Productivity Growth in Bahrain Manufacturing Industries

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ملخص

نمو الإنتاجية في قطاع الصناعات التحويلية البحريني

يعتبر معدل نمو الإنتاجية أحد أهم مؤشرات الأداء الاقتصادي الذي يتسم بالشمولية، والذي يمكن تحليله إلى عدة مكونات رئيسية. وعليه، فقد كان الهدف الرئيسي لهذه الدراسة هو قياس وتحليل معدلات النمو في الإنتاج وإنتاجية العمل والإنتاجية الكلية في قطاع الصناعات التحويلية البحريني خلال الفترة ١٩٩٠ ـ ٢٠٠١.

وقد اعتمدت الدراسة نموذج "حسابات النمو" في قياس وتحليل معدلات النمو في الإنتاج إلى مكوناته الرئيسية المتمثلة في معدل نمو الإنتاجية الكلية ومعدل نمو كثافة مدخلات الإنتاج كما تم تحليل معدل نمو إنتاجية العمل إلى مكوناته الرئيسية المتمثلة في معدل نمو الإنتاجية الكلية ومعدل نمو كثافة مدخلات الإنتاج إلى عنصر العمل.

وبناء على تحليل النتائج التطبيقية لنموذج القياس فقد تبين لنا ضعف مساهمة معدلات نمو الإنتاجية الكلية في معدلات نمو الإنتاج في قطاع الصناعات التحويلية البحريني. كما اتضح من التحليل أن التغير في معدلات نمو الإنتاجية الكلية لم يسهم بشكل كبير في رفع معدلات النمو في إنتاجية العمل، بل كان معدل النمو في كثافة مدخلات الإنتاج بمثابة العامل الرئيسي المؤثر في تغيرات معدلات النمو في إنتاج وإنتاجية العمل.

وكانت أهم توصيات الدراسة هي ضرورة العمل على رفع معدلات نمو الإنتاجية الكلية من أجل رفع معدلات نمو الإنتاج ومعدلات نمو إنتاجية العمل. كما أوصت الدراسة بضرورة القيام بدراسات مستقبلية لتحديد وتحليل مكونات الإنتاجية الكلية وإيجاد السياسات الكفيلة برفع مستوياتها في هذا القطاع الحيوي الهام.

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1. Introduction

Currently, one of the most compelling tasks facing Bahrain economy is to expand and diversify its industrial sector. The importance of this task stems primarily from the danger of being mostly dependent upon the financial sector. With the process of development and the importance of structural transformation, it is very important to understand the fundamental concepts of productivity analysis and measurement, which could help in the identification of the most proper industry-oriented policy.

Diversification and further industrialization in Bahrain economy would call for additional requirement of production factors, including human resources. As a long-run solution, attracting Bahraini labor force to enter the industrial sector, however, could satisfy labor requirements. Therefore, this may require an urgent need for more industry-oriented planning programs that aim at encouraging the Bahraini to participate in this sector. The importance of this factor prompts policy-makers to pay more attention to labor studies.

Most agreements of the World Trade Organization (WTO) have emphasized global openness and competition. Only nations with high level of productivity, however, would survive in face of the international harsh competition. Thus, it is about the right-time for Bahrain policy makers to pay more attention to productivity issues.

It follows that it is crucial at this stage to unfold the main components of the growth rates of output and labor productivity that can be used as powerful analytical tools in understanding the economic performance of Bahrain manufacturing industries. Thus, the main objective of this study is to measure and analyze the growth of output and labor productivity and their sources in Bahrain manufacturing industries over the time period 1990-2001. Estimating the sources of labor productivity growth is essential in the evaluation of alternative policies in Bahrain manufacturing industries.

This study is organized in the following way: Section 2 presents a review of the underlying theory of measuring productivity growth. Section 3 discusses the empirical model and methodology that are used in this study and establishing the relationships between labor productivity and its sources of growth. In Section 4, the data used in this empirical investigation is defined. The empirical findings are presented and analyzed in Section 5. The concluding remarks drawn from the empirical analysis are presented in Section 6.

2. Productivity Measurement: A Review of Recent Developments

Productivity can be defined either by increased output holding the level of inputs unchanged, or by reduced cost of production (input prices are held constant) holding the level of output unchanged. These definitions can, however, be presented theoretically either by an upward shift of the isoquant or by a downward shift in the average cost function. Thus, the production and/ or cost function can be used to represent the underlying technology and to develop the theoretical linkage between productivity growth and its major components.

