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Production Function Modeling of the Relationship between Quantity of Graduates and Federal Government Grants Case Studies: Universiti Sains Malaysia

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Abstract

In recent years, much work has been constructed in the area of productivity and growth in order to identify the link between factor inputs and output based on production function. However, in the field of tertiary education, there are less research to classify and discover a model to estimate the production of graduates in accord with the factor inputs. This paper discusses the usage of production function in which the properties are specified in order to fit the tertiary education sector with reference to the data of Universiti Sains Malaysia (USM). It is then estimated with the Cobb-Douglas Production function (C-D). Aspects such as the inferences caused by multicollinearity, heteroscedasticity, and autocorrelation are also analyzed. In this approach, OLS and GLS type of regression analysis have been carried out in order to analyze the productivity and growth of USM in producing graduates. A suitable model produced by using two independent variables namely emolument (from federal government operating expenditure) and capital (remaining federal government grant plus federal government developing grant), is in fact presentable in the form of C-D production function. The outcome of this study indicated a value greater than 1 for $\beta 1$ and less than 0 for $\beta 2$ which implies that USM is experiencing an increasing marginal product of emolument, E and negative marginal product of capital plus development grant, C.

Keywords: C-D production function, tertiary education sector, regression analysis

1. Introduction

The idea of developing production function models for tertiary education sector especially for universities has been a vital step to analyze the efficiency of producing graduates as well as to serve as an aid in the field of growth of the university. The need for proper variable selection is essential in order to construct the production function for the purpose of assisting in the production capacity planning.

Wicksteed [in Neoclassical Production Function by Goncalo, L.F & Leanne, U.] proposed a good production function, Y, to follow the general form below:

$$Y = f(X_1, X_2, \ldots, X_n) \quad (1)$$

which relates a single output y to a series of factor inputs of production; $X_1, X_2, \ldots, X_n$. In this form, joint production is excluded, meaning it is a "single-ware" production, as defined by Frisch [in Neoclassical Production Function by Goncalo, L.F & Leanne, U.]. The standard form of the Neo-classical production function is:

$$Y = A(t)f(K,L) \quad (2)$$

where K, L and A denotes capital, labor and technical change respectively. Generally, the chief factor inputs incorporated in the production process as resources are capital and labor. Intermittently, capital and labor are supplemented by land, materials or energy to attempt to “complete” the production function. There are empirical researches which incorporate additional factor inputs, for instance, Aschauer’s work in the USA [Aschauer, 1989]. He has implemented the standard form:

$$Y = A(t)f(L,K,G) \tag{3}$$

with Y indicating output, L labor, K the stock of private capital and G the stock of public capital. The other motivating example is Mefford’s effort to introduce management of the plant or firm, MGMT, as one of the factor inputs in the production function [Mefford, R.N., 1986]:

$$Y= A(t)f(L,K,MGMT) \tag{4}$$

A study on production functions in Malaysia has been carried out by Thillainathan [1969] in five major manufacturing sectors: West Malaysian Manufacturing sector, Food Manufacturing Industries, Timer-based industries, Chemical & Chemical Products and Metal, Machinery, Electrical Goods & Transport Equipment. The researcher used the neoclassical model’s factor inputs to fit the C-D and Constant Elasticity of Substitution (CES) production functions.

Generally, C-D production function is used for manufacturing type of sector which involves a firm or plant.

This pioneer study focuses in education sector at tertiary level to show the applicability of C-D production function. The production function which is developed incorporates adjusted variables for factor inputs followed by tests for its significance. The variables are used to estimate in a functional form, indirectly determining if the adjusted variables fit the production function. With the model, one can easily identify whether the resources, in this case federation government grants for operating and development expenditure, are maximized to produce graduates.

2. Approach and Methods

2.1 Theoretical Framework to Develop the Estimating Equation

Most of the local universities in Malaysia are subsidized by government grants. The grants are categorized under three major funds; operating expenditure grant, development grant and Short Term Intensification of Research in Priority Areas grant (IRPA). The latter is allocated for research and development purpose which is prearranged to academic staffs upon proposal acceptance. This study only considers the first two grants as factor inputs.

The proposed model for the University Sains Malaysia’s (USM) production function comprises of two factor input following the government’s specification of grants:

$$G = A(t)f(E,C) \tag{5}$$

where C=K+D and G denotes number of graduates, E denotes emolument, K denotes capital and D denotes development grant respectively. The estimated production function is analyzed for its significance in order to identify the suitable form.

