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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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A Simulation Technique for Evaluating Corporate Efficiency

By Lubor Karlik,* Industrial Development Officer, UNIDO

The efficient investment of a scarce resource is simply good management. Those in charge of development in private and public organizations, whether going concerns or fledgling entities, need a means to evaluate the efficacy and efficiency of investment.

This article presents a technique to evaluate those data which are necessary to efficient investment. The analysis requires no sophisticated mathematics and can be applied with good results to the most extreme cases. To prove this point, we shall examine the most critical arena for the evaluation of investment, the developing country. And of all the scarce resources available in a developing country, the scarcest is foreign exchange; we shall consider that our investment fund. Because foreign exchange reserves partially satisfy existing demand, their proper allocation, just as in a corporate structure, is of prime importance.

In the community of developing nations, most industrial planners face two major problems: scarcity of some necessary resources and a political framework which verbally espouses progress but, by its very nature, inhibits it.

Obviously, if a resource is used to satisfy the need for industrial development, the consumer sector is deprived of this resource. The political ramifications, expressed by vote, coup or strike, are usually negative. This is also true in a corporate entity where stock-holders often favour distribution of earned income to ploughback. Both reactions have basically the same root: The affected party may not be sufficiently interested in long-range returns but wants an immediate return on investment.

To work within the existing framework of scarce resources and politics requires a method which increases the efficiency of the resources at hand. Allocations of foreign exchange, therefore, should be made on the basis of a predictable increase in industrial output, through balanced growth and by stimulation of latent economic potential.

Decisions should favour allocations to corporations which offer the highest "multiplier factor" expressed in terms of the maximization of sector output per unit of foreign exchange invested.

If future allocations would have to be earned on the basis of relative merit, such a policy would promote a healthy competitive spirit among individual corporations.

Output optimization in an industrial sector may be envisaged as a concave function where only one set of conditions obtains optimum results. The apex, maximum output, would be predicted by the law of diminishing returns, since no significant improvement could be obtained by any other combination.

Evaluation of corporate efficiency

First, the evaluation of corporate efficiency requires establishing a base against which operational performance may be measured. This implies homogeneity in the nature of business, such as may prevail within an industrial sector, to assure a uniform basis of comparison as related to the general business environment.

The second condition requires the introduction of a common denominator, (by the application of) a set of meaningful ratios which describe operational conditions and which, at the same time, eliminate inequalities caused by differences in the size of operations.

Third, each corporation may follow different objectives which change with time or circumstances. Thus, the whole structure of the decision-making process and the value of data will change. A corporation engaged in the manufacture of electronic components may measure its efficiency in terms of profits. A corporation which manufactures

* While leader of a consulting team which was sponsored by the Government of India and the World Bank, Mr. Karlik designed an information system network to facilitate allocation of foreign exchange. He developed the outlined technique which aids in the discrimination of data without the application of sophisticated mathematical analyses.

precision stampings may measure efficiency in terms of "share of the existing market". A third corporation engaged in precision machining may measure its efficiency on the basis of the capital growth ratio. In short, the performance of corporations within the same industrial sector may be difficult to evaluate because they have diverse objectives. If one of the corporate objectives is the maximization of the return on invested capital, then the ratio of investment to profit will be a measure of relative efficiency.

Corporations having the highest "multiplier coefficient" per unit of foreign exchange invested are preferred because this factor tends to maximize the yield on each unit of foreign exchange allocated by mobilizing the latent available resources of the respective industrial sector.

Having recognized the problem of evaluating and comparing corporations with different and changing objectives, it is necessary to provide for a systematic interpretation of data which would be flexible enough to facilitate varying decision-making processes.

For the sake of this analysis, a set of 20 ratios (see Chart 1) has been designed to describe the performance of a corporation. These ratios are divided into four groups, each portraying a segment which may provide valuable information about a particular aspect and status of the analysed corporation relative to the sought objectives.

It should be pointed out that the ratios are interchangeable and may be substituted individually, or by another complete set, if the conditions of the decision-making process so require. Nonetheless, they should be related in a manner to supplement each other, at least partially, and thus form a meaningful set.