However, most of the recent developments in productivity measurement and analysis are based on the convexity and derivative properties of the dual cost function. In the modern approach to productivity measurement, productivity growth is measured in terms of cost saving for given levels of output rather than output increasing for given levels of inputs. That is, the fundamental concept underlying the cost-based measure of multi-factor productivity growth is: if a given output can be produced with a smaller amount of inputs due to technological improvement (other things remain the same), it implies that this level of output may be produced at a lower cost. That shows why productivity issues are important under international competition.

Over the last two decades, applied economists realized that the fundamental issues of isolating the contribution of scale economies and change in capacity utilization and efficiency to productivity growth remain unsolved, Kopp and Diewert (1982), Grosskopf

(1993), Morrison (1999), Brent and Fuss (1989), and Coelli al et.(1998). However, as a result of recent developments, the observed productivity growth could be decomposed into several important measures of economic performance, Shebeb (2000). These measures are mainly technical change, scale economies, productive efficiency, and capacity utilization.

It follows that productivity measure should be regarded as a composed measure of number of economic behaviors that are important pieces of the overall economic performance. Identifying and measuring these components of overall productivity help to provide a more accurate and interpretable measure of economic performance. It follows that if any of these major economic aspects of the production process is ignored, the resulting estimates of productivity are likely to have measurement bias, Shebeb (2002).

To summarize the theoretical linkages between MFP growth and its major decompositions (technical change, scale economies, cost-inefficiency, and capacity utilization), a comprehensive diagrammatic exposition is presented. Take an industry made up of identical firms whose input-output coefficients do not vary across firms at any level of output. Cost and production theory suggest that a reasonable representation of the representative firm in the industry, presumed to be realizing increasing returns to scale, is as in Figure 1. The downward slope on the long-run average cost curve (LRAC) implies that returns to scale are increasing, but at a decreasing rate, with additional scale expansion.

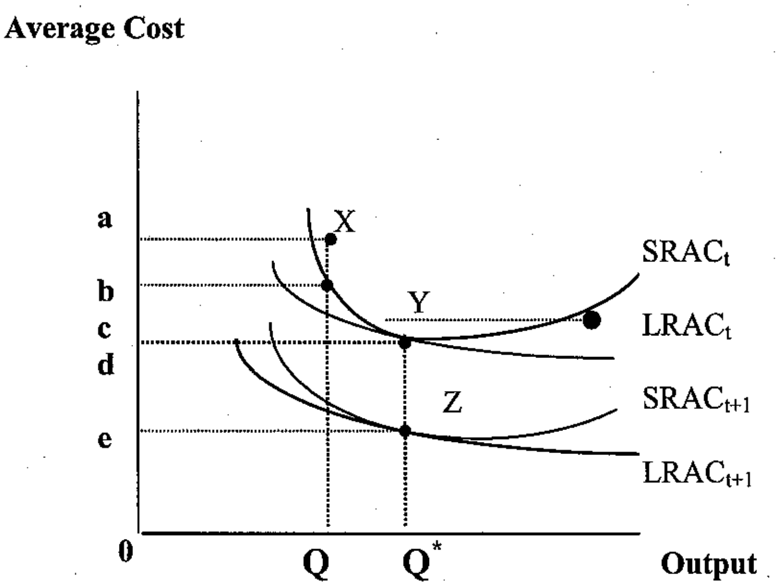

Figure1. MFP Decomposing Model: Allowing for Cost Inefficiency, Technological Change, Capacity Utilization, and Non-Constant Returns to Scale

The short-run average cost, $SRAC_t$, curve is tangential to the $LRAC_t$ at Y (***Disregard $SRAC_{t+1}$ and $LRAC_{t+1}$ curves in Figure 1 for the time being)***. When the firm is operating at capacity output level Q^*, it is said to be fully utilizing its capacity (in an economic sense) and it is cost efficient. At this level of output, Q^*, the short-run average cost is equal to that of the long-run, hence, no scope exists for further cost reduction by changing the capacity or the capacity utilization of the firm. More commonly, however, firms operate at levels of output other than Q^*. For example, if it is operating at output level Q at the point X and some cost inefficiency does exist, the average cost in this case would be equal to o<u>a</u> which exceeds the $SRAC_t$ and $LRAC_t$ by the amount <u>ab</u> and <u>ac</u> per unit of output, respectively. The <u>ab</u> portion is attributed to the cost inefficiency while the (<u>ac</u>-<u>ab</u>)=<u>bc</u> portion can be ascribed to capacity under-utilization in the short run.

