficiency in an attempt to level the playing field. Such studies (Alessi, 1974; Lindsay, 1976; Jamasb & Pollitt, 2003; Pestieau, 2009) dispute that public enterprises have objectives and constraints, such as uniform price requirements, fiscal balance, and universal service different from those of private sector, but also have a soft budget constraint.

Most recent literature about public units is concerned with public utilities and services, since developed countries started to privatize public manufacturing units from the 1980s and centralized countries followed the same way after the collapse of the Soviet Union at the end of 1991. The Egyptian public manufacturing sector

is considered different due to the following reasons. Firstly, the weakness of institutional and legislations against antitrust actions raised from wrong applied privatization policies. From the 1950s until the end of 1990s, the sector was considered as the main provider of some important goods at uniform prices, such as sugar, cement, steel, chemicals, engineering industries, and pharmaceutical products. Secondly, after launching the privatization program at the end of 1990s through selling some units, oligopolistic actions were revealed and followed by prices increment. Thirdly, governmental ignorance of the sector through the lack of injecting investments led to sector's slowdown. Finally, the sector already has huge unutilized assets, such as lands and buildings which need only maintenance to join production process.

Thus, the paper aims to investigate the reasons behind the deterioration of public units performance—some industries' performance is too low relative to private units as the study shows—during the period from 2006 to 2011 via measuring efficiency scores for different industries showing similarities and dissimilarities within industries and how to overcome problems that cause such deterioration so as to help the sector to survive.

The Model

A Cobb-Douglas production function in a stochastic frontier form is used for estimation (Cobb & Douglas, 1928). The time, varying inefficiency effects method proposed by Battese and Coelli (1992), is employed in the model. The model is defined as:

$$Y_{it} = f(x_{it}) \quad (1)$$

$$Y_{it} = \beta_0 + \sum \beta x_{it} + \varepsilon_{it} \quad (2)$$

The compound error term is:

$$\varepsilon_{it} = v_{it} - u_{it} \quad (3)$$

including inefficiency term with error term based upon the study of (Good, Nadiri, Röller, & Sickles, 1993) where u_{it} is the inefficiency term and is defined as:

$$u_{it} = \eta_t u_i \quad i = 1, 2, \dots, 434; t = 1, 2, \dots, 6 \quad (4)$$

$$\eta_t = \{\exp[-\delta(t - T)]\} \quad (5)$$

Output (Y_{it}) is the natural logarithm of the total value of the industrialized output rated by net sales for i firm, t year in Egyptian pounds (2006 constant prices). Inputs (X_{it}) are the natural logarithm of the total value of the factors of production for i firm, t year at constant prices. Factors of production are divided into three categories wherein labor services (L_{it}) represent the natural logarithm of the total paid wages per year for all labor categories at constant prices (signified x_1). Materials (M_{it}) are the natural logarithm of the total costs of purchased raw materials during the year (signified x_2) and capital services (K_{it}) show the natural logarithm of the expenditure on operating costs such as electricity, water and utilities, maintenance, repairs of capital goods, rents of buildings and machinery upgrading, etc., as a proxy of capital during the year (signified x_3).

ε_{it} is the compound error term, including v_{it} —the two-sided “noise” component of the error term and u_{it} as the inefficiency term. The v_{it} is assumed to be independently and identically distributed (*iid*) as $N(0, \sigma_v^2)$ and u_{it} is assumed to be *iid* non-negative random variables as $N^+(0, \sigma_u^2)$. Both v_{it} and u_{it} are distributed independently

of each other and regressors. Inefficiency term is included in the error term following good methodology. δ is a parameter that determines the behavior of TE over time. Battese and Coelli (1992) affirmed that if $\delta > 0$, TE rises at a decreasing rate. If $\delta < 0$, TE declines at an increasing rate. If $\delta = 0$, TE remains the same. Then maximum-likelihood estimates of parameters and efficiency scores are obtained through LIMDEP software (Greene, 2010).

Afterwards, TE scores are regressed against the following regressors to examine their impact on efficiency scores:

(1) Firm size: It has four values: zero for small, one for medium, two for large, and three for extra-large ones. The firm size is determined due to workers' number and activity's nature as the criteria of determining the firm size differ across activities.

(2) Firm age is regarded in two groups: new for less than 30 years old firms and old for firms with the age of more than 30 years. This is owing to that new firms are established during the 1980s. Values zero and one are given for new and old firms.

(3) INC: Zero value means that INC is poor and one value refers to good infrastructure services.

(4) EXR: Zero value means that EXR has not any impact on production process or output prices and one means that it affects inputs, output prices, or both.

(5) Access to finance (ATF): Zero value means that the firm fails to obtain finance whereas value one means that the firm is capable of getting finance. The second model will be:

$$TE_{it} = \text{Size}_{it} + \text{Age}_{it} + \text{INC}_{it} + \text{EXR}_{it} + \text{ATF}_{it} \quad (i = 1, 2, \dots, 434; t = 1, 2, \dots, 6) \quad (6)$$

Several studies (Margono & Sharma, 2006; Lundvall & Battese, 2009) employ some of such categorical and dummy variables to examine the impact of these variables on efficiency scores.

