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INVESTMENT PLANNING IN THE FERTILIZER INDUSTRY: RESEARCH AND APPLICATIONS AT THE WORLD BANK*

by

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As part of its policy on helping developing countries meet their fertilizer requirements, the World Bank has recommended that the Bank Group should provide financial and technical assistance to promote regional fertilizer production and trading arrangements.

The Bank and other International Agencies have also been asked by the World Food Conference, the FAO Commission on Fertilizer and the UNIDO Consultation Meeting on Fertilizers to assist in regional fertilizer planning and development.

Regional planning can involve long-range contracts, harmonization of investment programs and multi-national operations but, to be successful in any one, or all of these, it is important that such collaboration should be based on sound economic considerations which ensure mutual benefit. It should also, of course, as the prime motive, ensure cheaper fertilizers to the farmers than would otherwise be available.

One important aspect of this work is the preparation of regional investment plans and several major studies using models developed by the Development Policy Staff of the World Bank, are now being carried out. This work is coordinated by the World Bank Fertilizer Unit which is also responsible for liaison with the other International Agencies.

1. Introduction

There is an evergrowing body of literature on project evaluation. A survey on cost-benefit analysis by Prest and Turvey [17] published in 1965 contains already 90 references to the literature on the subject and since then a multitude of articles and books have appeared. Recent publications by OECD [12], UNIDO [9] and the World Bank [18] in the form of manuals on project appraisal have increased even more the interest in cost-benefit analysis. Most of this literature, however, explicitly assumes that the preceeding planning phase, that of project selection, formulation and design, has been properly conducted. Yet, few systematic guidelines exist on how to select investment projects and programs from among the many variants that may be possible.

This neglect may be due to the fact that before the advent of high-speed electronic computers and associated sophisticated software, a systematic screening of all possible project combinations was analytically intractible. However, now that such devices exist, it is, therefore, appropriate to investigate to what extent the art of investment planning can be formalized.

This is particularly important in industrial project planning where economies of scale and strong interdependencies permit a very large number of variants of a project. Similar problems arise in the design of agricultural development programs, including rural development and the design of river basin development schemes, irrigation works, and power planning. Several research projects at the World Bank have addressed themselves exactly to this problem of project selection and design in various sectors of the economy; most of

them based on the use of mathematical programming models. Special attention has been given to the fertilizer industry and research has now sufficiently well advanced to be applied to "real-life" situations.

In this note, we describe in fairly condensed form the scope and objectives of a long-term research program at the World Bank in the area of industrial investment planning as it relates to the fertilizer sector. Attention will be paid to the results achieved during the research phase as well as to the experience gained during a variety of attempts to apply the planning method under operational conditions.

2. Purpose and Scope

The delivered cost of fertilizers at the farm gate is the ultimate result of an intricate process of decisions at many different levels. Should a given country produce its own fertilizers or import them from abroad? Which fertilizers should be produced or imported? In the case of domestic production, which feestocks should be used? At what scale, and at which time and location should productive capacity be installed? If technological choice exists, how to select the appropriate production process? Which is the most efficient transportation and distribution pattern for products in the fertilizer industry? This questions come up during the initial phase in the project planning process for the chemical fertilizer industry, i.e. that of the selection of an investment, production and trade pattern in its broad outlines. This phase should be distinguished from the one that involves the detailed engineering and appraisal of a given project or set of projects. At that time, many of the important decisions relating to the structure of the industry have already been taken, either implicitly or

explicitly, and although sensitivity analysis may frequently lead to modification of the project, such changes are small compared to those that should normally be allowed for during the investment project or program selection phase.

One of the most difficult problems to handle during the project selection phase is related to the fact that many of the questions that come up at that time are highly interdependent, in the sense that decisions in one area affect decisions in other ones. To give one particularly obvious example, whether or not a given product should be produced domestically, or be imported from abroad depends, among other things, on the size of the market for the product in question as economies of scale, so characteristic of the fertilizer industry, tend to lead to lower production costs per unit as the output level increases. In turn, as fertilizer demand can normally be expected to increase over time, the timing of new capacity construction will be of crucial importance in deciding on the appropriate scale. It is not difficult to see how other issues such as technology, location and transportation would enter this decision-process, and influence the "make-buy" choice.

