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Economic Theory

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PRODUCTION FUNCTION FOR MEASURING RETURNS TO SCALE IN THE GARMENT SECTOR: A CASE STUDY OF BANGLADESH

Abstract

This paper empirically examines whether the production function of the garment sector of Bangladesh is operating under increasing returns to scale. The Cobb-Douglas production function is estimated using the advanced level of econometric techniques based on primary data. GLS estimates indicate that the productivity of labor force is 22.17% and the productivity of capital investment is 61.02%, statistically significant at any significance level. Thus, the production function of the garment sector of Bangladesh is operating under decreasing return to scale. From the GLS estimate of R^2, it is clear that about 99.97% of the total variation of the dependent variable output is explained by the fitted regression equation. Thus, the model fits the data very well. The diagnostic test results show that there are no problems of autocorrelation, heteroscedasticity, autoregressive conditional heteroscedasticity and normality of the random error terms. The test

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results also confirm that the model is correctly specified. It is also found that the average marginal productivity of labor force is 0.0236 and the average marginal productivity of capital investment is 0.5222 in the garment sector of Bangladesh. Since the marginal productivity of labor force is smaller than the capital investment, it can be said that these factories cannot reduce production costs by shifting resources from capital intensive techniques to labor intensive techniques. As a result, this sector cannot generate additional employment opportunities, which is not a good sign. The CUSUM and CUSUMSQ tests results confirm that the preferred production function of the garment sector of Bangladesh can be used for policy decision-making purposes.

Key Words:

Cobb-Douglas Production Function; returns to scale; primary data; labor force; capital investment; GLS; diagnostic test results; CUSUM and CUSUMSQ tests.

JEL: C01, C02, C010, C32, O11, O53, Q40.

7 figures, 4 tables, 8 formulae, 25 references.

Problem Statement

Bangladesh is one of the fastest growing economies among Asian countries, powered by the readymade garments (RMG) industry, which has promoted the country in the world through the motto «Made in Bangladesh». In Bangladesh economy, the garment sector contributes a major portion – about 83% – to the country's total export earnings. Formally, the RMG industry of Bangladesh has started its journey in the early 1980s and then continued to play an important role in the growth of economy by creating employment opportunities, earning foreign currencies, reducing poverty through socio-economic development, and by encouraging rural development, especially by creating empowerment of rural women. Thus, the RMG sector has played an important rule in the development of socioeconomic prospects, especially for women empowerment, by generating employment.

Our study found that about 93.5% of workers from rural areas are working in the RMG sector of Bangladesh. Most of them are rural poor illiterate female workers and their wage rate is very poor. Due to low grade and unskilled labor force, their productivity is very low. As a result, per unit production cost is very high, thus to production of high value products remains a challenge for this industry. Moreover, this industry highly depends on imported raw materials, especially woven garments, which causes high lead time to produce garment products. Due to time, value of money per unit production cost is higher relative to other Asian countries.

Therefore, in Bangladesh this sector is trying to produce low-value garment products at low price. For structural change from low-value products to high-value products, we need to develop technical skills, training and innovation, as well as research and development activities within this sector. But it is found that in this sector there is very little interest in developing technical skills or training up the unskilled workers, to increase the research and development expenditures or to recruit high-pay skilled workers. Therefore, the competitiveness in the sector is continuously falling in the long-run.

In addition, the sector is characterized by monotony, repetitive work, and low motivation in the workplace. Frequent political violence, natural disasters, insecurity within the environment created by the industries, lack of facilities, poor standards of living due to lower wage rates etc. provoke unrest and affect at the RMG sector. In 1998, this sector could not meet US$15,000 million of export orders on time due to flood, and more than 3 lakh workers were affected directly and indirectly due to the flood (Quddus & Rashid, 1999).

The garment sector was also greatly affected by COVID-19, for example, it lost $4.33 billion worth of exports between March and June 2020 due to cancellation of foreign orders and delayed payments. Due to 982 million cancellations by international buyers and brands, 2.28 million of garment workers were affected directly and indirectly and millions of workers – many of them women – experienced financial problems. The Department of Inspection for Factories and Establishments (DIFE) prepared a crisis report which provided information on the number of RMG factory shutdowns, terminations and laid-off workers during the period of the COVID-19 pandemic (from mid-March till September 17, 2020). According to the report, 90 thousand workers lost their jobs due to order cancellation or delayed payment; among them 43,049 workers (in 117 factories) lost their jobs due to factory shutdowns, 23,560 workers were terminated from 75 factories, and 23,523 workers of 26 factories were laid off (Hossain & Alam, 2022).

Due to the cheap labor cost, Bangladesh could be a great choice for the worldwide buyers and brands for having lower fabricating costs. However, there have been several accidents, namely Rana Plaza and Tazrin, due to which a large number of workers lost their lives, which raised a question to the foreign buyers and brands regarding workplace safety. This was a most pressing challenge for the RMG sector of Bangladesh. Therefore, the government, global brands and retailers have undertaken major initiatives through creation of the Bangladesh Accord on Fire and Building Safety and the Alliance for Bangladesh Worker Safety.

Besides the internal challenges, the RMG sector also suffers from the challenges of world political and economic crises. For example, recent devaluation of EUR against USD had a negative effect on the exports of the RMG products, making the Bangladesh RMG products expensive in the EU market, which is a major export zone for Bangladesh. Political crises such as the terrorist attack in the USA in 2001 followed by a depression in 2004 caused a decline in Bangladesh export to the USA of 13.04% (Abdin, 2008). Also, the demand for RMG products in the EU market has been greatly affected by the war between Russia and Ukraine.

Due to devaluation of BDT against US dollar, the production cost increased because this sector imports most of the raw materials from abroad. If the export of the RMG sector is not elastic, the garment sector and national economy are affected on a large scale due to devaluation of BDT currency against USD. In spite of its contribution to the economy in terms of employment, income generation, poverty reduction, and women empowerment, this sector is also facing some challenges from inside and outside. That is why, nowadays it is very important to formulate policies to create quality human resources to face these inside and outside challenges and ensure sustainable development of the RMG sector in Bangladesh. Therefore, it is very important for us to know about the contribution of the labor force in the garment sector of Bangladesh. Also, it is very much important to know whether the production of the garment sector in Bangladesh is running under increasing return to scale.

In this study, **the main aim** is to estimate the Cobb-Douglas production function for the garment sector of Bangladesh using modern econometric techniques based on the primary cross-sectional data of 130 garment factories. From the estimated results, we can investigate the contribution of the labor force and capital investment to the output of the garment sector of Bangladesh. Likewise, we can study whether or not the production of the sector is running under increasing return to scale.