Conventional data interpretation

Chart 2 may be regarded as a conventional form of data presentation. The interpretation of the data is dependent on the analytical ability of the executive and his experience in relating the information to a meaningful whole. There are 24 indicators for each company, and for the analysis

Chart 1. Twenty Suggested Ratios for Analysis of the Operating Efficiency

1.0 **Foreign Exchange Utilization and Yield Ratios**[a]

1.1 *Proportion of foreign Exchange used*

$$R = \frac{\text{FE used (received from government agency only}}{\text{FE used (all sources)}}$$

1.2 *Foreign Exchange Allocation Ratio*

$$R = \frac{\text{FE allocated}}{\text{FE requested}}$$

1.3 *Foreign Exchange Utilization*

$$R = \frac{\text{FE used (all sources)}}{\text{FE allocated (all sources)}}$$

1.4 *Foreign Exchange Earning Capacity*

$$R = \frac{\text{FE earned (exports)}}{\text{FE used (all sources)}}$$

1.5 *Essential Goods Yield on Foreign Exchange*

$$R = \frac{\text{Net sales}}{\text{FE used (all sources)}}$$

2.0 **Industrial Performance Ratios**

2.1 *Month's Orders in Backlog*

$$R = \frac{\text{Unfilled orders}}{\text{Capacity installed}}$$

2.2 *Production in Stock*

$$R = \frac{\text{Actual production (units/mo.)}}{\text{Capacity installed (units/mo.)}}$$

2.3 *Production Targets Verification*

$$R = \frac{\text{Actual production (units/mo.)}}{\text{Planned production (units/mo.)}}$$

2.4 *Utilization of Capacity Installed* (based on a single shift)

$$R = \frac{\text{Actual production (units/mo.)}}{\text{Capacity installed (units/mo.)}}$$

2.5 *Gross Output to Foreign Exchange Used*

$$R = \frac{\text{Gross sales (all products)}}{\text{FE used (all sources)}}$$

2.6 *Planned Indigenous Content*

$$R = \frac{\text{Planned domestic content (per cent)}}{\text{Actual material content (per cent)}}$$

3.0 **Economic Ratios**

3.1 *Export Potential Ratio*

$$R = \frac{\text{Price of manufactured product (ex. factory FOB)}}{\text{World market price}}$$

3.2 *Labour Intensiveness*

$$R = \frac{\text{Total labour cost}}{\text{Net sales}}$$

3.3 *Product Return on Foreign Exchange Invested*

$$R = \frac{\text{Net sales}}{\text{Imported equipment and spare parts}}$$

3.4 *Product Return on Foreign Exchange Spent*

$$R = \frac{\text{Net sales}}{\text{Imported material and components}}$$

3.5 *Imported Inventory to Usage*

$$R = \frac{\text{Imported materials inventory}}{\text{Imported materials and components (used)}}$$

4.0 **Capital Expansion Ratios**

4.1 *Profitability on Total Assets Employed*

$$R = \frac{\text{Profits (before taxes)}}{\text{Fixed assets (excluding land and buildings)}}$$

4.2 *Output on Machinery Investment*[b]

$$R = \frac{\text{Turnover (all products)}}{\text{Fixed assets (excluding land and buildings)}}$$

4.3 *Output on Machinery Investment (international standard)*[b]

$$R = \frac{\text{Gross sales (all products)}}{\text{Fixed assets (excluding land and buildings)}}$$

4.4 *Effectiveness of Balancing Equipment* (expansion)

$$R = \frac{\text{Capacity installed (units/mo.)}}{\text{Actual production (units/mo.)}}$$

[a] Time period for numerator and denominator must be identical (calendar or fiscal year, etc.).

[b] Refer to an international sample.