Assume now that the firm moves from X to Y. Short-run cost per unit will decline by ad and this would be translated into a gain in multi-factor productivity. Three possible effects underlie the decline in cost associated with the movement from Q to Q^*. These are as follows: (1) the efficiency gain (cost reduction, ab) associated with operating at the cost frontier; (2) the cost reduction associated with realizing the long-run average cost, bc; and (3) the cost reduction due to the realization of scale economies, cd. Noting that, if the move from Q to Q^* involves no change in plant capacity, the full MFP gain, ad would be attributed to better capacity utilization and full cost efficiency only. This analysis highlights the fact that MFP change, based on measured cost reduction, might be a result of changing the scale of the operation, capacity utilization and/or cost efficiency in the firm rather than technological change.

Now let us introduce technological change with $SRAC_t$ and $LRAC_t$ curves shifted downward as a consequence of technological improvement as depicted by $SRAC_{t+1}$ and $LRAC_{t+1}$ respectively. Suppose that the firm moves from X to Z in Figure 1. Thus, in this case, there are four sources of potential cost reduction that can be analyzed. These sources are associated with: (1) cost efficiency, ab; (2) the capacity utilization effect, bc; (3) the realization of scale effect, cd; and (4) the technological change, de. The overall gain in MFP would thus be measured by the overall cost reduction ae, which now could be ascribed to these four sources. To generalize the simplified analysis presented above we need to consider all combinations of levels of Q* and Q, including moving from one point where capacity is/ is not fully utilized and/or from points where no gain is associated with cost efficiency. That was not illustrated diagrammatically for ease of exposition.

That is, the observed change in MFP could be a result of various economic interactions in the production process, including technical change, scale economies, and changes in capacity utilization and inefficiency. Thus, if any of these major economic aspects of the production process is ignored, the resulting estimates of MFP are likely to have measurement bias.

3. Productivity Measurement Model

Due to unavailability of the necessary data, however, a full structural model that takes into account the contribution of the major components of the overall productivity change could not be used in this study. Therefore, rather restricted(1) growth accounting model is used in measuring and analyzing productivity growth in Bahrain manufacturing industries.

A growth accounting method is used in deriving the measurement model of output, MFP, and labor productivity growth rates. Given the main approaches in productivity and production modeling, the Deliveries to Final Demand (gross output) approach is exploited in this study. This complies with the fact that an analysis of productivity change in an open economy must be based on production function that contain all primary inputs (labor and capital) in addition to the intermediate inputs, Gollop (1983).

The general form of the industry-level production function can be written as:

$$(1)\quad Q_t = A_t f(K_t, L_t, M_t)$$

Where Q_t is the real output, A_t is the index of MFP (technical change), K_t is the inputs of the capital services (flow), L_t is the labor inputs, and M_t is the intermediate inputs, all in time period t.

Thus, differentiating the production function (1) with respect to time gives the growth equation, which can be written as:

$$(2)\qquad \frac{dQ/dt}{Q} = \frac{dA/dt}{A} + \left(\frac{\partial Q}{\partial K}\frac{K}{Q}\frac{dK/dt}{K} + \frac{\partial Q}{\partial L}\frac{L}{Q}\frac{dL/dt}{L} + \frac{\partial Q}{\partial M}\frac{M}{Q}\frac{dM/dt}{M} \right)$$

This equation (2) shows the rate of change of output as a sum of the rate of change in the MFP [(dA/dt)/A] and the weighted average of the rate of change in use of inputs. Conceptually, MFP indicates the change in output resulting from the shift of the production function. On the other hand, changes in inputs indicate that the change in output results from movements along the production function.

Exploiting the models' underlying assumptions, equation (2) can reproduced as:

$$\text{(3)} \qquad \frac{dQ/dt}{Q} = \frac{dA/dt}{A} + \left(S_K \frac{dK/dt}{K} + S_L \frac{dL/dt}{L} + S_M \frac{dM/dt}{M} \right),$$

Where $S_i = X_i/P_Q Q$, where i = K, L, and M, X_i is the total payment to input (i), and P_Q is the price of output (Q). The model's assumptions also imply that the weights (shares) sum up to one that is $S_K+S_L+S_M=1$.