Data Description

The structure of the Egyptian public-manufacturing firms is principally focused on 10 industries and they are defined as follows:

- (1) food and beverages;
- (2) textiles and apparel;
- (3) repair and maintenance;
- (4) petroleum;
- (5) mining and metals;
- (6) engineering;
- (7) wooden and paper;
- (8) chemical;
- (9) building and constructing products;
- (10) pharmaceutical.

Data cover a sample of 434 public firms involving industries' activities. Brief feedback regarding each industry and its relative importance is given as follows.

Preliminary, the food and beverages industry has the biggest share of total firms' number—as expected in most developing countries, which are mainly reliant on traditional industries—wherein it involves 195 firms or 45% of total firms.

They are ranged in size from the smallest one that hires less than 100 workers to the extra-large one that hires 10,029 employees. The industry embraces numerous activities, such as grain mills, bread industry, crude and refined sugar production, jams and juices, fruits and vegetables processing, tobacco, and other food products. The industry absorbs 63,799 laborers.

The share of ginning cotton, yarn, textiles, and apparel industry is 14% of total firms and employs 63,241 employees. Firms in industry vary in size from the smallest one that hires 27 workers to the largest one that hires 21,969 workers. It covers all related activities from upstream (ginning cotton, natural, and synthetic yarn manufacturing) to downstream process—with broad types of final products of textiles, such as numerous sorts of fabrics, home furnishing, and underthings and apparel activities, wherein the industry has thousands of differentiated products. Both food and textiles are naturally labor-intensive industries.

The repair and maintenance industry includes all activities related to vehicles repair and maintenance plus the construction, repair, and maintenance of ships and boats. The share of industry represents 11.5% of firms' population and employs 12,460 persons. Its size is also ranged from small size to extra-large size firms.

The share of the petroleum sector represents around 6% of public firms' number; it hires 33,416 employees and ranges in size from small to large firms rendering to activity's nature. It incorporates several products related to oil industry, such as crude oil extract, oil refining, petrochemicals, gasoline, petrol stations, roadbed materials, lubricants, and other oil products.

The mining and metals industry encompasses activities, such as crude phosphate extract, iron mining, metal ores, molten iron, coke extract, metals molten, steel chewer, aluminum manufacturing, metal ovens, manufacturing of steel pipes, metal vessels, bridges parts, and other metal products. It signifies 5% of the total firms and absorbs 44,472 employees. The size lies between medium and extra-large.

The engineering industry also denotes 5% of the sector firms' number. It comprises the doings of: machinery manufacturing, tires, vehicles spare parts, cars assembly, electric engines and generators, ovens, gas, electricity and water meters, electric lamps, and other related products. The industry engages 18,179 workforces and ranges in size from medium units to extra-large ones.

The wooden and paper industry represents 4% of sector's firms and absorbs 3,722 workers and produces wooden and paper products.

Similarly, the chemical industry accounts for 4% of sector's firms and employs 34,792 hands. It incorporates activities of manufacturing; detergents, paints, chemical oils, fertilizers, dried soap and soap pastes, main chemicals, pigments, and other chemical products.

The share of building and constructing industry products is 3.5% of total firms. It hires 39,233 employees and encompasses all activities related to construction industry.

Finally, albeit the pharmaceutical industry only signifies 2% of the total number of firms, it includes large and extra-large size firms, since it is a naturally capital-intensive industry. It produces all products related to pharma industry.

The population covers various firms' sizes. The production of small and medium firms is devoted to local markets whereas large and extra-large firms' production is dedicated to both domestic and international markets and they are fully integrated—more than one activity can be included in one firm. Furthermore, most firms have their own haulage system to obtain industry's factors of production and to deliver final products to clients. This population covers the period from 2006 to 2011. Such firms' activities range from fully integrated activities that cover all downstream processes to upstream processes as principal producers of some industries inputs.

Raw data are obtained through the Egyptian Central Agency of Population Mobilization and Statics [CAPMAS] (2013) for a six-year panel, besides obtained information from Business Sector Information Center [BSIC] (2013) bulletins and publications (the agent mentioned for public sector database). Data cover industries' inputs and outputs at current prices, then prices are deflated to achieve constant prices using 2006 as base year. Separate deflators are used for outputs, labor, capital, and raw materials and the total number of observations is 2,604.

Empirical Results

The Cobb-Douglas production function is estimated for public manufacturing firms. Data are obtained from CAPMAS along with acquirable data from the BSIC to construct dummies and categorical variables. Financial information is obtained via Central Bank of Egypt [CBE] (2013). After estimating efficiency scores, it is regressed against firm's size, age, INC, EXR, and ATF.

Food and Beverages Industry

Table 1 shows descriptive statistics for the food and beverages industry.