Chart 2. Conventional Data Presentation

	Company A	Company B	Company C
1. FE[a] used (received from government agency only) [b]	1 380 000	1 900 000	3 062 600
2. FE used (all sources)	1 380 000	1 900 000	3 244 470
3. FE allocated	3 301 000	1 900 000	3 168 750
4. FE allocated (all sources)	3 900 000	1 900 000	3 478 290
5. FE requested	4 100 000	1 900 000	3 916 960
6. FE earned (exports)	80 640	00 000	00 000
7. Capacity installed (units/mo.)	45	15	75
8. Unfilled orders	499	200	1.5
9. Net sales	13 030 000	3 030 000	15 208 920
10. Actual production (units/mo.)	31	2	38
11. Gross sales (all products)	15 646 130	4 175 000	33 906 080
12. Planned production (units/mo.)	450	50	630
13. Planned domestic content (per cent)	8	7	73
14. Total material cost	11 043 240	3 170 000	8 773 140
15. Price of manufactured product (ex. factory, FOB)	3 568	1 408	3 260
16. World market price (common port, FOB)	2 231	775	2 110
17. Imported equipment and spare parts	466 880	359 057	167 860
18. Total labour cost	335 428	50 110	267 765
19. Imported materials and components	2 696 400	2 907 875	3 047 659
20. Imported materials inventory	2 615 520	116 890	1 704 000
21. Imported materials and components (used)	5 252 213	491 250	2 383 800
22. Profits (before taxes)	1 682 249	485 584	3 616 640
23. Fixed assets (excluding land and buildings)	6 004 650	1 759 843	15 071 906
24. Actual material content (per cent)	8.4	11.7	77.0

[a] FE: Foreign Exchange.
[b] The above figures were extrapolated and do not relate to any existing company. The control limits are based on a sample of 75 companies of the same industrial sector.

of the relationships within only one company there are 20 factorial combinations. In relating these to the data for one or more competitive companies, it is obvious that there will be an astronomical number of possible combinations. In practice, the analyst will base his decisions on several key indicators. The experienced analyst also will probably rely on a considerable amount of intuition.

To facilitate interpretation, a rational approach should be followed, one which will single out information of critical importance – in this case, those variables which deviate from the "model conditions". Similarly, as in statistical quality control, a certain degree of variation is permissible as long as this occurs within the predetermined control limits. Particularly in this analysis we are not able to reject a whole corporation merely because it does not meet the accepted standard in relation to a few variables, however, and must determine the cause which brought about such a deviation.

Sequence of computations

Step 1: Substitute the values given in Chart 2 into each ratio under Chart 1 and compute.

Example (Company A)

$$1.3\ R = \frac{\text{FE used}}{\text{FE allocated (all sources)}} = \frac{1\,380\,000}{3\,301\,000} = .36 \text{ (In box, Chart 3)}$$

Step 2: Compute the value for each variable and average for sector mean $\bar{X}$; this will serve as the first base of evaluation. (These values are summarized in Chart 3.) The resulting set of index numbers will form a numerical profile of variables for each of the analysed corporations.

Step 3: Having established the first base, we can compute the Upper and Lower Control Limits for each variable, $\bar{X}'|\bar{X}''$. This is an arbitrary decision; in this study the average of the upper 25 percentile and the lower 25 percentile were chosen to form the UCL and LCL respectively.

Step 4: The computed statistical mean $\bar{X}$ consists of heterogeneous values. To simplify interpretation before plotting the graph, we can perform a transformation so that each sector Mean Value will be equated to 100 per cent. The UCL and LCL will be computed accordingly as shown in Chart 3. This operation will provide for the Statistical Mean $\bar{X}$ in the form of a straight line for all variables with only the control limits changing for each variable. In the same fashion, relative values are computed for companies A, B and C.[2]

Step 5: For subsequent interpretation, the graph is plotted in a regression sequence; i.e., with those variables with the largest difference between the UCL and LCL first. It should be remembered that our aim is to simulate the positive characteristics of the upper percentile group.

[2] If variable 1 (3) = .36 and the sector mean for the same variable is .9 equates to 100, the relative value for .36 = 40.

