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TRENDS OF TOTAL FACTOR PRODUCTIVITY IN EGYPT'S PHARMACEUTICAL INDUSTRY: EVIDENCE FROM THE NONPARAMETRIC MALMQUIST INDEX APPROACH

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Abstract

In this paper, trends in total factor productivity (TFP) growth in 13 of Egypt's largest and oldest pharmaceutical generics firms are examined. The paper relies on data envelopment analysis (DEA) —the non-parametric frontier methodology— to obtain the Malmquist productivity index for the sample firms, which account for 50% of Egypt's generics market. The study period ranges from 1993 to 2005. Best-practice firms and laggard firms in the three aspects of efficiency change, technical change and TFP change are identified. Empirical results indicate the best-practice firm in terms of TFP change belongs to the private sector, while the laggard firm belongs to the state-owned public business sector. No differences of significance exist between the performance of private sector and state-owned generics companies. Additionally, state-owned companies which have been subject to partial privatization did not exhibit higher levels of TFP change than those which remained under full state-ownership. Empirical results also indicated that mean TFP change for the sample firms throughout the study period (1.01) exceeded the mean TFP change for all Egyptian industries (0.75), and that there was evident disassociation, or weak correlation at best, between productivity growth/regress and the degree of export orientation.

ملخص

تبحث هذه الورقة اتجاهات نمو متغير العوامل الإنتاجية الكلية في اكبر و أقدم ثلاثة عشرة شركة مصرية في المجال الدوائي. ويعتمد هذا الورقة علي منهجية تحليل تطويق البيانات الغيرقياسية المحددة- وذلك من اجل الحصول علي مؤشر مالمكويست لعينة من هذه الشركات التي تمثل50% من السوق المصر. وقد تم تنفيذ الدراسة في الفترة من عام 1993 إلي عام 2005. و يتم تحديد أفضل الشركات أداء والشركات الأخرى ذات الأداء المتباطئ وذلك في ثلاث جوانب لتغير الكفاءة, و التغير الفني, و تغير العوامل الإنتاجية الكلية. وتظهر النتائج التجريبية انه بالنظر إلي تغير إنتاجية العوامل الكلية فان أفضل الشركات أداء تنتمي للقطاع الخاص, بينما تنتمي الشركات الأخرى ذات الأداء المتباطئ لقطاع الأعمال العام المملوك للدولة. ولا يوجد هناك اختلافات مهمة بين أداء القطاع الخاص وبين الشركات العامة المملوكة للدولة. وبالإضافة إلي ذلك فان الشركات المملوكة للدولة و التي تعرضت لخصخصة جزئية لم تظهر مستويات اعلي, فيما يتعلق بتغير إنتاجية العوامل الكلية, من الشركات التي ظلت تحت ملكية كاملة للدولة. كما أظهرت النتائج التجريبية أيضا أن معدل تغير إنتاجية العوامل الكلية لعينة هذه الشركات خلال فترة الدراسة (1.01) قد تجاوز معدل تغير إنتاجية العوامل الإنتجاية الكلية لكل الصناعات المصرية (0.75), وانه كان هناك فصل واضح أو ارتباط ضعيف- في أفضل الأحوال- بين نمو/هبوط الإنتاجية وبين درجة توجه التصدير.

I. Introduction

The Egyptian pharmaceutical industry has been thriving behind protective non-tariff regulatory trade barriers since the late 1950s, as well as an intellectual property rights (IPRs) regime which, up to January 2005,[1] excluded pharmaceutical products from patentability. While several episodes of trade liberalization have occurred during the 1980s and 1990s, eventually lowering tariff levels and eliminating non-tariff barriers to trade shielding Egyptian manufacturing industries—particularly under the framework of World Trade Organization (WTO) commitments during the second half of the 1990s and beyond— the pharmaceutical industry stands out by virtue of being subject to relatively resilient non-tariff regulatory trade barriers which have isolated local manufacturers from generics import competition. Currently, Egypt's pharmaceutical industry is a prime candidate to be affected in a major way as a result of the country's process patent regime giving way to a product patent regime since January 2005, as well as the gradual increase in generics import penetration.

The combined effect of such change has created a relatively dynamic environment compared to the formative years of this industry. The survival of Egyptian firms is likely to depend on the extent to which they are able to manufacture generics (off-patent drugs), for local as well as for export markets, at competitive prices to allow them to face competition and be part of a changing global economy. To this end and in an environment which will only accommodate the most efficient, it was important to examine the extent to which the internal efficiencies of individual firms operating in this sector have been contributing to their survival strategy.

During the study period, several key features of the Egyptian pharmaceutical market stand out. Firstly, during the 1980s and 1990s, this sector has seen significant expansions in private sector investments, both local and foreign, bringing the number of manufacturing companies to 58[2]. Secondly, the output orientation of this industry has remained largely inward. Thirdly, pharmaceutical imports are mainly accounted for by innovator brands manufactured of research-based companies, whereby relatively low levels of 'generics' import penetration characterize the Egyptian market.

In light of the above backdrop, issues of concern in policy circles have focused on the relative prices of pharmaceutical products in Egypt, as well as the efficiency and competitiveness of this industry. In close connection, two reports concerning the affordability of pharmaceutical products in Egypt (WHO and HAI, 2004), as well as the competitiveness of the pharmaceutical industry (ADE/DOL, 2004) have cautioned that essential drug prices are actually higher than they need be, making essential medicine 'unobtainable' for many, and that the pharmaceutical industry has not been contributing much to national economic growth, with sector performance having largely remained stagnant.

Clearly, the Egyptian pharmaceutical sector presents a rich field to address a set of interesting questions, most pertinent among which is related to the extent to which mechanisms used to protect and regulate the Egyptian pharmaceutical industry have been associated with productivity growth. Evidence of productivity dispersion in the Egyptian pharmaceutical industry in accordance to ownership, age and output orientation is also an equally important issue.

The fact that some of Egypt's local generic companies exhibit relatively high ratios of exports to output indicates that there have been efficiency gains in this sector sufficient enough for these companies to compete in world markets. The estimation of firm-level productivity

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[1] In 1995, Egypt became a founding member of the World Trade Organization and a signatory of the Agreement on Trade Related Aspects of Intellectual Property Rights, with an obligation to enforce higher standards of IPRs no later than January 2005, including a 20-year period of pharmaceutical product patent protection.

[2] These include the private sector, the public business sector and subsidiaries of research-based companies.

growth is one important avenue to contribute to the debate regarding productivity growth under a protectionist trade regime.

This paper is mainly concerned with the examination of patterns of 'association' between trade policy (regulatory protectionism), productivity and productivity growth in the Egyptian pharmaceutical sector based on a rich firm-level panel data obtained directly from a sample of 13 companies operating in this sector. These companies account for 50% of Egypt's generics market (by value). DEA is relied upon to estimate the Malmquist TFP Index (MPI), which can be decomposed into efficiency change, technical change and TFP growth.

The software DEAP, developed by Coelli (1996), is used to compute the indices.

This rest of this paper is divided into five sections. Section II presents an expose of the conceptual framework and the literature review. Section III provides a brief review of the history of Egypt's pharmaceutical industry and the ruling regulatory and institutional framework. Section IV outlines the methodology. Section V provides the empirical results and Section VI presents the main findings and conclusion.

II. Conceptual Framework and Literature Review

Conceptually, productivity measures the efficiency with which resources (including capital and labor) are employed in production (Klein, 1983: 4561). The concept of technical efficiency dates back to the work of Debreu (1951) and Koopmans (1951), when both scholars addressed the issue of efficiency in the economics literature. Farrel (1957) built on earlier work to introduce the notion of efficiency measurement.

Firm-level efficiency essentially consists of two main components. The first is technical efficiency, which deals with the ability of a firm to obtain maximal output from a given set of inputs. The second is allocative (price) efficiency, which indicates the ability of firms to use inputs in optimal proportions. Combining these two measures provides a measure of total economic efficiency (Haghiri et al., 2004). Technical efficiency is defined as a comparison between the observed and maximum values of a firm's inputs and outputs. Comparisons can embody the form of the ratio of observed to maximum potential output obtainable from given input (input-oriented measure), or the ratio of minimum potential to observed input required to produce the given output (output-oriented measure), or some combination of both (Haghiri et al., 2004).

Central to the measurement of productivity is TFP, which measures the economic as well as the technical efficiency with which resources are transformed into products. TFP is the portion of output not explained by the amount of inputs used in the production process. Levels of TFP are thus determined by how efficiently and intensely the inputs are utilized in the production process (Comin, 2006). TFP growth has assumed central importance in economic literature because of the fact that the growth of an economy, an industry or a firm is determined by the expansion rate of its productive resources and the ratio of TFP growth (Nishimizu and Robinson, 1984: 180).

