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MEASURING CAPACITY UTILIZATION USING A SHORT-RUN COST FUNCTION: AN APPLICATION TO BAHRAIN ECONOMY

Bassim Shebeb

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ECONOMIC RESEARCH FORUM

7 Boulos Hanna St. Dokki, Cairo, Egypt
Tel: (202) 3370810 – (202) 7485553 – (202) 7602882
Fax: (202) 7616042. Email: erf@idsc.net.eg. Website: http://www.erf.org.eg

Abstract

The main objective of this study is to measure and analyze one of the major components of economic performance, namely capacity utilization, in Bahrain (one of the six Gulf Cooperation Council, GCC, countries) economy over the time period 1984-1999. Exploiting recent developments in dual cost theory, a well-defined method for empirical estimation of capacity utilization was established. An empirical model, Cobb-Douglas short-run variable cost function, was employed as an application of this dual-cost estimate of capacity utilization in Bahrain economy. The findings of this study showed that the presently structured industries in the Bahrain economy, in general, have experienced capacity under-utilization. This implies that there is significant room for increasing production levels with no additional capital required. Three main considerations are given for full capacity utilization: rationalization of the existing structure of some industries and limitations of new entry; regional integration creating larger markets for existing industrial capacity; and technological adaptation that hold the efficient minimum economic scale of industries for small-market economy such as Bahrain.

1. Introduction

Bahrain's first economic and social development plan (1982-1986) came with a major emphasis on having stronger economic and social relationships among various economic and social sectors in exploiting the available resources. In subsequent plans, however, most government agencies shared the same objective, providing and upgrading the economic and social infrastructure. The main activities concentrated on attracting foreign investment that began with having several joint ventures.

However, with improperly planned economic expansion, more investment in capital-intensive technology was encouraged. This type of investment policy led to a high capital stock, thus a low level of capital utilization, given the size of Bahrain's economy. It follows, eventually, that such investments will not be able to earn an acceptable rate of return, have an inefficient use of the economic resources and infrastructure, and thus a lower competitive position.

One major consideration in Bahrain industries is the expectation of growing markets, which resulted in installing large plants to allow for this expected growth. However, this expected growth should not depend only on the growth rate of local market demand but also on the economic changes in other GCC economies. For example, rapid growth and economic expansion of other Gulf Cooperation Council (GCC) markets was able to absorb some of the expected local demand.

Capacity (capital) utilization is frequently occurring theme in most discussions on economic problems in a country, particularly in developing countries. The importance of this measure of economic performance results from its impact on productivity, Shebeb (2000 and 2002). Higher unit cost (lower productivity) can arise from under- or over-utilization of capacity. In addition, in most developing countries, capital is a scarce factor, thus under- or over-utilization involves not only additional cost but also 'wasting' this scarce resource. The degree of capacity utilization has been increasingly viewed as a crucial economic issue in developing countries. It is important to measure and to analyze the level of capital utilization at the economy level and at the industry level to develop proper policies with regard to new investments and the type of investments that should be encouraged. Therefore, with the process of development and the importance of the structural transformation, it is very important to comprehend the fundamental concepts of measuring and analyzing capacity (capital) utilization.

Bahrain's economy is a small open economy, thus, it is directly affected by the volatility of international and regional prices, demand, and supply. Accordingly, to enhance the interpretability and use of its economic performance (productivity) measures, they should be adjusted for short-run changes in capacity utilization as a result of this demand volatility. Therefore, the main objective of this study is to determine the main underlying concepts of capacity utilization and use this powerful analytic tool in understanding the economic performance of Bahrain's economy. Capacity utilization in the Bahrain economy is to be measured and analyzed over the last two decades (1984-1999).

Recent studies such as Morrison (1985, 1988a, 1988b) have placed considerable emphasis on capacity utilization. Berndt and Morrison (1981) conclude, "*We hope that applied researchers in the future will devote greater attention and care to the economic theory underlying the concept of capacity...which can then be interpreted more clearly.*" Thus, an estimate of the capacity utilization that is based on economic theory is needed to provide more reliable and rigorous dynamic explanations of economic performance.