Literature Review

The principal purpose of literature review is to establish a sound theoretical background on the concept of the Cobb-Douglas production function and its application in predicting a business outcome. Previously, many researchers have done different studies based on the application of the Cobb-Douglas production function, for example Bhashin and Seth (1980) conducted research to estimate a production function for Indian manufacturing industries in order to find out whether plausible and meaningful estimates can be obtained for returns to scale, substitution, distribution, and efficiency parameters. Data was collected through surveys specially designed for estimating the levels of technical efficiency (TE) and variations in TE only in small-scale industrial units. Researchers found little variation in TEs across industry groups and a high level of average TE in each industry groups.

Hossain (1987) conducted a study on allocative and technical efficiency for rural enterprises in Bangladesh and estimates Cobb-Douglas production function and detects those industries in Bangladesh have potential allocative efficiency as they are using at least some capital. By estimating the marginal productivity of labor and capital, study explains that allocative efficiency is achievable through appropriate pricing of capital and its proper disbursement among the proprietorships.

Lewis et al. (1988) used a production function approach to calculate productivity growth rates for agricultural, industry and service sectors for Australian economy and concluded that growth rate of productivity in agricultural sector is higher than industry and service sectors. Salim and Kalirajan (1999) conducted a study to evaluate the performance of firms in the Bangladesh food processing industries in terms of total factor productivity (TFP) growth which is decomposed into the changes in productive capacity realization (PCR) and technical progress (TP). This study found that there is some technological progress in a number of food processing industries. However, the overall poor performance of this sector is due to the low rate of capacity realization of several individual firms, even after the implementation of economic reforms. This study also found that the output growth from the early to late 1980s in recent years was mainly due to input growth.

Hossain et al. (2004) carried out a study on an econometric analysis of some major manufacturing industries and this study found that, the Cobb-Douglas production function with additive error performs better for the selected manufacturing industries based on the data under study period. They showed that the strictly nonlinear models (which are nonlinear with additive error terms) is better than intrinsically linear model (which are nonlinear with multiplicative error terms). Researchers estimated the parameters of the Cobb-Douglas production function with additive errors by using optimization subroutine. The estimates showed economies of scale in the manufacturing of drugs & pharmaceuticals, Furniture & fixtures, Iron & steel basic, Leather footwear, Fabricated metal products, Plastic products, Printing & publications and Tobacco. There are diseconomies of scale in the Beverage, Chemical, Glass & glass products, Leather & leather products, Paper & paper products, Textile, Wood & crock products industries and Transport equipment.

Baten et al. (2006) carried out a study to investigate the technical efficiency of selected manufacturing industries of Bangladesh using a stochastic frontier production function approach. A feasible Cobb-Douglas stochastic frontier production function, which has time-varying technical inefficiency effects, is estimated. In the study, researchers have analyzed the stochastic frontier production function using panel data in selected manufacturing industries in Bangladesh. Two alternative distributions are used to model the random inefficiency term: a truncated normal distribution and a half-normal distribution. Researchers have observed that the estimated values of the time-varying inefficiency parameter are positive for both the truncated and the half normal distribution. These indicate that technical inefficiency has declined over the reference period. Tests for different null hypotheses involved in the stochastic frontier production function show that the technical inefficiency effects for the selected manufacturing industries in Bangladesh are significant. It has been found that the mean efficiencies according to the truncated and the half normal distributions are 0.4022 and 0.5557 respectively. Here it should be noted that although the growth in technical efficiency is statistically significant over time as tested by the null hypothesis, the rate of increase in technical efficiency has been very slow over time in Bangladesh.

Hagendorf (2009) carried out a study on the Cobb-Douglas production function and political economy and showed that Cobb-Douglas Production function is only the production function which has the property of a constant functional distribution of income of the factors of production. The estimation of the parameters of an aggregate production function is central in work on growth and productivity.

Raval (2011) carried out a study on beyond Cobb-Douglas: estimation of a CSE production function with factor augmenting technology and this study found that the capital-labor ratio rises exactly in proportion to the rise in wages, so the factor cost ratio is constant. The slope of the relation between wages and the factor cost ratio then identifies the elasticity of substitution.

Dharmasiri and Datye (2011) carried out a study on application of Cobb-Douglas function for analyzing the process of Sri-Lankan agricultural production and this study found that there is a positive relationship between the market price of crop production and its yield, there is no significant relationship between harvested area and the yield and the CDCO analysis gives the normal distribution pattern than SCRP analysis. Yuan (2011) conducted a study to analyze the relation between agricultural output and input factors in Hebei province by applying the Cobb-Douglas production function. As input variables, cultivated area, agricultural manpower, effective irrigation area, chemical fertilizer usage, agricultural machinery usage and electricity consumption were taken. The research showed cultivated area and manpower have least impact on the output while effectiveness of irrigation area, chemical fertilizer, machinery and electricity usage influence the agricultural output in positive way. This report shed light on the fact that machine power can increase the productivity more than manpower.

Hassani (2012) carried out a study on application of Cobb-Douglas production function in construction time-cost analysis, and this study is concluded that labor force and equipment efficiencies have significant effects on total cost of a project. Cost inflation analysis makes managers aware of uncertain market which influences total cost and duration of a project. Hossain et. al. (2012) carried out a study on an application of non-linear Cobb-Douglas production function to selected manufacturing industries in Bangladesh. The main objective of this paper is to select the appropriate Cobb-Douglas production model for measuring the production process of some selected manufacturing industries in Bangladesh. They used different model selection criteria to compare the Cobb-Douglas production function with additive error term to Cobb-Douglas production function with multiplicative error term. Finally, they estimated the parameters of the production function by using optimization subroutine. This study observed that, the Cobb-Douglas production function with additive error performs better for the selected manufacturing industries based on the data under study period. Thus, the strictly nonlinear models (which are nonlinear with additive error terms) seem to be better than intrinsically linear model (which are nonlinear with multiplicative error terms.

Afzal and Manni (2013) conducted a study to uncover the nature and extent of productivity changes in Cobb-Douglas production function components and the growth of the knowledge economy of selected ASEAN countries, namely, Malaysia, Indonesia, Philippines, Thailand, Singapore plus South Korea which were analyzed over the period 2005 to 2010. The study was conducted to understand the varying levels of economic development in these countries. Utilizing non-parametric Data Envelopment Analysis (DEA) and the Malmquist total factor productivity (TFP) index, individual country's efficiency and productivity changes which took place within this period were estimated. Their results indicate that the Philippines and Singapore reported the highest increase in TFP within the referred years, and this growth in productivity is derived from both technical efficiency gains and technological progress. On the other hand, for the knowledge economy model, there is a remarkable growth in TFP for Thailand and Philippines.

