

*Survey Of Productivity Measurement Techniques And Application To Five Major Natural Resources Industries In Jordan**

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ملخص

تمت دراسة الانتاجيه وتحليلها لخمس صناعات أردنيه تساهم بنسبة ٦٠٪ في إنتاج القطاع الصناعي، كما تم تطبيق النموذج متعدد العناصر كوسيلة لقياس الانتاجيه ودراسة العلاقة بين الانتاجيه والربحية واسترداد السعر، وتشير الدراره بأن الشركات التي دُرست تُحقق ارباحها من خلال استرداد السعر وليس الانتاجيه، هذا ولقد تمت دراسة التغيرات في الانتاجيه الكليه والجزئيه لكل صناعه خلال الفترة ١٩٨٦ - ١٩٨٨.

ABSTRACT:

The productivity of five major Jordanian industries contributing 60% in the industrial sector production was studied

★ I wish to thank the two anonymous reviewers for their helpful comments with respect to a number of issues raised in this article.

and analyzed. The Multi-Factor Productivity Measurement Model (MFPMM) was applied to study the relationship between productivity, price recovery and profitability. The study revealed that the subject companies have increased their profits through price recovery and not productivity. Fluctuations in partial and total productivities for each company was also analyzed during the period of study (1986 - 1988).

(1) Introduction

Performance measurement is a critical component in the general management process. Reliable measurement systems constitute a sound basis for continuous monitoring and control of organizational performance.

Research and resources have been directed towards the productivity measurement, evaluation, planing and improvement (the four phases of productivity cycle); with the objective of effective and efficient utilization of resources.

Productivity is one of the best tools used to minimize inflation, create employment opportunities, increase competitiveness, provide for increasing capital investment, and improve the quality of life in general.

In Jordan, most companies do not have an explicit, goal oriented on-going program for productivity measurement. In order to derive tangible results, the function of productivity measurement should assume an integral place in company activities. It has to be planned, monitored and directed, Al-Kloub (1991).

Many studies show that a decrease in productivity in Jordan took place, for example Malkawi (1997), Hammour (1988), and

Malkawi (1989). The growth of Gross Domestic Product (GDP) during the last 20 years is mainly due to capital investment, more than any other factor. In addition, the difficulty of acquiring new resources due to current financial conditions lead to the conclusion that an important way to increase the GDP is by efficient use of existing resources, Al-Kloub (1991).

In recent years variations in the basic definition of productivity was observed. Three basic definitions of productivity appear in the literature, Sumanth (1985) described them stating their merits: Partial productivity (the ratio of outputs to one class of input), total productivity(ratio of total output to the sum of all input factors), and total factor productivity(ratio of net outputs to the sum of capital and labour inputs). Sink (1985) described in detail four techniques for productivity measurement which are :

1-The Normative Productivity Measurement Methodology (NPMM).

This is a structured participatory approach utilizing the Nominal Group Technique (NGT) to develop a decentralized measurement and evaluation system. Once the productivity measures are identified, it becomes the task of the group to operationalize and implement the productivity measurement system.

2- The Multi-Factor Productivity Measurement Model (MFPMM).

This technique is similar to the total productivity model of Sumanth (1985), but it is capable of blending the major inputs of a particular organizational system together and relate the resulting aggregate input to the total outputs of the same system. MFPMM can be utilized to measure productivity changes in labour, material, energy and capital. It, also, measures the corresponding effect each one has on profitability. It can provide additional

insight into the individual factors that are most significantly affecting profits.

3- The Multi-Criteria Performance/Productivity Measurement Technique MCP/PMT .

Once the criteria against which productivity is to be evaluated have been chosen a mechanism for aggregating this vector of criteria needs to be developed. The approach is to develop a prioritized set of (productivity / performance) measures utilizing the Nominal Group Technique.

A list of heterogeneous measures is prepared, then aggregating or evaluating performance against these criteria in an integrated fashion is sought. The next step is the development of a utility curve for each of the priority measures which converts all the uncommon measures into some common measure. A ranking and rating process is to be executed so as to weight the relative importance of each productivity measure. The final step is to integrate the performance utility graphs with the criteria weighting which will allow the development of one indicator that will indicate the overall performance of the organization.

4- Surrogate Approaches

A surrogate productivity measurement technique does not measure productivity but measures other indicators that are highly correlated with productivity.