Table 1

Public Sector Food & Beverage Firms Summery Statistics (1,170 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	15.5072	0.0000	21.7723	2.8032
Labor	13.2688	7.7351	19.5840	1.9597
Materials	11.6289	0.0000	20.5452	5.7290
Capital	12.5913	1.1436	22.6569	2.6134
Size	1.1214	0	3	0.9973
Age	0.6299	0	1	0.4830
INC	0.5530	0	1	0.4974
EXR	0.1855	0	1	0.3888
ATF	0.4590	0	1	0.4985

Table 2 displays the estimated MLEs (maximum likelihood estimates) for the food and beverages industry. The dependent variable is the output of net yearly sales for each firm evaluated in Egyptian pounds at 2006 constant prices and regressors are labor, raw materials, and capital. Results reveal that the coefficients are highly significant. As a traditional industry, the majority of food firms follow a labor-intensive technique. Eta indicator is insignificant showing that there are not major differences for efficiency scores across time. TE mean is 44% with the minimum of near 0% and the maximum of 93%. For the industry, the efficiency scores are varied within firms inside governorate and across governorates. The highest efficiency score is found in a small size firm of beef products activity—Cairo governorate—at 93% and the lowest at a small size firm of producing bread near 0%—Alexandria governorate.

Table 3 exhibits the impact of size, age, INC, EXR, and ATF on efficiency scores. Results show that INC, EXR, and ATF coefficients are highly significant, but age coefficient is significant at 10%, while size coefficient is insignificant meaning that firm's size has not any impact on efficiency scores. Results for food and beverages industry favor random effects model.

Figures 1 and 2 show efficiency scores for the whole public sector firms via histogram and Kernel density function, where figures in Appendix show efficiency scores for firms within each industry in turn. ATF is the reference dummy.

Table 2

MLE Production Function Estimates for Public Food & Beverage Firms

Variable	Coefficient	Standard error	P value
Constant β_0	0.7647	0.2044	0.0002
Labor β_1	0.5060	0.0235	0.0000
Materials β_2	0.0117	0.0036	0.0010
Capital β_3	0.6219	0.0133	0.0000
Year β_4	0.0807	0.0239	0.0008
Variance parameters for compound error			
Lambda	2.3710	0.0218	0.0000
Sigma (u)	1.2413	0.1239	0.0000
Eta parameter for time varying inefficiency			
Eta	0.0256	0.0235	0.2760
Estimated efficiencies			
Mean	Min	Max	Std.Dev.
0.4435	0.4435	0.4435	0.4435

Table 3

TE Regression Results for Food Firms' Size, Age, INC, ATF, & EXR

Variable	Random effects		
	Coefficient	Standard error	P value
Size	0.0021	0.0016	0.2019
Age	0.0024	0.0014	0.0922
INC	0.0237	0.0040	0.0000
EXR	0.0237	0.0018	0.0000
Constant	0.3701	0.0110	0.0000
Fixed vs. random effects (Hausman)	15.83	-	0.0033
LM test	2,759.09		0.0000
R ² %	7.344		

Textiles and Apparel Industry

Table 4 displays descriptive statistics for the textiles and apparel industry.

Table 5 shows that raw materials and capital coefficients are highly significant whereas the labor coefficient is insignificant. This may be attributed to several reasons: the imbalance, between white and blue collar employees ratios within firms in which it is considered the highest among public industries and wages, is very low relative to other sectors and rewards for productive workers are trivial which kill their motivation to produce; the retirement of skilled laborers increases the burdens on other workers and leads to more productivity slowdown. The cutoff training programs—the main source of generating skilled workers—affect worker's productivity. A lack of clear strategies eliminates massive quantities of inventory, which has negative impact on production process and wrong anti-dumping policies. All these factors have driven banks to be hesitated in providing finance to the sector. Elatroush and Montes-Rojas (2011) achieved similar results for Egyptian textiles and apparel industry. Eta is significant indicating that efficiency scores differ across time.

The mean TE among industry is 43% with high score of 88% for a yarn and textile firm (Gharbia governorate) and the lowest (less than 1%) for cotton ginning firm (Qalyubia governorate). Mean TE within industries is 23%, which represents the lowest efficiency score among public manufacturing industries. The lowest efficiency scores are mainly found in Qalyubia, Giza, and Cairo governorates firms.

Figure 1. Efficiency scores for public firms.

Figure 2. Efficiency scores for public firms.