This study is organized in the following way: Section 2 presents a review of the underlying theory of capacity utilization measurement. The model and methodology used in estimating the level of capacity utilization in the Bahrain economy are introduced. In Section 3, the econometric model and the data used in the empirical investigation are defined. The empirical findings are presented and analyzed in Section 4. Finally, an overall summary of the study and the concluding remarks are presented in Section 5.

2. Capacity Utilization Measurement: Dual Cost Approach

The terms capacity and capacity utilization[1] have long been used in economic analysis. The "traditional" approaches of capacity utilization measurement and analysis are mainly based on establishing an ad-hoc measure of capacity output (Q^*), to construct an index of the ratio Q/Q^*, where Q is the observed output. The fundamental concept of these traditional approaches is the estimate of capacity output, which represents the maximum output possible to be produced using the designed capacity. These approaches of measuring capacity utilization lack economic foundation and thus, a clear interpretation of these measures is not possible. It has ignored the fact that input scarcity, fixity, is the key element in capacity utilization.[2]

It was Cassels (1937) who first recognized that capacity utilization is a reflection of scarcity or "fixity" of the production factors that are available to a firm. Input scarcity can be seen as short-run constraints to the economic optimization of a firm. These short-run constraints would make the short-run minimum cost level of output differ from that of the long run. An economic theory-based measure of

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[1] It is worth noting that capacity utilization and capital utilization are the same only when capital consists of only fixed or quasi-fixed inputs, constant returns to scale exists, and variable inputs are used in fixed proportions to the fixed or quasi-fixed input. Under those assumptions, the term capacity utilization is used in this study to indicate capital utilization.

[2] For example, Berndt and Morrison (1981), Berndt and Hesse (1986), and Morrison (1985,1988a, 1988b, and 1989).

capacity utilization is developed to obtain a highly interpretable measure of capacity utilization. This measure takes account of the input fixity constraints and measures the optimal level of output given these constraints. The determination of the optimal level of output given the short-run input fixity presented by Klein (1960) following the clear distinction between excess capacity in the short-run and that in the long run made by Cassels (1937).

Referring to Figure 1, the capacity output may be measured by the horizontal distance $0Q^*$. The capacity output is defined to be that level of output at the tangency point of short- and long-run average cost curves. If the capacity level of production is equal to the output level in the long-run equilibrium for a given set of input constraints, full capacity utilization will exist. It implies that both capacity output and the observed output are equal. However, when the demand for output is less (i.e., Q^u) or greater (i.e., Q^o) than the output level in long-run equilibrium the capacity measure would show that capacity is under-utilized ($Q^u/Q^*<1$) or over-utilized ($Q^o/Q^*>1$).

Estimating this measure of capacity utilization is not straightforward, since it requires an estimation of the short-run and long-run average costs curves[3]. It also needs a relatively flexible form of cost function. However, recent developments in dual cost theory have established a well-defined method for empirical estimation. This method could explicitly restrict the cost function for short-run input fixity. Since an estimation of the primal-based measure of capacity utilization can be obtained using dual cost theory, presentation of the dual cost measure of capacity utilization follows. The presentation is based on the most recent development in the dual cost measure of capacity utilization, Morrison (1985, 1988a, 1988b, 1989) among others.

This approach explicitly takes into account the fixity of different inputs that may occur in the short-run production process. It also determines the firm's optimal responses under the fixity of these inputs. The main economic aspect underlying the dual cost measure of capacity utilization is the degree of fixity of the scarce production factors. Thus, input fixity is the key factor, which causes capacity not to be fully utilized in the short run. This implies that a measure of capacity utilization can be based on short-run specification of cost structures, which reflect underlying production relationships.[4]

A dual cost capacity utilization measure can be written in terms of short-run cost as follows: capacity utilization may be presented by the $\tilde{C}(\cdot)/C(\cdot)$ ratio, where $\tilde{C}(\cdot)$ is the shadow cost and $C(\cdot)$ is the observed cost, Morrison (1985, 1988a). That is, if a firm is under-utilizing its inputs, more output can be produced at lower cost, since the shadow price of the under-utilized input will be below its market price.

