ECONOMIC RESEARCH FORUM
منتدى البحوث الاقتصادية
2018

working paper series

SOURCES OF HETEROGENEITY IN LABOR PRODUCTIVITY AND TOTAL FACTOR PRODUCTIVITY IN EGYPTIAN MANUFACTURING

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Working Paper No. 1276

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December 2018

The authors would like to thank Dr. Amirah El Haddad, Dr. Ragui Assaad, and Dr. Caroline Krafft for useful comments and suggestions.

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First published in 2018 by
The Economic Research Forum (ERF)
21 Al-Sad Al-Aaly Street
Dokki, Giza
Egypt
www.erf.org.eg

Abstract

Egypt Ranking in the World Competitiveness Report deteriorated between 2004 and 2017. Boosting competitiveness requires reforms on several important fronts, but raising labor productivity and TFP are perhaps the most pressing. This paper identifies the correlates of both labor productivity and TFP at the firm level in Egypt's in manufacturing sector using Economic Census data for the year 2012/2013.We find significant heterogeniety in both Labor productivity and TFP between firms. By econometirically dicotomizing firms into low and high productivity regimes, we find that the correlates of productivity differ between these two sets of firms. By identifying the sources of heterogeneity between low and high productivity firms we show that there is considerable scope for the former to catch up with the lattter based on factors that are internal to the firm .However, the literature does not offer much insights as to how high productivity firms can increase their productivity further.

Keywords: Labor productivity, TFP, Egypt, Mixture model, Heterogeneity.

JEL Classifications: O14, O17, O33, O47

ملخص

تراجعت مصر في التصنيف العالمي للتنافسية في الفترة ما بين عامي 2004 و 2017. إن تعزيز القدرة التنافسية تتطلب إجراء إصلاحات على عدة جبهات مهمة ، ولكن رفع إنتاجية العمالة وعوامل الإنتاج الكلى هي الأكثر إلحاحًا. تحدد هذه الورقة العلاقة بين إنتاجية العمالة وعوامل الإنتاج الكلى على مستوى الشركة في قطاع الصناعات التحويلية في مصر. باستخدام بيانات التعداد الاقتصادي لعام 012/2013 ، نجد عدم تجانس كبير في إنتاجية العمالة وفى عوامل الإنتاج الكلى بين الشركات. ومن خلال الشركات تقسيم البيئة الاقتصادية إلى أنظمة الإنتاجية المنخفضة أوأنظمة الإنتاجية العالية ، نجد أن الارتباط بين الإنتاجية يختلف بين هاتين المجموعتين من الشركات. من خلال تحديد مصادر عدم التجانس بين الشركات ذات الإنتاجية المنخفضة والعالية ، نبين أن هناك مجالًا كبيرًا للحاق بالشركات ذات الإنتاجية العالية استنادًا إلى عوامل داخلية متعلقة بالشركة ذاتها. ومع ذلك ، لا تقدم الأدبيات الكثير من الأفكار حول كيف يمكن للشركات ذات الإنتاجية العالية زيادة إنتاجيتها بشكل أكبر.

1.Introduction

Egypt's ranking in the World Competitiveness Report deteriorated between 2004 and 2017. In 2004 Egypt ranked 62 out of 104 countries (Egypt competitiveness report 2014/2015) while in 2017, Egypt ranked 115 out of 138 countries, falling behind several countries in sub-Saharan Africa like Ghana and Gabon. While boosting competitiveness requires reforms on several important fronts, such as improving infrastructure and reforming institutions, raising Egypt's low labor productivity or TFP are perhaps the most pressing. While low labor productivity is eroding the country's comparative advantage in low wages vis a vis competitors like China (Elshennawy, 2009), the phasing out of water and energy subsidies have certainly served to increase competitive pressures facing producers. To cope with competitive pressure in general, "a robust finding in the literature- virtually invariant to country, time period or industry- is that higher productivity producers are more likely to survive than their less efficient industry competitors. Productivity is quite literally a matter of survival for businesses"(Chad, 2011 P.327).

Enhancing productivity is essential for stimulating manufactured exports as the January 11th revolution and the political turmoil it generated made apparent that relying on tourism to generate foreign exchange can be unsustainable. It is thus imperative to rely on other sources of foreign exchange earnings that are less sensitive to political instability. However, in order to raise productivity, it is necessary first to identify the factors underlying low productivity. Egypt's low labor productivity is mainly explained by the lack of structural change. Between 2000 and 2010, the structure of the economy remained largely unchanged with the bulk of employment concentrated in low productivity sectors, mainly agriculture and public and social services. Employment in agriculture and the public sector (including health and education services) accounts for more than half of employment in the economy, but their share output is just 30%. (Morsi et al, 2015). On the other hand, employment in high productivity sectors like mining and financial services have stagnated. With the exception of mining, in general sectoral labor productivity does not compare favorably to other countries in a sample consisting of a host of African and Asian countries with Egypt lying in the bottom half of this sample (Morsi et al, 2015).

Although factors underlying low labor productivity at the macro level – in the case of Egypt – are well understood as noted above, factors underlying low labor productivity at the micro level, namely the sector and firm level, are not well understood. This is especially true for sectors like manufacturing. Interestingly, a survey of firms in the readymade garment sector (Elshennawy 2009) revealed that most producers view low labor productivity as a major setback while few others did not. Most firms that complained of low labor productivity attributed this to either cultural factors that undermined work ethics or overly protective labor laws that rendered punitive

action against underperforming workers impossible. In short, most firms attributed low labor productivity to factors external to the firm and justified their request for protection from imports based on this claim. Such heterogeneity in labor productivity among firms however, suggests that the factors underlying low labor productivity might very well turn out to be internal to the firm.