(2) Methodology, Analysis and Results

The MFPMM was implemented on five major Jordanian natural resources industries for the following reasons:

1- It tracks changes in productivity over time.

- 2- It tracks changes in price recovery over time.
- 3- It tracks changes in profitability over time.
- 4- It enables analysis of the relationship between productivity, price recovery and profitability.
- 5- It shows the dinar (Jordanian dinar, JD) impacts for above changes.
- 6- It allows What if questions?
- 7- It provides partial factor productivity ratios.
- 8- It allows users to analyze cost drivers.
- 9-Methods of specifying dominant factors, potential factors and productivity improvement factors are possible.
- 10- It is an accounting - system based.
- 11- Diagnostic in an objective sense.

This model is capable of blending the major inputs of a particular organizational system together and relating the resulting aggregate input to the total output of the same system. MFPMM can be utilized to measure productivity changes in labour, material, energy, capital and total productivity. It also measures the corresponding effect each input has on profitability and can provide additional insight into the individual factors that are most significantly affecting profits.

The MFPMM is based on that profitability is a function of productivity and price recovery; that is, profit growth of an organizational system is generated from productivity improvement and/or from price recovery. The data for MFPMM are periodic for quantity, price and value of each output and input of

the system (Fig 1). It compares data for one period with data for another period. This comparison forms the basis of analysis. The ratios and indexes generated from the model include weighted change ratios, cost/revenue ratios, productivity ratios, weighted performance indexes and total dinar effects on profits.

Weighted change ratios depict the percentage increase (or decrease) of an item from the base to current period. Both price and quantity weighted change ratios are generated by the model to show the percentage changes from period to period. Cost/revenue ratios reflect the percentages of reported revenue consumed by a particular input in a given period. The most common method of productivity improvement is cost reduction and those ratios show exactly where cost reduction will pay the biggest dividends. Productivity ratios depict absolute productivity values in the base and current period. These absolute values used in calculating the price weighted productivity indexes which show increase or decrease in productivity for the overall system as well as for each component. Weighted performance indexes are output over input change ratios from period one to period two. The final set of indexes are dinar effects on profits. These indexes indicate the impacts (in dinars) which is caused by changes in productivity, price recovery and profitability. The ratios and indexes, along or together, provide management with information about their systems of outputs and inputs. The ratios and indexes identify areas that need improvement and they also identify areas that are operating at acceptable levels.

To provide the hierarchical structure of the measurement model, inputs and outputs of the system are disaggregated by class, type, level and sublevel.

The data base of the model contains quantity, unit value , and

value information about inputs and outputs at the lowest level defined. The definition of the outputs and inputs for this study is as follows Al - Kloub (1991) :

- Inputs:
- 1 - Labour.
 - 2- Capital (both fixed and working).
 - 3- Material.
 - 4- Energy.
 - 5- Other expenses.
- Outputs :
- 1- Finished products.
 - 2- Partial units produced.
 - 3- Dividends from securities.
 - 4- Other income.

During the period 1980 - 1986 the industrial sector averaged about 18% of GDP (about 60% came from the five industries under study). Year 1986 was chosen as a base year, and data were collected for the following three years (1986, 1987 and 1988).

The data required was taken mainly from the accounting departments of the companies. This data was not easy to collect since most of it was considered confidential, because it included prices of outputs and inputs. Another problem was that outputs, or inputs for some companies were too many (e.g. 136 different outputs for one of the companies).

A special questionnaire was designed [based on the requirement of the (MFPMM)] to collect data regarding inputs

and outputs for these companies.

The spreadsheet program Lotus 123 was used as a modeling tool which simplified the data base construction and model building effort considerably. Data transfer from lower levels to the higher levels of the hierarchical model was also performed by the aid of this software.

The results of analysis of applying the model on one company (Jordan fertilizers company) is presented as an example : there were 14 different outputs and 47 different inputs for the company.

The results shown in Table 1 are aggregated outputs and inputs. The following results are deduced from the analysis.

a - Analysis for the year 1987:

The analysis for the year 1987 shows that the company, relative to 1986 (Fig. 2) :

Produced more outputs by 9%.

Used 51% more labour.

Used 6% more material

Used 44% more energy.

Used 47.5% more capital.

Used 37% more "others".

Used 18.5% more inputs.

Regarding prices (Fig. 3) :

Prices of outputs went down 6%.

Prices of materials went down 9%.

Prices of energy went up 16%.

Prices of all inputs went down by 4%.