By using the short-run cost function, inputs-fixity can be explicitly treated. In the rest of this section, the concept of the dual cost measure of capacity utilization is presented. The general form of the short-run total cost function is written as:

$$C(P_i,Q,Z_k) = V(P_i,Q,Z_k) + \sum_k P_{Zk} Z_k \qquad 2.1$$

Where:

P_i = the price of the i^{th} variable input, i=1, 2, ..., n

Q = the observed output level

Z_k = the level of the k^{th} quasi-fixed input, k=1, 2, ..., m

P_{Zk} = the price of the k^{th} quasi-fixed input

The shadow price of the k^{th} quasi-fixed input (Z_k) can be defined as:

$\tilde{P}_{Zk} = \partial V(\cdot)/\partial Z_k$. Therefore, the short-run shadow cost can be written as:

$$\tilde{C}(P_i,Q,Z_k) = V(P_i,Q,Z_k) + \sum_k \tilde{P}_{Zk} Z_k \qquad 2.2$$

The level of capacity utilization can be determined by the difference between $\tilde{C}(\cdot)$ and $C(\cdot)$. Full utilization of capacity, in other words, will be recognized in the short-run if $\tilde{P}_{Zk} = P_{Zk}$. However, if $\tilde{P}_{Zk} <(>) P_{Zk}$, $\tilde{C}(\cdot)<(>)C(\cdot) \Rightarrow \tilde{C}(\cdot)/C(\cdot)<(>)1$, which implies that the k^{th} quasi-fixed input is under-utilized (over-utilized) which will encourage the firm to adjust its input combination over the long-run, Morrison (1985).

Morrison (1985, 1988a) has shown that a dual cost measure of capacity utilization (CCU) can be derived by exploiting the relationship between the elasticity of cost with respect to the quasi-fixed[5] input and with respect to output. To show how this can be done, first let equation 2.3 below define the elasticity of cost ($?_{CZk}$) with respect to the fixed or quasi-fixed inputs as:

[3] The discussion in this section assumes the behavior objective of cost minimization for a given single-output technology.

[4] Berndt and Fuss (1989) has also pointed out the difficulties in measuring capacity utilization with more than one fixed or quasi-fixed inputs.

[5] It is assumed that producers are facing a quasi-fixed input (capital) that may be adjusted partially in the short-run. However, its full adjustment is reached in the long run.

$$\sum_k \frac{\partial \ln C(\cdot)}{\partial \ln Z_k} = \sum_k ?_{CZ_k} = \sum_k \frac{\partial C(\cdot)}{\partial Z_k} \cdot \frac{Z_k}{C(\cdot)} \qquad (2.3)$$

Secondly, by exploiting the definition of the shadow price (cost) of the fixed input, the dual cost measure of capacity utilization, $\tilde{C}(\cdot)/C(\cdot)$, can be written as:

$$CCU = \frac{\tilde{C}(\cdot)}{C(\cdot)} = \frac{V(\cdot) + \sum_k \tilde{P}_{Zk} Z_k}{V(\cdot) + \sum_k P_{Zk} Z_k} = \frac{C(\cdot) - \sum_k Z_k (P_{Zk} - \tilde{P}_{Zk})}{C(\cdot)}$$
$$= 1 - \sum_k \frac{Z_k (P_{Zk} - \tilde{P}_{Zk})}{C(\cdot)} = 1 - \sum_k ?_{CZ_k} \qquad (2.4)$$

That is, this equation shows that the dual cost measure of capacity utilization may be obtained by subtracting the elasticity of cost with respect to the fixed inputs from unity, when constant returns to scale exist (or are assumed). The dual cost measure of capacity utilization may be greater or less than unity as is the case with the primal-based measure.