Chart 3. Summary of Ratio Values

Group	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	4	4	4	4
Ratio	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)
Company A	1.00	0.80	0.36	0.05	9.70	11.0	0.69	0.07	0.7	8.8	0.95	1.6	0.025	28.0	2.5	0.50	0.28	2.6	3.5[b]	N.A.[a]
	102	100	40	167	161	157	69	117	140	110	112	100	142	80	6.3	100	112	108	81	
Company B	1.00	1.00	1.00	0.0	1.84	13.00	0.13	0.04	0.15	2.2	0.60	1.9	0.015	10.0	7.1	0.22	0.18	2.2	3.5[b]	N.A.[a]
	102	125	111	0.0	31	186	13	67	30	27	71	119	88	28	177	44	72	91	77	
Company C	0.97	0.80	0.93	0.01	4.6	0.02	0.51	0.06	0.51	10.0	1.05	1.5	0.018	91.0	6.4	0.71	0.25	2.7	3.5[b]	N.A.[a]
	99	100	102	33	77	3	51	100	102	125	124	94	106	259	160	142	100	112	94	
Industry Sector Mean $\bar{X}$ (75 companies)	0.98	0.8	0.9	0.03	6.0	7.0	0.0	0.06	0.5	8.0	0.85	1.6	0.017	35.0	4.0	0.5	0.25	2.4	2.5	
	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	87	
Upper 25th Percentile Mean X' UCL	0.99	0.8	0.9	0.04	8.0	7.0	0.0	0.75	0.7	10.0	0.9	1.8	0.03	55.0	4.8	0.45	0.3	2.6	N.A.[a]	[c]
	101	100	100	132	133	100	100	125	140	125	106	112	176	157	120	105	120	108		
Lower 75th Percentile Mean X'' LCL	0.96	0.8	0.8	0.0	3.5	5.0	0.0	0.25	0.4	5.0	0.75	1.4	0.01	25.0	2.2	0.4	0.20	2.4		[c]
	97	100	88	000	58	71	100	42	80	62	88	87	59	71	55	95	80	10.0		
Variation % (UCL—LCL)	4	0	12	132	75	29	0	83	60	63	18	25	117	86	65	10	40	8		
Ranking Sequence	5	4	8	20	16	11	3	17	13	14	9	10	19	18	15	7	12	6		

[a] Figure not available. [b] International Standard. [c] Based on sample of 75 companies.

Therefore, the greatest difference between the UCL and LCL is indicative of those variables where the largest improvement can be secured within the framework of the existing business environment. With diminishing variation, characteristics of the upper and lower percentile groups are less pronounced and leave less room for simulation. (If there is no variation between the control limits, simulation is excluded and any variable which deviates from this joint standard will not have an assignable typical cause.)

Step 6: On first glance, we can assume that those variables which caused the greatest violation of the control limits, and in particular the LCL, offer the greatest potential for rectifying an inefficient operation. This is only partially true, because we have to bear in mind that the difference between the UCL and LCL is indicative of the scope of simulation of the positive characteristics. Thus, the products of the two values, i.e. the difference between the UCL and LCL multiplied by the difference between the LCL or UCL and the value of the variable, will create the sequence of priorities where conditions are most feasible for a corrective action. (For interpretations of computations see Chart 4.)

Similarly, as in statistical quality control, those values which are within the prescribed limits are less important in the initial stages of this analysis. They may not represent the ideal value, but are acceptable within the framework of the intended objectives. Yet the situation is not identical, for the analysed variables are mutually dependent and their relationship can be more exactly established by Multiple Regression and Correlation Analysis. Such statistical inference would provide additional insight into the relevant causes of non-compliance within the prescribed limits and aid in the development effort; it does not mean the complete rejection of a manufacturing unit on the grounds of not being able to meet the expected standard.

If the performance of certain industrial units is very superior, the extra excellence will not debit the national economy. On the contrary, their performance can be used as an indicator of the upper range of possibilities within the framework of existing conditions in which these manufacturing units operate.

Of course, some degree of variation is unavoidable. Every company operates under slightly different conditions and with varying objectives. For example, efforts to increase the yield on foreign exchange invested can assume many forms, such as the maximization of exports, the minimization of imports through expansion of indigenous capacity or the development of new processes and materials. Alternatively, we may strive to decrease regional unemployment through the expansion of certain labour intensive industries. These and many other alternatives have to be considered by the decision-maker to find the most beneficial route.