Hossain and Islam (2013) carried out a study on productivity analysis and measuring the returns to scale of manufacturing firms in the south-west region of Bangladesh. This study applied the Cobb-Douglas production function to estimate the productivity, allocative efficiency and measuring returns to scale. This study found that input labor has a significant impact on the production of these manufacturing firms. The estimated results showed that labor and capital inputs influence the total variation of production of cement, fertilizer, jute, sea foods and textile firms respectively by 0.93%, 0.92%, 0.90%, 0.93% and 0.85% respectively. The study also found that the marginal productivity of labor of these firms is greater than that of capital. Therefore, these firms could reduce production cost by shifting resources from capital intensive technique to labor intensive technique and at the same time they can generate additional employment opportunities. The study showed that the cement, jute, and textile manufacturing firms having decreasing returns to scale whereas fertilizers and seafood processing firms have increasing returns to scale. The estimated value of marginal productivity and allocative efficiency revealed that labor productivity of all sorts of manufacturing firms is greater than that of capital productivity. Therefore, additional employment can be generated by utilizing labor intensive technique. If investors invest in labor intensive technique, they can expect a positive return from investment.

Husain and Islam (2016) carried out a study on a test for the Cobb-Douglas production function in manufacturing sector of Bangladesh. This study is based on secondary data of the variables total output, total asset, total liabilities, number of permanent workers. This study is conducted for six major types of industries including Garments, Textiles, Food & Food Processing, Leather & Leather Products, Electronics and Chemicals & Pharmaceuticals. This study found that coefficient for K and L are 0.49 and 0.51 respectively for entire manufacturing sector. In case of garment sector, coefficient for K is 0.30 and L is 0.61 implying that labor is more productive than capital. The statement is also true for Textile sector and Leather & leather products. Capital is, on other hand, more productive than labor in Food & food processing industries, Electronics, Chemicals & Pharmaceuticals sectors. The coefficients are significant and do not suffer from MC and also not from Autocorrelation. To correct heteroscedasticity, WLS method (weighted Least Square) has been adopted. Findings reveal that Cobb-Douglas production function is applicable and exhibits constant returns to scale in the context of manufacturing sector of Bangladesh.

Rahman and Sayeda (2016) carried out a study on the effect of integration with global apparel value chain which is based on a case of Bangladesh apparel industry. This study tried to find the effect of integration with global apparel value chain on performance of Bangladesh apparel firms by estimating an augmented Cobb–Douglas production function. The findings show that both backward linkage with foreign suppliers of intermediate inputs and forward linkage with global retailers of apparels positively affect firms' output and labor productivity. By contrast, backward linkages with local suppliers have adverse effects on firm performances. The findings imply that it is a firm's integration with the global apparel value chain, not the conventional backward linkage with domestic suppliers, that defines success of Bangladesh apparel industry in a globalizing world.

Khatun & Afroze (2016) carried out a study to find the association between real GDP and labor and capital of selected Asian countries say Bangladesh, India, China, Malaysia and Thailand using the Cobb-Douglas production function. The study is based on secondary time-series data covering the period of 1990-2014. This study found that there is a strong positive and significant relationship between labor and capital and real GDP in case of all selected countries. This study found that the value of R^2 ranges between 0.930 to 0.988, indicating that most of the variations in real GDP in all these countries are explained by labor and capital alone. The results are statistically significant at 1% and 5% level of significance. The study also shows that there are increasing returns to scale in the production process in case of all the selected countries. It has been found that a 100% increase in labor will increase real GDP by 301% and a 100% increase in capital will increase real GDP by 40%. The contribution of both labor and capital is the highest in case of China followed by Bangladesh. The contribution of capital is lowest in case of Thailand (10%) and Malaysia (15%) because they both emphasized investing in human capital by giving importance to education, health and training of their labor force. The study concludes that investing in the huge labor force especially the female labor force in case of Bangladesh and India and proper use of capital by trained labor and management are essential to sustain the increasing growth process in these countries.

Wagle (2016) carried out study on spatial analysis of Cobb-Douglas production function in agriculture sector of Nepal. He used the Cobb-Douglas production function on the agricultural production of Nepal in various spaces and dimensions. This study states that agriculture is the main source of food, income, and employment of Nepal and economic growth of the country depends on both increasing the productivity of existing crops and diversifying the agricultural base for use as industrial inputs.

Mohajan (2021) conducted a study to predict the cost minimization policies of a running garments industry of Bangladesh by applying the Cobb-Douglas production function. This study examined the effects of the variation rate of capital, labor and other inputs with returns to scale in the garments industry of Bangladesh. This study tried to provide a reasonable interpretation of the Lagrange multiplier. This study observed that the value of the Lagrange multiplier is positive, and the study indicates shadow price. Based on the statistical analysis this study confirmed that the garments sector of Bangladesh has better future if it moves to increasing returns to scale production.

From the literature review it can be said that there have been many studies in the context of application of Cobb-Douglas production function in the world. While most of the studies are concentrated on the application of Cobb-Douglas production function at different manufacturing sectors of different countries in the world. There are hardly a few research works that are carried in order to examine nature of the production function in the garment sector of Bangladesh. For instance, Husain and Islam (2016) conducted a study to test for the Cobb-Douglas production function in manufacturing sector including the garment sector of Bangladesh. This study is based on secondary time series data. This study found that the output elasticities with respect to capital and labor force are 0.30 and 0.61 respectively implying that the production function is decreasing return to scale. Rahman and Sayeda (2016) carried out a study in order to find the effect of integration with global apparel value chain on performance of Bangladesh apparel firms by estimating an augmented Cobb–Douglas production function. The findings show that both backward linkage with foreign suppliers of intermediate inputs and forward linkage with global retailers of apparels positively affect firms' output and labor productivity. By contrast, backward linkages with local suppliers have adverse effects on firm performances. The findings imply that it is a firm's integration with the global apparel value chain, not the conventional backward linkage with domestic suppliers, that defines success of Bangladesh apparel industry in a globalizing world.

We believe that these studies are not sufficient enough to reach any definite conclusion about the production function of the garment sector of Bangladesh. Hence, any new study will add a value to the review of literature and attempts to fulfill the gap in the literature. By keeping this in our mind, the present study is carried out to investigate the productivity of labor force and capital investment in the garment sector, and also to find the technical efficiency in the garments sector. Also, to investigate whether the production function of the garment sector of Bangladesh is increasing return to scale or not. The marginal productivities of labor and capital are estimated for all the firms and also for this sector. We also testify whether the marginal products of labor and capital are statistically significant or not. Thus, we believe, that the findings of this study will throw some light to the policy makers and for the scope of future research. Moreover, the study has used sophisticated econometric approaches to find out linkage between output and its' determinants say labor force and capital investment of the garment sector of Bangladesh and mitigating gap in the existing literatures.

Methodology

Data Collection and Some Descriptive Statistics

This study is based on primary data. The information of different variables say output, labor force and capital investment are collected from 130 garment factories under Chattogram, Dhaka, Gazipur and Narayanganj cities using the structured questionnaire. The stratified random sampling is used to select the factories from each city as a stratum and a part of the sample is drawn at random of different factories of each city. For this study the primary data on different variables say total number of employees, yearly total output in crore TK, total investment in crore TK, are collected from 130 industries in order to estimate the Cobb-Douglas production function.