While the mere existence of heterogeneity in labor productivity across firms in the manufacturing sector as a whole must be first empirically assessed before one can assert the validity of this contention, it nonetheless raises several important questions: 1) what is the extent and what are the sources of heterogeneity, if any, in labor productivity?. Moreover, given that the empirical literature on the determinants of TFP provides evidence on the existence of large and persistent differences in productivity across firms in the same industry (Foster et al., 2001), then 2) is there also heterogeneity in TFP across firms in Egypt's manufacturing sector? If yes, then again 3) what is its extent and what are the underlying sources.? Answering these questions can provide valuable insights to both firms and policy makers on how productivity can be increased. However, to answer these questions it is essential to identify the determinants of both labor productivity and TFP.

In general, empirical evidence on the determinants of firm level labor productivity as well as TFP is scant in developing countries (Srithanpong, 2016) and Egypt is no exception in this regard. Apart from a study by Sekkat (2009) on labor productivity and Chaffai and Plane (2017) along with Gahli et al. (2013) for TFP, where the range of independent variables and/or sector coverage is rather limited, there is dearth of research in this area when it comes to the case of Egypt. It is thus no surprise that policy makers have done little if anything to address the problem of low productivity so far and firms continue to believe that their low productivity is due to factors beyond their control.

In light of this background, this paper seeks to identify not only the correlates of labor productivity and TFP but also the sources of heterogeneity in both variables, if any, at the firm level in Egypt's manufacturing sector using Economic Census data for 2012/13. Our contribution is both methodological and empirical. In contrast to the approach followed in the literature, rather than taking the statistical significance of various correlates of productivity as evidence for the existence of heterogeneity, we are actually able to econometrically dichotomize firms into high and low productivity regimes. This not only provides more concrete evidence on the existence and extent of heterogeneity, but also enables us to explore whether firms in each regime respond in the same way or differently to various correlates of productivity. We then proceed to uncover the sources of heterogeneity in productivity between the two regimes.

We find significant heterogeneity in productivity between firms in the two regimes. We also found that firms in each regime have different correlates of productivity. Estimation results show that factors related to low productivity are internal to the firm and that there is considerable scope for low productivity firms to catch up with high productivity firms. The scope for the latter firms to increase productivity further based on insights from literature is however quite limited. Polices that fail to take into consideration these limitations are likely to be at best overly optimistic.

The rest of this paper organized as follows: section two reviews both the theoretical and empirical literature on the determinants of labor productivity and TFP, section three presents methodology, section four discusses data, section five discusses estimation results and finally section six concludes.

2.Literature Review

In this section we seek to identify the factors that are related to labor productivity and TFP, here-after termed productivity, in Egypt's manufacturing sector. Following Zheng et al. (2017) we group these correlates into labor related, capital related, market related and institutional related factors. (A detailed survey of most of these variables can be also found in Ding et al 2016 and Harris and Moffat, 2015). These factors relate to productivity in general except for capital intensity, which relates to labor productivity only.

(a) Labor-Related Factors

Wages: Efficiency wage theory assumes that firms may find it optimal to pay a wage above the average wage or opportunity wage for workers. If higher wages lead to lower turnover, less shirking and a more efficient selection of workers in addition to improved morale, then the cost savings or induced higher productivity may outweigh the cost of the higher wage. Firms may find it profitable to pay efficiency wages, because monitoring individual behavior is costly and almost impossible while punishment for low performance may be legally restricted. Efficiency wages increase the cost of job loss to the worker, encouraging higher work effort (Sanchez and Toharia, 2000). In general firms pay high wages to more efficient workers and so the higher the wage the higher the productivity (Gonclaves and Martins, 2016). *The presumption is that there is a positive association between higher wages and productivity.*

Temporary versus permanent employment: A review of empirical studies conducted in Sanchez and Toharia, (2000) show that firms that pay higher wages also experience higher productivity. In analyzing the impact of a number of factors on the likelihood a firm pays efficiency wages for the

Spanish economy between 1990-94 using cross section data, Sanchez and Toharia (2000) found that the larger the share of temporary workers, the less likely firms will pay efficiency wages and thus the lower will be their productivity. The authors envisage that although temporary contracts may increase productivity as workers increase effort to increase their chances of being permanently employed, they nonetheless reduce productivity as both firms and workers invest less in human capital and training. Also, if temporary workers expect they will not be hired as permanent workers, their effort will be less. Firms hiring temporary workers may have less incentive to invest in functional (internal) flexibility which reduces their capacity to innovate and hence reduces productivity (Michie and Sheehan 2003). Temporary employment was found to impinge negatively on productivity particularly for skilled intensive sectors in Europe (Lisi and Malo, 2017). *Overall, the presumption is that there is a negative association between temporary employment and productivity.*

Skill Intensity: labor skills are the most important determinant of productivity, as skilled labor is more efficient (Ramstetter, 2004; Chad, 2011; Aiello et al., 2015; Srithanpong, 2016)). *The presumption is that there is positive association between skilled labor and productivity.*

Female share of labor: due to cultural factors that basically view women in Egypt as mothers and housewives, female employment is characterized by high turnover which impinges negatively on productivity. Chun and Lee (2015) also attribute the low productivity of female workers in Indian manufacturing to the fact that males are more educated than females, which also holds true in the case of Egypt. The lower level of human capital among females in Egypt can limit their ability to absorb and utilize advanced technology. *The presumption is that there is a negative association between female labor and productivity*.

Managerial Quality: Managerial quality as measured by educational attainment has a positive impact on productivity. Managers coordinate the use of labor, capital and intermediate inputs as well as incentivize workers. Managerial abilities such as the ability to develop new products, organize production, and adapt when faced with changing circumstances also affect productivity. Poor management is thus expected to affect the process of production negatively (Chad, 2011; Foster et al, 2001). Managerial quality is proxied by earnings per managerial staff. Managers' wages will thus be taken to reflect the quality of managerial staff. The higher managers' wages the more qualified they are (Lall et al., 2004). *The presumption is that there is a positive association between managerial wages and productivity.*

Location: Firms located in big cities have more access to qualified managers and hence labor productivity in these firms should be high (Papadogonas and Voulgaris, 2005). Moreover, as energy and labor costs may vary across locations, firm location can lead to heterogeneity in outcomes at the firm level (Foster et al., 2001; Srithanpong 2016; Harris and Moffat 2015; Ding et al. 2016; Aiello et al., 2015). *The presumption is that there is a positive association between firms being located in big cities and productivity.*

(b) Capital Related Factors

Capital Intensity: investment in capital raises productivity if it increases the capital-labor ratio. Also, since new capital usually embodies the latest technology it can raise labor productivity (Zheng et al, 2017). On the role of capital intensity in influencing productivity, using firm level data from the US over the period 1976-1999, Autor et al. (2007) show that as a result of inefficient dismissal protection, firms substituted capital for labor thus raising labor productivity. *The presumption is that there is a positive association between capital intensity and labor productivity*.

