AGGREGATE AND SECTORAL PRODUCTION FUNCTIONS OF THE WEST BANK AND GAZA STRIP

BASIM MAKHOOL *

ABSTRACT

The purpose of the study is to estimate production functions at the aggregate and sectoral level of the Occupied Palestinian Territories OPT over the period 1970-87 using regression analysis. The results show that production in the West Bank exhibits mostly constant and decreasing returns to scale with the exception of the industrial sector. While production in the Gaza strip exhibits increasing returns to scale except the service sector. The marginal productivity of capital in the West Bank was almost three times larger than that of the Gaza Strip. Labor was the most productive in the industrial and construction sectors in both regions even though the order of the sectors is reversed. Also, the marginal rates of technical substitution were lower in the West Bank than in the Gaza Strip except the industrial sector.

* **Assistant Prof. Faculty of Economics, Dept of Economics, An-Najah University / Nablus.**

دوال الانتاج الكلية و القطاعية لكل من الضفة الغربية و قطاع غزة

باسم مكحول

ملخص

تهدف هذه الدراسة الى تقدير دوال الانتاج على المستوى الكلي و القطاعي لاقتصاديات الضفة الغربية و قطاع غزة للفترة ١٩٧٠-١٩٨٧ ، و ذلك باستخدام تحليل الانحدار. و قد اظهرت النتائج الاحصائية ان دوال الانتاج في الضفة الغربية تتميز بثبات و تناقص عوائد الحجم باستثناء القطاع الصناعي الذي يتميز بتزايد عوائد الحجم، بينما تتميز دوال الانتاج في قطاع غزة بتزايد عوائد الحجم باستثناء قطاع الخدمات الذي يتميز بتناقص عوائد الحجم. كما تشير النتائج الى ان الانتاجية الحدية لراس المال في الضفة الغربية تعادل ثلاثة اضعاف ما هي عليه في قطاع غزة، كما ان عنصر العمل كان من اكثر العناصر انتاجية في قطاعي الصناعة و الانشاءات في كل من الضفة الغربية و قطاع غزة. كما تشير النتائج الى ان معدل الاحلال الحدي الفني للعمل محل راس المال في الضفة الغربية اقل مما هو عليه في قطاع غزة باستثناء القطاع الصناعي.

1. Introduction

Production function plays an essential role in the analysis of the economic aspects of the production process. Consumer and producer goods emerge out of the production process through the effect of manpower on the available resources. Since production has an essential effect on the state of human well being and capital accumulation, decision makers aim at maximizing the returns of production process. Therefore, the relation between inputs and output has great economic importance.

Decision making requires knowledge of the parameters of functions representing certain economic phenomenon. For example, a national economic plan for certain country needs to consider and estimate the effect of an increase in labor, and capital stock on gross domestic product. Therefore, the state of economic growth can be determined for an expected increase in capital accumulation, and labor. Therefore, the statistical analysis of production functions plays a major role in economic planning since it allows for the estimation of the parameters of production functions to determine the state of economic growth. Thus for a predicted increase in the growth rate of output, the necessary rate of growth in labor and capital, given the state of technology, can be determined to realize the predicted growth in output.[1]

---

(1) Given a production function in the form $Q_t=f(L_t, K_t)$, where Q_t is output level, L_t is the number of employed workers at time t, K_t is capital stock at time t. The change in output over time is given as,

$$\frac{dQ}{dt} = \frac{af}{al}\frac{dL}{dt} + \frac{af}{aK}\frac{dk}{dt}$$

The two terms on the right indicate the change in output due to a change in labor and capital respectively. Dividing this equation by output Q to convert to proportionate rate of change we get,

$$\frac{1}{Q}\left(\frac{L}{Q}\frac{aQ}{aL}\right)\frac{1}{L}\frac{dL}{dt} + \left(\frac{K}{Q}\frac{aQ}{aK}\right)\frac{1}{L}\frac{dK}{dt}$$

The two terms on the right are the proportionate rates of change in the two inputs each weighted by the partial elasticity with respect to the input.

Furthermore, the statistical analysis of production function plays an essential role in credit allocation policies and policies aimed at inducing structural changes in the production processes such as factor substitution policies. Production functions incorporate several economic concepts such as returns to scale, substitution effects, distributive effects, partial elasticities, factor intensity (i.e., capital or labor intensive), substitution effects, distributive effects and efficiency of factor utilization in terms of the marginal productivity of each factor. Thus comparing marginal productivity among the economic sectors would provide an insight for an appropriate investment allocation strategy. Therefore, scarce resources need to be directed to the sectors in which the factors have higher marginal productivity.