Some fundamental descriptive statistics say mean, median, standard deviation (Std. Dev), coefficient of variation (CV) in percentage, skewness, kurtosis, maximum (max.), minimum (min) and range of the variables say labor force (TEM), capital investment (TINV) and total output (OUT) are obtained and are given below in Table-1.

Table 1

Fundamental Descriptive Statistics of Different Variables

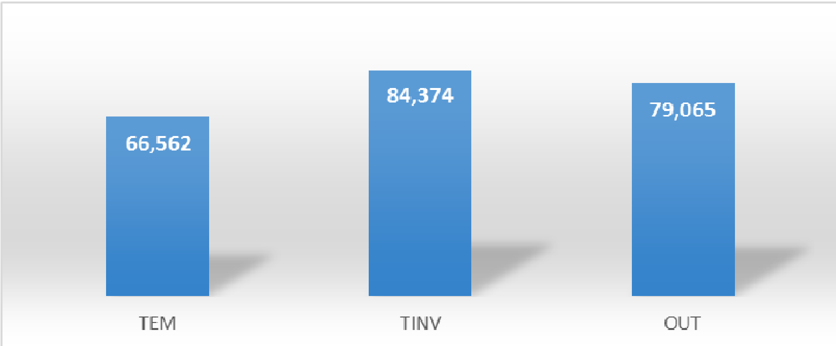
Variable	Mean	Median	Std. Dev.	C.V. (in %)	Skew.	Kurt.	Max.	Min.	Range
TEM	3150.22	2798.69	2096.85	66.562	0.534	2.673	10120	185	9935
TINV	381.09	320.34	321.54	84.374	1.159	4.488	1564	2.0	1562
OUT	359.82	278.63	284.49	79.065	0.969	3.436	1264	2.50	1261.5

From the estimated results in Table-1, it is found that on an average the total number of employments (TEM) in each factory is 3150.73, averagely in each factory the total investment (TINV) is 381.09 crore TK and in each year on an average the output (OUT) is 359.82 crore TK. It is also found that the coefficient of variation CV is highest for the variable TINV and followed by OUT and TEM. From the estimated results it is also found that all the variables are positively skewed also it is found that the curve of the frequency distribution of the variable

TEM is platykurtic and the curves of the frequency distributions of the variables TINV and OUT are leptokurtic. The coefficient of variations of these variables are presented below graphically to realize the scenario about the risk of these variables easily.

Figure 1

Coefficient of Variation in % (CV) of Different Variables



Econometrics for Data Analysis and Research Results

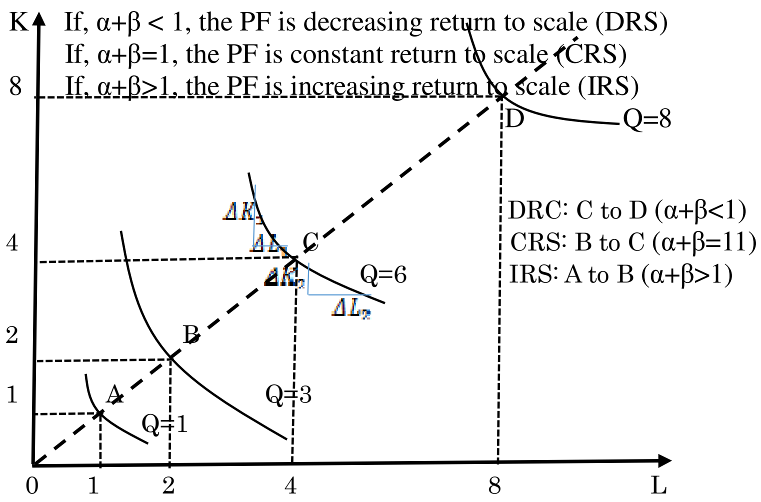
The main objective of this study is to determine the effects of the labor force and capital investment on the output of the garment sector of Bangladesh. For empirical analysis of this study the modern econometric techniques are applied. In order to find the impacts of the variable labor force (TEM) and capital investment (TINV) on the output variable (OUT) of the garment sector of Bangladesh here we consider the following Cobb-Douglas production function:

$$\mathrm{OUT}_i = \mathrm{A}_0 \mathrm{TEM}_i^{\alpha} \mathrm{TINV}_i^{\beta} e^{\varepsilon_i} \quad (1)$$

where, OUT_i indicates the yearly output of the *i*th garment factory, TEM_i indicates total labor force of the ith garment factory, TINV_i indicates capital investment of the ith garment factory and ε_i is the random error term corresponding to the ith set of observations, we assume that ε_i satisfies all the usual assumptions of a multiple regression equation. The parameter α indicates the output elasticity with respect labor and β indicates output elasticity with respect to capital of the garment sector of Bangladesh and A_0 is constant which indicates technology. The Cobb-Douglas production function is very important which can be used to explain many types of production activities. Some important features of Cobb-Douglas production are explained below with Figure-2.

Figure 2

Illustrative isoquant curves from Cobb-Douglas Production Function



An isoquant or equal product curve (Varian 1992) is defined as the locus of all input combinations from which the producer produces a specified level of output. Figure-2 shows a set of isoquants or equal product curves of a production function with two inputs say capital (K) and labor (L). K is equivalent to or interchangeable with equipment in this study. Now one of the most important features of a Cobb-Douglas production function can be explained by the summation of α and β. If, $\alpha+\beta <1$, then the production function is said to be a decreasing return to scale (DRS), which implies that the percentage change in output is less than the percentage changes in inputs or we can say that the double inputs of L and K will generate less than double output of Q. This is illustrated in Figure-2, if we move from the point C to D. If, $\alpha+\beta =1$, then the production function is said to be a constant return to scale (CRS) which implies that the percentage change in output is equal to the percentage changes in inputs or we can say that the double inputs of L and K will generate double output of Q, which is illustrated in Figure-2, if we move from the point B to C. If $\alpha+\beta > 1$, then the production function is said to be an increasing return to scale (IRS) which implies that the percentage change in output is greater than the percentage change in input or we can say the double the inputs of L and K will generate more than double output of Q, which is illustrated in Figure-2 if we move from the point A to B.

The OLS Estimation of the Cobb-Douglas Production Function

The logarithmic transformation of the equation (1) is given by:

$$\ln(\text{OUT}_i) = \ln(A_0) + \alpha\ln(\text{TEM}_i) + \beta\ln(\text{TINV}_i) + \varepsilon_i \quad (2)$$

Let us define, $Y_i = \ln(\text{OUT}_i)$, $X_{1i} = \text{TEM}_i$, $X_{2i} = \ln(\text{TINV}_i)$, and $\lambda = \ln(A_0)$, thus the equation (2) can be written as:

$$Y_i = \lambda + \alpha X_{1i} + \beta X_{2i} + \varepsilon_i \quad (3)$$

The OLS estimates of the regression equations (3) are obtained using the software STATA, EViews-12, and RATS and are given below in Table-2 with the diagnostic tests results.