Size: Large firms are better suited to exploit economies of scale and thus use both labor and capital more efficiently (Zheng et al, 2017; Fallahi et al 2010). Size may also affect productivity from a different angle. Size is one factor that determines the managerial organization of the firm. Large firms may suffer from bureaucratic frictions and lack of motivation by workers, which might lead to inefficiency (Diaz and Sanchez, 2008). On the other hand, as firms exploit economies of scale they can undertake R&D and thus increase productivity. *The presumption is that the relationship between size and labor productivity can be either positive or negative, but is positive in the case of TFP.*

Age: young firms are usually small or medium in size with high skills and knowledge intensity as well as new technology. Therefore, the younger firms are the higher their productivity (Papadogonas and Voulgaris, 2005). Conversely, older firms can be more productive through learning by doing (Srithanpong 2016; Ding et al 2016). *The presumption is that the relationship between age and productivity can be either negative or positive.*

Information and Communication Technology (ICT): According to Arvanitis and Loukis (2009) ICT can save on inputs, lower costs, introduce flexibility, improve lateral communication within the firm and therefore reduce coordination costs. ICT also can reduce the cost of monitoring by reducing the need for supervisors, which in turn has direct implications for firm organizational

structure. IT was the main factor underlying the dramatic increase in US aggregate productivity from mid-90's after a long period of stagnation (Chad, 2011:Mitra et al 2016). *The presumption is that the larger ICT capital is, the higher productivity is.*

(c) Market Related Factors

Export Status: Competition on world markets induces firms to increase efficiency and flexibility and therefore improve the productivity of both labor and capital to reduce costs or else the survival of the firm is threatened (Chen, 2002; Fu & Balasubramanyam, 2003; Ito, 2006; Krishna & Mitra, 1998; Li, 2003 in Zheng et al., 2017). Trade enhances productivity through learning by doing, import of innovative products or better managerial practices (Gonclaves and Martins, 2016; Srithanpong 2016: Mitra et al. 2016; Ding et al. 2016; Aiello et al., 2015). *The presumption is that there is a positive association between exporting and productivity*

Foreign Ownership: Theoretically speaking, Multi-National Corporations (MNC) are expected to be more efficient than local firms since they possess firm-specific assets, especially those that are intangible, such as those related to production techniques and processes, marketing networks and/or management skills. Possessing these assets renders it likely that labor and other factors of production are more productive than in other local plants. Because labor demand is determined by labor productivity, it is likely that if labor is more productive in MNCs then it is also paid higher wages. Labor productivity and wages may be also higher in MNCs because in general these companies are more capital and skill intensive than their local counterparts (Ramstetter, 2004). However, some argue that due to cultural differences and difficulty in assimilating new plants, local firms may be more productive than foreign firms (Papadogonas and Voulgaris, 2005; Srithanpong 2016; See Harris and Moffat, 2015 for a survey of the literature; Ding et al 2016). *The presumption is that the association of foreign ownership with productivity can be positive or negative.*

Research and Development (R&D): Hecht (2018) asserts that modern economic theory points to the importance of R&D in influencing labor productivity and finds a positive and significant effect of R&D on labor productivity in a sample of high tech firms across the advanced world, China and India over the period 1990-2013. Spending on intangible assets such as R&D enables firms to increase competitiveness and TFP as R&D increases both process and product innovation. In addition R&D leads to the development of absorptive capacity, which is the ability to benefit from R&D undertaken by other firms, universities and research institutes (See Harris and Moffat, 2015 for a survey of this literature; Mitra et al. 2016; Aiello et al., 2015). *The presumption is that there is a positive relationship between R&D and productivity*.

(d) Institutional Related Factors

Informality: Though in general no accurate data is available on the size of the informal sector, defined to encompass firms that do not abide by laws or regulations, the size of this sector is substantial in the case of many developing countries and Egypt is no exception.(Galal, 2004) These firms typically pay low wages and workers do not receive other benefits in the form of social or health insurance. In addition, the technological capabilities of these firms are rather primitive. All these characteristics lead to low productivity compared to firms operating in the formal sector. *The presumption is that informality is negatively associated with productivity.*

Finally, a factor that can be grouped under both market and institutional related factors is uncertainty: Uncertainty about the demand for new products or the cost effectiveness of various types of technologies induces firms to experiment with different technologies, products, etc. This process of experimentation gives rise to differences in outcomes across firms. Even when firms lack any incentives to experiment, the uncertainty surrounding future cost or demand conditions entices them to differentiate their products as well as technology to be able to compete (Foster et al, 2001). On the other hand, uncertainty in the institutional environment has the opposite effect. *The presumption is that the relationship between uncertainty and productivity can be either positive or negative.*

3.Methodology

In the analysis of the productivity heterogeneity between firms, we use the mixture model as a general framework. We assume that the *i* firms belong to *J* different groups where the variable productivity has possibly different distribution across each group. The group's j^{th} density is denoted by $f(y_i|\mu_j,\sigma_j,p_j)$. The group membership of a given firm is ex-ante unknown. The model has the following general form:

$$f(y_i|\theta) = \sum_{j=1}^{J} p_j f(y_i|\mu_j,\sigma_j,p_j)$$

where y_i is the productivity level, $\theta = (\mu_1,\mu_2,\ldots,\mu_J,\sigma_1,\sigma_2,\ldots,\sigma_J,p_1,p_2,\ldots,p_J)$ μ_j and σ_j are the productivity location and dispersion parameters and p_j ($0< p_j <1$) are mixing probabilities such that $\sum_{j=1}^{J} p_j = 1,\ j = 1,2\ldots,J.$.

