Economics and Business Quarterly Reviews

The Asian Institute of Research *Journal of Economics and Business* is a peer-reviewed International Journal. The journal covers scholarly articles in the fields of Economics and Business, which includes, but not limited to, Business Economics (Micro and Macro), Finance, Management, Marketing, Business Law, Entrepreneurship, Behavioral and Health Economics, Government Taxation and Regulations, Financial Markets, International Economics, Investment, and Economic Development. As the journal is Open Access, it ensures high visibility and the increase of citations for all research articles published. The *Journal of Economics and Business* aims to facilitate scholarly work on recent theoretical and practical aspects of Economics and Business.

ASIAN INSTITUTE OF RESEARCH
Connecting Scholars Worldwide

Contribution of Factors Affecting Crop Production in Bangladesh: An Empirical Analysis with Production Function Approach

Muhammad Faruq-Uz-Zaman[1]

[1] Dhaka School of Economics, Bangladesh. Email: faruq22@gmail.com

Abstract

Bangladesh has achieved a tremendous success in food production in last few decades amidst challenges of land degradation, land use changes and climate effect. In spite of the increasing trend of yields of crops, there still remain some challenges to meet the growing needs due to increase in population and loss of land to development activities. This study aims to identify the rate of contributions or economics of factors of crop production in Bangladesh. Cobb-Douglas production function has been applied in this study of crop production using a number of production factors within the broad terms land, labour and capital. Secondary data, representing factors of production, have been selected based on literature reviews so that they can be appropriate for this study. Data of crop production have been considered as dependent variables, whereas, land area coverage for agricultural production, labour employed in agriculture, agricultural household expenditure, fertilizer applied and irrigation coverage have been considered as independent variables. Land and labour is negatively correlated with crop production, whereas, fertilizer is positively correlated. Crop production which shows decreasing return to scale deserves the adoption of new technology and good agricultural management practices.

Keywords: Fertilizer, Irrigation, Land Degradation, Soil Fertility

1. Introduction

1.1 Background of the study

Bangladesh is entering into middle-income country group with increasing share of industry and service sector to GDP. The share of agriculture to GDP was 12.68% in 2019 while share of industry and service sector was 29.65% and 52.85% respectively (Plecher, H. 2020). Nevertheless, the agriculture sector is crucial for Bangladesh as it employs almost half of the labour force and economy of most of the rural people rolls with agriculture. This sector is also the primary source of inputs for industry sector. Improved and extensive farming require more labours in a sense but mechanization gradually reduces the demand for labour in agriculture. The landless poor finds jobs in industrial and service sectors and obtains higher real wages (Hossain, et al., 2003; Hossain, 2002). Many additional off-farm jobs are also linked with expansion of farming creating options for

higher income. O'Donnell, 2010 showed that increase in agricultural productivity allows labour and capital to be diverted to expand the non-agricultural sectors. Over time, although, the share of agriculture in GDP has significantly declined in Bangladesh, the contribution of agriculture to non-agricultural growth has maintained an upward trend and it remains an irreplaceable driving force for the economic growth of the country (Rahman, 2017).

A highly dense population imposes challenge to feed its people. The country also suffers from one of the lowest land–man ratios (0.2 ha per person) of the world (Rahman and Salim 2013) and climate vulnerabilities which further aggravate the challenge of food security. Bangladesh has lost about 1 million ha of productive arable land from 1983 to 1996 (BBS, 1999) and the processes of contraction of arable land is still going on. Rapid urbanization and increasing use of land for infrastructural development causes 1% annual loss of agricultural land in Bangladesh (Mohajon, 2013). Therefore, improvement in agricultural productivity and efficiency remains a top priority for Bangladesh in order to ensure food security for its population and industrial growth to meet the demand to become a middle-income country. This study has made an attempt to analyze the contributory effects of production factors for crop production in Bangladesh so that policy measures can be taken to increase crop productivity.

1.2 Objectives

The objective of this study is to identify the rate of contributions or economics of factors of crop production in Bangladesh. More specific objectives of this study are
  a) To identify the elasticity of basic inputs or factors in crop production in Bangladesh,
  b) To identify Marginal Productivity of factors or inputs and
  c) To find out policy suggestions to increase crop production.

