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Measuring the productivity of capital in the industrial sector of Sistan and Baloochestan state, Iran

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ABSTRACT. This working paper strives to measure analyze and the productivity of capital in the industrial sector in the case of the State of Sistan and Baloochestan over the period 1982-2009. Three production functions (Debertin, Cobb-Douglas and Transcendental logarithm (Translog)) are estimated by relevant variables such as labor, capital and GDP. Akaike, Schwarz information criteria and LR test indicate that the Cobb-Douglas model should be preferred. In order to avoid a spurious regressing Johansen test detects a cointegration. According to this detection the cointegration term (-0.46) indicates that the deviation from long-run equilibrium is rectified gradually through a series of partial short term adjustments after or so two years.The results of this function reveal that there's been a diminishing trend in productivity of capital since 1982.So it demonstrates the lack of attention to capital productivity. Thus we can conclude that Sistan suffers from the absence of comprehensive strategy and segregation between trade and production policies.

1. INTRODUCTION

Realizing the fountainhead of economic growth has been widely an inherent subject in economics. Productivity is assumed as a major source of this growth (Bernadette Biatour et al, 2007). It's defined as an economic measure of output volume per unit of input(s)(Risaburo Nezu et al, OECD Manual,2001).Different kind of inputs are considered in production equation which includes labor, capital and technology while output is mainly GDP (total quantity). Capital and labor are both rare resources especially in developing country. So maximizing and measuring their productivity and effects on GDP are always a core concern as a key role for forecasting future level of GDP growth. Thus it constitutes as a crucial role in modeling the effective and productive capacity of economics.

Various methods of productivity measurement are available and the selection between them relies either on the productivity measurement goal and /or data disposability. However one of the most commonly used manner of productivity measurement is total quantity per capital included or used. In principle the measurement of capital inputs should take into account differences in capital stock and investment. Thus a suitable measurement is the flow of services which can be drawn from cumulative stock of past investment. They are estimated by changing rate of productive capital stock.

The main purpose of this paper is to estimate this rate and investigate its impacts on industrial sector. So capital productivity (CP) is measured by three diverse production function estimation (Debertin, Cobb-Douglas and Translog) and hence according to reliable criteria Cobb-Douglas production pattern is preferred. Afterward to make sure that there is a stationary linear combination called cointegration equation Johansen cointegration test will be employed to detect this combination.Finally computation of the productivity of capital is performed .In the second part of this paper, we briefly look into background of the issue and literature review. The objectives of study will be debated in the third part. Next part indicates empirical results. Finally section five will conclude the paper.

2. BRIEF BACKGROUND AND LITERATURE SURVEY

The source of growth model has been the principal tool in explaining growth trends. This model which is introduced and promoted subsequently by Solow, Kendrick , Denison, Jorgenson and Griliches(1950s and 1960s) allots the growth rate of measured output to the growth rate of labor and capital inputs(Carol Corrado, Charles Hulten, and Daniel Sichel,2004). On the other hand, the origins of the concept of an aggregate production function can be obviously identified in the efforts of Paul H.Douglas and his associates. But later Jan Tinbergen took a critical step beyond the conception employed by Douglas. He added a time trend to the function of capital and labor inputs representing the level of efficiency. But all of these were integrated by Robert Solow's paper, “Technical Change and the Aggregate Production Function”. His working is within the tradition of production modeling established by Douglas and extended by Tinbergen (Dale W. Jorgenson, 1991). Huge empirical Studies have applied the source of growth framework to measure and analyze the economic growth that we'll review some of them more.

Bernadette Biatour, Geert Bryon and Chantal Kegels (2007) present the various methodologies to construct a volume index of capital services and analyze the impact of their changes on total production function estimates for Belgium during 1970-2004.They concluded that A higher growth rate of the volume indices generates a higher capital contribution and, consequently, a lower TFP contribution. Liu et al (1998) studied and investigated the marginal productivity of labor and capital in 140 industrial firms with Cobb-Douglas production function during 1989-1990. They derived that the labor training has increasing and positive impact on labor productivity and its productivity was higher than labor in their case study.

3. OBJECTIVES OF STUDY AND THEORETICAL FRAMEWORK

The main objective of this article is to measure and compute the capital productivity of industrial sector with pertaining estimation of three production functions through the OLS method. The production function describes the technical relationship between the volume of two or more resources, particularly capital and labor, and the volume of output, total quantity. This measurement lets to estimate the contributions of capital and labor inputs to quantity. Our model provided by Solow (1957) involves a neoclassical production function:

$$Q = A\,f(K, L) \tag{1}$$

Where Q is value added level of industrial sector, A is the technology level; K and L are real stock of capital and labor inputs. Cobb-Douglass (2), Debertin (3) and Translog (4) production functions can be estimated as a linear-logarithm (natural logarithm) relationship using the following expression:

$$\mathrm{LnQ} = \alpha_0 + \alpha_1 \mathrm{LnL} + \alpha_2 \mathrm{LnK} + \varepsilon_t \tag{2}$$

$$\mathrm{LnQ} = \gamma_0 + \gamma_1 \mathrm{LnL} + \gamma_2 \mathrm{LnK} + \gamma_3 \mathrm{L} + \gamma_4 \mathrm{K} + \gamma_5 \mathrm{LK} + \varepsilon_t \tag{3}$$

$$\mathrm{Ln\,Q} = \beta_0 + \beta_1 \mathrm{Ln\,L} + \beta_2 \mathrm{Ln\,K} + {}^{1}\!/_{2}\,\beta_3 \mathrm{Ln}L^2 + \beta_4 \mathrm{Ln\,L\,Ln\,K} + {}^{1}\!/_{2}\,\beta_5 \mathrm{Ln}K^2 + \varepsilon_t \tag{4}$$