The model implies that the heterogeneity may come from the fact that the groups have different average productivity (different μ_j) or from the difference in the degree of productivity dispersion between groups (different σ_j) or both.

To test for no heterogeneity in the unconditional means, we test the following hypothesis:

$$H_0 : \mu_1 = \mu_2 = \ldots = \mu_J,$$

and to test for no heterogeneity due to difference in the degree of dispersion, we test the following hypothesis:

$$H_0 : \sigma_1 = \sigma_2 = \ldots = \sigma_J.$$

To test for no heterogeneity of any kind, we test the following joint hypothesis:

$$H_0 : \mu_1 = \mu_2 = \ldots = \mu_J \text{ and } \sigma_1 = \sigma_2 = \ldots = \sigma_J.$$

To run these tests, we will use the likelihood ratio test.

3.1 The model for conditional heterogeneity

To model the conditional heterogeneity, we assume that the group *j*'s density is denoted by $f(y_i|\mu_{j,i}, \sigma_j, p_j)$ and the group membership of a given firm is ex-ante unknown. The model has the following general form:

$$f(y_i|\theta_{j,i}) = \sum_{j=1}^{J} p_j f(y_i|\mu_{j,i}, \sigma_j, p_j)$$

The regression equation (i.e. the conditional mean $\mu_{j,i}$), is modeled as follows:

$$\mu_{j,i} = \beta_0 + \beta_1 x_{1,t} + \ldots + \beta_\kappa x_{\kappa,t},$$

Where $x_{1,i}, \ldots, x_{\kappa,i}$ are the explanatory variables discussed in the section Literature Review " , $\beta_{0,j}, \ldots, \beta_{\kappa,j}$ are the regression parameters to be estimated and ε_{i} is the error term (unexpected productivity).

To test for no heterogeneity in the conditional means, we test the following hypothesis:

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_J,$$

and to test for no heterogeneity due to differences in the degree of dispersion, we test the following hypothesis:

$$H_0 : \sigma_1 = \sigma_2 = \ldots = \sigma_N.$$

To test for no heterogeneity of any kind, we test the following hypothesis:

$$H_0 : \beta_1 = \beta_2 = \ldots = \beta_J \text{ and } \sigma_1 = \sigma_2 = \ldots = \sigma_J.$$

As in the case of unconditional model, to run these tests we will use the likelihood ratio test.

There may be a problem of endogeneity in the model. However, in the absence of strong and valid instruments implementing an instrumental estimator is not feasible.

3.2 Group membership and difference in productivity

To study the disparities in productivity across firms, we first need the split them into different groups. Since a priori, we don't know the group membership of the firm, we have to determine the firm's belonging using the results of our model. To do that, we compute the conditional probability $p_{i,k}$ for the firm i to belong to group k. This probability is given by:

$$p_{i,k} = \frac{p_k f(y_i|\mu_k, \sigma_k, p_k)}{\sum_{j=1}^{J} p_j f(y_i|\mu_j, \sigma_j, p_j)}.$$

The firm i belongs to group g if

$$p_{i,g} = \max_k p_{i,k} \ (k = 1, 2, \ldots, J).$$

Once the groups are determined, we will study the difference between these different groups.

3.3 Estimation

We use the Maximum-Likelihood Estimator to estimate the models. In the case of the unconditional model, the log-likelihood function is given by:

$$\begin{aligned}\mathcal{L} &= \sum_{i=1}^{N} \ln(f(y_i|\theta)) \\ &= \sum_{i=1}^{N} \ln\left(\sum_{j=1}^{J} p_j f(y_i|\mu_j, \sigma_j, p_j) \right).\end{aligned}$$

The log-likelihood function in the case of conditional model is given by:

$$\mathcal{L} = \sum_{i=1}^{N} \ln(f(y_i|\theta))$$
$$= \sum_{i=1}^{N} \ln\left(\sum_{j=1}^{J} p_j f(y_i|\beta_j, \sigma_j, p_j) \right).$$

The gradient is given by:

$$\nabla_\theta = \frac{\partial \mathcal{L}}{\partial \theta}.$$

The Maximum-Likelihood Estimator of θ is the vector $\hat{\theta}$ that solves:

$$\nabla_\theta = 0.$$

We estimate the models using different specifications of the mixture components $f(y_i|\theta)$.

To discriminate between specifications, we use the Schwarz information criterion known also as Bayesian information criterion (BIC).

The Schwartz criterion measures the degree of loss of information caused by using a particular model. The criterion is given by:

$$Schwartz = -\frac{2\ln(L)}{N} + k\frac{2\ln(N)}{N}$$

where L is the maximized Likelihood function, k is the number of parameters and N is the sample size. The model with the lowest value is the one preferred. We note that the criterion penalizes models with a large number of parameters.

We also conducted the Wald test for the joint equality of betas across regimes. That is, we tested for the validity of the following hypotheses:

The test for no heterogeneity in the conditional means, we test the following hypothesis:

$$\beta_1 = \beta_2$$

and to test for no heterogeneity due to difference in the degree of dispersion, we test the following hypothesis:

$$\sigma_1 = \sigma_2.$$

4. Data

We use data from Egypt's Economic Census for the year 2012/2013. The total number of firms used in the estimation is 8,843 out of 62,108. The data used covers private firms in the manufacturing sector. A firm is excluded from the sample if it has missing data. The dependent variable in our study is labor productivity at the firm level, measured by gross output per employee, or TFP. The explanatory variables are measures of the various labor, capital, market and institutional related factors outlined in the previous section. In Matrix 1, these variables along with their exact definition and expected sign are listed below.