TFP growth essentially plays a pivotal role in economic growth, as well as cross-country per capita income differences. Solow (1956) has shown that the long-run growth in per capita income in an economy (with an aggregate neoclassical production function) must be driven by growth in TFP. Achieving rapid and sustained rates of TFP growth has thus become a prime objective for policy makers, particularly in a developing country context.

Looking into why there have been different productivity outcomes among various countries/ industries/ firms, the literature has indicated that this may actually arise from a plethora of sources. Trends in TFP may mirror the efficiency of a particular reform program, learning effects, the deployment of new generations of technology, technical know-how, organizational skills, enterprise response to changes in competition and other related aspects of market structure. In addition, TFP trends may also reflect the impact of social, political and institutional obstacles to potentially useful innovations. Nonetheless, it has remained difficult to ascertain the causes of productivity movements (Jefferson, Rawski and Zheng, 1996: 147).

Two issues in relation to TFP growth are particularly important and relevant from a development policy perspective. The first issue is related to the range of TFP growth rates that one can be 'reasonably' expected. This can be addressed by looking at confidence intervals for TFP growth rates which can be obtained from historical records of firms, industries or economies operating under various production and regulatory settings. For example, these observations provide significant insights in relation to an appropriate duration of infant industry protection. The second issue of policy relevance is related to the cause and source of TFP growth. In this regard, it has become important to both question as well as to find answers to whether or not protection from import competition blunts the incentives for efficiency improvements. (Nishimizu and Robinson, 1984: 180). It is this caliber of questions that is clearly central for this paper.

Researchers as well as policy makers have been interested in factors which underlie observations that some countries are more productive than others, some industries are more productive than others and some firms are more productive than others. Factors which proved important included ownership, quality of labor, technology used, exposure to competition in export markets and the regulatory environment (Bartelsman and Doms, 2000: 586). In close connection, among the central issues invoked in the literature on productivity is related to the extent to which exposure to foreign markets relates to producers' choice and productivity dispersion within a particular industry. In fact, plant level exporting has gained significant attention, and has been motivated by evidence of a strong relationship between exporting and productivity growth (Andrew Bernard and Jensen, 1995).

Researchers have extensively embarked on examining the underlying reasons behind observed productivity levels and growth rates in various nations, industries as well as firms. The objective has generally been to evaluate their mutual competitive positions, particularly with regards international trade. On this front, of significant policy relevance has been the contention that countries that have exhibited strong productivity growth, have also been highly competitive internationally (Klein, 1983: 4565).

Research regarding productivity served to answer a rich plethora of questions, which have in turn been tackled by using a narrow set of measurement techniques. On one hand, a large body of literature has looked into the relative productivity of locally owned firms versus foreign owned firms, with the objective of formulating more effective policies with regards to foreign direct investment (FDI). Along such lines, Asheghian (1982) attempted to evaluate the comparative efficiency of foreign firms and local firms in Iran in an effort to present intra-firm efficiency comparisons (based on three indices of efficiency including TFP). The study concluded that international joint-venture firms (as opposed to wholly owned subsidiaries) which have been operating in Iran during the pre-revolutionary period 1971–1976 have been more efficient than locally owned firms. Chung et al. (2006) focused on the influence of Japanese FDI on the productivity of US suppliers in the US auto-component industry during a study period which extended between 1979 and 1991. This study was based on observing linkages between various firms supplying auto-components to Japanese transplants, as well as the productivity and survival of the US component firms that did not supply Japanese transplants. The authors found out that the productivity of local suppliers with linkages to Japanese transplants did not grow faster than that of unaffiliated suppliers, and concluded that there was no evidence of direct technology transfer positively affecting US suppliers' productivity during the study period (which was coined as the initial stage of inward FDI in the USA).

An interesting segment of research work on productivity is the body of literature linking exporting to productivity growth. Exporting is regarded to positively contribute to productivity growth through three key channels: 1) economies of scale; 2) efficiency improvements on behalf of exporters though the process of 'learning by exporting', cross-efficiency promotion and resource reallocation from the less to the more efficient firms at the industry level and 3) technical progress which results from technology spillovers through foreign contracts and the encouragement of investment in research and development (Fu, 2005; Bartelsman and Domes, 2000).

Empirical research examining whether or not export-oriented firms exhibit higher levels of productivity than non-exporting firms has produced mixed results. One faction of the literature has argued that there is a process of 'learning-by-exporting' whereby exporting firms serve as a conduit for technology transfer from abroad and do generate technological spillovers to the rest of firms operating in their domain of operations. Another faction states that the relatively high productivity of exporting firms reflects the mere fact that it is the relatively more efficient producers who enter and sustain presence in the highly competitive export markets. This reflects a 'self-selection' process which works in the export industries (Fu, 2005).

On one side, research based on examining microdata in developing countries has shown that exporting firms are generally more efficient than non-exporting firms. The study by Clerides et al. (1998) confirms this pattern and adds the interesting finding that plants that cease to export typically become less efficient. Taking a step further in the analysis by looking into causation flows from exporting to productivity improvements, data from Colombia and Morocco pertaining to export-oriented industries was found to be inconsistent with this pattern of causality (Clerides et al., 1998). Fu (2005) also investigated the relationship between exports and industry-wide productivity growth in China's manufacturing sector. By relying on industry-level panel data for the period 1990–97 (using a non-parametric Malmquist TFP approach), the author found out that export-oriented industries did not appear to have been more efficient than non-export industries. No productivity gains of significance have been caused by exports at the industry level (Fu, 2005).

In contrast to this kind of observations, basing their empirical work on data from the Penn World Tables for 102 countries, and using measures of 'real' openness (defined as imports plus exports in exchange rate US Dollars relative to GDP in purchasing power parity US Dollars) Alcala and Ciccone (2004) have found that the causal effect of trade on productivity is statistically significant as well as robust. This finding has indicated that the channels through which international trade impacts on average labor productivity is through TFP. Handoussa, Nishimizu and Page (1986) have also provided evidence from Egypt's state-owned companies in the manufacturing sector after the Open Door policy, whereby exporting firms were found to be relatively more efficient than their inward-oriented counterparts.

Sofronis et al. (1998) also posed the interesting question of whether firms become more efficient *after* becoming exporters. The authors tracked the causal link from exporting to productivity growth using plant-level panel data. They also looked into whether the cost process of individual firms undergoes change after they move into export markets. The results indicate that the relatively more efficient firms become exporters. However, firms' costs are not significantly affected by previous exporting activities. The positive association between exporting and efficiency gains documented in the literature is, nonetheless, explained by the *self-selection* of the more efficient firms into export markets (Sofronis et al., 1998). In close connection, Pavcnik (2002) addressed the boarder issue of trade liberalization and productivity growth using panel data for the 1979–86 period for all manufacturing plants in Chile employing ten or more workers. The author found that there was significant support for productivity improvements related to liberalized trade. Following trade liberalization during the late 1970s and early 1980s, the productivity of plants in the import competing sectors grew by an average of three to10% more than in the non-traded-goods sector in Chile.

Another important and interesting dimension of research on productivity is that related to the nature of ownership of productive units. Hauner (2005) looked into the comparative efficiency performance of large German and Austrian banks. State-owned banks were found to be more cost-efficient (owing to their access to cheaper funds), while cooperative banks were found to be about as cost-efficient as private banks. The study also found out that Austrian banks were significantly less cost-efficient than German banks. In another attempt to link observed patterns of efficiency to ownership, Liu (2001) investigated the effect of state ownership on efficiency (using an econometric model which allowed for the separation of technical from allocative efficiency in a dynamic setting). Basing the estimation results on a sample of international airlines, the author suggested that state-ownership is associated with lower technical and allocative efficiency.

III. Sector Review

Starting from a very modest base comprised of three local companies during the early 1930s, which together covered less than 10% of local demand, the Egyptian pharmaceutical industry has undergone significant expansion and growth, whereby the industry currently meets 81% of demand in one of the largest markets of the Middle East and North Africa (MENA) region (CAPMAS, 2009).

Three critical benchmarks characterize the history of Egypt's pharmaceutical industry. The first of these benchmarks was the nationalization policy of 1961, which was an important point of departure for Egypt's pharmaceutical industry. On July 20, 1961 the government took controlling interest in the form of at least 50% of capital of the country's ten largest pharmaceutical companies, and by 1962 full nationalization of the industry was completed (Handoussa, 1974: 90). Throughout the 1960s, import substitution industrialization was the force driving Egyptian industry, and the pharmaceutical industry was no exception.