The purpose of this study is to estimate the aggregate and sectoral production functions for the OPT, and to study some of the economic aspects of the production process such as partial elasticities, returns to scale, factor marginal productivity, marginal rate of substitution, and efficiency of production. The calculation of these parameters might shed light on the characteristics of production in the Palestinian Territories and might help policy makers to better understand these characteristics and their implications.

2. The Econometric Model

The mathematical representation of production function is a priori formulation of how inputs are expected to affect output. These functions are physical or technological relations formulated in accordance with the economic theory of production. The general mathematical form of production function is $Q=f(L, K, R)$, where Q is output, L is labor input, K is capital input, R is raw materials. Since output is measured as value added (in monetary units), raw materials R will not be included in the estimated production function.

The traditional theory of production concentrates on the range of isoquants over which their slope is negative (economic zone of production) and convex to the origin. This means that factor marginal product is positive and growing at a decreasing rate (i.e., the slope of the marginal product curve is negative). Production function can be estimated at the macro (aggregate, sectoral) and micro (the firm level) levels. Under certain aggregation conditions, it may be possible to aggregate microeconomic production functions into a macroeconomic production function.(2)

The most widely used production function for empirical estimations is the Cobb-Douglas production function (because it is the easiest to handle mathematically) of the form

$$Q_t = AL_t^{\alpha} K_t^{\beta} e^{ut}, \qquad (1)$$

Where Q and L the same as defined earliear, K_t is capital stock which is estimated by the incremental capital-output ratio and will be discussed in the methodology section and u_t is a multiplicative stochastic disturbance term which satisfies the Classical Linear Regression Model (CLRM) assumptions. A is the efficiency factor. The exponents α and β are the partial elasticities with respect to labor and capital stock respectively. It is assumed that $0<\alpha<1$ and $0<\beta<1$ to assure that the marginal product of each input decreases when its utilization increases.(3)

In addition to the partial elasticities, other indicators can be calculated from equation (3). The first of these is the factor marginal product, which is the contribution of an additional unit of one input, holding all other inputs constant, to output. In a Cobb-Douglas production function type, factor marginal productivity of each input equals the partial

(2) For a detailed discussion of the aggregation conditions in the household consumption and production theory, we refer to Intriligator 1978 pp. 233-35 and 270.

(3) For a proof see Koutsoyiannis, pages 71-72, 1985.

output elasticity with respect to that input times its average product.[4] The marginal rate of technical substitution ($MRTS_{L,K}$) is another indicator that can be calculated. $MRTS_{L,K}$ measures the rate at which labor is substituted for capital in the production process without affecting total output. By the implicit function theorem,[5] the ($MRTS_{L,K}$) is given as

$$MRTS_{L,K} = -\frac{aK}{aL} = -\frac{aQ/aL}{aQ/aK} = -\frac{\alpha\left(\frac{Q}{L}\right)}{\beta\left(\frac{Q}{K}\right)} = -\frac{\alpha}{\beta}.\frac{K}{L} \qquad (2)$$

Another crucial indicator that can be estimated from equation (1) is returns to scale which relates to the question of how output responds to changes in the scale of the firm. Therefore, returns to scale is a longrun analysis of the production function that occurs when all factors of production are variable.[6] With a proportional factor change, it can be shown that Cobb-Douglas function is a homogenous function of degree $\alpha+\beta$.[7] Returns to scale are measured by the sum of α and β. Therefore, the production function will exhibit a constant returns to scale if $\alpha+\beta=1$, decreasing returns to scale if $\alpha+\beta<1$ and increasing returns to scale if $\alpha+\beta>1$.[8]

3. Data and Methodology:

Since Cobb-Douglas production function as stated in equation (1) is a nonlinear model, for estimation purposes it needs to be transformed into a linear form. This transformation can be done by taking the logarithm of equation (1). In doing so we get,

(4) For a proof see Koutsoyiannis, page 75,1985.

(5) For a proof see Koutsoyiannis, page 75, 1985

(6) Factors change need not be proportional, i.e., capital- labor ratio could vary along the expansion path.

(7) For a proofsee Koutsoyiannis, page 78, 1985.