2.2 Data: University Sains Malaysia

Universiti Sains Malaysia has three branches across peninsular Malaysia; Main Campus (Minden), Engineering Campus (Transkrian) and Medical Campus (Kubang Krian). The university’s Medical Campus is affiliated with the government hospital in which medical students undergo practical training. Operating and development expenditure for its operation are also allocated by the federal government (inclusion in the USM’s annual budget). It is fairly ‘expensive’ to produce a medical graduate compared to graduates in other field. The data obtained from USM’s annual report cannot be discriminated according to the campuses because that will lead to data constraint. The summary of data used in this study is as below [Simpson, H.A. & Levy, F.K., 1963]:

(i) Graduates

The number of graduates which represent the dependent variable is the summation of students graduating yearly, regardless of the field of study or type of degree. This is based on the assumption that all the facilities are equally accessible among students.

(ii) Emolument

This independent variable is represented by the elements as stated in Table 1. Allocation for emoluments comes from the operating expenditure grant.

Table 1 – Emolument

ELEMENTS OF EMOLUMENT:
Basic pay
Additional staff cost (EPF & SOCSO)
Overtime allowances
Other staff benefits

(iii) Capital

Capital is the second dependent variable and its allocation is also from the operating expenditure grant (Table 2). USM introduced a new policy for asset depreciation in 1989 and it has been put into practice since then. In order to synchronize the data ranging from 1972-2002, the depreciation value is excluded.

Table 2– Capital based on operating expenditure

ELEMENTS OF CAPITAL:
Supply & Services
Purchase of assets
Fixed Payments & commitments
Other Expenditures
Bad debts

(iv) Development grant

Development grants are defined as the sum of monies issued by government yearly as proposed by the university for development purposes. The Malaysian Ministry of Education was committed to the World Bank on behalf of USM for development purposes in the year 1976 (RM26,715,000), 1977 (RM19,702,000), 1978 (RM10,325,978), 1979 (4,126,910) and 1980 (RM5,535,846). These figures are excluded in the study for synchronization purposes.

2.3 The Cobb-Douglas Production Function

The first production function representing the quantity of labor and capital is suggested by Cobb and Douglas [1976] as

$$Y = \beta_0 L^{\beta_1} K^{\beta_2} e^u \qquad (6)$$

Where β_0 represents A(t), and e^u is multiplicative error, which becomes additive in the logarithmic transformation (for time series data):

$$\log Y_t = \log \beta_0 + \beta_1 \log L_t + \beta_2 \log K_t + u_t \qquad (7)$$

Hence, (7) has become log-linear form which permits straightforward estimation. With the factor inputs as stated in (5), the model in the form of C-D production function is:

$$\log Y_t = \log \beta_0 + \beta_1 \log E_t + \beta_2 \log C_t + u_t \qquad (8)$$

The production function expressed in equation (8) is then regressed with Ordinary Least Square (OLS) and General Least Square (GLS) methods. The first order Markov scheme is introduced in [8,9]:

$$u_t = \rho u_{t-1} + \varepsilon_t \tag{9}$$

where u_t is the error term from (8), ρu_{t-1} is the carryover effect and ε_t is new shock effect. Therefore (8) can be rewritten as:

$$\log Y_t = \log \beta_0 + \beta_1 \log E_t + \beta_2 \log C_t + \rho u_{t-1} + \varepsilon_t \tag{10}$$

In order to eliminate ρu_{t-1} for autocorrelation free model, (8) is multiplied with ρ, followed by lag the resultant equation by one time period:

$$\rho \log Y_{t-1} = \rho \log \beta_0 + \rho\beta_1 \log E_{t-1} + \rho\beta_2 \log C_{t-1} + \rho u_{t-1} \tag{11}$$

Now, subtract (11) from (10):

$$(\log Y_t - \rho \log Y_{t-1}) = \beta_0(1-\rho) + \beta_1(\log E_t - \rho \log E_{t-1}) + \beta_2(\log C_t - \rho \log C_{t-1}) + \varepsilon_t \tag{12}$$

$$Y_t^{\#} = (\log Y_t - \rho \log Y_{t-1}) \qquad (i)$$

$$\beta_0^{\#} = \beta_0(1-\rho) \qquad (ii)$$

$$L_t^{\#} = \beta_1(\log L_t - \rho \log L_{t-1}) \qquad (iii)$$

$$K_t^{\#} = \beta_2(\log K_t - \rho \log K_{t-1}) \qquad (iv)$$

If (i)-(iv) holds, then one can rewrite (12) as a GLS method:

$$Y_t^{\#} = \beta_0^{\#} + \beta_1 L_t^{\#} + \beta_2 K_t^{\#} + \varepsilon_t \tag{13}$$

The test for multicollinearity, heteroscedasticity and autocorrelation are Variance Inflation Factors (VIF), B-P-G test (based on R^2), Portmanteau Q-Test and Durbin-Watson d test respectively [Pindyck, R.S & Rubinfeld, 1998].