We may assume that the successful operation of a corporation depends on the balanced relationship of variables. As long as the control limits are not violated, the operation may function satisfactorily even when the corporation ranks on the lower scale. In situations where there is considerable variation with respect to the observed variables and they violate both Upper and Lower Control Limits, there is cause for alarm. This indicates that some functions are out of proportion, relative to others, and may not be reaching their full potential. On the other hand, they may be thriving at the expense of other functions.

For example, an exceedingly high profit does not necessarily represent a good operation. On the contrary, the capital resources may be drained ultimately with an impending decline in profits. Profits may be temporarily improved by depleting stock at hand, but in such a case the variable concerned with stock shall decline and reveal the adverse cause of the situation. The relations of the analysed variables to one another are of utmost importance in determining the operational efficiency of a corporation.

We can proceed with the analysis by circling all values which fall outside of the Lower Control Limit and Upper Control Limit (Figure I). The results are given in the following table.

Violations

Company	LCL	UCL	Total
A	1	8	9
B	8	5	13
C	1	6	7

From these results, it appears that Company A is most efficient, Company B least efficient and Company C above average. At this point, the analysis has been too superficial to provide a basis for drawing any definite conclusions. For this, the relationship of the variables has to be observed in depth. In order to follow our development objectives, let us turn our attention to Company B where, presumably, help is most needed.

On the basis of the data in Figure I, we may interpret that Company B has difficulty in proper utilization of foreign exchange. Four of the variables concerned with foreign exchange utilization are significantly out of control, with one violating the Upper Control Limit and three violating the Lower Control Limit.

To interpret the relationship of this phenomenon, we can start with variable 3 (3), Product Return on Foreign Exchange Invested (the relationship of Net Sales to Imported Equipment and Spare Parts). This condition is obviously unfavourable as compared to the sector average and implies that the imported equipment and spare parts are poorly utilized.

The second most significant variable concerned with Foreign Exchange is 2 (5), Gross Output on Foreign Exchange Used. Again we observe unsatisfactory performance which may have been caused by variable 3 (3).

Third in significance is variable 1 (5), Essential Goods Yield on Foreign Exchange (the ratio of Net Sales to Foreign Exchange Used). Since this variable is equally unsatisfactory as related to the sector average, it suggests that we are receiving an unsatisfactory yield on the foreign exchange invested.

Conversely, variable 3 (4), Product Return on Foreign Exchange Spent (the relationship of Net Sales to Imported Materials and Components), is far above sector average.

This indicates that Company B depends on a very small proportion of imported material and components and adds substantially to the final product in the form of domestic material and components. This is a positive characteristic, and the question arises as to whether the three unsatisfactory variables concerned with foreign exchange can be corrected.

To find the answer we have to probe further and gain a more accurate insight into the operating conditions. The next logical question should be directed to the financial status of Company B. We may examine the profitability of the total assets employed, which is reflected by variable 4 (1). This variable also appears below the Lower Control Limit, ranking sixth. From a rough calculation of existing figures, this performance is approximately 40 per cent below the sector average.

During the same period variable 3 (5), Imported Inventory Usage, has been twice as large in comparable companies in the sector. This is an indication that Company B's stock is being depleted and that the financial situation reflected by variable 4 (1) is, in reality, even worse than originally interpreted. It may be noted that all Foreign Exchange Allocated, 1 (3), has been used, that the company holds no unused assets. The question is whether or not we are subsidizing a company which is failing to yield the proper results in proportion to the foreign exchange.

Further observations reveal that this situation was not caused by a lack of demand, as shown by variable 2 (1), Months Order in Backlog, which is approximately 87 per cent above the sector average. Continued analysis points to the proper utilization of the Capacity Installed, 2 (4), as the cause of the situation. This assumption seems reasonable because 2 (4) ranks second in violating the Lower Control Limit. The related variable 4 (2), Output On Machinery Invested, indicates some definite relationship. This requires careful thought. The Output On Machinery Invested, 4 (2), represents a relatively small violation of the Lower Control Limit. The main cause could be attributed to the utilization of the capacity installed, which may have driven variable 4 (2) down below the LCL.