The relationship between this dual cost measure of capacity utilization and the long- and short-run cost elasticity with respect to output can be now derived more clearly. This relationship is derived first by assuming constant returns to scale then it is extended to the non-constant returns to scale case under homothetic technology. Under constant returns to scale the dual cost measure of capacity utilization can be obtained as follows:

$$\frac{d \ln C(\cdot)}{d \ln Q} = 1 = \frac{\partial \ln C(\cdot)}{\partial \ln Q} + \sum_k \frac{\partial \ln C(\cdot)}{\partial \ln Z_k} \cdot \frac{d \ln Z_k}{d \ln Q}$$
$$= ?_{CQ} + \sum_k ?_{CZ_k} \cdot ?_{QZ_k} \qquad (2.5)$$
$$\Rightarrow ?_{CQ} = 1 - \sum_k ?_{CZ_k}$$

This shows that the short-run cost elasticity with respect to output can be used as a dual cost measure of capacity utilization, under constant returns to scale. However, if the underlying technology is homothetic and non-constant returns to scale exist, then the dual cost measure of capacity utilization, the short-run elasticity of cost with respect to output, can be decomposed into two components: (1) the input fixity effect, and (2) the long-run scale effect. Thus, equation 2.5 may be rewritten as:

$$z_{CQ} = h(1 - \sum_k z_{CZ_k}) \qquad (2.6)$$

where $\eta = \frac{d \ln C(\cdot)}{d \ln Q} = \frac{d \ln Z_k}{d \ln Q}$, and $1/\eta$ is the long-run returns to scale for a homothetic[6] technology.

3. Econometric Framework and Data Measurement

In order to estimate a dual cost capacity utilization model, an econometric framework and data on indices of inputs and output is required. The construction of the econometric model and the necessary data set are discussed in this section.

3.1 Econometric Model

A short-run Cobb-Douglas variable cost function is exploited in this study. Although the underlying technology of the Cobb-Douglas function is fairly limiting, it was selected due to data limitation with regards to the degree of freedom due to the available number of observations.

A large number of applied studies in economics have exploited the Cobb-Douglas function. Most of these studies did not deal with data at firm or industry levels, but rather with aggregated data of the economy as a whole. Furthermore, most of these studies have proved to be constructive in describing the underlying technology[7].

The specific form of short-run Cobb-Douglas variable cost function $V(P_i, Q, Z_k)$, with no technological change and capital stock as the only quasi-fixed input (thus, let Z_k=K and $P_{Zk}=P_K$) can be written as:

$$VC = AP_L^{\alpha} P_M^{\beta} Q^{\delta} K^{\gamma}$$
$$\Rightarrow \log(VC) = \log A + \alpha \log(P_L) + \beta \log(P_M) + \delta \log(Q) + \gamma \log(K)$$

Where VC is the short-run variable costs, A is a positive constant (i.e., as an indicator of the state of technology), P_L is the price of labor, P_M is the price of intermediate described below), and a, ß, d, and ? are coefficients to be estimated (i.e. elasticity of the cost with respect to P_L, P_M, Q, and K respectively).

3.2 Data: Measurement and Sources

The econometric model described above requires data on indices of prices of inputs and quantities of output and capital (quasi-fixed) stock. Fortunately, data on output and inputs price indices can be obtained indirectly from published data. However, no data on capital stock is available, thus the capital stock is estimated.

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[6] For the case of non-homothetic technology, see Morrison (1985, 1988a).

[7] The interpretation of the results, on the other hand, may not be very meaningful as it is at the firm or industry levels, Fraser (2002).

All time series data[8] used for this research are obtained from various publications of the Central Statistical Organization, the official data source in Bahrain. The time period covered in this study is from 1984 to1999. The level of input prices (1989=100), output, and capital (quasi-fixed) stock are constructed as follows:

3.2.1 Gross Output (Q)

For all economic performance, output is measured in physical or real values. For products to be regarded as a homogeneous commodity (production in physical units) certain conditions should be satisfied. Physical (quantity) data are often not readily available, but the value (monetary) data usually exist. However, these value data have to be separated into their quantity and price. Then, the value of output could be adjusted for price changes by using appropriate price index. The adjusted value is usually known as constant price output or the real value of production. In this study, thus, output refers to the real value of production.