Regarding revenues and input values (Fig . 4):

An increase of total revenues from outputs by 2.2%.

An increase of 51% in labour.

A decrease of 3% in material consumption.

An increase of 66% in energy value.

An increase of 47% in capital consumption.

An increase of 37% in "other" consumption.

An increase of total value of inputs by 14%.

Regarding cost/revenue ratio (Fig s 5 and 6):

Labour costs to total revenue went up from 4.8% to 7.2%.

Material costs to total revenue went down from 71.9% to 68.35%.

Energy costs to total revenue went up from 8.4% to 13.4%.

Capital costs to total revenue went up from 15.2% to 16.9%.

All inputs costs to total revenue went up from 104.4% to 116.5%.

Regarding productivity ratios (Fig. 7):

Labour productivity went down from 20.44 to 14.75.

Material productivity went up from 1.391 to 1.425.

Energy productivity went down from 11.83 to 8.98.

Capital productivity went down from 7.12 to 5.3.

"Others" productivity went down from 19.38 to 15.43.

Total productivity of inputs went down from 0.96 to 0.881

(These numbers have meaning only when they are tracked overtime and interpreted in the context of what has been happening to the company).

Weighted performance indexes (Fig. 8):

1- Productivity:

Labour productivity went down 27.5%.

Material productivity went up 2.5%.

Energy productivity went down 24%.

Capital productivity went down 27%.

"Others" productivity went down 20%.

Total productivity went down 8%.

2- Price recovery:

Labour price recovery went down 7%.

Material price recovery went up 2.6%.

Energy price recovery went down 19%.

Capital price recovery went down 6%.

"Others" price recovery went down 6%.

Total price recovery went down 3% (this means that suppliers for inputs increased their costs to the company faster than the company raised its prices to its customers by 3%).

3- Profitability:

Profits decreased by 33% from productivity and price recovery of labour.

Profits increased by 5.2% from productivity and price recovery of materials.

Profits decreased by 38% from productivity and price recovery of energy.

Profits decreased by 25% from productivity and price recovery of "others".

Profits decreased by 10% from productivity and price recovery of all inputs (Overall profits decreased by 10% due to a decline in overall productivity (0.9196) and price recovery (0.975)(Fig. 16).

b - Analysis for the year 1988:

The analysis for the year 1988 shows that the company, relative to 1986 (Fig. 9):

Produced more outputs by 10.66%.

Used 108.5% more labour.

Used 15.5 % more material.

Used 50% more energy.

Used 42% more capital.

Used 324% more "others".

Used 41.4% more inputs.

Regarding Prices (Fig. 10):

Prices of outputs increased by 21.3%.

Prices of materials went down by 6%.

Prices of energy went up 50.1%.

A total drop of prices of all inputs by 2%.

Regarding revenues and value of inputs (Fig. 11):

An increase of total revenues from outputs by 34.2%.

An increase of 108.6% in labour.

An increase of 8.2% in material value.

An increase of 42% in capital consumption.

An increase of 324% in "others" consumption.

An increase of total value of inputs by 38.2%.

Regarding cost/revenue ratios (Fig.12):

Labour costs to total revenue went up from 4.8% to 7.6%.

Material costs to total revenue went down from 71.9% to 57.9%.

Energy costs to total revenue went up from 8.4% to 10.4%.

Capital costs to total revenue went up from 14% to 14.8%.

"Others" costs to total revenue went up from 5.2% to 16.3%.

All inputs costs to total revenue went up from 104% to 107%.

Regarding productivity ratios (Fig. 7):

Labour productivity went down from 20.44 to 10.84.

Material productivity went down from 1.391 to 1.33.

Energy productivity went down from 11.83 to 8.73.

Capital productivity went down from 7.12 to 5.56.

"Others" productivity went down from 19.38 to 5.06.

Total productivity went down from 0.958 to 0.75.

(These numbers have meaning only when they are tracked overtime and interpreted in the context of what has been happening to the company).

Weighted performance indexes (Fig. 13):

1- Productivity:

Labour productivity went down 48%.

Material productivity went down 4%.

Energy productivity went down 27%.

Capital productivity went down 22%.

"Others" productivity went down 75%.

Total productivity went down 22%.

2- Price recovery:

Labour price recovery went up by 21.3%.

Material price recovery went up by 29.4%.

Energy price recovery went up by 5.4%.

Capital price recovery went up by 21.3%.