We may conclude that corrective action for utilizing the Installed Capacity is the pivot point. If so, the outlook for corrective action for both operating efficiency and the yield on Foreign Exchange invested should improve considerably.

In the case of Company B, subsequent investigation revealed that balancing equipment was needed to secure a uniform flow of production and thereby take full advantage of the capacity installed. This points to poor planning. We know that the foreign exchange requested has been allocated and the allocation has been used, yet the balancing equipment has not been procured. The management planning, therefore, should be investigated to find the reasons for this condition. Since the variables are interdependent, the corrective action in securing greater yield on capacity installed will change the whole relationship of all the variables.

Thus the major cause of inefficiency has been located. To activate the latent capacity, Company B needs additional foreign exchange to purchase the balancing equipment. Variable 4 (4), Effectiveness of Balancing Equipment, may be applied to determine what type of equipment would maximize the production output with a fixed amount of foreign exchange.

The outlined method is meant only as an aid which will single out the areas of potential trouble so that by interrelating them we may arrive at the proper conclusion. It should be remembered that the application of this methodology is most suited for electronic data processing

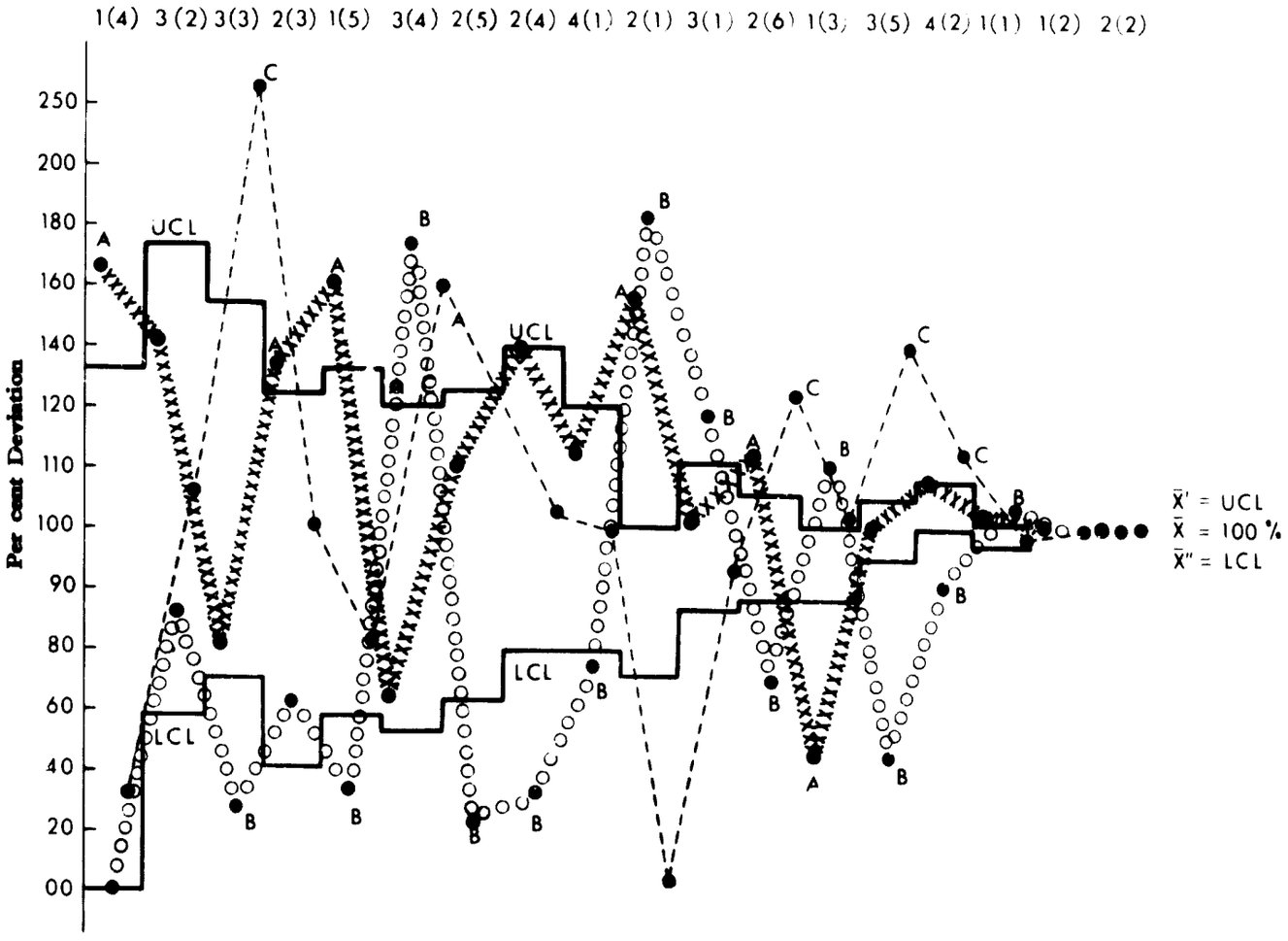
Chart 4. Company B—Control Limit Violations