3.2.2 Capital Stock (K)

No data on capital stock is available. However, both investment and depreciation are available (constant price, 1989=100). The data set on capital investments included capital expenditure on new buildings, other construction, new plants, machinery and equipment, land, and other fixed assets. An average annual capital depreciation rate of 10 percent[9] in 1984 is assumed. Based on this rate, an estimated benchmark for capital stocks in 1984 is computed. Then, using annual net investment (fixed prices), an aggregated capital stock is constructed. The perpetual inventory method[10] is employed in accounting for capital stock with adjustment for the change in prices and depreciation rates.[11]

3.2.3 Labor Input (L)

Compensation is defined as comprising of all payments, both in cash and in kind, and any supplement to wages and salaries. In this study, the real value of compensation is used as a measure of labor input, taking into account differences in skills among workers. This assumes that there is a strong relationship between wages and the worker's level of skill and experience. Then, the price of labor input is derived as the implicit wage deflator.

[8] The raw data are presented in Appendix A; including the estimated capital stock.

[9] For a justification of this assumption, see Hulten and Wykoff (1981a, 1981b) and Al Sadiq (1998).

[10] For a detailed discussion of this method, see ABS (Occasional Paper no. 1985/3).

[11] Capital Stock at 1984 was estimated as: K_{84} = (Depreciation$_{84}$ / 0.1) + investment$_{84}$ – Depreciation$_{84}$. It follows that: K_{85} = K_{84} + investment$_{85}$ – Depreciation$_{85}$. This method is a slightly modified version of the method presented in Adelman and Chenery (1960). The estimated annual capital stock for time period 1984-1999 is presented in Table A1 in appendix A.

3.2.4 Intermediate Inputs (M)

In this study, intermediate-inputs are defined as equal to the real value of the purchases of materials and supplies for production including fuels, electricity, water, and the cost of industrial services received minus the changes in their stock, plus the payments made for non-industrial services. In other words, intermediate inputs represent the cost of all production inputs excluding the cost of labor and capital inputs. The implicit deflator was used as the most appropriate price index for intermediate inputs (M).

4. Empirical Results and Results Interpretation

The annual data form 1984-1999 was fitted to the short-run Cobb-Douglas cost function model. The Cobb-Douglas short run cost model regression results[12] are presented in Table 1. Table 1 shows that most of the estimated parameters of the cost function are significantly different from zero at less than the five per cent level of significance. In particular, the estimated parameters of output and capital stock are highly significant.

Given the estimated parameters presented in Table 1, the estimated Cobb-Douglas short run variable and total cost functions are[13]:

$$\hat{VC} = 4.975 P_L^{-1.354} P_M^{-0.325} Q^{1.339} K^{-0.569}\text{, and}$$

$$\hat{TC} = 4.975 P_L^{-1.354} P_M^{-0.325} Q^{1.339} K^{-0.569} + P_K K\text{, respectively.}$$

The estimated variable cost function satisfies most of the regularity conditions. Monotonicity in input prices requires the cost-share equations to be greater than zero; S_i>0, and the necessary and sufficient condition for the monotonicity in output is that the partial derivative of the cost function with respect to output is non-negative. This, monotonicity of the cost function in output is satisfied. However, monotonicity of the cost function in input prices is not satisfied. Underlying the economic theory, the coefficient of input prices should be positive. That is when price increases total variable cost increases. The negative coefficient here may be the result of high correlation among the variables.

Although a short-run cost function is estimated, it is reasonable to determine returns to scale (RTS) from the estimated coefficients (Caves, Christensen, and Swanson, 1981). Recall that $\zeta_{CQ} = \eta(1 - \sum_k \zeta_{CZ_k})$, and $1/\eta$ is the long-run returns to scale, when the underlying production technology is homothetic. Thus,

[12] The model estimations and its related calculations are carried out using SHAZAM Econometrics Computer Program, Version 7.0.