Matrix 1 Variables and Definitions

Variable	**Definition**	**Expected Sign**
Labor productivity	Ratio of firm's gross output to firm's employment (dependent variable)	
Labor Related Factors		
Average Wages	Ratio of firm total wages to firm's employment	+
Temporary to Permanent Employment	Ratio of temporary to permanent Employment	?
Skill Intensity	Ratio of skilled to unskilled labor	+
Share Female	Ratio of female to total employment	-
Managers Compensation	Ratio of managers' wages to number of managers	+
Location	Dummy Variable =1 if firm is located in Greater Cairo or Alexandria	
	and is zero otherwise	+
Capital Related Factors		
Capital Intensity	Ratio of firm's fixed assets to firm's employment	+
Size	Firm's number of employees	?
Age	Years since start of operation until 2013	?
ICT	Value of computers used by the firm	+

Market Related Factors		
Export	Dummy Variable=1 if firm exports and zero otherwise	+
Foreign Ownership	Dummy Variable=1 if firm is foreign owned and zero otherwise	?
R&D	Dummy Variable=1 if firm undertakes R&D and zero otherwise	+
Institutional Related Factors		
Formality	Dummy Variable=1 if firm pays social security and zero otherwise	+

5. Results

5.1 Labor Productivity Results

The estimation results are reported in table 1. The table presents the regression of the mixture model of one and two regimes (two different heterogeneous groups of firms). The Schwarz criterion strongly favors the two regimes model versus one regime (14.305 for two regimes in Table 1 versus 21.544 for one regime). The likelihood ratio test also strongly favors a two regimes model with a value of 38777.779.

The Wald test of joint equality of the coefficients on the explanatory variables in the two regimes is strongly rejected (a Chi-square statistic of 309431). The hypothesis of same degree of dispersion is also strongly rejected (a Chi-square statistic of 130100). The first regime (group) is characterized by low productivity level and high number of companies with about 86.3% of firms in this group. The second group consists by high productivity firms, which constitute 13.7% of the total. Concerning the low productivity group, the factors that are correlated with productivity are capital intensity, manager compensation, and ratio of female to total labor, skill-intensity, age, exporting, R&D, and average wage, all entering with the correct sign except for skill intensity that enters with a negative sign. One reason behind this unintuitive result might be that low productivity firms are overstaffed. It is noteworthy to mention that the mean skill intensity of low productivity firms was found to be higher than for high productivity firms, as evident from the descriptive statistics in table 3 and 4. On the other hand, the high productivity group had productivity that is correlated with capital intensity only.

Estimation results also show that high productivity firms have higher degree of dispersion compared to low productivity firms as indicated by the standard-deviations reported in Table 1. That is, low productivity firms react more or less in the same way in response to unexpected changes in their environment – unexpected changes in economic policy, supply shocks etc. - while high productivity firms do not react homogenously to those changes. If uncertainty creates a

negative atmosphere, high productivity firms want to dissociate themselves from but in the other side low productivity can't. The high productivity firms usually practice the "wait-and-see" effect (Bloom 2009; Bloom et al. 2009): if they find themselves faced by a more uncertain environment they stop investing and hiring which create high level of heterogeneity in their reaction because they have different constraints depending on their sector of activity and the experience of their managers. Therefore, the effect of the uncertainty on their business is heterogeneous inside this group.

Table 1 Correlates of Labor Productivity: Two Regimes

	One Regime	Two Regimes	
		Regime 1 (low productivity)	Regime 2 (high productivity)
Constant	932.921*	101.330***	3105.269
	(477.588)	(4.723)	(10496.010)
Temp to Perm Emp.	1.768	-0.417	-55.683
	(41.480)	(0.597)	(11045.520)
Capital Intensity	1.602***	0.064***	1.726***
	(0.177)	(0.002)	(0.609)
Size	-0.644	-0.009	-4.475
	(0.678)	(0.008)	(43.726)
Size Squared	0.000	0.000	0.000
	(0.000)	(0.000)	(0.023)
Manager Compensation	0.621	0.198***	1.110
	(1.305)	(0.015)	(8.979)
Location	752.795**	1.678	4671.167
	(318.986)	3.012	(7426.012)
Foreign Ownership	5978.167**	-18.191	18941.830
	(2397.322)	20.927	(15348.150)
Share Female	-1017.906	-82.572***	-1221.600
	(619.009)	(7.031)	(33169.890)
Skill Intensity	2.350	-1.531***	19.802
	(34.393)	(0.263)	(899.894)
Age	-18.006	-1.784***	-24.371
	(24.785)	(0.246)	(569.665)
Age Squared	0.031	0.014***	-1.000
	(0.350)	(0.004)	(10.511)
Formality	-481.199	-1.993	-728.531
	(392.058)	3.954	(5495.240)

Export	-533.443	64.954***	-829.552
	(753.572)	(5.321)	(21309.440)
R&D	-362.670	12.275**	-3.000
	(681.287)	(5.577)	(18790.550)
Average Wage	30.420***	3.193***	34.986
	(6.784)	(0.067)	(50.209)
ICT	-0.006	0.000	0.016
	(0.021)	(0.001)	(0.735)
Standard Deviation		93.383***	30300.520***
		(0.946)	(375.666)
Regime One Probability		0.863***	0.137***
		(0.005)	(0.005)
Log likelihood	-57373.990		-37985.110
Schwarz criterion	21.544		14.305
Sample size	8,843	7,634	1,209

*** Significant at 1% level, ** significant at 5% level

Standard Errors in Parenthesis

The results in Table 2 show that the equality of the means of the explanatory variables for the two regimes are rejected in all cases except for temporary to permanent employment and formality. Sources of heterogeneity between the two regimes are capital intensity, share of female labor to total labor, age, export, R&D and wages.