Land, labour, household expenditure, usage of fertilizer and irrigation coverage have been considered in this study as the factors of crop production.

1.3 Significance of the study

Since Bangladesh is an agrarian country with high population density and low land-man ratio, there is no alternative to increase crop productivity. Crop productivity should be as high as in the developed country. Improving productivity and efficiency are fundamental strategies to develop a country's economy. Bangladesh has achieved a tremendous success in food production in last few decades amidst challenges of land degradation, land use changes and climate effect. In spite of the increasing trend of yields of crops, there still remain some challenges to meet the growing needs due to increase in population and loss of land to development activities. This study will be able to identify the push factors of agricultural production and provide some insights to increase productivity of crops.

Findings from this research may be helpful for planners and policy makers in order to bring about desired adjustment in resource allocation and consequently in formulating strategies for the production of agriculture.

1.4 Scope of the study

A number of studies have applied the production function approach to identify effects of factors. But different studies have taken different factors as capital. But a little attempts have been identified which have studied effects of factors of crop production using Cobb-Douglas production function in Bangladesh. This study has considered Cobb-Douglas production function for the time series data of five important factors of crop production in Bangladesh. Data have been collected from the recognized and important sources which are illustrated in following subsections. Fertilizer, irrigation and household consumption have been taken as proxies for capital factor besides land and labour. Only the mechanization is not included in this study since Bangladesh is very new in introducing mechanization and data is still not widely available.

2. Literature review

2.1 Theoretical concept

Production function was introduced by Cobb-Douglas in 1928 to describe the distribution of the national income (Wang and Fu, 2013). According to Wang and Fu (2013), production functions specify the output of a firm, an industry, or an entire economy for all combinations of inputs. Felipe and Adams (2005) opined that the Cobb-Douglas production function is still the most ubiquitous form in analyses of growth and productivity.

Olsson (1971) opined that Cobb and Douglas concentrated on the industrial sector, but Wicksell used production function for the production process in agriculture. Cobb-Douglas ignored the land, whereas, Wicksell added the factor 'land' to discuss the production process in agriculture. Even if production function assumes earlier to be constant returns to scale, Olsson (1971) opined, referring Wicksell, that it can also be thought as increasing or decreasing return to scale for agricultural sector.

Armagan and Ozden (2007) also expressed that Cobb-Douglas type production function equations were appropriate for the functional analysis intended for the agricultural activities. It was preferred since it provides easy calculation, ability to test production flexibilities statistically. It introduces a different point of view about the productivity concept and determines the input use efficiency putting forth the function of the outputs obtained based on the inputs used.

Cobb Douglas production function has also been used by Renting, H. et al. (2013) where they have used four independent variables such as agricultural machinery, capital, land and labour investment to investigate the contribution rate of mechanization to agricultural production. Capital investment as shown by agricultural material consumption in their study was the largest contributor in agriculture production in Shaanxi province of China.

According to Echevarria (1998) agriculture is less labor-intensive than both services and industry in Canada, but capital intensity is similar in the three sectors. In his case labour must have negative effect on agricultural production. On the other hand, transformations and technological developments occurred in the agricultural sector in time have absolutely affected productivity (Armagan and Ozden, 2007).

Rahman and Parvin (2009) has shown, using linear and exponential growth model for time series data, that boro rice production was highly correlated with irrigated area. They have suggested expansion of irrigated area to increase rice production.

Merga & Haji (2019) has reviewed various existing research findings and identified most common factors of impeding crop production such as lack of more recently introduced improved seeds, initial capital for investment, loss of cropland, labour, pesticides, invasive alien species, farm storage techniques, methods of small scale irrigation, and religious and cultural challenges. From their study, it was understood that capital for investment, improved seeds, crop land, labour, irrigation are important factors of crop production.

Khatun and Afroze (2016) has also applied Cobb-Douglas production function to identify the relation of GDP with labour and capital for some selected Asian countries. They have used ordinary least square for model estimation using time series data.