[13] The constant of 1.604 is a logarithm and 4.975 is its anti-log.

it follows that estimated RTS = (1+0.57)/(1.34)= 1.17 (increasing returns to scale), which indicates the presence of economies of scale. However, the hypothesis of constant returns to scale (RTS=1) cannot be rejected using a Wald test. That is, the Wald test statistics for the null hypothesis [(1- ?)/d=1] is 1.864 versus a 95 percent critical value of 3.84 Chi-square with *df* =1. Thus, over this time period the underlying technology in Bahrain's economy exhibits, statistically, a constant return to scale.

Turning next to the estimation of the level of capacity utilization in the Bahrain economy[14], it is instructive at this stage to recall the underlying theoretical concept and the dual cost measure of capacity utilization. Consider the following data for year 1984:

Total Production (Q) =2935.200

Total Variable costs (VC) =2279.000

Capital Stock (K) =2359.900

Price of Capital (P_K) = 0.983

Now equation (2.4) is applied using the estimated model. To do so, first we need to derive $\tilde{P}_K$ which can be obtained by taking the first derivative of the estimated short-run function with respect to the capital stock:

$\tilde{P}_K$ = - ? (VC / K) = -(-0.570)*(2279.000 / 2359.900) = 0.550

CCU = 1-[K (P_K- $\tilde{P}_K$) / TC] = 1-[2359.9(0.983- 0.55)/4598.061]= 0.778

This shows that the shadow price of capital (0.55) is less than the market price (0.983)[15], which implies that there is excess capital stock. Consequently, the dual cost measure of capacity utilization is less than one, which implies the existence of capital under-utilization by 22.2 percent. Capacity utilization can also be measured using the elasticity of the short-run cost function $\{1-\sum_k \zeta_{CZ_k}\}$ as it has been shown above. This measure is obtained as follows:

CCU =1 - [(? (VC/K) + Pk)*(K/TC)]

=1-[((-0.570) (2279.000/2359.900)+0.983) (2359.900/4598.061)]= 0.778

This confirms that the two dual cost measures of capacity utilization (presented above) are numerically the same.

Next, average annual level capacity utilization in Bahrain's economy is estimated. First, annual level of capacity utilization is estimated and, then, these estimates are averaged over the study period 1984 –1999. Table 2 shows descriptive statistics of the level of capacity utilization, elasticity of cost with respect to output, elasticity of variable cost with respect to the level of capital stock, and the shadow price of capital.

Examining Table 2 it can be seen that the maximum level of capacity utilization was 77.8 percent with an annual average rate of 58.6 percent. This implies that there is significant room for increasing output with no additional capital required. Under-utilization as a persistent structural problem of Bahrain industries has productivity implications beyond the misuse of scarce resources. Another possible justification of excess capacity (capacity under-utilization) may be related to the small size of Bahrain markets.

Table 2 also shows that average elasticity of cost with respect to capital stock is 0.414. This implies that for a 1 percent increase in capital, total cost increases by 0.414 percent. However, increasing capital inputs by 1 percent reduces total variable cost by 0.57 percent. The elasticity of cost with respect to output (the impact of scale economies) indicates that most industries in the Bahrain economy experience economies of scale, that is, increasing the scale of production reduces the long-run average cost. Thus there is significant room for increasing output with a very low cost of capital, due to the excess in capital stock.

Figure 2 shows the annual level of capacity utilization in the Bahrain economy over the time period 1984 to 1999. Over the 1990s, average capacity utilization was less than that in 1980s. This relatively low level of capacity utilization in the 1990s could be a result of the 1990 Gulf War. The findings also indicate that there was a significant drop in capacity utilization in 1990 compared to 1989. However, the continuation of this low level of capacity utilization could also be a result of civil unrest in the mid-1990s.