Primarily as a result of the existence of such interdependencies, the number of options at the project selection phase is frequently very large, and literally thousands of project combinations may be technically feasible. The know-how and judgement of the sector specialist from an important guide to decision-making during this time. More often than not, rules of thumb

assist the project planner in choosing from the many alternatives that are normally available. There appear to be reasons to doubt the validity of such rules of thumb in any given situation, and increasingly, there is dissatisfaction among sector specialists with the absence of more systematic planning tools to assist in the selection of the appropriate investment project or program. The primary objective of this volume is to present such planning tools for the analysis of the most important aspects of the investment planning problem in the chemical fertilizer industry.

3. Basic Approach

The planning tools to be described in this note are designed to analyze the implications of alternative investment, production, trade and distribution patterns for the fertilizer industry, over time, and in a given geographical context. Moreover, criteria are provided on the basis of which the project planner can rank alternative programs, and ultimately, take a decision regarding the attractiveness of a given program as compared to others. This program forms the basis for subsequent analysis during the project engineering, appraisal and implementation phases of the project cycle.

The approach to be adopted is the following. The fertilizer industry is represented by a set of mathematical expressions that capture the essential technical and economic relations that characterize the industry. They concern primarily the relations among products at various levels of processing, in the form of input-output coefficients, and investment and operating costs, at various scales of production. The fact that fertilizer production costs are highly dependent on the scale of operations is explicitly modelled in the investment cost function. A further

set of expressions describes the transportation cost of the various products in the model, between producing sites, import and export points, and marketing centers. Given a set of demand projections for fertilizer nutrients, over time, and by marketing center, the model is used to find the least-cost investment, production, and transportation pattern to meet these demands. The possibility of importing from abroad versus domestic production is normally taken into account. Furthermore, a range of area-specific restrictions can be specified in the form of constraints. Some of these may reflect industry-specific constraints, such as raw material availability, while others may reflect government policies, such as a limitation on the investment resources available for expansion of the fertilizer industry. Also, choice among fertilizers may be constrained by more or less stringent fertilizer recommendations.

It is important to point out that planning problems in the fertilizer industry do not always cover the entire range of issues outlined above. It may be that the planner is interested only in alternative transportation and distribution patterns for an existing industry, or in an efficient capacity expansion plan for a given firm. In such cases, a much less complex problem is posed and a simplified model would be applicable.

Another important aspect to stress is that the sector planner may not always be interested in finding the least-cost production pattern for the industry as a whole, but is simply interested in costing out the implications of a given project proposal, or of competing proposals. As will be demonstrated later, the model framework provides a highly efficient and simple-to-use framework of analysis for such questions.

Having given the reader a flavor of the range of problems to which the proposed methodology can be applied, we hasten to add a qualification. Models are simplified representations of reality, designed to guide decision-making, not to replace it.

They are highly efficient tools to evaluate and quantify the implications of a certain understanding of the economic and technical relationships that typify the fertilizer industry, and the environment in which the industry is supposed to function. However, the decision process involves normally more elements than can or should be incorporated in a planning model. More or less important modifications of the initial investment program may therefore appear desirable in subsequent stages of the planning process. This should not disturb the reader, as it is neither a weakness of the methodology nor unique to this particular approach to project planning. All project planning methods proceed in phases, and it is inevitable that as an investment project or program takes shape, greater attention is paid to detailed aspects. In the process, certain inconsistencies with earlier assumptions and judgements will frequently appear, and it is in fact one of the main advantages of the proposed approach that in such cases, a rapid and efficient re-assessment of broad strategy options is possible.

4. Applications at the World Bank

The development of quantitative methods to incorporate economies of scale was begun with Chenery [1, 2], extended by Manne [13], Vietorisz and Manne [23], Kendrich [10] and Westphal [22]. Since these early studies were undertaken, tremendous progress has been made in computer technology and large scale problems can now be solved on a routine basis. It appeared therefore quite attractive for an institution such as the World Bank to further investigate the potential usefulness of this type of planning model for sector and project planning.

We shall now turn to a brief description of progress made to-date.