3. Results and Discussion

When the model of G= A(t)f(E,C) is analysed, heteroscedasticity test shown by the B-P-G and Q test did not pose a problem. The resultant production function is also multicollinearity free. However, the OLS method has a possibility of being bias (the presence of autocorrelation), as indicated by DW test. Consequently, this method is either underestimating or overestimating the C-D production function. Albeit, GLS method is free of inferences and it estimates the coefficients of factor inputs relatively precise. The factor input (capital) is significant at ~10%.

Table 3– Results for G= A(t)f(E,C)

	R^2	Constant	Log E	Log C	DW Test
OLS	0.9588	-10.854° (0.7347)	1.4173° (0.1148)	-0.4061° (0.1132)	0.88575
GLS	0.4896	-	1.3873° (0.2225)	-0.2339°°° (0.1418)	1.89020

Notes: Standard errors are as stated in parenthesis. ° Significant at 1% level, °° Significant at 5% level & °°° Significant at 10% level

The GLS method can be used to estimate the C-D production function. USM shows a good performance as it has maximized the number of graduates over the years. The elasticity of emolument shows that one percent increase in emolument would increase 1.4 percent in the number of graduates. This indicates that the strength of the university relies on quantity of academic and non academic staff. However, one percent of increase in C (capital + development grant) indicates 0.3 percent of decrease in the number of graduates. Our judgment on this matter is; the existing facilities are enough for maximal production of graduates and higher expenditure in terms of C indicates overspending in the current years. However, the intrinsic idea of investing in C would potentially attract more students to enroll in the future.

The constraints that occur in this study are:

i) The university started to accumulate bad debt on 1995 onwards because students who are sponsored for scholarships neither payback nor work for the university and this data has been omitted for this study for synchronization purpose.

ii) The cost involved to subsidize medical students is comparatively higher, thus overloading the factor inputs of the elasticity.

iii) The adjustment made for synchronization purpose on the debt with the World Bank could occur as an inference as well.

iv) As one can argue, depreciation value which indicates the decreased percent (in accord with the policy implemented) of purchased or existing assets does play a role until it is written off. The exclusion of it has been discussed under section 2.

4. Conclusion

In this research, C-D production function has been incorporated to analyze USM's annual data. The results proofs that federal operating expenditure grants which excludes emoluments plus development expenditure grants ought to be represented as capital, as whole. The GLS method can be used to construct inference free C-D production function with significant factor inputs. The outcome of this study indicated a value greater than 1 for β_1 and less than 0 for β_2 which implies that USM is experiencing an increasing marginal product of emolument, E and negative marginal product of capital plus development grant, C. Based on the points stated above it can be concluded that the C-D production function can be used for production and capacity planning in the tertiary education sector.

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5. References

Goncalo L. Fonseca. & Leanne Ussher. Neoclassical Production Function. Http://cepa.newschool.edu/het/essays/product/prodcont.htm

Aschauer, D. 1989. Is Public Expenditure Productive?. Journal of Monetary Economics 23: 177-200.

Mefford, R. N. 1986. Introducing Management into the Production Function. The Review of Economics and Statistics 23 (1): 96-104.

Thillainathan, R. 1969. Prodcution Functions in the West Malaysian Manufacturing Sector. Malaysian Economic Studies 4 (2): 27-35.

Douglas, H.P. 1976. The Cobb Douglas Production Function Once Again: Its History, Its Testing and Some New Empirical Values. Journal of Political Economy 84 (5): 903-916.

Simpson, H.A & Levy, F.K. 1963. A Note on Production Function. The Review of Economic Studies 30 (2): 93-94.

Universiti Sains Malaysia Yearly Report. 1970-2002. Various Volumes.

Gujarati, D.N. 4th Eds. 2003. Basic Econometrics. New York: Mc Graw Hill.

Pindyck, R. S & Rubinfeld, D. L. 4th Eds. 1998. Econometric Models and Economic Forecast. New York: Mc. Graw Hill.