Table 4

Public Sector Textiles & Apparel Firms Summery Statistics (372 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	15.4893	0.0000	20.4586	2.7680
Labor	15.1193	12.7691	19.7002	1.6339
Materials	9.2516	0.0000	19.9884	7.8272
Capital	14.4576	9.8897	20.2399	2.0400
Size	1.9032	0	3	0.7848
Age	0.8575	0	1	0.3500
INC	0.4462	0	1	0.4978
EXR	0.4543	0	1	0.4986
ATF	0.0780	0	1	0.2685

Table 5

MLE Production Function Estimates for Textiles & Apparel Firms

Variable	Coefficient	Standard error	P value
Constant β_0	8.3088	1.3043	0.0000
Labor β_1	0.1454	0.0941	0.1224
Materials β_2	0.0561	0.0184	0.0022
Capital β_3	0.4479	0.0570	0.0000
Year β_4	-0.3066	0.1157	0.0082
Variance parameters for compound error			
Lambda	2.7082	0.0507	0.0000
Sigma (u)	3.5288	6.4454	0.5840
Eta parameter for time varying inefficiency			
Eta	-0.2976	0.0178	0.0000
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.4342	0.00000	0.8815	0.2302

Results of Table 6 show that size, EXR, and ATF coefficients are significant whereas age and INC coefficients are insignificant. Reasons behind that are that the majority of firms are age-old with poor INC.

Table 6

TE Regression Results for Textiles Firms' Size, Age, INC, ATF, & EXR

Variables	Random effects		
	Coefficient	Standard error	P value
SIZE	0.0719	0.0216	0.0009
AGE	0.0313	0.0328	0.3396
INC	0.0094	0.0373	0.8008
EXR	-0.0643	0.0361	0.0751
Constant	0.2471	0.1119	0.0273
Fixed vs. random effects (Hausman)	9.30	-	0.0540
LM test	123.44		0.0000
R ² %	9.7		

Repair and Maintenance Industry

Table 7 exhibits descriptive statistics for the repair and maintenance industry.

Table 7

Public Sector Repair & Maintenance Firms Summery Statistics (300 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	14.5326	0.0000	19.6516	2.9194
Labor	14.1377	10.2381	17.3051	1.6778
Materials	2.3676	0.0000	17.7330	5.5481
Capital	13.4970	1.0297	18.4900	2.8300
Size	1.6333	0	3	0.9319
Age	0.5200	0	1	0.5004
INC	0.5267	0	1	0.5001
EXR	0.5933	0	1	0.4920
ATF	0.4533	0	1	0.4986

Labor and capital coefficients in Table 8 are significant whereas raw materials coefficient is insignificant. Interviews with industry's experts give reasonable explanations for materials insignificance. They attributed insignificance to corrupted formal tenders of spare parts purchases with bad qualities making them expire too quickly. The mean TE score is 32% with a minimum of less than 1% for a car maintenance firm (Alexandria governorate) and a maximum of 87% is for an extra-large firm of ships building and repairs firm (Suez governorate). The main reasons behind low scores in repair and maintenance industry may be ascribed to overstaffed labor, lack of fund to buy good quality spare parts, and obsoleted equipment and most car maintenance firms are set to fix and repair public vehicles only, which led to low rates of utilized capacity. Eta is insignificant.

Table 9 shows that INF, EXR, and ATF coefficients are significant and affect efficiency scores whereas size and age coefficients are insignificant. Hausman test favors fixed effects model.

Table 8

MLE Production Function for Repair & Maintenance Firms

Variable	Coefficient	Standard error	P value
Constant β_0	3.7539	1.6750	0.0250
Labor β_1	0.4580	0.1161	0.0001
Materials β_2	-0.0150	0.0197	0.4463
Capital β_3	0.3955	0.0331	0.0000
Year β_4	0.2196	0.0680	0.0012
Variance parameters for compound error			
Lambda	1.7645	0.1082	0.0000
Sigma (u)	1.8230	1.8691	0.3294
Eta parameter for time varying inefficiency			
Eta	0.0804	0.0530	0.1292
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.3246	0.00000	0.8711	0.1959

Table 9

TE Regression Results for Repair Firms' Size, Age, INC, ATF, & EXR

Variables	Fixed effects		
	Coefficient	Standard error	P value
SIZE	0.0004	0.0081	0.4630
AGE	0.0085	0.0101	0.3963
INC	0.0462	0.0254	0.0701
EXR	0.0535	0.0188	0.0048
ATF	0.0215	0.0120	0.0737
		-	
LM test	653.86		0.0000
R ² %	95.49		

Petroleum Industry

Table 10 demonstrates descriptive statistics for the petroleum industry.

Table 11 signifies that labor, raw material, and capital coefficients are insignificant. This may be ascribed to overstaffed and unskilled labor force, outdated machinery and equipment in most firms, prevalence of

corruption, obsoleted refining labs, lack of new investments and finance, bad quality products relative to private sector products, wrong policies of pricing and subsidies, and inefficient policies for gasoline distribution.