"Others" price recovery went up by 21.3%.

Total price recovery went up by 24.1%.

3- Profitability:

Profits decreased by 35% from productivity and price recovery of labour.

Profits increased by 24% from productivity and price recovery of materials.

Profits decreased by 22 % from productivity and price recovery of Energy.

profits decreased by 5% from productivity and price recovery of Capital.

Profits decreased by 67% from productivity and price recovery of "others".

Profits decreased by 3% from productivity and price recovery of all inputs. (Overall profits decreased by 3% due to both decline in productivity (0.7826) and price recovery (1.2407) (Fig. 16).

(4) Conclusions

- a) For the years 1987 & 1988 the only input causing profit is materials as shown in Fig's. 14 and 15. In view of the fact that only 6.4% more materials were used in 1987, the productivity of material was increased from 1.39 to 1.42 but in 1988 productivity decreased to 1.02 (partial productivity). The reason for changes in the productivity of materials is not clear. This, however, is not within the scope of this study. It remains an area for further research.
- b) For the Year 1987 the only source of profit was "material". All other inputs were causing losses in the following descending order (Fig. 14):
 - 1- Capital.
 - 2- Energy.
 - 3- Labour.
 - 4- "Other" expenses.

In order to increase productivity the cost of capital, energy, Labour and "other" expenses need to be reduced. The following

questions need to be investigated to find the best way to increase productivity:

- 1- How can the cost of capital be reduced?
 - 2- How can the cost of energy be reduced?
 - 3- How can the cost of Labour be reduced?
 - 4- How can the cost of "other" expenses be reduced?
- c) For the year 1988 the causes of losses were the same but in a different descending order as follows (Fig. 15):
- 1- "Other" expenses.
 - 2- Labour.
 - 3- Energy.
 - 4- Capital.
- It is not evident why this change occurred, but still there is a need to reduce costs in order to raise productivity.
- d) The relationship between productivity, price recovery, and profitability is shown in Fig.16. It is clear that this company has increased its profitability through price recovery and not productivity which is something rarely maintained in the long run.
- e) Dominance of material productivity on total productivity is clear as shown in Fig's 5 and 6. Primary analysis points out the extensive fluctuations of productivity indexes throughout the analysis periods. This can presumably be caused by non standard material consumption of the firm, but needs more investigation.

If comparison is made between this company and other companies there is a need to enhance the productivity of all inputs . From the relationship between productivity, price recovery, and profitability for all companies it is clear that all companies increased profitability through price recovery and not productivity which is something rarely maintained in the long run. Dominance of material productivity on total productivity is also clear, therefore improving material productivity will benefit Jordanian industries.

Table 1 : Results of Applying the MFPM to the Jordan Fertilizers Company For the Years 1987 and 1988 (Base Year 1986).

Results 1987	Col.7	Col.8	Col.9	Col.10	Col.11	Col.12	Col.13	Col.14	Col.15	Col.16	Col.17	Col.18	Col.19
Output	1.0900	0.9380	1.0220										
Inputs:													
Labor	1.5100	1.0000	1.5100	0.0480	0.0723	20.4400	14.7500	0.7210	0.9380	0.6770	-821345	-132392	-953675
Material	1.0600	0.9100	0.9720	0.7190	0.6635	1.3900	1.4250	1.0240	1.0260	1.0520	748952.4	694952.3	1443904
Energy	1.4360	1.1580	1.6630	0.0840	0.1375	11.8300	8.9850	0.7590	0.8100	0.6150	-1166889	-995853	-2162743
Capital	1.4750	1.0000	1.4750	0.1400	0.2030	7.1200	5.2620	0.7390	0.9380	0.6930	-2160777	-379738	-2540515
Others	1.3680	1.0000	1.3700	0.0516	0.0690	19.3800	15.4300	0.7960	0.9380	0.7470	-5735933	-139571	-713164
Total Inputs	1.1850	1.9620	1.1400	1.0443	1.1649	0.9600	0.8810	0.9196	0.9750	0.8960	-3973653	-952540	-492193