The 1970s brought the second turning point for this industry, whereby the transition from import-substitution industrialization to export-led growth following the Open Door Policy (ODP) in 1974 brought back the private sector—both local and foreign— to the manufacturing forefront. Nonetheless, this transition was neither smooth nor immediate. Throughout the 1970s and 1980s, the public sector continued to be the dominant player on the Egyptian pharmaceutical production and trade scenes, with inward orientation, the continuation of protectionist measures, price controls and eventually deteriorating financial performance being key features which persisted throughout the two decades. Moreover, while the private sector was remobilized to participate in industrial activity following the legislation of the ODP in 1974, it was not until the early 1980s that the manufacturing scene saw the entry of new private sector pharmaceutical companies, but with marginal export interests.

In 1995, Egypt became one of the founding members of the WTO and a signatory to the TRIPS Agreement. Commitment to enforcing higher standards of IPRs and the harmonization of pharmaceutical patent protection with global standards was the third and perhaps the most important point of departure for this industry, with far reaching implications both from the demand as well as the supply side perspectives.

Pharmaceutical IPRs and Regulatory Regimes

While Egypt's pharmaceutical institutional and regulatory framework underwent significant change during the 1970s, 1980s and 1990s, one common denominator persisted, namely the exemption of pharmaceuticals from patent protection.

IPRs regime

The exclusion of pharmaceutical products from patentability has emerged as one of the most consistent denominators which characterized Egypt's patent regimes during the 1960s, 1970s, 1980s and 1990s.

According to Patent Law 132 of 1949, patents were granted for every new invention susceptible to industrial exploitation, whether related to industrial products, to new industrial processes or to new application of known industrial methods or ways (Hassan, 1997: 4). The exclusion from the framework of patents, however, covered chemical inventions including foodstuff and pharmaceutical products.

Egypt has been a member of the General Agreement on Tariff and Trade (GATT) and a founding member of the WTO in 1995. Having made use of the longest transition period allowed for developing countries under the TRIPS Agreement, Egypt did not enforce TRIPS consistent pharmaceutical product patent protection except in January 2005. Egypt was, however, obliged to meet all other TRIPS transitional requirements by January 1, 2000.[3] Under the provisions of the TRIPS Agreement, the Government of Egypt was obliged to provide full protection of process patents as stipulated by Article 28, formal protection of confidential data (Article 39.3) and the patent mailbox and exclusive marketing rights (EMR) (Article 70.8 and 70.9). In 2002, the new TRIPS consistent Law 82 of 2002 on the 'Protection of Intellectual Property Rights' was enacted, replacing law 132/1949.

Regulatory regime

The regulation of the pharmaceutical sector in Egypt falls under the auspices of the Ministry of Health (MOH). Several laws, decrees and regulatory measures govern the registration, production, trade, pricing, and distribution of pharmaceutical products.

Egypt's drug regulatory regime is comprised of three key government bodies, namely the Central Administration of Pharmaceutical Affairs (CAPA), the Drug Planning and Policy Centre (DPPC) and the National Organization for Drug Control and Research (NODCAR). The three organizations cooperate in managing the registration and sales of pharmaceutical products in Egypt. Administrative functions are undertaken by DPPC and CAPA, while laboratory and bioavailability analysis are undertaken by NODCAR.

Pricing

Pharmaceuticals products in Egypt are priced on the basis of a cost-plus formula, in order to ensure both the affordability of medicine and to guarantee a positive profit on all drug products sold on the Egyptian market (Nathan Associates, 1995:4). The profit margin ceiling is 15% for essential drugs, 25% for non-essentials and 40% or more for over-the-counter drugs. The Pricing Committee of the DPPC is responsible for price setting on the basis of reviewing the cost sheet presented by applicant firms to determine ex-factory prices.[4]

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[3] Art. 43 states that "The Patent Office shall receive patent applications with regard to food-related agrochemical products and to pharmaceuticals, and shall maintain such applications, along with applications relating to the same products and filed as of 1st January 1995, pending their examination as of 1st January 2005".

[4] The cost sheet is topped by a distribution mark-up (12.36%), pharmacists' mark-up (25%) a sales tax (5% of ex-factor price). The public (retail) price for local products is 45.5 percentage points above the ex-factory price. Once a price is set, it is rarely re-evaluated to account for any adjustments in cost, and has to be approved by the Prime Minister.

Manufacturing scene

A total of 58 pharmaceutical manufacturing companies are currently present on the Egyptian market, including 9 companies which fall under public business sector ownership, and 7 subsidiaries of research-based companies. Research-based companies with no manufacturing presence in Egypt, supply the market through a large number of representative scientific offices.

After having been the dominant players during the 1960s, 1970s and 1980s, the market share of public business sector companies underwent a marked decline during the 1990s and beyond, a new development which ran parallel to the increase in the number of new private sector entrants to the manufacturing scene.

Pharmaceutical trade

Egypt has consistently maintained a deficit on the pharmaceutical trade balance, with imports standing at US$ 887 million and exports at US$ 238 million (in 2006/07). The pharmaceutical trade deficit has actually been widening, from US$ 410 million in 2000/01 to US$ 649 million in 2006/07.

Imports are accounted for by products of the research-based industry, which account for roughly half of total imports by value. The balance is accounted for by generic imports. The pharmaceutical industry generally meets more than 50% of raw material (active ingredients) from aboard.

Egyptian manufacturers of generics have lagged behind other regional competitors in terms of penetrating export markets. Jordanian generics companies for example export up to 70-80% of total output, compared to an average of 5% in Egypt. Among the justifications given for the modest export performance is the fact that a relatively large segment of products manufactured by local generic companies in Egypt are manufactured under license. The output structure of local pharmaceutical companies indicated that a large segment of total output was by default not exportable. In 1980, 20% of total output was manufactured under license. By 1995, this share increased to reach 33% (CAPMAS, 1997). A standard license agreement clearly states that the sale of products manufactured under license was authorized for the territory of Egypt. Only a few license agreements allowed for export sales. Unless negotiations allow for wider geographic coverage for products manufactured under license, output is made exclusive to the local market.

Another important reason explaining why local companies have been relatively slow in expanding their export markets is related to the argument that most of the private as well as the public business sector companies have been incurring losses on a significant number of their products. This has been particularly true following the devaluation of the Egyptian pound in January 2003 (Survey, 2004). Few price adjustments have been allowed to accommodate the increase in the cost of imported raw material inputs. With importing countries stipulating that prices charged on their markets have to match prices charged on the Egyptian market, if pharmaceutical companies were to export —some products—at the prices charged in Egypt, this would in fact constitute a direct subsidy to foreign consumers. Pricing remains to be one of the most important export related dilemmas facing pharmaceutical companies in Egypt (Survey, 2004).[5]

[5] The Managing Director of CID, one of the public business sector companies, stated that the company is incurring losses on most of its products on the Egyptian market, and that exporting at the same price as stipulated by importing country regulations (such as Saudi Arabia) he will in fact be subsidizing the consumers in the importing market at his own expense. This argument has been widely acknowledged in all of the companies interviewed.

Tariff and non-tariff barriers

Tariffs on pharmaceutical products have been relatively low in Egypt. The reason being that high tariff levels would have been equivalent to taxing the sick, in principle. Tariff levels currently imposed on imports of pharmaceutical products have been lowered to an average of 5% (Ministry of Finance, 2005). In February 2007, a new tariff schedule was introduced in Egypt, whereby some medicines have been exempted from tariffs. In the new 2007 tariff schedule, tariffs on pharmaceutical products ranged between two and five percent depending on the nature of the product.

Despite the low level of tariffs prevailing, non-tariff barriers facing pharmaceutical imports in Egypt remain significant, particularly for products with local equivalents. Non-tariff regulatory trade barriers are manifested in the extent to which registration procedures facing imported products —as administered by the Ministry of Health— are made both stringent and cumbersome.

For an imported product to be registered with the regulatory authorities in Egypt, proof of a free sales certificate in one of five of the world top pharmaceutical markets has to be provided by the importer. This requirement has historically ruled out import competition from low cost generic manufacturers in other parts of the world, most notability from India and China.

IV. Estimation of TFP Growth Using Non-Parametric Productivity Measurements

Research that has relied on longitudinal microdata has traditionally been divided into two key groups. The first group has been concerned with documenting and describing productivity, while the second has been concerned with examining the factors behind productivity growth. The first group has endeavored to document the cross-sectional distribution of productivity and the evolution of productivity growth. This faction of empirical work has presented useful stylized facts regarding the dispersion of productivity "across firms and establishments, productivity differentials and the consequences of entry and exit and the importance of changes in the resource allocation across firms to aggregated productivity growth" (Bartelsman and Doms, 2000). It is to this stand of the literature that this thesis is aliened. The second strand of the literature documented the correlation between productivity and variables believed to influence it. The more sophisticated faction of the literature takes a step further to answer the relatively more difficult yet highly important question of causality (Bartelsman and Doms, 2000).

This paper uses DEA, a non-parametric frontier methodology, to obtain the Malmquist productivity index at the firm-level for a representative sample of firms operating in the Egyptian pharmaceutical industry during a study period which extends between 1993 and 2005. The results will help identify the best-practice firm and the laggard firm in three aspects: efficiency change, technical change and TFP growth, which are the qualitative productivity improvements needed to achieve long-term growth.