4. EMPIRICAL RESULTS

4.1Calculation of Capital Stock

Before estimating our model, the time series data of real capital stock must be estimated. In order to compute and attain this data we use investment exponential trend process. With this method, first the capital will be computed (estimated) through below equation written as:

$$IN_t = IN_0 e^{\lambda t} \tag{5}$$

Where IN_t shows current gross investment, IN_0 is gross investment in basic (1974). It can be written in terms of logarithm as follows:

$$LnIN_t = LnIN_0 + \lambda t \tag{6}$$

We estimate this equation with OLS method. The test results suggest that it needs to modify principal specification to take account of the serial correlation. So the first-order autoregressive term (AR (1)) is included in our equation:

$$LNIN_t = 3.132 + 0.348t + 0.3705AR(1)$$

T-statistic: 5.04 11.6

Prob: 0.00 0.00

Durbin-Watson stat: 1.866 R-Squared: 0.93

The capital stock in 1974(K_0, with no account of capital depreciation) is calculated by:

$$K_0 = \frac{IN_0}{\lambda} = \frac{41}{0.348} = 117.816 \tag{7}$$

If capital deprecation is included[1], the current capital stock in 1974 will be:

117.816-0.05(117.816) =111.9252

Here we can use below relation (8) in order to compute volume of capital stock for each year:

$$K_t = \frac{K_{t-1} + I_t}{1+\delta} \tag{8}$$

Where δ shows industrial sector depreciation rate of capital stock. (8) Calculates the current amount of capital (K_t) with current investment (I_t) and lagged series of capital stock after taking into account the capital Depreciation deduction. So with this method the current capital stock can be calculated over the period of 1982-2009 and used in estimation of our production functions. Table-1 indicates current capital stock:

Table-1: The estimated capital stock at constant prices(million Rial)

year	Capital stock	year	Capital stock
1982	2223	1996	250740
1983	10889	1997	247583
1984	12055	1998	243580
1985	12661	1999	221378
1986	19807	2000	217669
1987	31408	2001	232358
1988	59875	2002	267261
1989	57593	2003	337844
1990	43503	2004	378802
1991	39030	2005	441605
1992	38768	2006	487358
1993	66362	2007	504883
1994	91790	2008	644724
1995	112290	2009	1065607

[1].Depreciation deduction equals 5%.

4.1. Estimation the production functions

Three mentioned production functions are estimated by OLS method summed up by table-2. According to the results the Cobb-Douglas production functions is preferred. The estimated coefficients in this pattern are statistically significant. The overall regression fit, as measured by the R-Squared and Adjusted R-Squared, demonstrates a very tight fit. The Durbin-Watson statistic is very close to two, also LM test, indicating the absence of serial correlation in the residuals. Accordingly, we will work with this model in our future debate.

Table-2:Three production function estimation, Independent variable: value added of Industrial(VAI) in Sistan

Cobb-Douglas				Debertin				Transcendental logarithm			
Variables	Coefficient	Std-Error	Prob	Variables	Coefficient	Std-Error	Prob	Variables	Coefficient	Std-Error	Prob
Ln(L)	0.65	2.08	0.04	Ln(L)	0.29	2.8	0.03	Ln(L)	5.99	4.9	0.00
Ln(K)	0.165	4.22	0.00	Ln(K)	0.128	1.91	0.06	Ln(K)	-1.41	-3..16	0.00
Constant	12.5	22.99	0.00	L	-9.09	-1.84	0.07	Ln(L)Ln(K)	0.23	4.79	0.00
AR(1)	0.56	4.39	0.00	K	5.44	-2.08	0.83	LnL^2	-0.42	-5.52	0.00
R-Squared: 94%	R-Bar-Squared:92%			Constant	10.97	8.4	0.00	LnK^2	-0.38	-1.93	0.66
Durbin-Watson:2.13				AR(1)	0.56	4.7	0.00	MA(2)	-092	22.43	0.00
Serial Correlation LM test:0.1(0.9)				R-Squared:87%	R-Bar-Squared:84%			Constant	-7.77	-1.25	0.00
				Durbin-Watson:2.02				R-Squared:92%		R-Bar-Squared:90%	
				Serial Correlation LM test:0.72(0.49):				Durbin-Watson:1.63			
								Serial Correlation LM test:0.64(0.53)			