Results 1988	Col.7	Col.8	Col.9	Col.10	Col.11	Col.12	Col.13	Col.14	Col.15	Col.16	Col.17	Col.18	Col.19
Outputs	1.1070	1.2130	1.3420										
Inputs:													
Labor	2.0850	1.0000	2.0860	0.0480	0.0760	20.4400	10.8450	0.5310	1.2130	0.6430	-1912922	460276	-1452646
Material	1.1550	0.9400	1.0820	0.7190	0.5795	1.3900	1.3300	0.9580	1.2940	1.2400	-1384382	8851998	7467615
Energy	1.5000	1.5100	1.7270	0.0840	0.1087	11.8300	8.7300	0.7370	1.0540	0.7770	-1329773	31227.7	-1298545
Capital	1.4170	1.0000	1.4170	0.1400	0.1482	7.1200	5.5600	0.7810	1.2130	0.9470	-1738514	1320827	-417686
Others	4.2400	1.0000	4.2400	0.0516	0.1630	19.3800	5.0590	0.2610	1.2130	0.3170	-6453886	485464.11	-5968422
Total Inputs	1.4140	0.9770	1.3820	1.0443	1.0754	0.9600	0.7490	0.7830	1.2410	0.9710	-1.3E+07	111149793	1669685

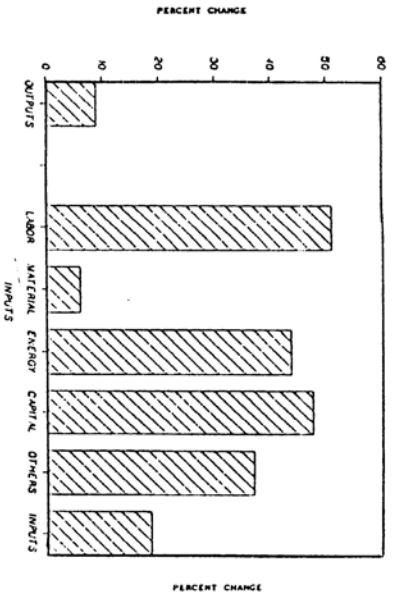


Fig.2 Percent Change in Quantity of Inputs and Outputs of the Jordan Fertilizers Company, 1987 (Base Year 1986)

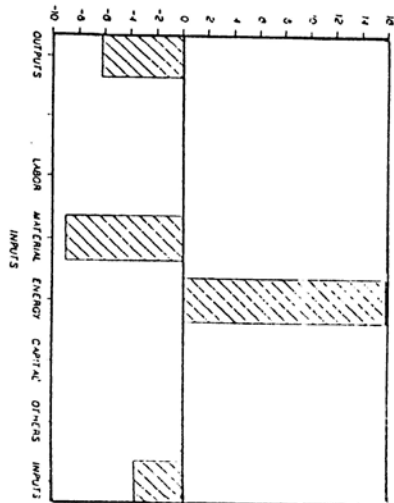


Fig.3 Percent Change in Prices of Inputs and Outputs of the Jordan Fertilizers Company, 1987 (Base Year 1986)

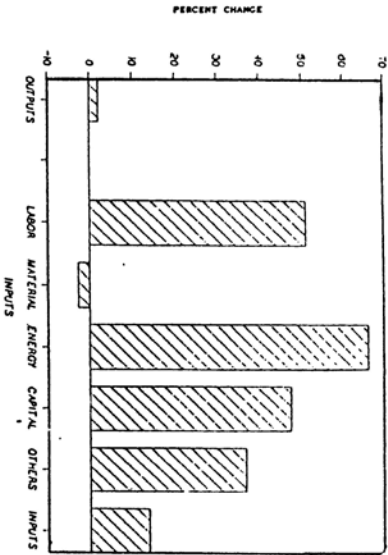


Fig.4 Percent Change in Revenues and Input Values of the Jordan Fertilizers Company, 1987 (Base Year 1986)

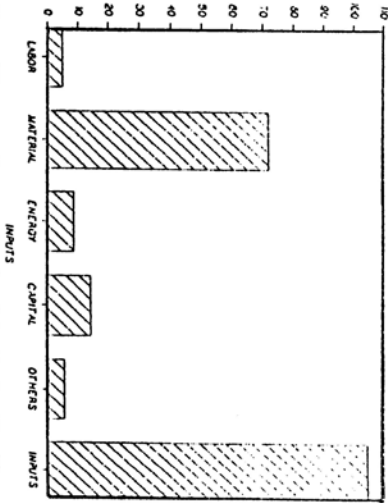


Fig.5 Cost of Inputs to Revenue Ratio of the Jordan Fertilizers Company, 1986.

COST OF INPUTS TO REVENUE RATIO OF THE JORDAN FERTILIZERS COMPANY, 1987.