(8) An increasing returns to scale means that output is growing at rate higher than those of labor and capital, and v.s for decreasing returns to scale. A constant returns to scale means that output and inputs are growing at the same rate.

output elasticity with respect to that input times its average product.[4] The marginal rate of technical substitution ($MRTS_{L,K}$) is another indicator that can be calculated. $MRTS_{L,K}$ measures the rate at which labor is substituted for capital in the production process without affecting total output. By the implicit function theorem,[5] the ($MRTS_{L,K}$) is given as

$$MRTS_{L,K} = -\frac{aK}{aL} = -\frac{aQ/aL}{aQ/aK} = -\frac{\alpha\left(\frac{Q}{L}\right)}{\beta\left(\frac{Q}{K}\right)} = -\frac{\alpha}{\beta}\cdot\frac{K}{L} \qquad (2)$$

Another crucial indicator that can be estimated from equation (1) is returns to scale which relates to the question of how output responds to changes in the scale of the firm. Therefore, returns to scale is a longrun analysis of the production function that occurs when all factors of production are variable.[6] With a proportional factor change, it can be shown that Cobb-Douglas function is a homogenous function of degree $\alpha+\beta$.[7] Returns to scale are measured by the sum of α and β. Therefore, the production function will exhibit a constant returns to scale if $\alpha+\beta=1$, decreasing returns to scale if $\alpha+\beta<1$ and increasing returns to scale if $\alpha+\beta>1$.[8]

3. Data and Methodology:

Since Cobb-Douglas production function as stated in equation (1) is a nonlinear model, for estimation purposes it needs to be transformed into a linear form. This transformation can be done by taking the logarithm of equation (1). In doing so we get,

(4) For a proof see Koutsoyiannis, page 75,1985.

(5) For a proof see Koutsoyiannis, page 75, 1985

(6) Factors change need not be proportional, i.e., capital- labor ratio could vary along the expansion path.

(7) For a proofsee Koutsoyiannis, page 78, 1985.

(8) An increasing returns to scale means that output is growing at rate higher than those of labor and capital, and v.s for decreasing returns to scale. A constant returns to scale means that output and inputs are growing at the same rate.

$$\log Q_t = \log A + \alpha \log_1 + \beta \log K_t + u_t, \qquad (3)$$

Real GDP will be used as a measure of output at the aggregate level and the contribution of each sector in the GDP will be used as a measure of that sector's output. In theory inputs should be measured in terms of services of the input, but such data are not available. Therefore, labor inputs will be measured as the number of workers, and capital as net capital stock is defined as

$$K_t = K_o + \sum_{i=1}^{t} (GI_i - D_i) \qquad (4)$$

where K_0 is capital stock in the base year, GI_i and D_i are gross investment and depreciation in the ith year. Capital stock of the economy is calculated as the following: First, the incremental capital-output ratio (ICOR) is estimated by,

$$ICOR = \frac{\sum_{t=1970}^{1988} I_t}{GDP_{1988} - GDP_{1970}}$$

where I_t is net investment at time t. Depreciation is assumed to be 10% of gross investments per year. There is no specific reason why 10% is used as the depreciation rate. However, that is what has been used in he literature [Brendit 1991]. Over the period 1970-88, the ICOR was 4.113 and 6.367 for the West Bank and Gaza Strip respectively in 1986 prices. The aggregate capital stock for the initial period 1970 is calculated as: $K_{1970} = GDP_{1970}$ *ICOR.

Capital stock thereafter is calculated as: $K_t = K_{t-1} + I_t$. Sectoral capital stock is calculated on the basis of the sectoral share out of the gross domestic product, i.e., the industrial capital stock K_i=industrial share of GDP times the aggregate capital stock at each year.

This approach implies that average product is identical in all sectors. Let APK = GDP/K be the average product of capital in the economy and GDP_i is the industrial output, then industrial capital is $GDP_i/GDP*K$. The average product of capital in the industrial sector is same method applies to all sectors is .

$$APK_1 = \frac{GDP_1}{(GDP_1/GDP)*K} = \frac{GDP}{K} = APK \quad \text{,The}$$

same method applies to all sectors.

Data used in the estimation are extracted from the Statistical Abstract of Israel. This is the only source of time series data about the Palestinian Territories. Israeli figures will be used regardless of all their deficiencies simply because there is no alternative source that can be used in this study. The analysis has been limited to the period 1970-87 since serious gaps and shortcomings in the official statistics began to appear due to difficulties in data collection. after the beginning of the Intifada. Average product of factors have been calculated using average values of variables involved over the study period.