TFP has theoretically proven superior —as an indicator of technical efficiency— to any other partial factor measure of productivity including labor productivity, because it measures the productivity of all inputs used in the production process jointly (Keay, 2000).

Methods to measure TFP growth generally fall in two key classes. The first is growth accounting which has been the standard measurement device since Solow (1957). In this case, measurement relies on accounting for the contribution of growth in factor inputs to the growth of output. The residual part of output growth which cannot be accounted for by inputs is TFP growth (Krüger, 2003). The conventional approach based on the Solow residual method has four basic assumptions: 1) that the form of the production function is known; 2) constant returns to scale exist; 3) firms exhibit optimizing behavior, with no room for inefficiencies and 4) that there is neutral technical change. Once these assumptions do not hold, measurements of

TFP will become biased (Coelli et al., 1998; Arcelus and Arocena, 2000). The second method measures TFP growth by estimating frontier production functions "and then derive productivity changes from both the changes in inputs and outputs of countries and the sifts of the frontier function (Krüger, 2003). These are basically the two techniques to measuring TFP growth. Details regarding the advantages of each methodology are presented in Mahadevan (2004).

Within this strand, two conceptually different methods exist. In the first case, the estimation of the frontier function can be done using parametric methods for the stochastic frontier analysis (SFA). The advantage of this method is being able to deal with measurement errors. However, it requires the specification of the functional form of the production function. In addition, specific distributional assumptions are necessary for the separation of the distance to the frontier from measurement error (Krüger, 2003). "The primary shortcomings of parametric frontier estimation techniques are the need to use predetermined functional forms (e.g. Cobb-Douglas, translog, Transcendental etc.) and their reliance on pre-specified types of error distribution. In the second case, a nonparametric estimator is a robust estimator that allows the data to determining the shape of the functional form without any constraints derived from relevant economic theory. The advantage of nonparametric estimators they do not possess the same limitation as paramedic frontier estimation techniques because they do not rely on these same strict assumptions. Among the commonly used nonparametric methods is the DEA" (Haghiri et al., 2004: 1235).

DEA is used to estimate the Malmquist TFP index. The technique of DEA to measure firm-level performance is useful for the comparative evaluation of firm-level efficiency and has been extensively used in the literature (Ahuja and Majumdar, 1998)

In the case of the nonparametric approach of DEA, the deviation of observations from the frontier function is taken as a result of inefficiency. Measurement error is neglected and results are made more sensitive to outliers. Using linear programming methods, the advantage of DEA (against SFA) is that the frontier function is determined without any functional or distributional assumptions. "DEA is a local method in that it calculates the distance to frontier function through a direct comparison with only those observed in the sample that are most similar to the observations for which the inefficiency is to be determined" (Krüger, 2003: 267)

Regardless of the methods used to calculate distances, growth of TFP is then quantified by the Malmquist index. The Malmquist index introduced by Malmquist (1953) in a consumption context and by Caves et al. (1982) as a productivity index has been extensively used and referred to in the literature (Krüger, 2003: 267). The MPI can be decomposed into efficiency change, technical change and TFP growth. The software DEAP which has been developed by Coelli (1996) has been used to compute the indices.

The exposition of the essentials of the procedures to obtain the Malmquist index of TFP is outlined in Annex 1.

Data sources

Data needed for the application of the Malmquist-DEA procedure were obtained directly from the sample firms for the period 1993–2005. Three inputs have been used, namely labor, intermediate inputs and capital. Labor input has been quantified by the number of workers. Intermediate inputs included raw material (local+ imported), packaging material, gas, electricity and spare parts. Capital input is based on the value of the capital stock. As the output variable, output value (in current prices) for each firm was used.

Several price indices have been resorted to in order to deflate output, intermediate inputs and capital stock values. The investment deflator has been obtained from the Ministry of Planning, and has been used to deflate the value of the capital stock. The various components of the wholesale price index have been relied on to deflate intermediate input values. The CPI has been used to deflate output values.

Sample characteristics

Local generics pharmaceutical companies in Egypt exhibit marked heterogeneity in terms of ownership structures, age and output orientation. This heterogeneity in fact enriched the analysis based on variations in performance which can be linked to other characteristics of the sample firms.

Eight of the sample companies fall under state ownership (Law 203 public business sector), of which 5 have been subject to partial privatization. The remaining five sample generics pharmaceutical firms are privately owned.

EIPICO holds the largest share of the generics market, which stood at 9.4% in 2008, while PHARCO is the lead firm in terms of exports as a percent of output value. Only one of the private firms, namely SEDICO, has a large foreign equity share of 34% (GAFI, 2009).[6]

V. Results and Discussion

This section summarizes the results which were obtained through DEA by calculating the required distances functions using the DEAP program developed by Coelli (1996). For the *i*th firm, four distance functions to measure the TFP change between two periods have been calculated. This required solving four linear programming (LP) problems (four for each firm in the sample).

The pool of data required for the calculation of the MPI has been detailed earlier in the paper. Looking at the empirical results, an index of one represents no change in productivity growth from the previous to the current period. In any year, an index of 0.90 represents a decline of 10% in productivity growth, while an index of 1.01 would represent an increase of 1% in productivity growth.

Time series efficiency change

Table 5 shows the scores for average efficiency change for all sample firms during the 13-year study period. The year 2000 marks the largest effect on efficiency change. 1995 was also a relatively good year in terms of efficiency change.

Time series technological efficiency change

Table 5 indicates that the highest score for technological change occurred in 1994, with the second best score occurring in 1998, and then as late as 2004. Most of the private sector sample firms had actually begun production during the early 1990s, which means that these formative years saw the installation of new production machinery and equipment. During the second half of the 1990s, and particularly with the uncertainty associated with what was judged to be a relatively detrimental impact of the TRIPS Agreement on the future of the local generics industry, most of the private sector companies in Egypt were in a situation which entailed conservative investments in new state-of-the-art production machinery. In addition, during the second half of the 1990s and up to January 2003, Egypt faced severe foreign currency shortages. Local generics companies have been particularly sensitive to exchange rate fluctuations. Though they imported more than 50% of their intermediate raw material, local generics companies were rarely able to accommodate exchange rate movements in terms of price adjustments. The implications for profitability levels were significant, which in turn affected their ability to modernize as well as invest in state- of-the-art generations of technology.

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[6] GAFI data classifies firms to have FDI shares if the share of foreign capital in the issued capital exceeds the threshold of 10%.

Because public business sector companies account for the largest number of firms in the sample, results are likely to be sensitive to the overall performance of these companies. On the technological front, public business sector companies have been facing serious profitability problems (in association with pricing) and have not been able to invest appropriately in technological upgrades. For example, CID, Al-Kahira and Misr were judged to be technically incapable of surviving with the current condition of their capital stock (Interview, Drug Holding Company). For example, regular inspections conducted by the Ministry of Health (in 1999 and 2000) cautioned that the manufacturing facilities of the Arab Drug Company (ADCO) were in dire need for rehabilitation, which otherwise, would make the company subject to closure. The reason is that some of ADCO's machinery, which date back to 1963, is still in operation. Of no less importance, foreign licensors have been threatening ADCO to withdraw their licenses, unless the rehabilitation and modernization of the company's manufacturing facilities is addressed (ADCO Records, 2003).

Time series TFP change

Table 5 indicates that during the study period, mean TFP change for the entire sample of firms was relatively favorable. This is particularly true if compared to the overall performance of Egyptian manufacturing industries (Annex Table 1). Mean TFP change throughout the study period (1.01) exceeded mean TFP change for all Egyptian industries (0.75) during the period 1980/80–2000/01 (Galal, Ahmed and El-Megharbel, 2005). Taking into consideration that this industry has been thriving behind significant regulatory non-tariff barriers, TFP change has been generally positive, with only a few years registering productivity regress.

Firm-level technical efficiency change

One important observation concerning firm-level technical efficiency change (Table 6) is that three of the private sector companies, namely Amriya, PHARCO and MUP have experienced no change in technical efficiency change during much of the study period. The three firms are in fact among the oldest in terms of year of establishment and also among the key players on the market by virtue of market shares. The remaining two private sector companies in the sample —EIPICO and SEDICO— have experienced fluctuations in technical efficiency change, with a non-consistent pattern moving from the positive to the negative throughout the study period. Public business sector companies have also shared the same pattern.

Firm level technological change

Table 7 indicates that 1994 and 1998 have been two significant years for technological change across all sample firms. MUP is the lead firm in terms of consistency in positive technological change in 9 of the 13-year study period. There are no significant differences between public and private sector firms in terms of achievements on the technological change front.