The lowest level of capacity utilization occurred in the early 1990s. Thus, one may conclude that this low level of capacity utilization, or under-utilization of the capital stock, is one of the major factors affecting the growth rate of multifactor productivity in this time period. The findings of the study (given the underlying technology and its assumptions) come to support in part the findings of Al Sadiq (1998) who reported that "*over the time period 1983-1993 the total factor productivity accounted for a small proportion (17.5 percent) of the growth of GDP*".

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[14] Since the underlying technology is assumed to be Cobb-Douglas technology (function), which is fairly limited, it is quite reasonable with regards the findings of this study with some degree of circumspection.

[15] Indexed to the price of capital in 1989 = 1.00.

5. Summary and Concluding Remarks

This paper is concerned with measuring and analyzing capacity utilization in the Bahrain economy. An economic theory-based measure of capacity utilization, which takes account of these input fixity constraints and measures the optimal level of output given these constraints, was exploited to obtain a highly interpretable measure of capacity utilization. In order to meet this objective a short-run Cobb-Douglas cost function is employed. Although the underlying technology of the Cobb-Douglas function is fairly limiting, its selection was due to data limitations and also resulted from trying alternative functional forms and it was with best fit.

The present analysis shows that the presently structured industries in Bahrain's economy, on average, have experienced capacity under-utilization. The reasons behind this low economic performance (given the underlying technology and its assumptions) are most likely due to the presence of a number of sub-optimal plants (industries) with significant capacity under-utilization. Three main considerations are given below for full capacity utilization. These are:

1. Rationalization of the existing structure of some industries (this needs further research) and limitation of new entry.
2. Regional integration creating a larger market for existing industrial capacity.
3. Technological adaptation that reduces the minimum economic size of industries for a small- market economy such as Bahrain.

However, to avoid any misinterpretation of the current economic performance of Bahrain's economy, a comparison with that of its challengers among the GCC countries is another requirement for a policy decision to be recommended. Productive efficiency, on the other hand, should also be isolated and analyzed before any policy decisions are drawn to improve the economic performance of the Bahrain economy.

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Figure 1: Capacity Output under Inputs Fixity Allowing for Non-constant Returns to Scale