Table 10

Public Sector Petroleum Firms Summery Statistics (156 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	19.2096	14.7084	23.5158	2.3274
Labor	17.3815	12.7622	19.9091	1.5766
Materials	13.7249	0.0000	23.9553	8.0704
Capital	16.8419	10.9534	19.9289	1.6644
Size	2.1923	0	3	0.7544
Age	0.6667	0	1	0.4729
INC	0.6154	0	1	0.4881
EXR	0.6539	0	1	0.3620
ATF	0.8654	0	1	0.3424

Table 11

MLE Production Function Estimates for Public Petroleum Firms

Variable	Coefficient	Standard error	P value
Constant β_0	23.9065	2.4282	0.0000
Labor β_1	-0.0138	0.0746	0.8534
Materials β_2	-0.0047	0.0082	0.5717
Capital β_3	-0.0250	0.0983	0.7993
Year β_4	0.0513	0.0451	0.2551
Variance parameters for compound error			
Lambda	10.5953	0.0333	0.0000
Sigma (u)	4.8363	37.6188	0.8977
Eta parameter for time varying inefficiency			
Eta	-0.0103	0.0087	0.2364
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.1394	0.0002	0.8596	0.2481

The mean TE score is 14%, which is considered as one of the lowest scores among public industries. The minimum TE is less than 1% (gasoline-refining firm in Suez) and the maximum is 86% (petrol-refining firm in Alexandria) wherein the first firm has outdated equipment while the second has new equipment. The oil sector firms have various techniques of production in which some of them have more advanced and modernized refining laboratories, but the majority are suffering from primitive and obsoleted refining laboratories. Additionally, efficiency scores are varied within activities, such as crude oil extract, petrol refining, gasoline, lubricants, and other petrol products.

Table 12 illustrates that size and ATF coefficients are significant whereas age, INC, and EXR are insignificant. Random effects model is favored for industry.

Mining and Metals Industry

Table 13 expresses descriptive statistics for the mining and metals industry.

Table 14 reveals that capital coefficient is significant while labor and materials are insignificant. The reasons behind insignificance may be attributed to: (1) wasted resources especially in mining sector wherein

most of minerals are sold in low prices and lack of policies aims to maximize minerals value added through selling them as a final product form rather as a raw material shape; (2) lack of FDI and technology transfer; (3) dominated corruption in mining sector contracts; (4) using primitive ways of minerals extraction; and (5) plus intense rivalry mainly from private steel firms. Mean TE is 57% with the minimum of less than 1% (iron-mining firm Giza governorate) and the maximum of 89% (metal vessels firm Alexandria governorate).

Table 12

TE Regression Results for Petroleum Firms' Size, Age, INC, ATF, & EXR

Variables	Random effects		
	Coefficient	Standard error	P value
Size	-0.0028	0.0007	0.0002
Age	0.0003	0.0008	0.9755
INC	-0.0026	0.0023	0.2606
EXR	-0.0015	0.0013	0.2521
Constant	0.1544	0.0425	0.0003
Fixed vs. random effects (Hausman)	11.53	-	0.0000
LM test	328.18		0.021
R ² %	9.5		

Table 13

Public Sector Mining & Metals Firms Summery Statistics (132 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	18.0816	0.0000	23.3389	2.7768
Labor	16.6390	10.0161	20.0090	2.0446
Materials	14.3365	0.0000	21.3943	6.6066
Capital	16.4826	8.1387	21.3568	2.6109
Size	2.3485	0	3	0.8994
Age	0.6364	0	1	0.4829
INC	0.5000	0	1	0.5019
EXR	0.4697	0	1	0.5010
ATF	0.5227	0	1	0.5014

Table 14

MLE Production Function Estimates for Public Mining & Metals Firms

Variable	Coefficient	Standard error	P value
Constant β_0	3.0087	3.6205	0.4060
Labor β_1	0.4401	0.3490	0.2074
Materials β_2	0.0312	0.0778	0.6888
Capital β_3	0.5002	0.2812	0.0753
Year β_4	-0.0877	0.9149	0.9236
Variance parameters for compound error			
Lambda	1.4416	1.9595	0.4619
Sigma (u)	2.0273	45.8915	0.9648
Eta parameter for time varying inefficiency			
Eta	0.3457	1.6079	0.8298
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.5672	0.0010	0.8937	0.2112

Table 15 shows significance for ATF and insignificance for size, age, INC, and EXR.

Table 15

TE Regression Results for Mining & Metals Firms' Size, Age, INC, ATF, & EXR

Variables	Random effects		
	Coefficient	Standard error	P value
Size	-0.0304	0.0314	0.3329
Age	-0.0405	0.0428	0.3441
INC	0.0147	0.0023	0.7947
EXR	0.0014	0.0542	0.9794
Constant	0.7113	0.1462	0.0000
Fixed vs. random effects (Hausman)	13.21	-	0.0103
LM Test	12.32		0.0005
R ² %	1.8		

Engineering Industry

Table 16 displays descriptive statistics for the engineering industry.

Table 16

Public Sector Engineering Firms Summery Statistics (132 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	16.4976	0.0000	19.2186	4.0294
Labor	15.8637	10.0343	17.8913	1.6905
Materials	12.8859	0.0000	18.5870	6.9614
Capital	15.4594	8.3250	18.5670	2.0307
Size	2.3258	0	3	0.7666
Age	0.4242	0	1	0.4961
INC	0.5455	0	1	0.4998
EXR	0.5530	0	1	0.4991
ATF	0.4470	0	1	0.4991

Table 17 shows that both labor and capital coefficients are significant, however materials coefficient is insignificant. Eta is also significant. Despite that the industry, like other pubic industries, receives subsidy, it is an intensive power consumption industry.