Firm level TFP change

Table 8 indicates that MUP emerged as the best-practice firm in terms of positive TFP change. No difference of significance mark TFP change between public and private sector firms. TFP change exhibited by public business sector firms which have been subject to partial privatization did not differ much from those which remained under full state ownership. In fact Misr, which is under full state ownership, achieved consistently positive TFP change compared to all other public business sector companies. Foreign participation in equity (e.g. SEDICO) did not seem to have a significant impact on TFP change.

Table 9 indicates that the dominant effect for most of the sample firms is technological change. Having identified the dominant effect of TFP change in the sample firms, should allow these companies to address and strengthen weaknesses

Export-orientation and productivity growth

Table 10 indicates evident disassociation or very week correlation at best between productivity growth/regress and the degree of export orientation. Firms that exported a larger share of output were not necessarily gaining on the efficiency front compared to those exporting relatively smaller shares. The opposite is also true. Firms which were not exporting much of their output were not necessarily less efficient than their opposites.

VI. Conclusion

While there has been empirical evidence of positive TFP growth in Egypt's pharmaceutical industry (sample firms), under the ruling trade and regulatory regime which has historically kept generics imports' competition at bay, this should not be judged as a healthy phenomenon. Protectionism may have aided this industry to survive during its formative years, especially since there has been ample historical proof of the inequality and possibly detrimental competition with foreign companies during the 1930s (Handoussa, 1994). However, the absence of generic import competition during most of this industry's history may have created an environment in which local manufacturers of generics were able to reap significant profits in association with higher than average prices in a market where generic import competition was a fairly new phenomenon. This in fact is an important avenue for future research work concerning the affordability of generics in Egypt under the ruling regulatory and trade regimes.

The absence of a positive correlation between export orientation and TFP change must also be interpreted with cautiousness. As explained earlier, because of pricing rigidities, which have in fact been present during the period which saw the rise of Egypt's modern pharmaceutical private industry, most companies have not been very successful in penetrating export markets. Exporting in the case of pharmaceuticals also involves atypical costs, whereby pharmaceutical registration procedures in importing markets sometimes involve expenses which may reach as high as US$ 200 thousand for a single product, with no grantee that the product will eventually obtain the registration license. This is an additional explanatory variable related to the absence of positive correlation between productivity growth and outward orientation.

One important avenue to further support the results of this paper is to expand the size of the sample. Alternatively, sector level analysis may be undertaken. Another important avenue for future research in this area is to compare the growth performance of Egypt's pharmaceutical industry with the rest of the manufacturing industries, particularly with those sub-sectors which were most protected by regulatory as well as by tariff barriers to further highlight the favorable performance of this industry.

References

ADE/DOL. 2004. *Egypt's Pharmaceutical Sector Survival and Development Strategy Report*. Prepared for the Industrial Modernization Centre.

Ahuja, Gautam and Sumit K. Majumdar. 1998. "An Assessment of the Performance of State-Owned Enterprises". *Journal of Productivity Analysis* 9, pp.113–132.

Alcala, Francisco and Antonio Ciccone. 2004. "Trade and Productivity". *Quarterly Journal of Economics*. (May), pp.613–646.

Arcelus, F. and P. Arocena. 2000. "Convergence and Productive Efficiency in Fourteen OECD Countries: A Non-parametric Approach". *International Journal of Production Economics*, Vol. 66, pp. 105-117.

Asheghian, Parviz. 1982. "Comparative Efficiency of Foreign Firms and Local Firms in Iran". *Journal of International Business Studies* Vol. 13, No. 3 (Winter), pp. 113–120.

Bartelsman, Eric J. and Mark Doms. 2000. "Understanding Productivity: Lessons from Longitudinal Microdata". *Journal of Economic Literature* Vol. XXXVIII (September), pp. 569–594.

Bernard, Andrew B. and J. Bradford Jensen. 1995. "Exporters, Jobs, and Wages in U.S. Manufacturing, 1976-1987." *Brookings Papers on Economic Activity*, Microeconomics. Washington DC.

Capon, N., J. V. Farley, and S. Hoening. 1990. "Determinants of Financial Performance: A Meta-Analysis". *Management Sciences* 36, pp. 1167–117.

Caves, Douglas W., Laurits R. Christensen and W. Erwin Diewert. 1982. "Multilateral Comparisons of Output, Input, and Productivity Using Superlative Index Numbers". *The Economic Journal* Vol. 92, No. 365 (March), pp. 73–86.

Chow, Clement Kong-Wing and Michael Ka-Yiu Fung. 1997. "Measuring the Technological Leadership of International Joint Ventures in a Transforming Economy". *Journal of Business Research* 39, pp. 147–157.

Chung, Wilbur, W. Michell and B. Yeung. 2003. "Foreign Direct Investment and Host Country Productivity: The American Automotive Component Industry in the 1980s". *Journal of International Business Studies* Vol. 34, No. 2, focused Issue: *The Future of Multinational Enterprises: 25 Years Later*, (March), pp. 199–218.

Clerides, Sofronis K., Saul Lach and James R. Rybout. 1998. "Is Learning by Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico and Morocco". *The Quarterly Journal of Economics* Vol. 113, No. 3 (August), pp. 903–947.

Coelli, T.J. 1996. "A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program. CEPA Working Paper 96/8, Department of Econometrics, University of New England.

Comin, Diego. 2006. "Total Factor Productivity". Reproduced from "*The New Palgrave Dictionary of Economics*". Palgrave-Macmillan.

Debreu, Gerard. 1951. “The Coefficient of Resource Utilization”. *Econometrica*, Vol. 19, No. 3, pp. 273-292.

Edwards, Sebastian. 1993. “Openness, Trade Liberalization, and Growth in Developing Countries”. *Journal of Economic Literature* Vol. 31, No. 3 (September), pp. 1358–1393.

El-Shinnawy, Azza. 2004. Survey of Pharmaceutical Manufacturing Industry.

Farrell, M. J. 1957. “The Measurement of Productive Efficiency”. *Journal of the Royal Statistical Society* Series A (General) Vol. 120, No. 3, pp. 253–290.

Fu, Xiaolan. 2005. “Exports, Technical Progress and Productivity Growth in a Transition Economy: A Non-Parametric Approach for China”. *Applied Economics* 37, pp. 725–739.

Galal, Ahmed and Nihal El-Megharbel. 2005. “Do Governments Pick Winners or Losers? An Assessment of Industrial Policy in Egypt”. *Egyptian Center of Economic Studies Working Paper* No. 108, December 2005.

Handoussa, Heba. 1974. “The Pharmaceuticals Industry in Egypt”. *Unpublished Ph.D. Thesis*. University of London. SOAS.

Handoussa, H., M. Nishimizu, and J.M. Page, Jr. 1986. “Productivity Change in Egyptian Public Sector Industries after the "Opening", 1973-79”. *Journal of Development Economics*, Vol. 20, pp. 53-74.

Haghiri, Morteza, James F. Nolan and Kien C. Tran. 2004. “Assessing the Impact of Economic Liberalization Across Countries: A Comparison of Dairy Industry Efficiency in Canada and the USA”. *Applied Economics* 36, pp. 1233–1243.

Hauner, David. 2005. “Explaining Efficiency Differences among Large German and Austrian Banks”. *Applied Economics* 37, pp. 969–980.

J.R. Norsworthy and David H. Malmquist. 1983. “Input Measurement and Productivity Growth in Japanese and U.S. Manufacturing”. *The American Economic Review* Vol. 73, No. 5 (December), pp. 947–967.

Jefferson, Gary H., Thomas G. Rawski and Yuxin Zheng. 1996. “Chinese Industrial Productivity: Trends, Measurement Issues and Recent Developments”. *Journal of Comparative Economics* 23, 146–180.

Keay, Ian. 2000. “Assessing the Performance of Canada's Manufacturers: Firm Level Evidence, 1902–1990”. *The Journal of Economic History* Vol. 60, No. 2 (June), pp. 497–501.

Kin, Sangho and Gwangho Han. 2001. “A Decomposition of Total Factor Productivity Growth in Korean Manufacturing Industries: A Stochastic Frontier Approach”. *Journal of Productivity Analysis* 16, pp. 269–281.

Klein, L.R. 1983. “*International Productivity Comparisons (A Review). Proceedings of the National Academy of Sciences of the United States of America*”. [Part 2: Physical Sciences], Vol. 80, No. 14 (July), pp. 4561–4568.

Kong, Nancy Y.C. and Jose Tongzon. 2006. “Estimating Total Factor Productivity Growth in Singapore at Sectoral Level Using Data Envelopment Analysis”. *Applied Economics* 38, pp. 299–314.

Krüger, Jens J. 2003. “The Global Trends of Total Factor Productivity: Evidence from the Nonparametric Malmquist Index Approach”. *Oxford Economic Papers* 55, pp. 265–286.