Table 2: Mean Equality Test

	Mean Equality Test	
	Student-t Statistic	**P-Value**
Temporary to Permanent Employment	-1.331	0.183
Capital Intensity	11.519	0.000
Size	1.885	0.060
Manager Compensation	10.809	0.000
Location	4.081	0.000
Foreign Ownership	2.346	0.019
Share Female	-14.725	0.000
Skill Intensity	-2.849	0.004
Age	-9.865	0.000
Formality	-0.979	0.328

Export	5.192	0.000
R&D	5.808	0.000
Average Wage	19.920	0.000
ICT	3.949	0.000

Tables 3 and 4 show that firms belonging to the high productivity regime have lower temporary to permanent employment, have higher capital intensity, are bigger in size, hire better-paid managers, hire less females, and are younger compared to firms belonging to low productivity regime. They also export more and 48.6% of these firms are located in Cairo and Alexandria.

Table 3: Descriptive statistics of explanatory variables in low productivity group

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
Productivity	98.072	53.043	573.217	0.002	112.940	1.678	5.459
Temporary to Permanent Employment	0.359	0.000	234.333	0.000	4.035	44.999	2490.755
Capital Intensity	50.471	13.297	4287.489	0.000	143.468	12.650	261.755
Size	94.449	23.000	22652.000	2.000	449.566	30.911	1415.717
Manager Compensation	23.857	15.962	629.141	0.001	35.615	7.471	89.091
Location	0.406	0.000	1.000	0.000	0.491	0.385	1.148
Foreign Ownership	0.003	0.000	1.000	0.000	0.059	16.875	285.754
Share Female	0.270	0.170	0.989	0.000	0.281	0.708	2.195
Skill Intensity	2.627	0.778	110.000	0.014	4.939	7.015	98.008
Age	21.512	17.000	113.000	0.000	16.237	1.333	5.681
Formality	0.795	1.000	1.000	0.000	0.404	-1.461	3.135
Export	0.047	0.000	1.000	0.000	0.211	4.285	19.364
R&D	0.058	0.000	1.000	0.000	0.234	3.782	15.305
Average Wage	11.873	9.713	119.851	0.097	9.959	2.361	13.623
ICT	116.417	2.400	189759.000	0.000	3281.065	51.141	2744.474

Table 4: Descriptive Statistics of explanatory variables in high productivity group

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
Productivity	5354.278	1142.492	557108.400	212.131	30861.580	12.952	195.191
Temporary to Permanent Employment	0.159	0.000	22.000	0.000	1.106	13.685	234.871
Capital Intensity	460.941	48.565	46064.820	0.000	2392.099	12.665	205.769
Size	127.457	18.000	4541.000	2.000	367.465	6.841	66.949

Manager Compensation	79.585	26.400	7080.167	0.678	338.342	17.043	324.307
Location	0.486	0.000	1.000	0.000	0.500	0.058	1.003
Foreign Ownership	0.010	0.000	1.000	0.000	0.098	10.057	102.153
Share Female	0.112	0.024	0.857	0.000	0.169	1.978	6.954
Skill Intensity	2.076	0.500	36.895	0.008	4.237	4.163	24.419
Age	15.261	12.000	109.000	0.000	13.555	2.620	13.956
Formality	0.779	1.000	1.000	0.000	0.415	-1.346	2.811
Export	0.093	0.000	1.000	0.000	0.291	2.797	8.823
R&D	0.115	0.000	1.000	0.000	0.320	2.410	6.809
Average Wage	32.008	15.960	1334.018	0.634	63.888	12.710	241.355
ICT	1324.274	3.000	498640.900	0.000	19056.500	24.601	638.534

5.2 TFP Results

Table 5 presents the results of translog production function estimation. The Schwarz criterion favors the two regimes model (see Table 5). For a given firm, the probability to be in the first regime is 49.7%. This group is characterized by low TFP level. It is more labor intensive given that the elasticity of the production with respect to labor is 91.1% compared with 20.5% for the capital. In contrast, the second group is relatively more capital intensive with elasticity of the production with respect to labor equal to 57.9% compared with 45.8% for capital.

Table 5: Translog productivity function: Two regimes

	One Regime	Two Regimes	
		Regime one (low productivity)	Regime Two (high productivity)
Constant	3.580***	2.147***	3.785***
	(0.111)	(0.644)	(0.088)
Labour	0.763***	-0.104	1.030***
	(0.067)	(0.431)	(0.074)
Capital	0.354***	1.033***	0.178***
	(0.035)	(0.216)	(0.041)
Capital*Labour	-0.069***	-0.260***	-0.031**
	(0.013)	(0.087)	(0.014)
Labour Squared	0.053***	0.296***	-0.002
	(0.012)	(0.107)	(0.013)

Capital Squared	0.023***	0.042**	0.021***
	(0.005)	(0.018)	(0.006)
Standard-Deviation		2.796**	1.188***
		(1.229)	(0.098)
Regime Probability		0.176**	0.824***
		(0.078)	(0.078)
Log likelihood	-5294.27		-5073.84
Schwarz criterion	3.910		3.774
Sample Size	8843	7,287	1,556

*** Significant at 1% level, ** significant at 5% level

Standard Errors in Parenthesis

Table 6 presents the estimation outputs of TFP models. Regime one consists of low TFP firms while regime two consists of high TFP firms. For the low TFP firms the effect of size and age is convex: positive effect of the squared value and negative for the level. This is consistent with the fact that younger firms enter the market with new technologies compared to these available for older firms. Higher compensation to managers has positive correlation with the TFP for low TFP firms, while it has no correlation in the case of the high TFP group. Foreign ownership has a positive relationship with TFP for both types of firms. The higher the ratio of females to total labor the lower TFP is for both types of firms. On the other hand, location matters for low productivity firms only. Formality relates to TFP positively for both types of firms. Increasing the wage-rate has a negative relationship in low TFP firms and positive relationship in high TFP firms. Increasing the use of computers correlates with an increase in TFP in the case of low TFP firms only. High TFP firms experience a high degree of dispersion compared to low TFP firms.