Materials insignificancy may be attributed to inefficient and unclear tenders system, expensive and bad quality raw materials relative to private units that have cheap and good quality raw materials, and soft budget constraints like any other public agencies. Mean TE score for the industry is 53% with the minimum of less than 1% and the maximum of 97%. Whereas its efficiency scores were 26%, less than 1%, and 67% in turn relative to whole industries. Same explanations for low efficiency scores in mining and metals industry can be applied for the engineering industry.

Results of Table 18 reveal that INC and EXR coefficients are significant, but size, age, and ATF are insignificant. The random effects model is the favored model for the industry.

Wooden and Paper Industry

Table 19 shows descriptive statistics for the wooden and paper industry.

Table 20 demonstrates that materials coefficient is significant, but labor and capital are insignificant and this may be ascribed to overstaffed and non-productive labor, outdated designs, obsoleted machinery, lack of

finance for equipment upgrade, and all these factors lead to old-fashioned products. Eta also is highly insignificant. The mean efficiency score for the wooden and paper industry is 24% with the minimum of less than 1% (packaging paper firm) and the maximum score of 74% (wooden stationary products firm). Efficiency scores for industry are nearly the same for its scores relative to scores of whole industries.

Table 17

MLE Production Function Estimates for Public Engineering Firms

Variable	Coefficient	Standard error	P value
Constant β_0	-7.3542	2.6388	0.0053
Labor β_1	1.0774	0.3433	0.0017
Materials β_2	0.0135	0.0764	0.8598
Capital β_3	0.4238	0.2537	0.0949
Year β_4	0.4633	0.4900	0.3444
Variance parameters for compound error			
Lambda	0.1362	0.2740	0.6190
Sigma (u)	0.2197	3.4265	0.9489
Eta parameter for time varying inefficiency			
Eta	0.5995	0.3110	0.0539
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.5317	0.0000	0.9611	0.3015

Table 18

TE Regression Results for Engineering Firms' Size, Age, INC, ATF, & EXR

Variables	Fixed effects		
	Coefficient	Standard error	P value
Size	0.1151	0.1926	0.5512
Age	0.0703	0.0722	0.3323
INC	0.1252	0.0633	0.0478
EXR	0.3244	0.1498	0.0321
ATF	0.1365	0.0810	0.1045
R ² %	30		

Table 19

Public Sector Wooden & Paper Firms Summery Statistics (108 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	14.3070	0.0000	18.8124	4.4306
Labor	14.0509	9.1966	16.9988	1.7969
Materials	10.9135	0.0000	18.1272	6.2192
Capital	12.8608	7.2342	17.8031	2.2944
Size	1.5370	0	3	0.7541
Age	0.3241	0	1	0.4702
INC	0.5278	0	1	0.5016
EXR	0.8611	0	1	0.3474
ATF	0.5556	0	1	0.4992

Fixed effects model is prevailed for the industry as shown in Table 21. Age and EXR coefficients are significant, whereas size, INC, and ATF are insignificant and do not affect efficiency scores.

Table 20

MLE Production Function Estimates for Wooden & Paper Firms

Variable	Coefficient	Standard error	P value
Constant β_0	2.7269	9.4763	0.7735
Labor β_1	0.1074	0.8012	0.8934
Materials β_2	0.1782	0.0747	0.0170
Capital β_3	0.8117	0.6912	0.2402
Year β_4	-0.2026	0.4679	0.6650
Variance parameters for compound error			
Lambda	1.4724	0.2311	0.0000
Sigma (u)	2.5830	11.7758	0.8274
Eta parameter for time varying inefficiency			
Eta	0.0327	0.1714	0.8485
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.2447	0.00004	0.7435	0.1639

Table 21

TE Regression Results for Wooden & Paper Firms' Size, Age, INC, ATF, & EXR

Variables	Fixed effects		
	Coefficient	Standard error	P value
Size	0.0055	0.0088	0.5359
Age	0.0102	0.0065	0.0944
INC	-0.0034	0.0075	0.6533
EXR	0.0151	0.0090	0.0984
ATF	0.0044	0.0090	0.6215
Fixed vs. random effects (Hausman)	3.73	-	0.5895
LM test	236.88		0.0000
R ² %	98.99		

Chemical Industry

Table 22 displays descriptive statistics for the chemical industry.

Table 22

Public Sector Chemical Firms Summery Statistics (96 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	18.0329	14.7742	21.5470	1.7076
Labor	16.1741	12.3779	18.8840	1.5991
Materials	15.2750	0.0000	21.1942	4.8933
Capital	15.8870	11.7377	19.4014	2.0840
Size	2.0792	0	3	0.9318
Age	0.5313	0	1	0.5016
INC	0.5313	0	1	0.5016
EXR	0.3854	0	1	0.4892
ATF	0.6979	0	1	0.4616

Table 23 illustrates that both labor and capital coefficients are significant, whereas materials coefficient is insignificant. Like engineering industry, analyses of materials insignificance can be applied for chemical

industry. Eta also is insignificant. The mean efficiency score is 13% with the minimum score of less than 1% and the maximum of 89%. Low levels of efficiency are apparent in fertilizers industry, since it produces inefficiently due to lack of raw materials supplies (natural gas and electricity are main raw materials for industry). Thus, the cost of production is increased along with declining in the utilized capacity. Instead, activities, such as paints, detergents, and other chemical products, have higher efficiency scores.