Liu, Zhiqiang. 2001. “Efficiency and Firm Ownership: Some New Evidence”. *Review of Industrial Organization* 19, pp. 483–498.

Mahadevan, R. 2004. “*The Economics of Productivity in Asia and Australia”*. Edward Elgar, Cheltenham, UK.

Nelson, Richard. 1981. ”Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures”. *Journal of Economic Literature* Vol. 19, No. 3 (September), pp. 1029–1064.

Nishimizu, Mieko and Sherman Robinson. 1984.”Trade Policies and Productivity Change in Semi-industrialized Countries”. *Journal of Development Economics* 16, pp. 177–206.

Pavcnik, Nina (2002). Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants. *Review of Economic Studies* 69, pp. 245–267.

Solow, Robert M. A. 1956. “*Contribution to the Theory of Economic Growth*”. *Quarterly Journal of Economics*, Vol. 70, No. 1, pp. 65–94.

Tybout, James R. 2000. “Manufacturing Firms in Developing Countries: How Well Do They Do and Why?”. *Journal of Economic Literature* Vol. XXXVIII (March), pp. 11–44.

WHO/HAI. 2004. “Medicine Prices Project: The Prices People Have to Pay for Medicines in Egypt”. *Egypt Survey Report*. July 2004.

Table 1: Market Share (%)

	UnitsY/2004	UnitsY/2008	LE SalesY/2004	LE SalesY/2008
Total market ('000)	873,498	1,323,496	6,279,026	12,565,859
Public business sector (Holdipharma)	25.8	18.4	14.9	10.2
Imported	4.4	6.8	12.2	17.3
Multinational	23.5	18.7	28.4	22.4
Private (local generics companies)	46.3	56.2	44.6	50.0

Source: IMS (2009)

	Public Sector (Drug Holding Com.)		Foreign Companies		Private Sector		
1	**ADCO**	1	**AMGEN**	1	Acapi	22	Marcyrl
2	**ALEX**	2	**AVENTIS**	2	Adwia	23	Mepaco
3	**CID**	3	**BMS**	3	Hikma	24	Minapharm
4	**KAHIRA**	4	**GLAXO**	4	Amoun	25	Multiapex
5	**MEMPHIS**	5	**NOVARTIS**	5	Amriya	26	MUP
6	**MISR**	6	**PFIZER**	6	Arabcaps	27	New Life
7	**NASR**	7	**SERVIER**	7	Arabcomed	28	October Pharm
8	**NILE**			8	Army (logistic)	29	Opi Pharm
9	**SEPCO**			9	Atos	30	Pharco
				10	Bio-Original	31	Pharopharm
				11	Borg	32	Philopharm
				12	Chemipharm	33	Rameda
				13	Delta Pharm	34	Rivapharm
				14	EIPICO	35	SEDICO
				15	Epci	36	Sigma
				16	European Egyptian	37	Simco
				17	Eva Pharm	38	T3A
				18	Global Napi	39	Technopharm
				19	Haidelyna	40	Unipharm
				20	Hi Pharm	41	Veitopharm
				21	Jedco	42	Vitapharm

Source: Ministry of Health, 2006

Table 2: Pharmaceutical Trade in Egypt (US$ million)

	2001/2002	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
Total Imports**	14,637	14,820	18,286	24,193	30,441	37,834
Pharmaceuticals	583	499	477	525	627	887
Total Exports**	7,121	8,205	10,453	13,833	18,455	22,018
Pharmaceutical products	83	130	209	215	125	238

Source: Central Bank of Egypt, 2007

Table 3: Pharmaceutical Raw Material Imports, 2006 (LE '000)

	Local	Imports	Total
Pharmaceutical raw material	1,536,604	1,687,765	3,224,369
	47.7%	52.3%	100%

Source: CAPMAS (2009)

Table 4: Sample Characteristics

Company Name	Establishment Date	Production	Issued Capital LE '000	Ownership	Market Share 2008 (value)	Exports as a % of Total Output 2006
Misr	1937	n.a.	n.a.	Public business sector	1.3	14.6
Memphis	1940	n.a.	n.a.	Public business sector 40 percent of total stocks privatized	2.0	8.5
CID	1950	n.a.	n.a.	Public business sector	2.5	3.0
Alex	1963	n.a.	n.a.	Public business sector 40 percent of total stocks privatized	1.3	7.7
Kahira	1963	n.a.	n.a.	Public business sector 40 percent of total stocks privatized	3.6	12.0
Nile	1963	n.a.	n.a.	Public business sector 33.3 percent of the total stocks privatized	2.4	8.6
ADCO	1964	n.a.	n.a.	Public business sector 40 percent of total stocks privatized	1.5	5.7
Nasr	1964	n.a.	n.a.	Public business sector	0.4	8.5
EIPICO	1980	1985	n.a.	Private	9.4	14.5
PHARCO	1982	1987	500,000	Private	7.9	14.7
SEDICO	1983	1990	223,768	Private	2.6	12.6
Amirya	1984	1988	216,000	Private	2.6	7.4
MUP	1984	1989	313,387	Private	7.3	7.3

Sources: Public Business Sector Drug Holding Company; General Authority for Investment and Free Zones; IMS Health; Handoussa (1974).

Table 5: Malmquist Index Summary of Annual Means

Year	Technical Efficiency Change (relative to a CRS technology)	Technological Change	Pure Technical Efficiency Change (relative to VRS technology)	Scale Efficiency Change	Total Factor Productivity Change
1994	0.693	1.544	0.821	0.844	1.071
1995	1.426	0.743	1.267	1.126	1.060
1996	1.036	0.911	1.004	1.032	0.944
1997	1.018	1.007	1.016	1.003	1.026
1998	0.963	1.037	0.982	0.981	0.999
1999	1.028	0.985	0.995	1.033	1.012
2000	1.046	0.958	1.046	1.000	1.002
2001	1.017	0.978	1.023	0.994	0.995
2002	0.995	0.983	0.977	1.018	0.978
2003	1.025	0.977	1.014	1.011	1.001
2004	0.950	1.009	0.957	0.993	0.959
2005	0.962	1.101	0.976	0.986	1.059
mean	1.002	1.006	1.002	1.000	1.008

Table 6: Firm Level Technical Efficiency Change (relative to a CRS technology)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ADCO*	0.694	1.446	1.118	1.043	0.955	0.911	1.295	1.077	1.000	1.000	0.914	0.881
Alex*	0.637	1.385	1.049	1.090	0.968	0.988	1.083	1.038	0.971	1.083	0.844	0.921
Amirya	0.761	1.314	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CID*	0.475	1.982	1.032	1.037	1.020	1.085	1.154	1.000	0.996	0.903	0.948	0.831
EIPICO	1.000	1.000	0.980	1.003	0.897	1.127	0.866	0.960	1.091	1.048	1.059	0.937
Kahira*	0.771	1.391	1.016	1.029	0.896	0.979	1.039	0.997	0.975	1.053	0.987	0.879
Memphis	0.552	1.638	0.997	1.153	0.972	1.046	1.019	0.973	1.053	1.032	0.870	0.974
Misr*	0.591	1.593	1.153	1.119	0.973	0.977	1.296	0.995	1.015	0.920	1.063	0.970
MUP	1.056	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Nasr*	0.392	3.069	1.149	0.798	0.800	1.211	0.985	1.236	0.929	1.026	0.987	0.964
Nile*	0.518	1.729	1.046	1.023	1.033	1.042	0.992	1.049	0.934	1.134	0.740	1.264
PHARCO	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SEDICO	0.992	1.008	0.951	0.988	1.035	1.029	0.958	0.924	0.979	1.154	1.000	0.947
Mean	0.693	1.426	1.036	1.018	0.963	1.028	1.046	1.017	0.995	1.025	0.950	0.962

* Public Business Sector Companies

Table 7: Firm Level Technological Change

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ADCO	1.631	0.635	0.890	1.020	1.044	1.004	0.811	1.019	0.982	0.985	1.023	1.162
Alex	1.590	0.730	0.880	0.996	1.029	0.999	0.984	0.904	1.020	0.977	1.017	1.139
Amriya	1.511	0.801	0.952	0.967	1.056	0.980	1.079	1.051	0.949	0.918	1.024	0.893
CID	1.974	0.598	0.874	0.995	1.036	0.999	0.936	0.976	0.999	0.986	1.040	1.148
EIPICO	1.569	0.779	0.818	1.039	1.061	1.002	1.021	0.949	1.000	0.941	0.960	1.152
Kahira	1.417	0.723	0.894	1.029	1.054	1.002	0.985	0.961	0.992	0.970	1.026	1.104
Memphis	1.931	0.644	0.920	0.952	1.003	0.993	1.014	1.004	0.950	0.951	1.030	1.057
Misr	1.827	0.584	0.879	1.005	1.039	1.001	0.965	0.962	1.001	0.961	1.028	1.116
MUP	1.223	1.138	1.070	1.068	1.020	0.867	1.064	0.984	1.034	1.039	0.874	1.279
Nasr	1.843	0.644	1.042	0.960	1.001	0.991	1.036	1.106	0.928	0.939	1.047	0.990
Nile	1.685	0.587	0.877	0.971	1.012	0.996	0.999	0.968	0.981	0.955	1.005	0.984
PHARCO	1.089	1.106	0.778	1.038	1.100	1.015	0.630	0.912	0.954	1.186	1.151	1.212
SEDICO	1.130	0.945	1.021	1.066	1.034	0.961	1.042	0.941	1.000	0.921	0.916	1.135
mean	1.544	0.743	0.911	1.007	1.037	0.985	0.958	0.978	0.983	0.977	1.009	1.101