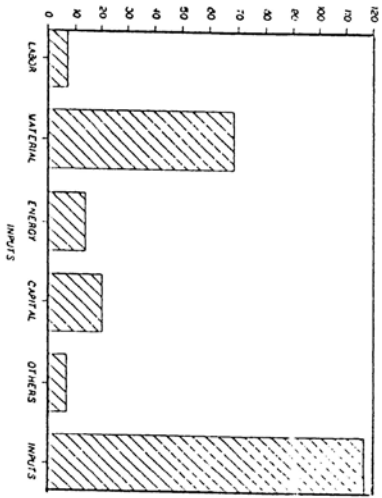


Fig.6 Cost of Inputs to Revenue Ratio of the Jordan Fertilizers Company, 1987.

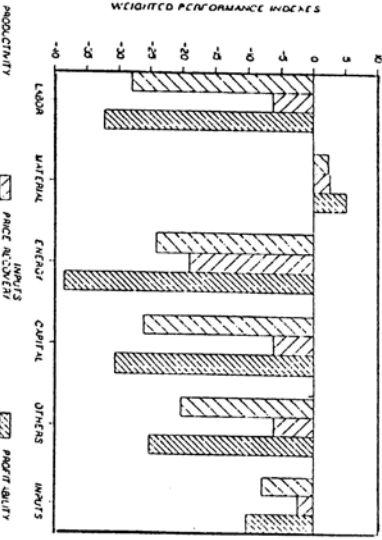


Fig.8 Weighted Performance Indexes of the Jordan Fertilizers Company, 1987.

INDEX OF PARTIAL PRODUCTIVITIES.

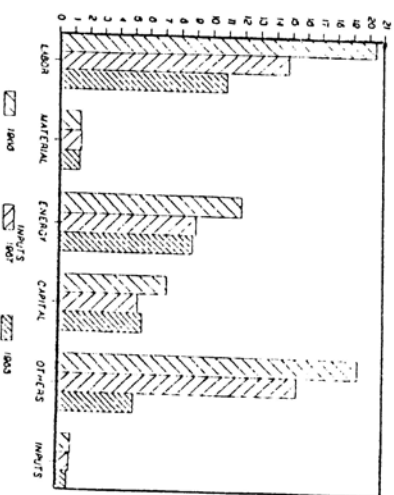


Fig.7 Change in Partial Productivity Index of the Jordan Fertilizers Company Over the Period 1986-1988.

PERCENT CHANGE

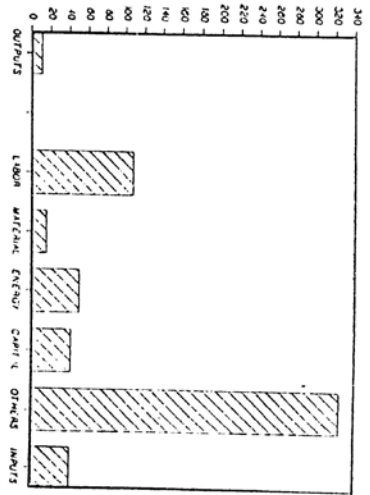


Fig.9 Percent Change in Quantity of Inputs and Outputs of the Jordan Fertilizers Company, 1988 (base year 1986)

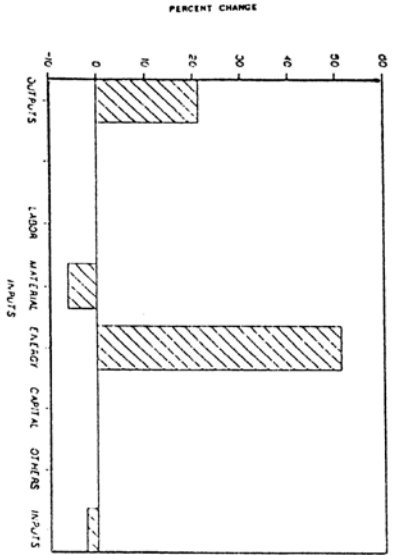


Fig.10 Percent Change in Prices of Inputs and Outputs of the Jordan Fertilizers Company, 1988 (Base Year 1986)