Table 2 shows that the coefficients of lnTEM and lnTINV are statistically significant at any significance level indicates that the variables labor force and capital investment have significant impacts on the output level in the garment sector of Bangladesh. From the estimated results it can be said that the output elasticity with respect labor force is 0.2246 while capital is constant indicates that for increasing 100% input labor force the output will be increased by 22.46% and the output elasticity with respect to capital is 0.6063 when labor force is constant indicates that for 100% increases in input capital the output will be increased by 60.63%. From the estimated value of R^2 it can be said that about 80.12% of the total variation of the dependent variable output is explained by the fitted regression equation. Thus, it can be said that the fit is very good. It is found that the summation of the elasticities is 0.2246+0.6063 = 0.8309 which is less than 1 implies that the production function of the garment sector of Bangladesh is decreasing return to scale.

Therefore, it can be concluded that the production in the garment sector of Bangladesh does not operate under increasing return to scale, which is not a good sign for this sector. Therefore, the government including other stakeholders have to reform the policy frameworks to supply quality labor force in the garment sector for which the production function of the garment sector will be increasing return to scale.

Table 2

The OLS Estimates and the Diagnostic Test Results

Dependent Variable: ln(OUT)	Coeff.	Std. Error	t-test	Prob.	95% CI Estimate	
					Lower Limit	Upper Limit
Constant	0.4734	0.3867	1.2241	0.2232	-0.2919	1.2388
lnTEM	0.2246*	0.0625	3.5947	0.0005	0.1009	0.3482
lnTINV	0.6063*	0.0401	15.1268	0.0000	0.5269	0.6856

R^2	0.8012	Mean dependent Var	5.4364
Adjusted R^2	0.7981	S.E. dependent Var	1.1686
S.E. of Regression	0.5251	Akaike info criterion	1.5725
Sum of Squared Residual	35.0238	Schwarz criterion	1.6387
Log likelihood	-99.2141	Hannan-Quinn criterion	1.5994
F-Statistics	255.9109	Durbin-Watson stat	2.1103
Prob(F-statistics)	0.0000		

Sensitivity Analysis: The Diagnostic Test Results

Test Statistics	Test Value	Prob.
LM Test for Autocorrelation	1.0846	0.5814
LM test for Heteroscedasticity	9.8110*	0.0074
ARCH Test	0.2047	0.6509
F-test for Misspecification	0.0398	0.8421
JB Test for Normality of Errors	19.1517*	0.0000

Test for Multicollinearity	VIF	1/VIF
ln(TEM)	1.65	0.6057
ln(TINV)	1.65	
Mean VIF	1.65	

*: indicates significant at 1% level

Sensitivity Analysis: The diagnostic tests for serial correlation, heteroscedasticity, autoregressive conditional heteroscedasticity, functional form misspecification, non-normal errors and for multicollinearity are conducted and the results are reported in Table-2. The test results indicate that there is no problem of autocorrelation and the autoregressive conditional heteroscedasticity is not present in the production function. The test results also support that there is no problem of multicollinearity and the model is correctly specified. But the test result indicates that there is an evidence of heteroscedasticity problem in the data set. The test results also support that there is a problem of normality of random error terms in equation (3).

CUSUM and CUSUMSQ Tests: The stability of the long-run parameters together with the short-run movements for the equations has been examined using cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests proposed by Borensztein et al. (1998). The related graphs of these tests are presented below in Figures 3 and 4.

Figure 3

Plot of Cumulative Sum of Recursive Residuals

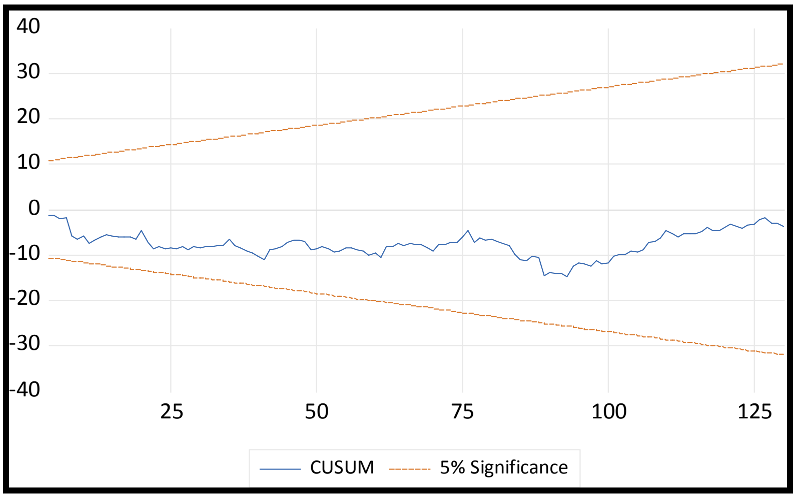
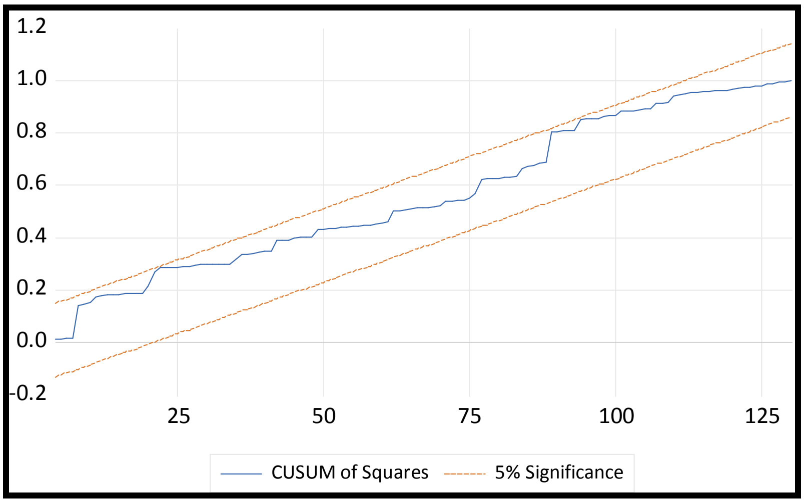


Figure 4

Plot of Cumulative Sum of Squares of Recursive Residuals



From Figures 3 and 4 it can be seen that the CUSUM and CUSUMSQ tests results are within the critical bounds implying that all coefficients in the production model are stable. Therefore, the preferred production function of the garment sector of Bangladesh can be used for policy decision making purpose, such that the impact of policy changes considering the explanatory variables of Cobb-Douglas production function will not cause major distortion in the level of output, since the parameters in this equation seem to follow a stable pattern during the estimation period.