Group	Variable		Value "B"	LCL	Differ.	×% Variation[a]	Total	Rank[b]
		Variables below LCL						
3	(3)	**Product Return on FE Invested**	028	071	043	086	3698	1
2	(4)	**Utilization of Installed Capacity**	030	080	050	060	3000	2
2	(5)	**Gross Output on FE Used**	027	062	035	063	2205	3
1	(5)	**Essential Goods Yield on FE**	031	058	027	075	2025	4
3	(5)	**Imported Inventory to Usage**	044	095	051	010	0510	5
4	(1)	**Profitability on Total Assets Employed**	072	080	008	040	0320	6
2	(6)	**Planned Indigenous Content**	071	088	017	018	0306	7
4	(2)	**Output on Machinery Invested**	091	100	009	008	0072	8
		Variables above UCL		UCL				
3	(4)	**Product Return on FE Spent**	177	055	122	065	7930	1
2	(1)	**Month's Orders in Backlog**	186	100	086	029	2494	2
3	(1)	**Export Potential Ratio**	119	112	007	025	0175	3
1	(3)	**FE Utilization**	111	100	011	012	0132	4
1	(1)	**Proportion of FE Used**	102	101	001	004	0004	5

[a] See Chart 3.

[b] The rank was obtained by multiplying the difference between the control limit and the value of the analysed variable. This difference in itself does not indicate how much room for improvement may exist within the framework of the environmental conditions. The product of the variable difference multiplied by the limits variation shall be indicative of the relative rank.

Fig. 1. Graphic Presentation of operational performance



which would provide the analyst with a fairly intimate insight into the operation of any company within the sector in a matter of seconds and provide uniform criteria of comparison at the same time.

Obviously the analysis can be carried out against different criteria. Instead of measuring performance of an individual company against the sector average, we may use another standard, such as the average performance of an industrial sector in developed countries. This comparison would be most informative, but it has one inherent disadvantage. The foreign companies may operate in a substantially different political, economic and social environment, making these comparisons of industrial entities not only difficult but inapplicable.

ECAFE Appoints Manuel Regional Adviser

The Economic Commission for Asia and the Far East (ECAFE) appointed Canuto C. Manuel,[1] Manila, senior regional adviser on industrial research in July 1967. In this capacity, Dr. Manuel is visiting industrial research institutes throughout the area in order to observe activities, exchange views and promote co-operation.

Dr. Manuel retired as the commissioner of the National Institute of Science and Technology, Manila, in order to accept this new position. In addition to his duties as commissioner, he was chairman of the Board of Grants to Inventors and a member of the National Science Development Board, the Board of Trustees of the Philippine Coconut Research Institute and the UNESCO National Commission of the Philippines. He was a recipient of the President's Gold Star Merit Medal as Outstanding Philippine Student.

He has represented his country in many international conferences on science and technology.

[1] For more information on Dr. Manuel, see *Industrial Research News*, Vol. I, No. 1, p. 20.

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