Cobb-Douglas production function has also been used by Yuan (2011) to analyze the relation between agricultural output and input factors in Hebei province. Cultivated area, agricultural manpower, effective irrigation area, chemical fertilizer usage, agricultural machinery usage and electricity consumption have been taken as input. They have found that cultivated area and manpower causes less effect on the output while effectiveness of irrigation area, chemical fertilizer, machinery and electricity usage have greater influence on the agricultural output.

2.2 Conclusion from literature reviews and Research Framework

On the basis of theoretical concept, it can be outlined that Cobb-Douglas production function can be applied in the study of crop production using a number of production factors within the broad terms land, labour and capital. Effects of land and labour are not prominent in crop production. Capital in the form of fertilizer application, irrigation coverage, and expenditure for agricultural material consumption as well as technology plays the most effective role for crop production.

3. Research Methodology

3.1 Types of Data

The Secondary data have been used for this study. Data, representing factors of production, have been selected based on literature reviews so that they can be appropriate for this study. Data of crop production have been considered as dependent variables, whereas, land area coverage for agricultural production, labour employed in agriculture, agricultural household expenditure, fertilizer applied and irrigation coverage have been considered as independent variables. For all the variables, data have been collected for 32 years from 1985 to 2016 so that the data has become a time-series data.

3.2 Data Sources

The data used for the analysis are constructed from different sources for different variables.

Crop production: This data represents overall yearly crop production for whole of Bangladesh. The data under this variable are measured in physical quantities, i.e., in lac metric tons. The data was derived from the various issues of the annual Statistical Yearbook of Bangladesh covering the period 1985 to 2016.

Land area coverage under cultivation: Area (in lac hectares) under which all the crops are cultivated is considered as the land area coverage under cultivation. The data was derived from the theglobaleconomy.com. Land is, somewhat, treated as fixed capital and therefore Cobb Douglas function equates only two factors representing labour and capital (Olsson, 1971). But for the food supply for the growing population the nations adopt extension agriculture. The land area for extension agriculture increases historically to produce more crops. But due to population pressure in Bangladesh, area of land has started decreasing to accommodate housing and growth centres. From this point of view, land has been taken as a variable input rather than fixed input.

Labour: Percentage of employment engaged in agriculture with reference to total population in lac has been considered as agricultural labour. The data was derived from the theglobaleconomy.com.

Household expenditure: Household expenditure has been taken as proxy for capital input. The use of seeds, machineries and expenditures for sowing and harvesting are considered as responsible for increase in consumption for rural household. In this sense, the household expenditure causes effect on crop production. This data has been taken from various issues of the annual Statistical Yearbook of Bangladesh.

Fertilizer: The data provides the quantity of fertilizers used per hectare of land (kg/hectare). Though the quantity of fertilizer to be put in a unit of land for a particular crop is fixed, the farmers in Bangladesh mostly cannot put it in optimum level due to high cost of fertilizer. Therefore it has been taken as a variable input for crop production. The data was derived from the theglobaleconomy.com.

Irrigation: This data provides the information about the proportion of total cultivated area under irrigation. It was derived from the website https://knoema.com/ atlas/Bangladesh/topics/Land-Use/Area/Total-area-equipped-for-irrigation.

3.3 Model specification

Production function describes the technical relationship that transforms inputs (resources) into outputs (commodities) (Deberten, 2012). The agricultural output is the result of investment in land, labour and capital. For this analysis crop production in lac metric ton has been treated as agricultural output. Total area used for crop production has been considered as land and number (in lac) of agricultural labour has been considered as labour. Agricultural household consumption, fertilizer used in crop land and proportion of irrigation coverage have been considered for capital inputs. Although machineries, fertilizer, irrigation, seeds, water and training are valuable capital inputs for crop production, fertilizer, irrigation and household consumption have been taken as proxies for capital input for data constraints. The use of seeds, machineries for sowing and harvesting are considered as responsible for increase in consumption for rural household.