East Africa (1971): The research program started off with a detailed investment planning study of the East African Fertilizer industry [21]. Our original goal to specify a model that was meaningful for operational purposes lead to a formulation of unreasonable large dimensions. Initially, solutions could only be obtained with extreme difficulties and high cost. Much effort was spent in developing new techniques to overcome those technical problems, requiring us to take a comprehensive and in-depth view and thus establishing a firm basis for future applications. The original plan of testing in an operational environment was unfortunately overtaken by political events.

World-Wide (1973): A world-wide model (16) has been specified, dividing the world up in twenty major regions, and with the objective to determine the most efficient manner in which the projected shortfall in fertilizer supplies

by some future date could be met. The main factors influencing world-wide production patterns are the location of raw materials, the size and expected growth of demand for fertilizer material in the various regions, differences in investment and production costs among regions, and transportation cost. Various levels of self-sufficiency and risk aversions were explored. A study of this nature gives considerable insight into the capital requirements for an industry on a world-wide basis, and potential production and trade patterns. It showed that developing nations are in a comparatively favorable position to expand their fertilizer production capacity as opposed to traditional producers. However, in the view of some serious data problems, no further work has been undertaken.

Egypt (1975): A very detailed and comprehensive application was done for Egypt, where in fact a series of planning models was formulated, jointly with Egyptian planners [6, 7]. The first model was designed to reproduce the current situation in the sector, both to demonstrate to a skeptical audience that the model could indeed capture the salient characteristics of the industry, and to use the model framework to generate sets of base-year data that could not be collected in the field, but that were in fact implied by available data on related matters, e.g., detailed domestic transport flows. Next a detailed planning model was formulated for capacity planning in the medium term, focusing on the conventional issues such as production scheduling, product mix, and domestic trade in fertilizer products as well as raw materials and intermediates. A number of scenarios were investigated and compared to the

"reference solution". The latter was the solution for optimal capacity expansion given realistic (or "most likely") assumptions regarding the fertilizer sector. The seven scenarios subsequently considered were used to relax or alter these assumptions to determine the robustness of the investment program and evaluate the costs and benefits of certain strategies.

ASEAN (1975, 1977): In addition to national studies, the planning approach has great potential as an analytical device to study the scope for project-oriented cooperation among several adjacent developing countries that, because of their limited domestic markets, cannot fully capture economies of scale. The model was adapted to study the prospects for such cooperation in ASEAN, the Association of South East Asian Nations (Indonesia, Philippines, Malaysia, Thailand, Singapore) [14]. A number of alternative investment scenarios were designed (incorporating a variety of strongly expressed preferences for specific allocations of projects in the region) and assessed in terms of its attractiveness to the region as a whole, and to each of the countries individually. Recently, the original study has been revised and expanded [3, 4]. The primary advantage of the planning framework for the study of such multi-country investment planning problems is that rapid quantification of a particular allocation of investments within the regional market is feasible. It is possible to provide adequate quantified information on the distribution of costs and benefits among partner countries associated with alternative allocative schemes. Ideally, the project model could be used to accompany negotiations on the implementation of the agreement. An attempt in this direction is the next project.

Andean Common Market (1977): A joint study team was formed by the Junta and the World Bank to design and implement a model system for the fertilizer sector to provide the main analytical input for the upcoming negotiations. From the outset emphasis was given on dissemination and transfer of a planning methodology. The World Bank acted only as a general consultant and adviser to the secretariat. The model is now operational in Lima after being built completely by local staff. The main problems encountered were connected with computational aspects, the lack of large scale computers and extreme scarcity of experienced personnel to handle sophisticated software systems.

India (1977 -): The Ministry of Chemicals and Fertilizers and the World Bank are jointly undertaking a planning study of the fertilizer sector in India [5]. A workshop was held in Delhi during December 1977 to familiarize Indian planners with the methodology and its data requirements. To apply this type of planning model to a sector as large and as complex as the Indian fertilizer industry is a very ambitious undertaking. This is, however, justified by the importance of the problem and the excellent data available with the government and industry.

5. Dissemination and Transfer

Efforts to disseminate the World Bank research in the area of industrial investment planning takes several forms besides applications and case studies. A monograph [21] addressing primarily the professional audience of mathematical economists and development planning specialists is to appear shortly and provides a thorough treatment of the planning methodology.