The Generalized Least Squares Estimates (GLS) of the Heteroscedastic Model

Sometimes some of the observations in our regression equation are less reliable than others. This means that the variances of the observations are not equal, in other words the non-singular matrix is not of the form $\mathrm{Var}(\varepsilon) = \sigma^2 I_n$, but rather diagonal with unequal diagonal elements. It may also happen in some problems that the off-diagonal elements of $\mathrm{Var}(\varepsilon)$ are not zero or both of these events occur. When either one or both of these events occur, then the OLS method is not applicable to obtain the regression equation. In this situation we transform the original equation in such a way that the random error term of the transformed model satisfies all the usual assumptions. The transformation of the original model depends on the particular form of heteroscedasticity. In general, the transformation of the original model entails dividing the original relationship by the square root of the term which is responsible for the heteroscedasticity. The estimators which are obtained from the transformed model using the principle of least squares are called the generalized least squares estimators. Since the problem of heteroscedasticity is found in the data set, therefore the production function is estimated again using the generalized least squares (GLS) method and the results are given below with the diagnostic test results in Table 3.

From the GLS estimate of the production function in Table-3, it is found that the coefficients of lnTEM and lnTINV are statistically significant at any significance level indicate that the variables labor force and capital investment have significant positive impacts on the output level in the garment sector of Bangladesh. From the estimated results it can be said that the output elasticity with respect to labor force is 0.2217 while capital is constant indicates that for increasing 100% input labor force the output will be increased by 22.17% and the output elasticity with respect to capital is 0.6102 when labor force is constant indicates that for 100% increases in input capital the output will be increased by 61.02%. From the estimated value of R^2 it can be said that about 99.97% of the total variation of the dependent variable output is explained by the input variables labor force and capital investment i.e., by the fitted regression equation. Thus, it can be said that the fit is perfect. It is found that the summation of the elasticities is 0.2217+0.6102 = 0.8319, which is less than 1 implies that the production function of the garment sector of Bangladesh is decreasing return to scale. Therefore, it can be concluded that the production in the garment sector of Bangladesh does not operate under increasing return to scale, which is not a good sign for the garment sector of Bangladesh. Therefore, the government including other stakeholders have to reform the policy frameworks to create quality labor force in this sector for which the production function of the garment sector will run under increasing return to scale in near future.

Table 3

The GLS Estimates and the Diagnostic Test Results

Dependent Variable: ln(OUT)	Coeff.	Std. Error	t-test	Prob.	95% CI Lower Limit	95% CI Upper Limit
Constant	0.4754*	0.0268	17.74	0.0000	0.4224	0.5285
lnTEM	0.2217*	0.0055	39.96	0.0000	0.2107	0.2326
lnTINV	0.6102*	0.0036	168.14	0.0000	0.6030	0.6174
R^2	0.9997	SE of Regression			0.0157	
Adjusted R^2	0.9996	Mean dependent Var			1.4821	
Sum of Squared Regression	86.3824	S.E. dependent Var			5.3629	
Sum of Squared Residual	0.0299	Akaike info criterion			-5.4766	
Log likelihood	258.9811	Schwarz criterion			-5.4104	
F-statistics	167455.9	Hannan-Quinn criterion			-5.4497	
Prob(F-statistics)	0.0000	Durbin-Watson stat			2.1072	
Sensitivity Analysis: The Diagnostic Test Results						
Test Statistics			Test Value		Prob.	
LM Test for Autocorrelation			0.4059		0.5240	
LM test for Heteroscedasticity			0.050		0.8192	
ARCH Test			0.2111		0.6458	
F-test for Misspecification			0.0387		0.8442	
JB Test for Normality of Errors			0.6656		0.7168	

*: indicates significant at 1% level

Sensitivity Analysis: Diagnostic tests for serial correlation, heteroscedasticity, autoregressive conditional heteroscedasticity, functional form misspecification, and for non-normal errors are conducted and the results are reported in Table-3. The test results indicate that there is no problem of autocorrelation and the autoregressive conditional heteroscedasticity is not present in the production function. The test results also support that there is no problem of heteroscedasticity and the model is correctly specified. The test results also support that there is no problem of normality of random error terms in equation 1.

Marginal Productivity of Labor and Capital

The predicted value of the production function is given by:

$$\ln(\widehat{OUT_i}) = \ln(\hat{A}) + \hat{\alpha}\ln(TEM_i) + \hat{\beta}\ln(TINV_i) \quad (4)$$

Taking partial derivative of the equation (4) with respect to TEM_i, then we have:

$$\frac{\delta \ln(\widehat{OUT_i})}{\delta TEM_i} = \frac{\hat{\alpha}}{TEM_i}$$

$$\frac{1}{\widehat{OUT_i}}\frac{\delta(\widehat{OUT_i})}{\delta TEM_i} = \frac{\hat{\alpha}}{TEM_i}$$

$$\frac{\delta(\widehat{OUT_i})}{\delta TEM_i} = \frac{\hat{\alpha} \times \widehat{OUT_i}}{TEM_i} \quad (5)$$

$$MP_L = \frac{\hat{\alpha} \times \widehat{OUT}}{\overline{TEM}} \quad (6)$$

where, MP_L indicates the marginal product of input labor. Equation (5) indicates the marginal product of labor force of individual factory and the equation (6) indicates the marginal product of labor for the whole sector.

Again, taking partial derivative of the equation (4) with respect to $TINV_i$, we have

$$\frac{\delta \ln(\widehat{OUT_i})}{\delta TINV_i} = \frac{\hat{\beta}}{TINV_i}$$

$$\frac{1}{\widehat{OUT_i}}\frac{\delta(\widehat{OUT_i})}{\delta TINV_i} = \frac{\hat{\beta}}{TINV_i}$$

$$\frac{\delta(\widehat{OUT_i})}{\delta TINV_i} = \frac{\hat{\beta} \times \widehat{OUT_i}}{TINV_i} \quad (7)$$

$$MP_K = \frac{\hat{\beta} \times \widehat{OUT}}{\overline{TINV}} \quad (8)$$

where MP_K indicates the marginal product of input capital investment. Equation (7) indicates the marginal product of capital investment of individual factory and the equation (8) indicates the marginal product of capital investment for the whole sector.

The marginal products of labor force and capital investment for each factory are obtained using the software RATS and are shown below in Figure 5.

Also, the marginal products of labor force and capital are estimated for the whole industry and are given below in Table 4.