Table 8: Firm Level TFP Change

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ADCO5	1.132	0.917	0.996	1.064	0.997	0.915	1.051	1.098	0.982	0.985	0.935	1.024
Alex6	1.012	1.011	0.922	1.086	0.997	0.986	1.065	0.939	0.99	1.058	0.859	1.049
Amirya6	1.15	1.053	0.952	0.967	1.056	0.98	1.079	1.051	0.949	0.918	1.024	0.893
CID5	0.937	1.186	0.902	1.033	1.056	1.084	1.08	0.976	0.995	0.89	0.986	0.955
EIPICO6	1.569	0.779	0.802	1.041	0.952	1.129	0.885	0.911	1.091	0.987	1.017	1.079
Kahira6	1.093	1.005	0.909	1.059	0.945	0.98	1.024	0.958	0.967	1.022	1.013	0.97
Memphis6	1.065	1.055	0.917	1.097	0.975	1.038	1.033	0.977	0.999	0.982	0.897	1.029
Misr8	1.08	0.931	1.013	1.125	1.011	0.978	1.25	0.957	1.016	0.884	1.092	1.083
MUP9	1.292	1.138	1.07	1.068	1.02	0.867	1.064	0.984	1.034	1.039	0.874	1.279
Nasr6	0.723	1.978	1.197	0.766	0.801	1.201	1.021	1.367	0.862	0.963	1.033	0.954
Nile6	0.872	1.015	0.917	0.992	1.045	1.037	0.991	1.016	0.916	1.083	0.743	1.244
PHARCO8	1.089	1.106	0.778	1.038	1.1	1.015	0.63	0.912	0.954	1.186	1.151	1.212
SEDICO5	1.122	0.952	0.971	1.053	1.07	0.988	0.998	0.869	0.979	1.063	0.916	1.075
mean	1.071	1.06	0.944	1.026	0.999	1.012	1.002	0.995	0.978	1.001	0.959	1.059

Table 9: Malmquist Index Summary of Firm Means

	Technical Efficiency Change (relative to a CRS technology)	Technological Change	Pure Technical Efficiency Change (relative to VRS technology)	Scale Efficiency Change	Total Factor Productivity Change
ADCO	1.011	0.995	1.026	0.986	1.006
Alex	0.990	1.006	0.990	1.000	0.996
Amriya	1.000	1.003	1.000	1.000	1.003
CID	0.992	1.011	0.988	1.004	1.003
EIPICO	0.995	1.009	1.000	0.995	1.004
Kahira	0.992	1.002	0.991	1.001	0.994
Memphis	0.997	1.007	0.994	1.003	1.004
Misr	1.031	1.000	1.034	0.996	1.031
MUP	1.005	1.049	1.002	1.003	1.053
Nasr	1.014	1.017	1.004	1.010	1.031
Nile	1.005	0.977	1.001	1.004	0.982
PHARCO	1.000	0.999	1.000	1.000	0.999
SEDICO	0.995	1.007	1.000	0.995	1.002
mean	1.002	1.006	1.002	1.000	1.008

All Malmquist index averages are geometric means

Table 10: TFP Change and Export Orientation

	ADCO		Alex		Amriya		CID		EIPICO		Kahira		Memphis	
	TFP Δ	Exports*	TFP Δ	Exports	TFP Δ	Exports	TFP Δ	Exports	TFP Δ	Exports	TFP Δ	Exports	TFP Δ	Exports
1994	1.132	3.9	1.012	4.2	1.150	1.2	0.937	4.1	1.569	10.2	1.093	6.4	1.065	5.1
1995	0.917	5.5	1.011	4.1	1.053	1.3	1.186	2.3	0.779	11.9	1.005	6.6	1.055	4.6
1996	0.996	7.2	0.922	5.5	0.952	2.7	0.902	0.7	0.802	10.6	0.909	5.6	0.917	5.7
1997	1.064	5.4	1.086	3.7	0.967	2.4	1.033	2.9	1.041	9.5	1.059	7.5	1.097	5.1
1998	0.997	6.9	0.997	4.2	1.056	2.6	1.056	3.9	0.952	13.8	0.945	13.9	0.975	5.0
1999	0.915	10.8	0.986	4.9	0.980	2.6	1.084	3.3	1.129	11.4	0.980	13.7	1.038	5.3
2000	1.051	7.8	1.065	4.0	1.079	1.6	1.080	2.0	0.885	10.7	1.024	10.5	1.033	1.9
2001	1.098	6.6	0.939	4.0	1.051	2.5	0.976	2.2	0.911	11.9	0.958	12.0	0.977	4.5
2002	0.982	7.8	0.990	4.5	0.949	2.8	0.995	2.6	1.091	12.1	0.967	14.3	0.999	5.1
2003	0.985	13.3	1.058	5.5	0.918	5.8	0.890	3.9	0.987	12.7	1.022	11.5	0.982	3.6
2004	0.935	18.1	0.859	6.8	1.024	4.1	0.986	4.5	1.017	12.3	1.013	13.3	0.897	6.9
2005	1.024	6.0	1.049	7.1	0.893	9.0	0.955	4.7	1.079	12.7	0.970	11.2	1.029	8.8
Correlation Coefficient		-0.56		-0.34		-0.73		-0.14		-0.25		-0.29		-0.19

	Misr		MUP		Nasr		Nile		PHARCO		SEDICO	
	TFP Δ	Exports	TFP Δ	Exports	TFP Δ	Exports	TFP Δ	Exports	TFP Δ	Exports	TFP Δ	Exports
1994	1.080	9.7	1.292	1.2	0.723	7.1	0.872	9.1	1.089	7.5	1.122	0.2
1995	0.931	9.0	1.138	0.8	1.978	8.1	1.015	9.3	1.106	10.4	0.952	0.5
1996	1.013	10.8	1.070	2.6	1.197	4.2	0.917	8.5	0.778	14.7	0.971	1.4
1997	1.125	13.5	1.068	2.6	0.766	4.1	0.992	7.2	1.038	12.6	1.053	0.6
1998	1.011	14.1	1.020	3.4	0.801	3.8	1.045	7.9	1.100	13.1	1.070	2.0
1999	0.978	15.4	0.867	3.5	1.201	4.7	1.037	9.7	1.015	12.6	0.988	3.6
2000	1.250	5.0	1.064	3.4	1.021	5.2	0.991	8.1	0.630	9.3	0.998	3.7
2001	0.957	8.6	0.984	4.4	1.367	5.7	1.016	9.6	0.912	13.2	0.869	6.0
2002	1.016	11.3	1.034	5.0	0.862	9.0	0.916	13.1	0.954	17.8	0.979	6.3
2003	0.884	13.6	1.039	0.7	0.963	8.6	1.083	16.1	1.186	18.9	1.063	8.0
2004	1.092	13.2	0.874	7.0	1.033	9.5	0.743	15.5	1.151	19.5	0.916	4.8
2005	1.083	12.3	1.279	6.7	0.954	8.8	1.244	11.1	1.212	15.5	1.075	12.8
Correlation Coefficient		-0.39		-0.25		0.11		-0.17		0.34		0.00

*Exports as a share of total output

Annex 1[7]

The Malmquist index of TFP growth *M* between period t and period t+1 is stated as follows

$$M_h^{t+1}(\chi_h^t, y_h^t, \chi_h^{t+1}, y_h^{t+1}) = \left[\frac{D_h^t\left(\chi_h^{t+1}, y_h^{t+1}\right) D_h^{t+1}\left(\chi_h^{t+1}, y_h^{t+1}\right)}{D_h^t\left(\chi_h^t, y_h^t\right) D_h^{t+1}\left(\chi_h^t, y_h^t\right)} \right]^{1/2} \tag{1}$$

The two inputs (in the case of this paper there are three inputs) capital *K* and labor *L* of firm *h* (*h*=1, …,*n*) in period *t* are contained in the input vector $x_h^t = (K_{ht}, L_{ht})'$ and the sector wide output $Y_h^t = (Y_{ht})$. The Malmquist index is the geometric mean of two ratios of distance functions of the type

$$D_h^q\,(\chi_h^q, y_h^q) = (\sup\{\phi : (\chi_h^q, \phi\, y_h^q) \in S(p)\}^{-1}\ ;\ p,q = t, t+1 \tag{2}$$

this gives the reciprocal of the maximum augmentation of output in period *q* that is needed to reach the boundary point of the technology set

$$S(p) = \{(\chi_h^p, y_h^p) : \chi_h^p \geq 0 \text{ can produce } y_h^p \geq 0,\ \forall h = 1,\ldots, n) \tag{3}$$

in period *p*. The Malmquist index will then indicate positive (negative) TFP growth between period t and *t*+1 if it is larger (smaller) than 1.