4.2. Johansen Cointegration Test

The Johansen vector error-correction approach (1995) tests to detect long-run equilibrium relationships among time series that are known to be nonstationary.so we must test for cointegration in order not to estimate a spurious regression. Before performing this test, we must be sure of the presence of unit root. Table-3 shows the Augmented Dickey-Fuller unit root test:

Table 3:Unit Root Test

Variables	Calculated ADF Level	Critical level
DLn(VAI)	-2..44	0.05
Ln(L)	-5.55	0.05
DL(K)	-5.98	0.05

Johansen describes five cases regarding the deterministic terms (intercept and/or trend) and indicates the number of cointegrating relations. It must therefore be chosen between them without any simple algorithm for deciding which one is true by two statistics that can be used to assess the value of the cointegration rank, namely the trace test and the maximum eigenvalue test (Allin Cottrell, 2011). Since the distribution of the trace test depends on the case selected, it is clearly considerable to select an appropriate case.[2] In practice two cases[3] are rarely used. Table-4 and 5

[2] Because the asymptotic distribution of the LR test statistic for cointegration does not have the ordinary Chi-Square distribution and depends on the assumptions made with respect to deterministic terms.

indicates the results of trace and eigenvalue test for other three cases. The results demonstrate one cointegration equation and second case (intercept but no trend) is chosen[4].

Table-4:Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix (λ_{max})							
Null	Alternative	R-Intercept no trend		UR-Intercept no trend		UR-Intercept R-trend	
H_0	H_1	Trace Statistic	95%Critical value	Trace Statistic	95%Critical value	Trace Statistic	95%Critical value
r=0	r=1	30.941	22.299	30.093	21.131	30.506	25.823
r≤1	r=2	15.859	15.892	6.961	14.294	10.383	19.387
r≤2	r=3	6.957	9.164	0.164	3.841	6.4	12.517

Table-5:Cointegration LR Test Based on Trace of the Stochastic Matrix (λ_{trace})							
Null	Alternative	R-Intercept no trend		UR-Intercept no trend		UR-Intercept R-trend	
H_0	H_1	Trace statistic	95%ritical value	Trace statistic	95%ritical value	Trace statistic	95%ritical value
r=0	r=1	53.758	35.192	37.219	29.797	47.290	42.915
r≤1	r=2	22.817	20.261	7.126	15.494	16.783	25.872
r≤2	r=3	6.957	9.164	0.164	3.841	6.4	12.517

Now we can estimate this single cointegrating vector by VEC model which has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The cointegration term known as the error correction term is zero in long run equilibrium. As previously noted the production function has intercept but no trend so the error correction equation will be as follows:

$$DLn(AVI) = \theta_0 + \theta_1 DLn(K) + \theta_2 DLn(L) + \theta_3 ECM(-1) + \varepsilon_t \quad (9)$$

According to the result shown below the cointegration term (-0.46) indicates that the deviation from long-run equilibrium is rectified gradually through a series of partial short term adjustments after or so two years. The short run effects of capital and labor on VAI are conflicting.

$$DLn(AVI) = 0.051 + 0.0795DLn(L) - 0.115DLn(K) - 0.251AR(2) - 0.464ECM(-1)$$

T-statistic:	2.557	3.491	-2.101	-2.807	-1.695
Prob:	0.01	0.00	0.04	0.1	0.01

4.3. Calculating the capital productivity

After determining and estimating the Cobb-Douglas production function, the CP can be measured by derivation of this equation. Thus the derivative of Q with respect to K is defined as:

$$CP = \frac{dQ}{dK} = \alpha_2 \frac{Q_t}{K_t} = 0.165 \frac{Q_t}{K_t} \quad (10)$$

Here we can put amount of Q_t and K_t in above equation and measure the CP for each year. The calculated CP is given by table-6:

[3] No intercept or trend, intercept or trend in cointegration equation.
[4] Akaike and Schwarz information criteria indicate that lag order of VAR is one.

Table-6:The calculated CP(million Rial)			
year	CP	year	CP
1982	21.6	1996	2.3
1983	49.14	1997	2.47
1984	39.06	1998	2.5
1985	40.19	1999	2.95
1986	19.92	2000	3.04
1987	15.45	2001	3.02
1988	5.76	2002	2.78
1989	6.54	2003	2.29
1990	10.92	2004	2.01
1991	12.4	2005	1.99
1992	13.1	2006	1.82
1993	8.42	2007	1.76
1994	6	2008	1.41
1995	4.85	2009	0.84

5. CONCLUSION

This paper purposes to measure the capital productivity of industrial sector of Sistan. To achieve to this target we choose and estimate three production functions. According to the results the Cobb-Douglas is selected. Then the Johansen cointegration test is performed to detect the long run relation. This relation is confirmed and the calculated error correction term (-0.46) shows that the deviation from long-run equilibrium is rectified gradually through a series of partial short term adjustments after or so two years.Finally the CP measured by derivation of mentioned equation indicates that there's been a diminishing trend in productivity of capital since 1982.So it demonstrates the lack of attention to capital productivity. Thus we can conclude that Sistan suffers from the absence of comprehensive strategy and segregation between trade and production policies.

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