Equation (3) is known as the Divisia index, Solow (1957) was among the first to show that Divisia MFP index can be naturally derived from a simple production relationship. With an index number framework[(2)] and taking the (log) for the inputs and output index and with using the average inputs share, we can get the approximation of the Tornqvist index number as:

$$\text{(4)} \qquad \log\frac{Q_t}{Q_{t-1}} = \log\frac{A_t}{A_{t-1}} + \left(\overline{S}_K \times \log\frac{K_t}{K_{t-1}} + \overline{S}_L \times \log\frac{L_t}{L_{t-1}} + \overline{S}_M \times \log\frac{M_t}{M_{t-1}} \right)$$

where: $\overline{S}_i = (0.5)(S_{i,t} + S_{i,t-1})$

It follows that MFP growth rate can be presented as:

$$\text{(5)} \qquad \log\frac{A_t}{A_{t-1}} = \log\frac{Q_t}{Q_{t-1}} - \left(\overline{S}_K \times \log\frac{K_t}{K_{t-1}} + \overline{S}_L \times \log\frac{L_t}{L_{t-1}} + \overline{S}_M \times \log\frac{M_t}{M_{t-1}} \right)$$

This shows that MFP can be seen as the growth rate of output over and above the growth rate of inputs.

Now the relationship between the labor productivity and sources of its growth can be obtained. The average labor productivity can be defined as the ratio of total output to labor input (Q/L). This average depends on two factors: (1) the shift in production function; and (2) the intensities of other (not labor) inputs. Changes in MFP shifts the production function while changes in input intensities results in movement along the production function.

Let the average labor shares of inputs and output be defined as follows:

1. $q_t = Q_t / L_t$; the average output per unit of labor
2. $k_t = K_t / L_t$; the average capital input per unit of labor
3. $m_t = M_t / L_t$; the average intermediate inputs per unit of labor

Then, the growth rate of labor productivity can be computed as the sum of the growth rate of MFP and the weighted growth rate of non-labor input intensity.

$$(6) \qquad \log\frac{q_t}{q_{t-1}} = \log\frac{A_t}{A_{t-1}} + \left(\overline{S}_K \times \log\frac{k_t}{k_{t-1}} + \overline{S}_M \times \log\frac{m_t}{m_{t-1}}\right)$$

One of the advantages of this method is that the Hicksian parameter (A) or (the growth rate of MFP) can be measured using price and quantity data. The MFP growth rate, however, is a valid measure of technological change (A) only under the model's assumptions.

4. Data[3]

For all productivity measures, 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. In this study, output is equal to the summation of the real values of the produced output.

The number of persons employed is defined as the total number of persons who work in the establishment. Compensation is defined as comprising of all payments, both in cash and in kind, and any supplements to wages and salaries. In this study the real value of compensation is used as a measure of labor input to take into account the difference in skill among workers assuming that there is a strong relationship between wages and the workers' level of skill and experience.

The most preferred measure of capital input for productivity analysis is the flow of capital services used. The flow of capital services, which should in principle include the value, at current replacement cost, of the reproducible fixed assets used up during the year as a result of normal wear and tear, and the normal rate of accidental damage. Thus, flow measures could be a good indication of the amount of capital employed to produce current output. In practice, however, data are generally not available in the details required for the estimation of capital flow, Shebeb (2002). In this study the capital depreciation (in real terms) has been used as a measure of the flow of the capital service,(4) and intermediate-inputs are defined as equal to the real value of all production inputs excluding the cost of labor and capital inputs.

5. Empirical Results and Results Interpretation

The basic model is applied to measure the growth rates of output, labor productivity, multi-factor productivity (MFP), and factor intensities in Bahrain manufacturing industries over the time period 1990-2001. The results are presented in two main subtitles; (1) output and its sources of growth; and (2) labor productivity growth and the sources of its growth.

5.1 Output and Its Sources of Growth

Table 1 shows the year-by-year growth rates of output, factors intensity, and MFP in Bahrain manufacturing industries during the time period 1990-2001. The annual growth rate of output ranged from a maximum of 19.3% in 1993 to a minimum of 1.9% in 1995 and 1998. The average annual growth rate over the time period 1990-1995 was 10.1%. Table 1 also shows that the average annual growth rate was higher in the early 1990s compare to mid and late 1990s. This low rate of growth in the mid-1990s could be associated indirectly to the civil unrest and economic instability over that time period.

