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A Comparison of Optimization and Non-Optimization Approaches in IS Business Value Research

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In spite of remarkable improvements in computing power in the recent decades, empirical research on the productivity of IT does not reveal a consistent pattern. We speculate that the mixed results of information technologies, or IT productivity might be attributed to research methodology; that is, the classical OLS model of business value created by IT spending does not follow the economic assumption - cost minimization or profit

maximization. The purpose of the comparison in this paper is to understand the importance of the incorporation of this assumption. We argue that firms search for the optimal output and input alignment to maximize the profit or to minimize the cost and the ignorance of this assumption may lead to incorrect conclusion. Even if we recognize the importance of incorporating optimization assumptions, the empirical data may not allow us to make correct estimation because the empirical data from firms may not be the consequence of optimization due to mismanagement of input resources.

The comparison is done between the non-optimization method and the optimization method. The non-optimization models usually involve inputs as independent variables and output level as the dependent variable. An OLS will be performed after the variables have been specified (e.g., Loveman, 1994.). We use the following specific Cobb-Douglas formulation in our study:

(1)

where Q = output level

X_1 = information processing equipment

X_2 = non-information processing equipment

X_3 = structures

X_4 = inventories

X_5 = wages and salaries

B, β_i = parameters

The log transformation yields:

(2)

where , ln $B = \beta_0$. Since this is a linear equation, OLS can be applied to find the estimators of the parameters.

The optimization approach states that given a competitive market output price p, an input price vector $\boldsymbol{w}$, and an output quantity y, cost minimization is obtained by choosing input quantity vector, $\boldsymbol{x}$, as the following cost function:

(3)

where y is a production function, $y = f(\mathbf{x})$.

The optimal input quantities can be solved by formulating a Lagrangian function. The first order conditions of the Lagrangrian function will form a system of equations as the follows:

(4)

These five equations will be used in order to solve the quantities for five $X_i's$. The profit maximization problem can be solved in a similar way by constructing the following profit maximization function:

(5)

In cost minimization, the Lagrangian function will produce the optimal set of input quantities based on the given price information, output quantity level, and a given predefined set of parameters, α's for the input variables which are information processing equipment, non-information processing equipment, construction, inventories, and wages in our analysis. The quantity data are produced by a simulation based on the macroeconomic price deflators, and GDP ranged from 1980 to 1993. 7,000 data sets of prices and outputs are acquired to represent data of 500 pseudo companies in 14 years so that 7,000 sets of optimal input quantities can be obtained by the cost minimization function. The source of the deflators is WEFA group reports. The WEFA group, founded by L. R. Klein, the 1980 Nobel Laureate of Economics, has provided consulting services across the world. They consolidate the data from different sources such as Bureau of Labor Statistics, Bureau of Census, etc. The 7,000 sets of input quantities combined with input prices, output quantities, and output prices can constitute the data elements for Full Information Maximum Likelihood (FIML) estimation which is an econometric tool in which the estimates of all the parameters in both production function and the first order conditions are created simultaneously by maximizing the likelihood function. Similarly, profit maximization will produce both input and output quantities for the data elements of FIML. The difference is that in profit maximization, input and output quantities y and $\boldsymbol{x}$ are decision (endogenous) variables, and prices, p and $\boldsymbol{w}$, are exogenous variables which are out of a firm's control; while in cost minimization problem, only input quantities are endogenous variables, and the others are exogenous variables. For OLS model, the input expenditures, $w_i x_i$, form the independent variables which regress the independent variable, y. To ease the reading, we list the input variables and the corresponding parameters in the following table:

Table 1: Parameters of the Input Variables

Variables	Non-Optimization	Optimization
Constant	β_0	α_0
Information Processing Equipment	β_1	α_1
Non-Information Processing Equipment	β_2	α_2
Construction	β_3	α_3
Inventories	β_4	α_4
Wages and Salaries	β_5	α_5
Time	β_6	α_6