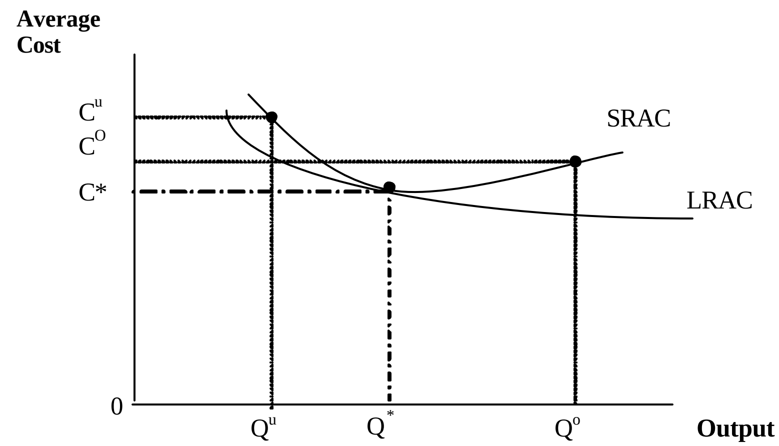

Figure 2: Annual Level of Capacity Utilization in Bahrain Economy

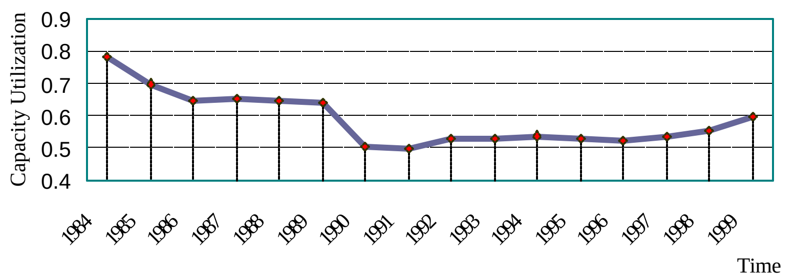

Table 1: The Cobb-Douglas Short Run Cost Model Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Probability
Constant	1.604	1.215	1.320	0.214
Log Q	1.339	0.138	9.734	0.000
Log P_L	-1.354	0.477	-2.838	0.016
Log P_M	-0.325	0.212	-1.536	0.153
Log K	-0.570	0.120	-4.752	0.001
R-squared	0.909	Mean dependent variable		7.710
Adjusted R-squared	0.875	S.D. dependent variable		0.103
S.E. of regression	0.036	F-statistic		27.319
Sum squared residual	0.015	Probability (F-statistic)		0.000
Log likelihood	33.268			

Table 2: Descriptive Statistics of Capacity Utilization and Elasticities of Cost

Description	Capacity Utilization	Elasticity of cost w.r.t.* Capital	Elasticity of cost w.r.t.* Output
Mean	0.586	0.414	0.500
Median	0.544	0.456	0.464
Maximum	0.778	0.503	0.664
Minimum	0.497	0.222	0.425
Std. Dev.	0.081	0.081	0.069

Notes: * w.r.t. = with respect to.

APPENDIX A: DATA SETS

Table A1: Output and Inputs in Bahrain Economy for 1984-1999 (BD Million – Current Prices)

Year	Value of Production	Value of Input	Wages & Salaries	Depreciation	Investment
1984	3501.8	2008.8	604.5	200.7	636.0
1985	3269.5	1876.4	613.0	206.0	487.8
1986	2577.1	1429.4	620.2	208.6	370.1
1987	2791.8	1625.7	606.0	207.6	341.9
1988	2827.0	1546.5	624.0	218.5	326.8
1989	3080.5	1706.4	656.0	224.1	364.2
1990	2823.6	1120.7	702.4	248.9	291.8
1991	2912.6	1177.0	699.9	261.8	343.5
1992	3073.6	1287.4	729.3	262.8	386.2
1993	3402.3	1447.0	763.6	307.5	454.2
1994	3692.0	1598.7	800.1	326.7	417.5
1995	3840.0	1640.6	824.6	332.6	381.3
1996	3909.5	1615.2	836.8	328.7	284.1
1997	4077.1	1689.8	874.5	332.4	285.9
1998	4087.4	1762.2	933.8	343.6	326.2
1999	4293.0	1803.6	975.9	358.7	338.4

Table A2: Output, Inputs, and estimated Capital Stock in Bahrain Economy for 1984-1999 (BD Million - Constant Price, 1989)

Year	Value of Production	Value of Input	Wages & Salaries	Depreciation	Investment	Estimated Capital Stock
1984	2935.2	1693.3	585.7	190.3	647.2	2359.9
1985	2850.5	1644.5	596.5	212.4	489.5	2816.8
1986	2771.4	1563.8	609.5	225.4	367.9	3093.9
1987	2927.2	1696.6	620.9	226.4	337.6	3236.4
1988	3058.8	1717.2	631.4	237.3	325.1	3347.6
1989	3080.5	1706.4	656.0	224.1	364.2	3435.4
1990	2772.8	1114.0	675.1	230.0	277.4	3581.7
1991	2826.2	1138.4	669.2	238.0	320.0	3629.1
1992	3082.2	1281.6	691.1	252.7	366.6	3711.1
1993	3468.0	1435.5	719.7	258.8	411.1	3825.0
1994	3632.1	1604.8	735.0	273.4	368.4	3977.3
1995	3679.7	1572.8	763.4	277.5	334.8	4072.3
1996	3741.2	1547.7	770.6	286.7	252.5	4129.6
1997	3853.4	1592.0	783.7	287.2	254.0	4095.4
1998	4016.4	1646.6	818.0	304.3	291.4	4062.2
1999	4201.7	1738.3	853.8	310.6	325.0	4049.3