Ordinary least squares (OLS) techniques will be utilized to estimate equation (3). Diagnostic tests, including tests of autocorrelation, multiclinearity, and hetroskedasticity, were conducted and corrective measures were done when needed.

4. Results:

Tables (1) through (4) present the estimated regression results. As seen from Table (1), production exhibits approximately constant returns to scale in the West Bank. This means that real gross domestic product is growing at a rate equivalent to the rate of growth of labor and capital. However, production exhibits decreasing returns to scale in the agricultural, construction and service sector and increasing returns to scale in the industrial sector[9].

(9) The service sector includes public and community services, transport, storage, communication, commerce, restaurants and hotels.

Output elasticity with respect to capital was almost identical (about 0.5) at the aggregate and sectoral level in the West Bank. This result indicates that the estimated marginal product of capital is very close in all sectors as seen in Table (2). However, there is a great divergence (ranging from 0.16 in the service sector to 0.74 in the industrial sector) in the output elasticity with respect to labor reflecting the difference in the marginal productivity of labor as reported in Table (2). Marginal productivity of labor was the least in the agricultural sector (0.74) and most productive in the industrial sector followed by the construction and service sectors. The low productivity of labor in the agricultural sector is probably attributed to the high level of disguised unemployment in the agricultural sector. The high marginal productivity of labor in the industrial sector is due to a high average labor productivity in the sector. The marginal rate of technical substitution was 24.9 at the aggregate level in the West Bank. This means that creating 1000 job opportunities requires a reduction of capital by 24.9 million NIS holding the level of output.

Table (1)
Regression Results of Cobb-Douglas Production Function for the West Bank.

	Log A	α	β	R^{-2}	DW
Economy	0.47 (0.41)	0.47 (0.053)	0.5 (0.0)**	0.96	3.07*
Industry	-0.09 (0.78)	0.74 (0.0)	0.51 (0.0)	0.97	2.02
Agriculture	1.25 (0.003)	0.3 (0.06)	0.48 (0.0)	0.92	3.07*
Construction	1.16 (0.003)	0.34 (0.11)	0.5 (0.0)	0.97	3.09*
Services	1.49 (0.002)	0.16 (0.003)	0.55 (0.0)	0.97	2.25

Notes : D-W is Durbin-Watson statistics.

Values in parentheses are the P-values.** indicates that the P-value is < than 0.0001.

* Indicates that DW lies in the inconclusive region at 1% level of significance. An Exact Durbin-Watson test was conducted and it showed that correction for autocorrelation is needed and the reported estimates are those obtained after the correction.

Table (2)
Returns to Scale, AP_L, MP_L, MP_K, and $MRTS_{L,K}$ for the West Bank.

	$\alpha+\beta$	AP_L	MP_L	MP_K	$MRTS_{L,K}$
Economy	0.97	11.43	5.38	0.96	-24.9
Industry	1.25	22.49	16.64	0.22	-75.6
Agriculture	0.78	2.46	0.74	0.207	-3.57
Construction	0.84	15.01	5.1	0.216	-23.6
Services	0.71	13.61	2.18	0.237	-9.2

Notes: MP_L and AP_L are measured in thousand NIS while MP_K and AP_K are measured in one NIS. Average product of capital AP_K = 0.431 (million NIS).

This measure could give us a rough indicator of the cost of job creation in terms of the volume of investments needed to accommodate labor. As for Gaza Strip at the aggregate level, production exhibits increasing returns to scale thus output is growing at a rate faster than inputs. All sectors, except the service sector, exhibit increasing return to scale.

Output elasticity with respect to capital exhibits a great difference among the sectors ranging from (0.97) in the industrial sector to (0.47) in the construction sector as seen from Table (3). However, it was almost identical in all sectors except the industrial sector. Therefore, the estimated marginal product of capital (see Table 4) is very close in all sectors except the industrial sector where the marginal productivity of capital was the highest (0.148). As for the output elasticity with respect to labor, the result showed great divergence (ranging from 0.37 in the service sector to 0.69 in the construction sector) in the output elasticity with respect to labor reflecting the difference in the marginal productivity of labor as reported in Table (4). Labor was the least productive in the service sector (1.78) and most productive in the construction sector followed by the industrial and the agricultural sectors. As seen from Table 4, the marginal rate of technical substitution was smallest in the agricultural sector followed by service, construction and the industrial sector.

Table (3)
Regression Results of Cobb-Douglas Production Function for the Gaza Strip.