If both optimization and non-optimization approaches are indifferently correct, they should generate a set of estimates similar to the predefined parameters. The predefined parameters are (0.25, 0.25, 0.15, 0.15, 0.2). We speculate that the classical OLS model and models following the basic microeconomic assumption are not interchangeable. That is, models lacking of the microeconomic behavioral assumption cannot generate the same results as those following that assumption. We can get the estimates of the above cost minimization approach in the following table:

Table 2: Cost Minimization with FIML

Parameter	Estimate	Standard Error	t-Statistic	p-value
α_0	1.0000173	.384209E-04	.450032	0.22428
α_1	.250000	.1221327E-05	206055	0.00000
α_2	.250000	.121008E-05	206598	0.00000
α_3	.149999	.733479E-06	204504	0.00000
α_4	.150000	.746536E-06	200928	0.00000
α_5	.200000	.978331E-06	204429	0.00000
α_6	.283505E-06	.760603E-06	.372736	0.00000

The estimates from the profit maximization model can be obtained in the similar way:

Table 3: Profit Maximization with FIML

Parameter	Estimate	Standard Error	t-Statistic	p-value
α_0	1.00000	.865910E-06	.115485E+07	0.10023
α_1	.250000	.817873E-07	.305671E+07	0.00000
α_2	.250000	.806458E-07	.309997E+07	0.00000

α_3	.150000	.708275E-07	.211782E+07	0.00000
α_4	.150000	.750884E-07	.199764E+07	0.00000
α_5	.200000	.749850E-07	.266720E+07	0.00000
α_6	-.177843E-07	.275399E-07	-.645765	0.00000

The OLS estimation is done by directly estimating the log-transformed Cobb-Douglas function in equation (2):

Table 4: OLS Estimation

Parameter	Estimate	Standard Error	t-Statistic	p-value
β_0	5.34841	4.97767	1.07448	0.28261
β_1	-17.3110	11.4418	-1.51296	0.13029
β_2	3.85431	10.7609	.358176	0.72021
β_3	2.62745	7.05088	.372641	0.70942
β_4	.438083	7.85726	.055755	0.95554
β_5	11.2071	8.52018	1.31536	0.18839
β_6	-0.920998E-02	.293191E-03	-31.4129	0.00000

Table 2 and Table 3 reveal that the estimations of both cost minimization and profit maximization are efficient since the *p*-values are almost zero except the ones for the constants, A. All the parameter estimates are equal to the ones we have given; that is, α's = (0.25, 0.25, 0.15, 0.15, 0.2).

Table 4, however, gives us a different story. The table is produced by using OLS model. It is apparent that the estimates are not unbiased and the p-values are not statistically significant except the one for time variable, T. That means OLS produces a set of parameters which are not equal to the one we have given. Of course, that concludes that the OLS model is erroneous. Econometricians have explained the reason that OLS model is not appropriate in estimating a model involving simultaneous equations like the one we have shown: the OLS model specifies that the observations on the regressors can be considered fixed in repeated samples. In many economic contexts, however, the independent variables are themselves random or stochastic variables and thus could not have the same values in repeated samples. Since the behavior of firms follows the profit maximization or cost minimization assumption, the input quantities should be generated from a system of equations composed by the first order conditions. Thus, all the endogenous (or input) variables will be determined concurrently when the disturbance is changed. This violates the traditional OLS model assumption and thus an OLS model cannot posit an accurate estimation to the parameters.

In this short paper, we have shown that although OLS has been popularly employed to assess the IT business value, it does not posit correct answer because it does not incorporate the basic economic assumption -- cost minimization or profit optimization. We believe that the basic economic assumption is the guideline to most business entities, so the OLS model may not be appropriate in IT business value empirical analysis. On the other hand, some econometric models, such as FIML, since they are developed under the assumption, should be considered one of the major paradigms in MIS studies.

(references available upon request from the author.)