The equation of Cobb-Douglas production function is

$$Y = AL^{\beta 1} K^{\beta 2} \ldots\ldots\ldots..(1)$$

where,   Y = crop production (output)
     A = factor productivity
     L = labour input
     K = capital input
     $\beta 1$ = share of labour for output
     $\beta 2$ = share of capital for output

Since household consumption, irrigation and fertilizer have been taken as proxies for capital, the function for this study stands as

$$Y = AL^{\beta 1}\, D^{\beta 2}\, C^{\beta 3}\, F^{\beta 4}\, I^{\beta 5} \ldots\ldots\ldots..(2)$$

where,   Y= crop production (output)
     A = factor productivity
     L = area of cultivated land as input
     D = labour input
     C = household consumption input
     F = fertilizer
     I = Irrigation

     $\beta 1$= share of land for output
     $\beta 2$= share of labour for output
     $\beta 3$ = share of household consumption for output
     $\beta 4$ = share of fertilizer for output
     $\beta 5$ = share of irrigation for output

Equation 2 is non-linear as the derivatives of Y with respect to the parameters are dependent on the parameters themselves. So non-linear least squares approach should be used to estimate this equation. But Ordinary Least Squares (OLS) can be applied to estimate the model after linearizing the equation by taking natural logarithm for both sides.

By   linearizing, the equation 2 will be,

$$\ln Y = \ln A + \beta 1\, \ln L + \beta 2\, \ln D + \beta 3\, \ln C + \beta 4\, \ln F + \beta 5\, \ln I + \ldots\ldots\ldots.. (3)$$

The β values represent the elasticity of production with respect to the corresponding input. The summation of β values represents the degree of returns to scale. Earlier it was discussed that Cobb-Douglas production function could be thought as increasing, decreasing or constant returns to scale for agricultural sector.

Marginal productivity is the change in production resulted from the change in input of factor of production. To measure the marginal productivity the following equation has been used:

$$MP = \frac{\Delta Y}{\Delta I}$$

Where   MP = marginal productivity,
            Y   = output,
            I   = input

4. Discussion of Results and Implication

4.1 Estimation and interpretation

The Ordinary Least Squares (OLS) estimation has been derived using Stata which is shown in the following.

Table 1: Summary of OLS estimates

Variable	parameter	coefficient	Std Err
Intercept	lnA	9.80834	4.220378
ln land	β1	- 1.544281*	.8246276
ln labor	β2	- .1100611	.402417
ln household expenditure	β3	.0879697	.086162
ln fertilizer	β4	.5208205**	.1631253
ln irrigation	β5	.0682432	.15794

No. of obs = 32
F (5, 26) = 105.18
Prob>F = 0.0000
R^2 = 0.9529
Adj R^2 = 0.9438
Root MSE = 0.07009

Durbin Watson d –statistic (6, 32) = 1.04594

Durbin-Watson test shows that dwatson (1.045) is greater than R^2 (0.9529). Santaularia (2009) and Baumohl & Lyocsa (2009) have observed much higher values of adjusted R^2 and much lower values of Durbin-Watson statistics for spurious regression. The higher value of Durbin-Watson statistic than R^2 in this study tells that the time series is stationary which confirms the OLS estimation as not spurious. The coefficient of determination (R^2) indicates that 95% of data are explained in this model.

The p-value associated with the F value is very small (0.0000) which conclude that the independent variables predict the dependent variable. **P>|t|** value for land and fertilizer indicates the coefficients of these two variables are statistically significant. The coefficients of labour, expenditure and irrigation are less significant. The coefficient of land indicates that 1% increase in cultivated area causes 1.54% less production and coefficient of fertilizer indicates that 1% increase in fertilizer causes 0.52% increase in production. The labour is negatively correlated whereas consumption and irrigation are positively correlated with crop production.

Inverse correlation of land with crop productivity was also found by Msangi (2017) and Ansoms et al. (2008). It can be described in two ways. Area of land increases due to increase in individual farm size. Large farmers may not be interested to plough all their land with same efficiency, whereas small farmers, having no alternative for livelihood, plough with full efficiency. The efficient use of fertilizer causes increase in crop production. Since the fertilizer is subsidized, the small farmers can avail fertilizer with less cost. Another explanation of less

productivity is inclusion of fallow land in order to extension of crop production to feed its large population. Char lands and coastal saline lands are included for the area of cultivation to be increased. However the crop production cannot be at its optimum level because of infavourable condition of soil.