Table 1: Output and Its Sources of Growth

Year	Annual Growth Rate		
	Output	**Factor Intensity**	**MFP**
1990	0.101	0.073	0.029
1991	0.085	0.077	0.007
1992	0.091	0.086	0.004
1993	0.193	0.182	0.011
1994	0.116	0.127	-0.011
1995	0.019	0.002	0.018
1996	0.020	0.032	-0.012
1997	0.054	0.025	0.029
1998	0.019	0.029	-0.009
1999	0.048	0.037	0.011
2000	0.060	0.045	0.015
2001	0.031	0.011	0.020
Time Periods	**Average Annual Growth Rate**		
1990-1995	**0.101**	**0.091**	**0.010**
1996-2001	**0.039**	**0.030**	**0.009**
1990-2001	**0.070**	**0.060**	**0.009**

Table 1 shows the effect of factor intensities on the output growth. A positive growth rate of factor intensities means that at least one input (capital, labor, and/or intermediate) was growing during these years. Thus, factor intensities have a direct positive effect on output growth rate. The average annual growth rate of factor intensities was 9.1% over the time 1990-1995. This has contributed to the positive average growth rate of output. On the other hand, factor intensities experienced a lower average growth rate in the second half of 1990s. This low annual average growth rate of factor intensities is the major factor that resulted in lower annual average growth rate of output during these years.

Table 1 shows that the average annual contribution of MFP to the growth of output was 12% [(0.01/0.101)(100)] compared to the contribution of the factor-intensity which was about 88% [(0.091/0.101)(100)] over the time period 1990-1995. This implies that the growth of MFP has insignificant contribution to the output growth rate in this sector. Thus, one may conclude that this low contribution of MFP to the growth of output is due to the use of less developed economic and management techniques. One could also argue that inefficient production techniques may contribute significantly to the low growth of MFP.

5.2 Labor Productivity and Its Sources of Growth

Table 2 shows the annual growth rate of labor productivity and its sources of growth in Bahrain manufacturing industries for the time period 1990-2001. The table shows that labor productivity has a declining growth rate over the study period. It also shows that the average annual growth of labor productivity over 1990-1995 was higher than that of 1996-2001. Careful examination to the growth rate of the two components of labor productivity reveals that the low (negative) growth of MFP was not the primary factor causing the general declining trend in the growth rate of labor productivity.

Table 2: Labor Productivity and Its Sources of Growth

Year	Annual Growth Rate		
	Labor Productivity	**Labor-Factor Intensities**	**MFP**
1990	0.045	0.017	0.029
1991	0.087	0.080	0.007
1992	0.057	0.052	0.004
1993	0.132	0.121	0.011
1994	0.088	0.099	-0.011
1995	-0.015	-0.032	0.018
1996	0.013	0.025	-0.012
1997	0.044	0.015	0.029
1998	0.014	0.023	-0.009
1999	0.058	0.047	0.011
2000	0.069	0.054	0.015
2001	0.012	-0.007	0.020
Time Periods	**Average Annual Growth Rate**		
1990-1995	**0.066**	**0.056**	**0.010**
1996-2001	**0.035**	**0.026**	**0.009**
1990-2001	**0.050**	**0.041**	**0.009**

Over the time period 1990-2001, the average annual growth rates of labor productivity, labor-factor intensities, and MFP were about 5%, 4.1%, and 0.9% respectively. This implies that about 82% of the growth in labor productivity was attributed to the increase in labor-factor intensities and only about 18% was the contribution of technological change (MFP).

A positive growth rate of labor-factor intensities means that the cal-labor and/or the intermediate-inputs-labor ratios were growing over these years. An increase in the capital-labor ratio is a result of a more rapid growth of capital input than the growth of labor input, and the same is true for the intermediate-inputs-labor ratio. Thus, factor intensities have a direct positive effect on labor productivity growth rate.

Table 2 shows the effect of factor intensities on the labor productivity growth rate in Bahrain manufacturing industries. The average annual growth rate of factor intensities in Bahrain was 4.1% over the time period 1990-2001. This has contributed significantly to the positive average growth rate of labor productivity during these years. On the other hand, factor intensities experienced a negative growth rate in two years (1995 and 2001). This negative annual growth rate of labor-factor intensities is the major factor that resulted in a negative annual growth rate of labor productivity in 1995 and to a less extent in year 2001. The average annual growth rate of factor intensities was 5.6% over the time period 1990-1995 compared to 2.6% in 1996-2001. However, this also shows that factor intensity growth experienced a declining trend over the time period 1991-1999. This down trend had adversely affected the growth of labor productivity accordingly. Furthermore, it indicates a reduction in the use of production factors, as clearly shown in Chart 1, in Bahrain manufacturing industries that is highly desirable given scarcity of the economic resources in Bahrain.