Table 23

MLE Production Function Estimates for Chemical Firms

Variable	Coefficient	Standard error	P value
Constant β_0	19.7785	3.9949	0.0000
Labor β_1	-0.2170	0.0651	0.0008
Materials β_2	0.0095	0.0251	0.7050
Capital β_3	0.2878	0.1542	0.0619
Year β_4	0.0246	0.0807	0.7603
Variance parameters for compound error			
Lambda	11.5395	0.0872	0.0000
Sigma (u)	3.4644	39.5800	0.9302
Eta parameter for time varying inefficiency			
Eta	-0.0180	0.0180	0.3165
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.1267	0.0036	0.8913	0.2140

Table 24 shows that size and ATF coefficients are significant, but age, INC, and EXR coefficients are insignificant. The fixed effects model is a favored method for industry.

Table 24

TE Regression Results for Chemical Firms' Size, Age, INC, ATF, & EXR

Variables	Fixed effects		
	Coefficient	Standard error	P value
Size	-0.0071	0.0023	0.0022
Age	0.0003	0.0018	0.8458
INC	-0.0011	0.0022	0.6084
EXR	-0.0017	0.0022	0.4541
ATF	-0.0030	0.0027	0.2542
Fixed vs. random effects (Hausman)	9.13	-	0.1039
LM test	175.35		0.0000
$R^2\%$	99.94		

Building and Construction Industry

Table 25 shows descriptive statistics for the building and construction industry.

Capital coefficient is significant, but labor and materials are insignificant. Eta also is insignificant as in Table 26. Key reasons behind insignificance are prevailed oligopoly in cement and steel industries (main components of the building industry) which increases building costs, restrictions imposed on imported materials, ignorance of low- and middle-income accommodations accompanied by strong attention to luxurious accommodations, weak and ineffective antitrust laws, managerial failure, and severe competitiveness between industry's firms and private sector entities. All these factors create surplus in luxurious housing and shortage in

economy housing, raise accommodation prices, and affect industry as a whole. TE mean for industry is 67% with the minimum of 17% (cut and polish stones) and the maximum is 96% (the ceramics and tiles industry).

Table 25

Public Sector Building Firms Summary Statistics (90 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	15.1581	11.5544	20.8397	2.4306
Labor	14.3644	11.3964	18.8007	1.9613
Materials	11.2870	0.0000	18.4312	5.8181
Capital	13.4925	9.4775	20.1643	2.7106
Size	1.4111	0	3	0.9468
Age	0.3444	0	1	0.4778
INC	0.3111	0	1	0.4655
EXR	0.0556	0	1	0.2303
ATF	0.2556	0	1	0.4386

Table 26

MLE Production Function Estimates for Building Firms

Variable	Coefficient	Standard error	P value
Constant β_0	3.8731	0.8830	0.0000
Labor β_1	0.0824	0.1092	0.4508
Materials β_2	0.0039	0.0161	0.8081
Capital β_3	0.7969	0.0770	0.0000
Year β_4	-0.0988	0.1386	0.4758
Variance parameters for compound error			
Lambda	1.7422	0.3497	0.0000
Sigma (u)	0.9899	0.9331	0.2887
Eta parameter for time varying inefficiency			
Eta	-0.2944	0.2211	0.1829
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.6733	0.1696	0.9604	0.1888

Table 27 shows that EXR and ATF are significant, however size, age, and INC coefficients are insignificant and fixed effects model is a favored technique for industry.

Table 27

TE Regression Results for Building Firms' Size, Age, INC, ATF, & EXR

Variables	Fixed effects		
	Coefficient	Standard error	P value
Size	-0.0084	0.0537	0.8765
Age	-0.0302	0.0443	0.4969
INC	0.0767	0.0716	0.2872
EXR	-0.1861	0.0667	0.0065
ATF	-0.1029	0.0504	0.0443
Fixed vs. random effects (Hausman)	8.46	-	0.1325
LM test	24.92		0.0000
R ² %	64.56		

Pharmaceutical Industry

Table 28 demonstrates descriptive statistics for the pharmaceutical industry.

Labor and capital coefficients are highly significant, whereas materials coefficient is insignificant as in Table 29. This may be attributed to Egyptian pharmaceutical products ineffective relative to multi-national corporations products owing to lack of outlay on research and development (R&D), effective ingredient in drugs lower than world standards, uniform prices that are imposed by the government (for social considerations), which are considered among main obstacles for industry modernization. The drawbacks of uniform pricing policy led to reducing profits and hindering capital accumulation, which affects significantly on firms' returns and declines R&D funds. Mean efficiency scores for industry are 80% with the minimum of 52% and the maximum of 95%.