Table 6: Correlates of TFP: Two Regimes

	One Regime	Two Regimes	
		Regime one (low productivity)	Regime Two (high productivity)
Constant	3.115***	2.672***	3.223***
	(0.338)	(0.494)	(0.633)
Temporary to Permanent Employment	-0.063	0.075	-0.923***
	(0.082)	(0.067)	(0.320)
Size	-0.001***	-0.001***	-0.001
	(0.000)	(0.000)	(0.000)
Size Squared	0.000**	0.000***	0.000

	(0.000)	(0.000)	(0.000)
Manager Compensation	0.001**	0.000**	0.000
	(0.000)	(0.000)	(0.000)
Location	0.178	0.691**	-0.543
	(0.165)	(0.335)	(0.410)
Foreign Ownership	3.300**	4.329**	1.450***
	(1.436)	(2.012)	(0.505)
Share Female	-2.507***	-1.972***	-2.359***
	(0.358)	(0.668)	(0.802)
Skill Intensity	0.038***	0.020**	0.027
	(0.013)	(0.010)	(0.023)
Age	-0.015	-0.018	-0.021
	(0.013)	(0.025)	(0.032)
Age Squared	0.000	0.001**	0.000
	(0.000)	(0.000)	(0.000)
Formality	0.771***	0.737**	0.839**
	(0.268)	(0.413)	(0.498)
Export	0.156	0.251	0.269
	(0.230)	(0.266)	(0.434)
R&D	0.272	0.401	-0.401
	(0.233)	(0.339)	(0.537)
Average Wage	0.005***	-0.005**	0.038***
	(0.002)	(0.001)	(0.006)
ICT	0.000***	0.000***	0.000
	(0.000)	(0.000)	(0.000)
Standard Deviation		0.421***	1.003***
		(0.101)	(0.047)
Regime Probability		0.497***	0.503***
		(0.129)	(0.129)
Log likelihood	-2201.15		-2140.630
Schwarz criterion	4.74947		4.759
Sample Size	8,843	4,445	4,398

*** Significant at 1% level, ** significant at 5% level

Standard Errors in Parenthesis

Tables 7, 8 and 9 present descriptive statistics and test of equality of means of the regressors in different TFP groups. The tables show that the main variables related to the difference in TFP between high TFP and low TFP groups are manager compensation, location, foreign ownership, ratio of female labor to total labor, age, formality, average wage and computer use.

Table 7: Mean Equality Test

	Mean Equality Test	
	Student-t Statistic	P-Value
Temporary to Permanent Employment	-0.655	0.513
Size	-0.121	0.904
Size Squared	-0.836	0.403
Manager Compensation	5.400	0.000
Location	3.709	0.000
Foreign Ownership	1.657	0.098
Share Female	-8.497	0.000
Skill Intensity	-0.046	0.963
Age	-5.130	0.000
Age Squared	-4.266	0.000
Formality	3.669	0.000
Export	3.828	0.000
R&D	6.577	0.000
Average Wage	9.210	0.000
ICT	3.495	0.001

Table 8: Average of explanatory variables in low TFP group

	Mean	Median	Maximum	Minimum	Standard-Deviation	Skewness	Kurtosis
TFP	2.824	2.176	14.518	-4.246	2.992	1.495	5.892
Temporary to Permanent Employment	0.113	0.000	4.844	0.000	0.454	6.178	50.204
Size	330.125	89.000	4541.000	2.000	653.234	4.120	22.797
Size Squared	534297.800	7921.000	2062068 1.000	4.000	2378237.0 00	6.721	51.027
Manager Compensation	125.735	44.208	7080.167	0.678	508.800	11.705	147.798
Location	0.426	0.000	1.000	0.000	0.495	0.298	1.089
Foreign Ownership	0.003	0.000	1.000	0.000	0.057	17.378	303.003
Share Female	0.139	0.080	0.833	0.000	0.168	1.713	5.893
Skill Intensity	1.894	0.600	34.000	0.026	3.977	4.689	29.436
Age	20.511	16.000	109.000	1.000	15.442	2.530	12.070

Age Squared	658.387	256.000	11881.000	1.000	1338.513	5.323	36.227
Formality	0.892	1.000	1.000	0.000	0.311	-2.523	7.364
Export	0.216	0.000	1.000	0.000	0.412	1.377	2.897
R&D	0.233	0.000	1.000	0.000	0.423	1.265	2.599
Average Wage	41.263	22.773	1334.018	2.970	87.154	11.229	161.171
ICT	3012.906	15.200	498640.900	0.000	29695.560	15.534	256.820

Table 9: Average of explanatory variables in high TFP group

	Mean	**Median**	**Maximum**	**Minimum**	**Standard-Deviation**	**Skewness**	**Kurtosis**
TFP	3.699	3.837	10.533	-5.483	2.369	-0.575	4.347
Temporary to Permanent Employment	0.248	0.000	16.440	0.000	1.155	9.461	107.327
Size	252.381	59.000	22652.000	2.000	1014.763	17.465	373.168
Size Squared	1091844.000	3481.000	513000000.000	4.000	20314936.000	24.905	627.651
Manager Compensation	43.688	21.809	540.281	0.540	68.891	3.997	22.375
Location	0.422	0.000	1.000	0.000	0.494	0.317	1.101
Foreign Ownership	0.003	0.000	1.000	0.000	0.056	17.875	320.503
Share Female	0.254	0.158	0.974	0.000	0.255	0.840	2.552
Skill Intensity	3.029	0.833	110.000	0.025	7.241	8.148	98.285
Age	24.059	19.000	104.000	0.000	17.250	1.230	4.807
Age Squared	875.932	361.000	10816.000	0.000	1277.697	3.361	19.542
Formality	0.901	1.000	1.000	0.000	0.299	-2.681	8.188
Export	0.153	0.000	1.000	0.000	0.361	1.923	4.696
R&D	0.140	0.000	1.000	0.000	0.347	2.081	5.329
Average Wage	18.389	13.648	240.196	0.309	19.178	4.397	38.903
ICT	208.745	5.524	45925.530	0.000	1896.749	22.087	526.432

The sum of the two elasticities in the two groups are 1.116 (0.205+0.911) and 1.037 (0.579+0.458) (Table 10 and Table 11). Table 12 shows that the constant return to scale hypothesis is not rejected for both regimes.