4.2 Returns to scale and interpretation

The sum of the coefficients of independent variables ($\beta 1 + \beta 2 + \beta 3 + \beta 4 + \beta 5 = - 0.977$) shows decreasing returns to scale. It implies that if land, labour, fertilizer, irrigation and household consumption increase by some proportion, crop production decreases with less than proportionately over time. Soil fertility is decreased over time due to extensive cultivation if new technology cannot be adopted. It causes the decreasing returns to scale.

4.3 Estimated marginal productivity and interpretation

The analysis has also been done to estimate marginal productivity of land, labour, household consumption, fertilizer and irrigation.

Table 2: Marginal Productivity of Variables

Variables	Marginal productivity
Land	- 1.544281
Labour	- .1100611
Household expenditure	.0879697
Fertilizer	.5208205
Irrigation	.0682432

The marginal productivity of land implies that crop production will be 1.54 metric ton less due to increase in one more hectare of land. Similarly crop production will be 0.11 metric ton less due to increase in one more labour. But 0.52 lac metric ton more crops will be produced if one more kg of fertilizer applied per hectare and 0.06 metric ton more crops will be produced due to increase in one more hectare of irrigation coverage.

5. Conclusion and Recommendations

5.1 Conclusion

In this study, the Cobb-Douglas production function model has been used to estimate the contribution rate of factors for crop production. Regression analysis of factors of production demonstrated that the growth of crop production significantly depends on application of fertilizer. Irrigation and household consumption also has positive impact on production. Since the use of seeds, machineries and expenditures for sowing and harvesting are considered as responsible for increase in consumption for rural household, the use of seeds, machineries must have some positive impact on production. But the effect of these factors is not so much significant. On the other hand, land and labour interestingly have become negatively correlated with crop production. From this finding it may be considered that quality of soil or land area is degrading rapidly more than the area included for cultivation every year. Overall crop production shows decreasing returns to scale. It may happen due to decrease in land productivity, use of traditional plough methods, land degradation, decrease in soil fertility and increase in soil salinity in coastal region. The data showing increasing crop production is the result of application of fertilizer and improved seeds. The excess use of inorganic fertilizer may further aggravate the soil fertility.

5.2 Recommendations
From the findings of the above study the following recommendations can be suggested:
1) Increasing land productivity is must since Bangladesh has low land-man ratio and every year arable land is being lost due to urbanization.
2) Improved agricultural practices should be adopted.
3) Traditional sowing and harvesting should be replaced by highly mechanized techniques.
4) Farmers should be provided with proper technical knowledge of farming,

5) Crop rotation technique should be adopted in a way so that the soil health can be rejuvenated rapidly.
6) Proper management of production practices and inputs are necessary.
7) Research on transformative and technological development should also be given priority.

References

Ansoms, A. et al, 2008: The Inverse Relationship between Farm Size and Productivity in Rural Rwanda, Discussion Paper, Institute of Development Policy and Management, University of Antwerp.

Armagan, G. and Ozden, A., 2007: Determinations of Total Factor Productivity with Cobb-Douglas Production Function in Agriculture: The Case of Aydin-Turkey, Journal of Applied Sciences, 2007, Volume 7, Issue 4, Page No.: 499-502

Baumohl, Eduard and Stefan Lyocsa, 2009: Stationarity of time series and the problem of spurious regression, MPRA Paper No. 27926, posted on 07 Jan 2011 20:50 UTC retrieved from the URL https://mpra.ub.uni-muenchen.de/27926/ on 17 December 2020.

BBS, 1999: Statistical Yearbook of Bangladesh. 1999, Bangladesh Bureau of Statistics, Government of Bangladesh.

Debertin, David L., 2012: Agricultural Production Economics, Second edition, University of Kentucky.