The Malmquist index can be decomposed into two factors of importance

$$M_h^{t+1} = (x_h^t, y_h^t, x_h^{t+1}, y_h^{t+1}) = \underbrace{\frac{D_h^{t+1}(x_h^{t+1}, y_h^{t+1})}{D_h^t(x_h^t, y_h^t)}}_{EF_h^{t+1}} = \underbrace{\left[\frac{D_h^t(x_h^{t+1}, y_h^{t+1})\ D_h^t(x_h^t, y_h^t)}{D_h^{t+1}(x_h^{t+1}, y_h^{t+1})\ D_h^{t+1}(x_h^t, y_h^t)}\right]^{1/2}}_{TP_h^{t+1}} \tag{4}$$

in which the first factor EF denotes the change in productive efficiency between period *t* and *t*+1, while the second factor TP denotes the rate of technological change (Krüger, 2003).

Using real data, the application of the above theoretical device for inputs and output, a method for the quantification of the various distance functions (2) is required. Such calculations are performed by solving the linear programming problems of DEA. In this paper the output-oriented envelopment for firm *h* (assuming constant returns to scale) is

$$\max_{\varphi,\lambda} \varphi_h$$

$$\text{s.t. } \phi_h Y_{hq} - \sum_{i=1}^{n} \lambda_i Y_{ip} \leq 0$$

$$\sum_{i=1}^{n} \lambda_i K_{ip} \leq K_{ip}$$

[7] Source: Krüger, Jens J. (2003). The Global Trends of Total Factor Productivity: Evidence from the Nonparametric Malmquist Index Approach. Oxford Economic Papers 55 (2003) pp. 265–286.

$$\sum_{i=1}^{n} \lambda_i L_{ip} \leq L_{hq}$$

$$\lambda_1, \ldots\ldots, \lambda_n \geq 0 \qquad (5)$$

and then setting $D_h^p(x_h^q, y_h^q) = \phi_h^{-1}$ for all (p,q) Є {(t,t), (t,t+1),(t+1,t), (t+1,t+1)}.

According to this procedure, the input-output combinations of each firm in period q is compared to the piece-wise linear frontier production function which consists of the input-output combinations of the most productive firms in period q. The maximization increases ϕ_h. Each firm in period q is compared to a point on the frontier function that is constructed by the λ-weighted linear combination on the inputs and outputs of the all firms in period p, whereby only the firms that are most similar to h are assigned a positive value to λ (Krüger, 2003).

Annex 2

TFP Growth in Manufacturing Industries in Egypt, 1980/81–2000/01

Sector / TFP Growth	1980/81-1994/85	1985/86-1990/91	1991/92-1995/96	1996/97-2000/01	1980/81-2000/01
Food Processing	-0.46	1.48	1.42	0.67	0.75
Spinning and Weaving	-0.04	0.96	1.72	0.59	0.81
Readymade Garments	0.67	2.16	1.89	0.59	1.33
Leather and Leather Products	1.61	-0.27	-0.9	1.32	0.44
Footwear	-1.25	0.62	2.44	0.77	0.65
Wood and Wood Products	0.46	-0.3	1.7	5.44	1.83
Furniture	1.72	0.75	-0.42	1.17	0.81
Paper and Printing	0.55	-0.3	1.11	1.06	0.61
Chemicals	0.96	5.39	-0.57	-0.24	1.39
Rubber, Plastic and Related Products	1.36	2.4	2.78	-0.65	1.47
Porcelain, China and Ceramics	0.1	2.33	3.01	-2.48	0.74
Glass Products	0.57	0.3	0.88	-0.14	0.4
Non-Metal Products	1.55	-1.56	-0.75	-0.92	-0.42
Steel, Iron and Metal Products	1.76	-1.29	0.85	0.02	0.34
Machinery and Equipment	-0.06	1.92	1.91	-1.38	0.6
Means of Transportation	1.29	0.86	-0.48	-0.96	0.18
Mean	0.67	0.97	1.04	0.3	0.75
Standard Deviation	0.84	1.64	0.26	0.67	0.53

Source: Galal, Ahmed and Nihal El-Megharbel (2005). Do Governments Pick Winners or Losers? An Assessment of Industrial Policy in Egypt. Egyptian center of Economic Studies Working Paper No. 108, December 2005

Annex 3

Egypt Consumer Price Index (2000 = 100)

Year	
1987	25.50
1988	30.00
1989	36.38
1990	42.48
1991	50.87
1992	57.80
1993	64.79
1994	70.07
1995	81.10
1996	86.93
1997	90.95
1998	94.48
1999	97.39
2000	100.00
2001	102.27
2002	105.07
2003	109.81
2004	122.18
2005	128.13

Source: World Development Indicators

Wholesale Price Index (1986/87=100)*

End of June	1993**	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
General Index	287.0	300.4	316.7	348.6	365.2	367.5	373.6	379.4	384.2	397.7	469.2	543.7	571.5
Farm Products	199.1	214.6	227.9	266.1	284.3	275.9	292.8	302.9	316.9	333.0	432.2	488.8	497.3
Food Stuffs	376.3	395.7	408.7	464.4	497.7	494.3	502.7	503.6	500.3	517.9	631.7	741.1	787.1
Beverages & Tobacco	265.0	265.4	272.0	294.2	298.5	298.5	325.6	325.6	328.5	328.5	340.9	394.7	405.0
Yarn &Textiles	266.6	275.0	291.7	320.6	328.2	334.3	336.5	366.2	389.3	396.4	426.3	555.4	582.6
Wearing Apparel	335.2	351.6	368.7	376.1	378.4	386.6	393.9	410.4	417.9	429.3	444.6	495.0	506.3
Leather & Footwear	347.8	355.5	363.5	363.9	388.5	388.5	388.5	386.2	395.4	404.2	425.4	500.2	526.7
Wood & its Products	278.7	283.3	310.9	313.6	314.8	315.7	317.1	311.4	310.3	311.0	401.3	470.2	407.7
Paper & Printing	283.7	284.0	365.5	389.9	390.4	400.2	339.1	356.7	354.4	354.4	409.2	452.1	488.6
Chemicals & its products	311.5	330.7	346.4	375.3	385.2	402.2	402.3	404.5	400.4	405.5	419.1	462.0	486.3
Fuel & Related Products	610.5	620.9	623.3	632.7	632.7	684.0	684.1	679.2	679.2	690.4	686.7	733.9	845.3
Rubber & Plastic Products	213.7	217.3	260.0	293.5	295.6	300.5	306.5	306.2	269.4	313.5	336.3	377.4	405.1
Nonmetallic Mineral Products	232.6	262.3	273.8	293.9	297.2	317.4	320.1	323.8	320.9	332.7	338.7	386.6	427.1
Metals	279.0	279.1	325.9	338.0	352.7	361.9	322.0	333.4	333.4	352.8	454.0	630.2	707.8
Metallic Products, Machinery&Equipment	271.9	279.7	284.6	293.7	301.1	308.9	314.2	306.7	308.8	317.8	348.1	389.9	408.4
Transportation Equipment	340.0	341.4	385.6	393.6	393.6	401.2	370.8	362.0	362.0	362.5	428.0	589.2	572.5
Other Manufacturing Products	204.1	209.5	214.2	227.6	346.2	344.8	358.7	398.7	399.4	426.7	486.8	503.9	614.8

Source: Central Bank of Egypt

* As from January 1994. The base year became 1986/87 = 100, instead of 1965/66=100.

** at End of July 1993

Investment Deflator

	Investments in Current Prices (LE billion)	Investments in Constant Prices (LE billion)	Index
1992/93	29	6.2	100
1993/94	34	6.9	105
1994/95	39.1	7.3	115
1995/96	39.7	8.2	104
1996/97	47.7	9.3	110
1997/98	61.3	11.4	115
1998/99	64	11.8	116
1999/00	64.4	11.5	120
2000/01	63.6	11.3	120
2001/02	67.5	11.9	121
2002/03	68.1	11	132
2003/04	79.6	11.7	145
2004/05	96.5	13.4	154
2005/06	115.7	15.2	163
2006/07	155.3	20	166

Source: Ministry of Planning