	Log A	α	β	R^{-2}	D-W
Economy	-0.71 (0.002)	0.47 (0.0)**	0.5 (0.0)	0.77	1.77
Industry	-2.58 (0.011)	0. 48 (0.003)	0.97 (0.0)**	0.77	1.70
Agriculture	-0.14 (0.34)	0.51 (0.0)**	0.59 (0.0)	0.99	1.79
Construction	-0.70 (0.24)	0.69 (0.0003)	0.47 (0.0)**	0.98	1.82
Services	0.16 (0.33)	0.37 (0.001)	0.54 (0.0)	0.97	1.86

Notes: Values in parentheses are the P-values. ** indicates that the P-value is smaller than 0.0001.

Table (4)
Returns to Scale $\alpha+\beta$, AP_L, MP_L, MP_K, and $MRTS_{L,K}$ for Gaza Strip.

	$\alpha+\beta$	AP_L	MP_L	MP_K	$MRTS_{L,K}$
Economy	1.18	1.74	5.18	0.078	-66.0
Industry	1.45	16.43	7.89	0.148	-53.1
Agriculture	1.1	3.84	2.27	0.078	-29.1
Construction	1.16	28. 1	19.3	0.072	-269.3
Services	0.91	4.81	1.78	0.083	-21.45

- Average product of capital AP_K=0.153.

Comparing the result for the West Bank and Gaza Strip we notice the following: Production in the West Bank exhibits mostly constant and decreasing returns to scale with the exception of the industrial sector while production in the Gaza strip exhibits increasing returns to scale except the service sector. Large differences exist in the marginal productivity of capital between the West Bank and Gaza Strip. The marginal productivity of capital in the West Bank was almost three times larger than that of the Gaza Strip. Labor was the most productive in the industrial and construction sectors in both regions even though the order of the sectors is reversed. Also, the marginal rates of technical substitution were lower in the West Bank than in the Gaza Strip except the industrial sector.

5. Conclusions:

The development policies of the Palestinian authority represent a new stage in the forward thrust of the Palestinian economy in the direction of greater progress and prosperity. However, the challenge to policy makers is to implement in a firm and credible manner the strategy to achieve certain goals and deal with economic imbalances. Therefore, a primary objective of the OPT is to secure the greatest increase in its income from the available resources. It is well known that Investment is the primary source of economic growth, therefore investment priorities need to be ascertained in the accordance with the national economic goals. There are many criterion by which investment priorities can be established, these include capital marginal productivity, contribution to job creation, and contribution to the redistribution of work centers.

The results of the study suggest that grater portion of capital need to be steered to the industrial and construction sectors both in the West Bank and Gaza Strip since the marginal productivity of capital was the highest in these two sectors. In general, a greater portion of investment needs to be channeled to the activities characterized by high value added.

The empirical estimates had demonstrated that production in the West Bank exhibits mostly constant and decreasing returns to scale with the exception of the industrial sector while production in the Gaza strip features increasing returns to scale except the service sector. Large disparity exists in the marginal productivity of capital between the West Bank and Gaza Strip. The marginal productivity of capital in the West Bank was almost three times larger than that of the Gaza Strip. Labor was the most productive in the industrial and construction sectors in both regions even though the order of the sectors is reversed. Also, the marginal rates of technical substitution were lower in the West Bank than in the Gaza Strip except the industrial sector.

The results of the study suggest that greater portion of capital needs to be directed to the industrial and construction sectors both in the West Bank and Gaza Strip since the marginal productivity of capital was the highest in these two sectors.

References:

1- Brendt, E. The Practice of Econometrics: Classic and Contemporary. Addison Whiley. 1992.

2- CBS, Israeli Statistical Abstract, No. 39, 1989.

3- Intriligator, Michael D. Econometric Models, Techniques, and Applications.Prentice-Hall Inc, New Jersey 1978.

4- Koutsoyiannis, A. Modern Microeconomic,ELBS/Macmillan. 1985.

5- Makhool, Basim. "Production Function and Factor Decomposition of the Growth Rate in Real GDP of Gaza Strip: Econometric Analysis." A paper presented at the First Scientific Conference: Towards a New View of Modern Problematic Issues in the Gaza Strip. Gaza 1993.

6- The National Accounts of Judea and Samaria and Gaza Strip. 1968-86 No. 818., special issue. Israeli Central Bureau of Statistics 1986.

7- Thirwall, A. P. Growth and Development, with Special Reference to Developing Economies. 3ed ed. Hong-kong, 1983.