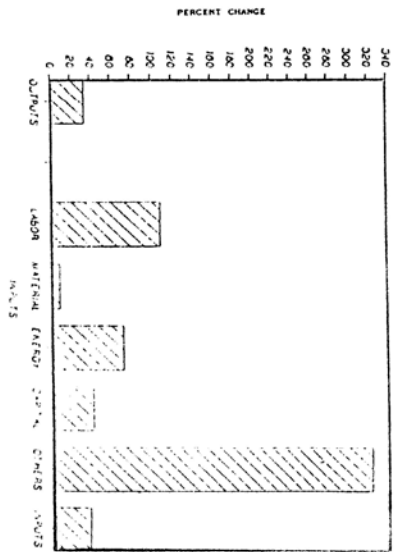


Fig.11 Percent Change in Revenues and Input Values of the Jordan Fertilizers Company, 1988 (Base Year 1986)

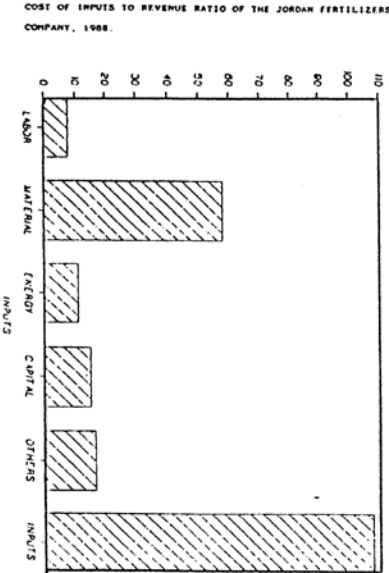


Fig.12 Cost of Inputs to Revenue Ratio of the Jordan Fertilizers Company, 1988.

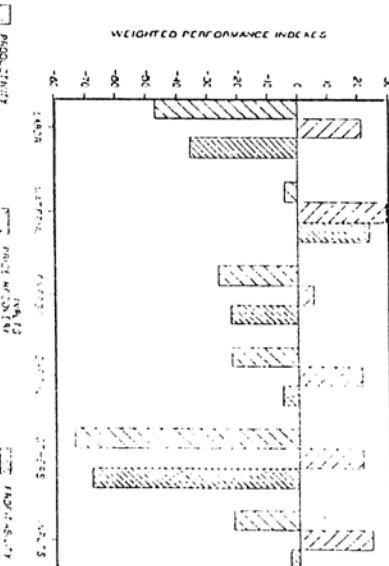


Fig.13 Weighted Performance Indexes of the Jordan Fertilizers Company, 1988.

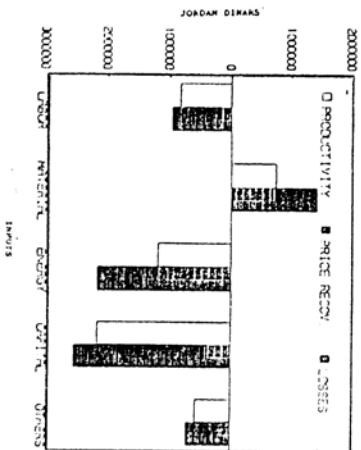


Fig.14 Effects (In JD'S) of Inputs on Productivity, Price Recovery and Profitability of the Jordan Fertilizers Company, 1987.

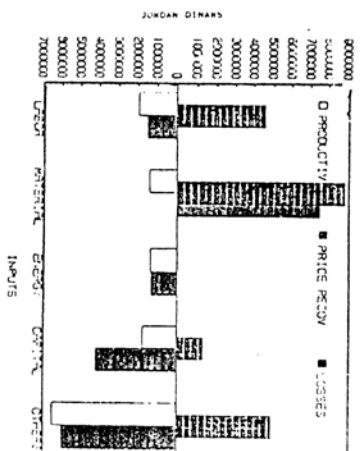


Fig.15 Effects (In JD'S) of Inputs on Productivity, Price Recovery and Profitability of the Jordan Fertilizers Company, 1988.

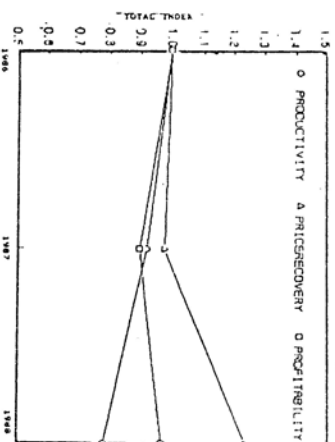


Fig.16 The Relationship Between Productivity, Price Recovery and Profitability Over the Period 1986-1988 for the Jordan Fertilizers Company.

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