Figure 5

Marginal Productivity of Labor Force and Capital Investment

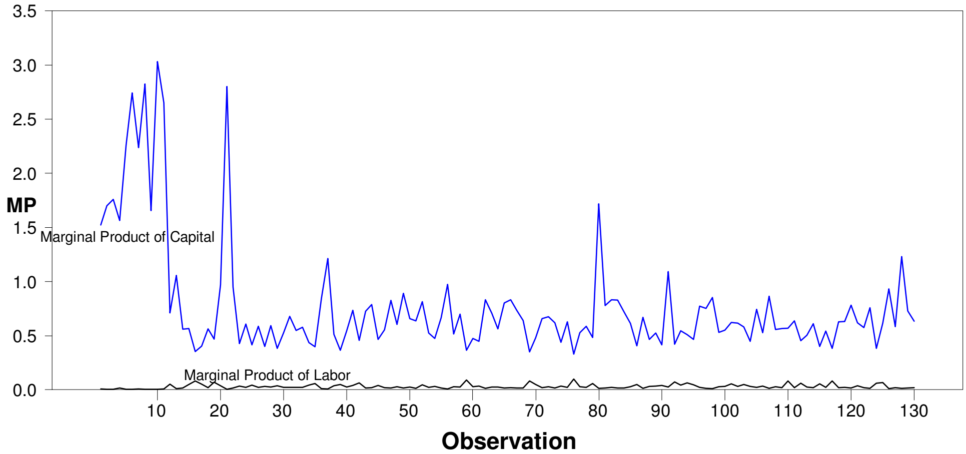


Table 4

Marginal Productivity of Labor Force and Capital Investment for the Garment Sector of Bangladesh

Inputs		Marginal Productivity
Labor		0.0236
Capital		0.5222
Test of Significance		
Variable	t-test	Prob.
Labor	16.751	0.0000
Capital	16.590	0.0000

From Figure 5, it can be said that the marginal products of labor force of the firms are smaller than the marginal products of capital investment in the garment sector of Bangladesh. This is happened due to the existence of unskilled and low-quality labor force in the garment sector of Bangladesh. From the estimated results in Table 4, it is found that the marginal product of labor force is 0.0236 and the marginal product of capital is 0.5222% in the garment sector of Bangladesh. The marginal productivity of labor force is quite smaller than the marginal productivity of the capital investment which is happened due to the existence of a large number of unskilled and low-grade workers. This is not a good sign for the garment sector of Bangladesh. It is a red alarming for the sustainable development of the garment sector of Bangladesh. If this situation is continued for a long-period of time, the development of this sector will not be sustainable and once upon a time, in this sector, the same situation like a Jute sector can be happened. Therefore, the government and other stakeholders have to reform policy frame-workers for which in the garment sector the quality and skilled workers will be increased rapidly, otherwise, in the global market the garment sector will suffer from different problems.

Impulse Response Analysis

Impulse response function implies one variable's response due to shock or innovation in another variable. It encapsulates changes (responses) in a particular variable due to one standard deviation shock or innovation in another variable. In this section the responses of output with respect to one standard deviation shock (innovation) in labor force and capital investment are estimated and are depicted below in Figure 6 and Figure 7.

From Figure 6, it can be said that due to one standard deviation shock (innovation) in labor force, output responds positively for the first two years and then responds negatively for the next two years with positive response subsequently. From Figure-5(b), it is found that due to one standard deviation shock (innovation) in capital investment, output responds positively for the first two years and then responds negatively for the next 8 years.

Figure 6

Responses of Output due to One Standard Deviation Shock (Innovation) in Labor Force

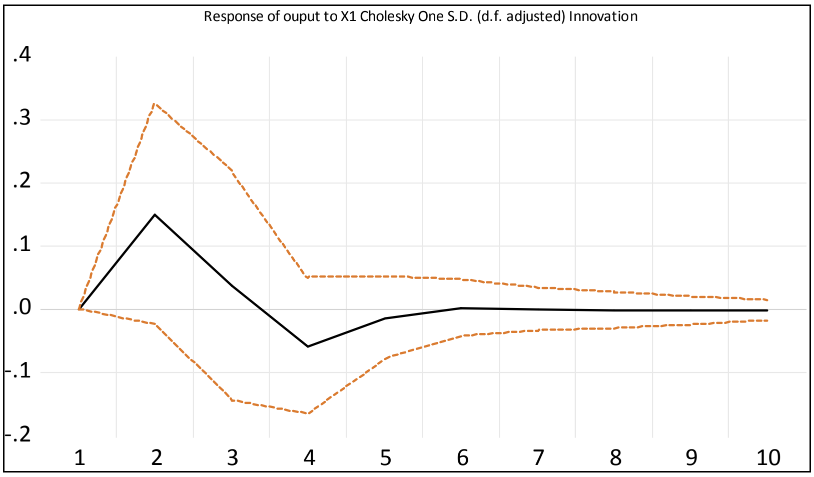
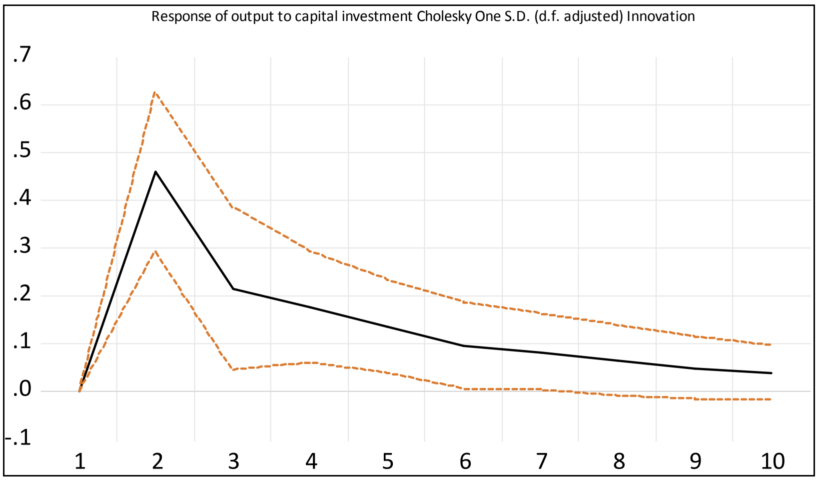


Figure 7

Responses of Output due to One Standard Deviation Shock (Innovation) in Capital Investment



Practical Implementation

From the findings, the following points are recommended that should be implemented to increase the productivity of the labor force which may play an important role for sustainable development of the garment sector of Bangladesh.

First. It is found that the productivity of labor force is smaller than the productivity of capital investment. It is happened due to the existence of a large number of unskilled, low quality and low-grade workers in this sector. The productivity of a labor depends on his/her quality. Primarily the quality of any labor depends on his/her education level. If he/she has a quality education with other characteristics like honesty, sincerity, dignity, energetic, hardworking, having a sense of responsibility etc., then the labor can easily increase his or her expertism irrespective of any field which may play an important role to increase his/her productivity. That is why, policy should be reformed to recruit only those workers who have at least 10 years of education for which the productivity of the labor force of this sector will be increased and per unit production cost will decline.