Table 28

Public Sector Pharma Firms Summery Statistics (48 Obs)

Variable	Mean	Min	Max	Std. Dev.
Output	18.8909	16.8782	20.5795	0.7087
Labor	17.2662	15.6784	18.0316	0.6024
Materials	15.9078	0.0000	19.6776	5.0981
Capital	17.2837	14.6842	18.3556	0.9286
Size	2.8333	0	3	0.3766
Age	0.8750	0	1	0.3342
INC	0.8542	0	1	0.3567
EXR	0.9583	0	1	0.2019
ATF	0.8333	0	1	0.3766

Table 29

MLE Production Function Estimates for Pharma Firms

Variable	Coefficient	Standard error	P value
Constant β_0	4.9723	9.0329	0.5820
Labor β_1	0.4053	0.1915	0.0343
Materials β_2	0.0090	0.0110	0.4165
Capital β_3	0.3814	0.1232	0.0020
Year β_4	0.0749	0.0341	0.0282
Variance parameters for compound error			
Lambda	0.0006	31.7602	1.0000
Sigma (u)	0.3499	0.0050	0.0000
Eta parameter for time varying inefficiency			
Eta	0.1500	0.12D + 7	1.0000
Estimated efficiencies			
Mean	Min	Max	Std. Dev.
0.7978	0.5267	0.9513	0.1127

Table 30 displays that INC and EXR regressors are significant. This maybe, as some of raw materials are imported besides fluctuations in EXR, affects firms' exports especially with fluctuations in EXR relative to other currencies. Size, age, and ATF coefficients are insignificant. The prevailed technique is fixed effects model.

Overall, the Egyptian public units have their notable characters relative to private units among them; imbalance is between the share of white- and blue-collar employees in which the share of blue-collar represents

at least 60% of total labor force in the sector and it participates in the major portion of income. Alternatively, the white-collar ratio in private entities does not exceed 10% of total labor force. Moreover, the public wages increase for social considerations—whether productivity increased or decreased. Such wrong policies kill the motivation for productive laborers. In contrast, wages are determined in private units due to workers' productivity and this is obvious from low efficiency scores in most public industries. The third factor is the early pension scheme wherein its main goal was to reduce the number of white-collar employees by letting them to apply for optional retirement. Unfortunately, the opposite happened wherein the skilled blue-collar laborers have retired and the gap between white- and blue-collars has widened.

This lack of skilled workers in most industries creates more burdens on current workers and leads to more productivity slowdown. Furthermore, deliberate and unplanned strategies for machinery upgrading led to arbitrarily modernization policies within firms in the same industry and among industries. Efficiency scores for firms within the same industry and within industries are notably varied.

Table 30

TE Regression Results for Pharma Firms' Size, Age, INC, ATF, & EXR

Variables	Fixed effects		
	Coefficient	Standard error	P value
Size	-0.0268	0.0720	0.7112
Age	-0.0015	0.0258	0.9541
INC	0.1611	0.0882	0.0747
EXR	0.1160	0.0626	0.0709
ATF	0.0101	0.0219	0.6456
Fixed vs. random effects (Hausman)	4.77	-	0.4448
LM test	61.59		0.0000
R ² %	87.37		

Conclusions

The Cobb-Douglas production function is used to estimate TE for 10 Egyptian public industries. Efficiency scores are predicted per industry to detect similarities and dissimilarities among them.

Results show that the average TE is varied across industries and per firms within the same industry. Some industries are labor-intensive and others are capital-intensive. Results also reveal major differences in: industry's characteristics, regions, and utilized technique of production.

All industries are inefficient with different rates, but the common factor among them is that they are suffering from governmental ignorance, which is characterized in a lack of new investments that are used to finance machinery upgrading, purchase high quality raw materials, training programs for unskilled labor, clear strategies for boosting all production processes, maximize value added, and function in other managerial factors. To overcome these problems, the government should show great concern for improving sector's performance as it covers some strategic industries.

After estimating TE, it is regressed against size, age, INC, EXR, and ATF to examine their impact on efficiency scores. The influences of such coefficients are varied across industries. Results also show that some industries favor random effects model, whereas the others follow fixed effects model. Upcoming paper will deal with wages distortions in Egyptian public manufacturing firms.

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Appendix A

Appendix A1. Efficiency scores for food firms.

Appendix A2. Efficiency scores for textiles firms.

Appendix A3. Efficiency scores for repair firms.

Appendix A4. Efficiency scores for petroleum firms.

Appendix A5. Efficiency scores for mining firms.

Appendix A6. Efficiency scores for engineering firms.

Appendix A7. Efficiency scores for wooden firms.

Appendix A8. Efficiency scores for chemical firms.

Appendix A9. Efficiency scores for building firms.

Appendix A10. Efficiency scores for pharma firms.