Chart ١: Labor Productivity and Its Sources of Growth

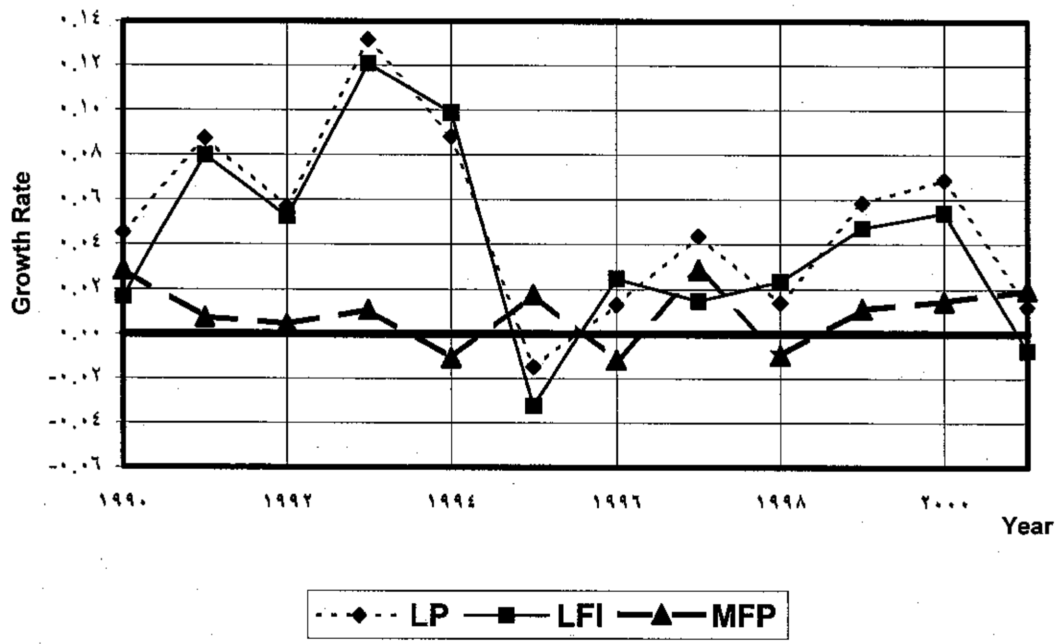

Table 2 shows also the trends in the annual growth rate and the average annual growth rate of multi-factor productivity (MFP) in Bahrain manufacturing industries. MFP has experienced a relatively lower average annual growth rate of 1% during the time period of 1990-1995, and even a lower average annual growth rate during the time period of 1996-2001. In general the annual growth rate of MFP was found to have rather a weak effect on labor productivity growth in Bahrain manufacturing industries. Furthermore, this contribution was relatively low (average of 18%) compared to the contribution of factor intensities (average of 82%) to the growth of labor productivity over the time period 1990-2001. Thus, one may conclude that there is an urgent need to improve MFP in these industries in order to enhance its contribution to the growth of labor productivity[5].

6. Concluding Remarks

The findings show that there is an urgent need to improve MFP in these industries thus to be able to contribute more significantly to the growth of output and labor productivity. Therefore, the study calls for further research in the decomposition of MFP to point out the main factors that contribute to its growth rate. MFP can be improved by refining its sources of growth. This would allow policy makers to set out proper policies that could enhance the level of productivity and its major components.

Footnotes:

(1) The assumptions underlying the use of this model (production function) are as follows: Constant return to scale, Hicks's neutral technical change, perfect competition in both input and output markets, full capacity utilization of all inputs, and all production process (operations) are efficient (inefficiency does not exist). For detailed methodology of growth accounting approach, see Gollop (1983) and Norsworthy (1984).

(2) Divisia index number and the Tornqvist index number, which is an approximation of Divisia, index, Tornqvist (1936), Jorgenson (1971) and Diewert (1976, and 1978a).

(3) data used for this research was obtained from the Department of Economic Planning, Ministry of Finance and National Economy, an official source of economic data in the Kingdom of Bahrain. The time period covered is from 1989 to 2001. however, the analysis is carried out over the time period 1990-2001 due to lag operation.

(4) It is known that this measure mainly refers to the capital consumed not capital services, and is based on different accounting methods. However, due to many difficulties of measuring capital flow, in productivity studies capital depreciation is normally used as approximate, Norsworthy and Malmquist (1983) and Shebeb (2002).

(5) MFP can be improved by improving its sources of growth. See Section 2 above.

Additional Readings:

For those who wish to explore further the topics presented in the study, we recommend the following readings: -

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