Second. Still now, the production function of the garment sector of Bangladesh is running under decreasing returns to scale which is happened due to the existence of huge number of unskilled and low-grade workers in this sector. That is why the government including other stakeholders has to develop policy frameworks through development different training institutions to create skilled workers, providing handsome salary, adequate facilities, providing such type of environment for which workers feel secured etc. for which the quality labor force will be increased rapidly in this sector. As a result, in near future the productivity of labor force will be increased at a faster rate and the production of this sector will run under increasing returns to scale and the development of this sector including national economic growth will be sustainable, otherwise in future same situation like a Jute industry can be happened of this sector.

Third. It is found that the marginal product of labor force is very much smaller than the marginal product of capital investment, which implies that the firms of this sector cannot reduce production cost by shifting resources from capital intensive technique to labor intensive technique as a result this sector cannot generate additional employment opportunities. This is not a good sign for this sector. That is why, the government including other stakeholders has to reform policy frameworks for which the productivity of the labor force will be greater than the productivity of capital investment, otherwise the development of this sector will not be sustainable.

Fourth. The government has to develop different institutions including training centers that can supply the skilled workers with quality education in the garment sector as a result the productivity of the garment sector will be increased. If the productivity of the labor force increases, per unit production cost will decline and profit will be increased. Therefore, this sector can accelerate the development at a faster rate and this sector may contribute more and more for the national economic growth including socio-economic development.

Fifth. The garment sector including other stakeholders has to operate different training programs to create skilled workers as a result the productivity of this sector will be increased.

Sixth. Research and development expenditure should be increased to create the skilled workers in this sector.

Conclusions

The contribution of the garment sector of Bangladesh is higher than that of any other sector in terms of economic growth and foreign exchange earnings. The garment sector contributes significantly to the national economy by creating job opportunities and reducing poverty through socio-economic development. This sector plays a significant role in rural development by creating employment opportunities for country people. Over the last twenty years, the garment sector has been vital in terms of improving the lives of rural women. That is why, it is very important for us to formulate different policies for the sustainable development of the garment sector of Bangladesh. Therefore, it is very important to analyze the productivity and measure the returns to scale of the garment sector of Bangladesh.

Thus, the principal purpose of this study was to estimate the Cobb-Douglas production function in order to determine the productivity of the labor force and capital investment. This study is based on the primary data collected from 130 garment factories in Chattogram, Dhaka, Gazipur and Narayanganj using the structured questionnaire. Before estimating the Cobb-Douglas production function for the garment sector, at first some fundamental descriptive statistics of these variables are estimated.

From the estimated results (see Table 1), it is found that on an average the total number of employed (TEM) in each factory is 3150.73, average total investment (TINV) in each factory is 381.09 crore TK, and in each year average output (OUT) is 359.82 crore TK. It is also found that the coefficient of variation CV) is highest for the variable TINV, followed by OUT and TEM. Thus, the risk is highest for the variable TINV. It is also found that all the variables are positively skewed and the curve of the frequency distribution of the variable TEM is platykurtic, while the curves of the frequency distributions of the variables TINV and OUT are leptokurtic.

The Cobb-Douglas production function for the garment sector of Bangladesh is estimated using the econometric techniques based on the primary data. From the OLS estimates (see Table 2), it is found that the coefficients of lnTEM and lnINV are statistically significant at any significance level, which indicates that the variables of labor force and capital investment have significant positive impacts on the output in the garment sector of Bangladesh. Results show that the output elasticity with respect to labor force is 0.2246 given that capital is constant. This indicates that increasing input labor force by 100% will lead to a 22.46% increase in the output. The output elasticity with respect to capital investment is 0.6063 when labor force is constant, so for 100% increase in input capital investment, the output will be increased by 60.63%. From the estimated value of R^2, it is clear that about 80.12% of the total variation of the dependent variable is explained by the fitted regression equation. Thus, the fit is good. The summation of the elasticities is 0.8309, which being less than 1, implies that the production function of the garment sector of Bangladesh has decreasing returns to scale. The diagnostic test results indicate that there is evidence of heteroscedasticity in the data and there is also a problem of normality of random error terms in equation 3.

Due to the problem of heteroscedasticity, the Cobb-Douglas production function is estimated again using the generalized least squares (GLS) method. From the GLS estimates (see Table 3) of the production function, it is found that the coefficients of labor force and capital investment are statistically significant at any significance level. This indicates that the variables of labor force and capital investment have significant positive impacts on the output in the garment sector of Bangladesh. The output elasticity with respect to labor force is 0.2217 when capital is fixed and the output elasticity with respect to capital investment is 0.6102 when labor force is fixed. From the estimated value of R^2, it is clear that about 99.97% of the total variation of the dependent variable output is explained by the fitted regression equation. Thus, the fit is perfect. The summation of the elasticities is 0.8319, which being less than 1, implies that the production function of the garment sector of Bangladesh has decreasing return to scale. The diagnostic test results (see Table 3) show no problems of autocorrelation, heteroscedasticity, autoregressive conditional heteroscedasticity, or normality of random error terms in the equation (3); the model is correctly specified.

It is found that the marginal products of labor force and capital investment are statistically significant at any significance level and that the marginal products of capital investment are much higher than those of labor for each and every firm (see Figure 5). Also, it is found that the marginal product of labor force is 0.0236 and the marginal product of capital investment is 0.5222 for this sector. Since the marginal product of the labor force is much smaller, it can be said that this sector cannot reduce the production costs by shifting resources from capital intensive techniques to labor intensive techniques to minimize the per unit production cost;

as a result, this sector cannot generate additional employment opportunities. This is not a good sign for this sector.

Since the summation of the output elasticities with respect to labor force and capital investment is less than 1, the production function of the garment sector of Bangladesh does not operate under increasing returns to scale, which is also not a good sign for the garment sector of Bangladesh. This is due to the existence of a huge number of unskilled and low-grade workers in the garment sector of Bangladesh. Therefore, the government and other stakeholders have to reform the policies that would ensure that the productivity of the labor force is higher than the productivity of capital – then the production function of the garment sector will operate under increasing returns to scale in near future and the development of this sector will be sustainable.

It is found that output responds positively to one standard deviation shock (innovation) in labor force for the first two years and then responds negatively for the next two years, with subsequent positive response (see Figure 6). Meanwhilw, output response to one standard deviation shock (innovation) in capital investment is positive for the first two years and then negative for the next 8 years (see Figure 7).

Finally, the CUSUM and CUSUMSQ (see Figures 3, 4) tests results suggest that the preferred production function of the garment sector of Bangladesh can be used for policy decision making purposes, such that the impact of policy changes considering the explanatory variables of Cobb-Douglas production function will not cause major distortion in the level of output growth, since the parameters in this equation seem to follow a stable pattern during the estimation period.

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