Another series of publications is being prepared that can best be characterized as "manuals" since they provide detailed and comprehensive guidelines on the use of programming models in a process analysis format for the formulation of sectoral investment programs [7, 11]. Volumes on other industries such as forest and forest industries, steel, petrochemicals and multi-country investments are under preparation or completed.

Finally, efforts are underway to design computer languages and modelling systems that would greatly facilitate communication between the computer and the analyst by replacing the existing skill intensive modelling technology by a new capital (machine) intensive technique.

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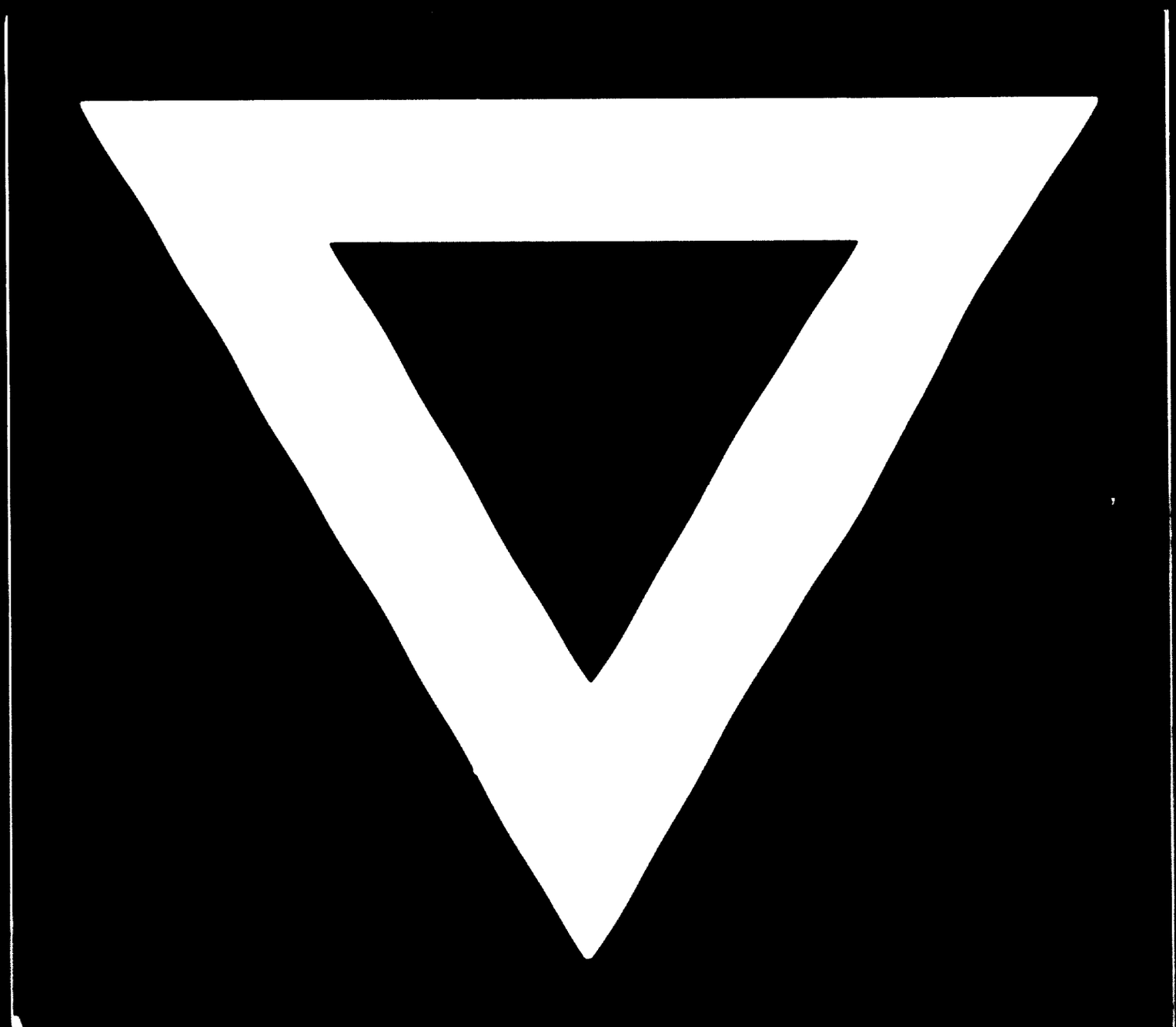

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