Table 10: Elasticities with respect to Capital

	Low Regime	High Regime
Mean	0.205	0.579
Median	0.214	0.578

Table 11: Elasticities with respect to Labor

	Low Regime	High Regime
Mean	0.911	0.458
Median	0.917	0.494

Table 12: Returns to scale

	Low Regime	High Regime
Mean	1.116	1.037
Median	0.117	0.068
P-Value	0.999	0.998

6. Conclusions and Policy Implications

Using firm level data from 2012/2013 economic census for Egypt's manufacturing sector, this research showed that there is significant heterogeneity in productivity among firms in this vital sector. The average labor productivity in high productivity firms is 55 times higher than that of low productivity firms. With respect to labor productivity, the sources of heterogeneity are capital intensity, manager's compensation, ratio of female labor to total labor, skill intensity, age, export, R&D and wage. In other words, firms are classified as high labor productivity firms when they have higher capital intensity, have access to better quality managers, hire less females and less skilled labor, are younger, export more, spend more on R&D and pay higher wages compared to low productivity firms. It is important to note that the lower female ratio of high productivity firms should not be taken to imply that hiring fewer females is conducive to productivity, but rather that firms should address the root causes of high female turnover. It is noteworthy to mention that one of the firms surveyed in Elshennawy (2009) indicated that having a nursery in the factory has greatly contributed to less female turnover.

While the role of external factors such as culture and the regulatory environment (ex: labor laws) cannot be determined, these result suggests that factors related to low productivity are, at least partially, internal to the firm. Thus there is considerable scope to improve productivity -at least to catch up with the higher productivity firms- based on factors lying under the control of firms. However, this is not entirely true for high productivity firms as apart from capital intensity, labor productivity was found to be unrelated to all of the variables hypothesized to affect productivity. With regards to the latter type of firms, one can safely assert that the literature offers

little insights on how productivity can be increased further. Such a result must be taken in consideration when advising firms on how to increase their productivity and when designing policies for this purpose. Failing to account for the heterogeneous response of different firms to various determinants of productivity can be misleading.

With respect to policies, government policies that promote exports and encourage R&D activities like subsidies might serve to increase the labor productivity of low productivity firms only. It is noteworthy to mention that the fact that factors underlying low productivity are internal to the firm provides little justification for protection from imports since firms have not exploited their potential yet. On the other hand, policies that lead to higher capital accumulation will boost labor productivity for both types of firms. These policies include but are not limited to lower interest rates made possible through stimulating competition in the financial sector and lower tariffs on capital goods.

Sources of heterogeneity in TFP are manager's compensation, location, foreign ownership, ratio of female labor to total labor, age, formality, wages and ICT. In other words, firms are classified as high TFP firms when they pay managers higher wages, they are located in big cities, they are foreign owned, hire less female workers, are young, are mostly formal, pay higher wages and use more computers. Because low productivity firms were found to have TFP related to all these variables, there is considerable scope for these firms to catch up with high productivity firms. Like the case with labor productivity, apart from hiring less temporary workers and paying higher wages, again the literature offers little insights on how high productivity firms can further increase productivity. As to government policies, removing obstacles to formalization is perhaps the most pertinent.

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Cobb Douglas Production Function

	One Regime	Two Regimes	
		regime one	regime two
Constant	3.634***	2.218***	3.958***
	(0.072)	(0.398)	(0.077)
Labour	0.859***	0.724***	0.882***
	(0.025)	(0.179)	(0.027)
Capital	0.298***	0.555***	0.241***
	(0.015)	(0.091)	(0.020)
Standard-Deviation		2.949**	1.204***
		(1.536)	(0.105)
Regime Probability		0.170**	0.830***
		(0.084)	(0.084)
Log likelihood		-5310.630	-5100.720
Schwarz criterion		3.914	3.777
Sample size	8,843	7340	1503

Regime one: low productivity firms,

Regime two: high productivity firms

*** Significant at 1% level, ** significant at 5% level

Standard Errors in Parentheses

Cobb-Douglas Correlates of Productivity

	One Regime	Two Regimes	
		Regime one	Regime Two
Constant	3.469***	2.584***	5.043***
	(0.273)	(0.366)	(0.627)
Temporary to Permanent Employment	-0.080	0.011	-0.681**
	(0.066)	(0.059)	(0.322)
Size	0.000**	-0.001*	0.000
	(0.000)	(0.000)	(0.000)
Size Squared	0.000**	0.000	0.000
	(0.000)	(0.000)	(0.000)
Manager Compensation	0.000	0.000	-0.001
	(0.000)	(0.000)	(0.001)
Location	0.230*	0.249	-0.297
	(0.133)	(0.205)	(0.423)
Foreign Ownership	3.447***	2.392***	4.065***
	(1.159)	(0.657)	(1.156)
Share Female	-2.517***	-1.977***	-2.622***
	(0.289)	(0.369)	(0.839)
Skill Intensity	0.026**	0.014	0.089
	(0.010)	(0.009)	(0.142)
Age	-0.019*	0.061***	-0.175***
	(0.011)	(0.017)	(0.039)
Age Squared	0.000	-0.001***	0.002***
	(0.000)	(0.000)	(0.000)
Formality	0.708***	0.635**	0.724
	(0.216)	(0.320)	(0.506)
Export	0.341*	0.146	0.933*
	(0.186)	(0.221)	(0.561)
R&D	0.056	0.096	-0.326
	(0.188)	(0.238)	(0.656)
Average Wage	0.001	-0.001	0.017
	(0.001)	(0.001)	(0.015)
ICT	0.000	0.000	0.000*
	(0.000)	(0.000)	(0.000)
Standard Deviation		0.433***	0.705***
		(0.047)	(0.083)

Regime Probability		0.6648***	0.336***
		(0.142)	(0.142)
Log likelihood		-1997.695	-1963.270
Schwarz criterion		4.321	4.386
Sample size	8,843	5,871	2,972

Regime one: low productivity firms,

Regime two: high productivity firms

*** Significant at 1% level, ** significant at 5% level

Standard Errors in Parenthesis