Echevarria, Cristina, 1998: A Three-Factor Agricultural Production Function: The Case of Canada, International Economic Journal, volume, 12, 1998, issue 3.

Felipe, J. and Adams, F. G. (2005). "A Theory of Production" The Estimation of the Cobb-Douglas Function: A Retrospective View. Eastern Economic Journal, Vol. 31(3), pp. 427-445.

Hossain, M., D. Lewis, M. Bose and A. Chowdhury, 2003: Rice research, technological progress, and the impact on the poor: the Bangladesh case (summary report), Discussion paper no. 110, Environment and Production Technology Division, International Food Policy Research Institute: Washington, DC, USA.

Hossain, M. 2002. Promoting the rural non-farm economy of Bangladesh, CPD- IRRI Policy Brief, 3, Centre for Policy Dialog - International Rice Research Institute, Dhaka, Bangladesh.

Khatun Tahmina and Sadia Afroze, 2016: Relationship between Real GDP and Labour & Capital by Applying the Cobb-Douglas Production Function: A Comparative Analysis among Selected Asian Countries, Journal of Business Studies, Vol. XXXVII, No. 1, April 2016.

Knoema, (n. d.): Data for irrigation was retrieved from URL https://knoema.com/ atlas/Bangladesh/topics/Land-Use/Area/Total-area-equipped-for-irrigation on 17 December, 2020.

Merga, Bulti & Jema Haji, 2019: Factors Impeding Effective Crop Production in Ethiopia, Journal of Agricultural Science; Vol. 11, No. 10; 2019

Mohajon, H., 2013: Food, Agriculture and Economic Situation in Bangladesh, proceedings of 2nd International Conference on Global Sustainable Development, 2013, Office of Research, Innovation and Commercialization, Khadim Ali Shah Bukhari Institute of Technology.

Msangi, H. A., 2017: Examining the inverse relationship between farm size and efficiency in Tanzanian agriculture, unpublished MSc thesis, Sokoine University of Agriculture, Tanzania.

O`Donnel, C. J., 2010. Measuring and decomposing agricultural productivity and profitability change, Australian Journal of Agricultural and Resource Economics, 54: 527- 560.

Olsson, Carl-Axel, 1971: The Cobb-Douglas or the Wicksell function? Economy and History, 14:1, 64-69, DOI: 10.1080/00708852.1971.10418884

Plecher, H. 2020: Share of economic sectors in the GDP in Bangladesh 2019, web edition published *in* www.statista.com, cited on 14 January, 2021.

Rahman, M. T., 2017: Role of Agriculture in Bangladesh Economy: Uncovering the Problems and Challenges, International Journal of Business and Management Invention, Volume 6 Issue 7, July 2017, PP 36-46.

Rahman, M Wakilur and Lovely Parvin, 2009: Impact of Irrigation on Food Security in Bangladesh for the Past Three Decades, Journal of Water Resource and Protection, Vol. 1 No. 3 (2009), Article ID: 687

Rahman, Sanzidur, and Ruhul Salim, 2013: Six Decades of Total Factor Productivity Change and Sources of Growth in Bangladesh Agriculture (1948–2008). Journal of Agricultural Economics 64: 275–94.

Renting, H. et al., 2013: Investigation of the contribution rate of agricultural mechanization to agricultural production using Cobb Douglas model, Information Technology Journal, 12(8), 1607-1613.

Santaularia, Ventosa, 2009: Spurious Regression, Journal of Probability and Statistics, Volume 2009, Article ID 802975, 27 pages

TheGlobalEconomy.com, (n. d.): Data for labour and fertilizer was retrieved from URL https://www.theglobaleconomy.com/compare-countries on 17 December, 2020.

Wang, Xiaoshu and Yu Fu, 2013: Some Characterizations of the Cobb-Douglas and CES Production Functions in Microeconomics, Abstract and Applied Analysis, vol. 2013, Article ID 761832, 6 pages.

Yuan, Zaijian, 2011: Analysis of agricultural input-output based on Cobb–Douglas production function in Hebei Province, North China, African Journal of Microbiology Research 5(32), pp 5916-5922.