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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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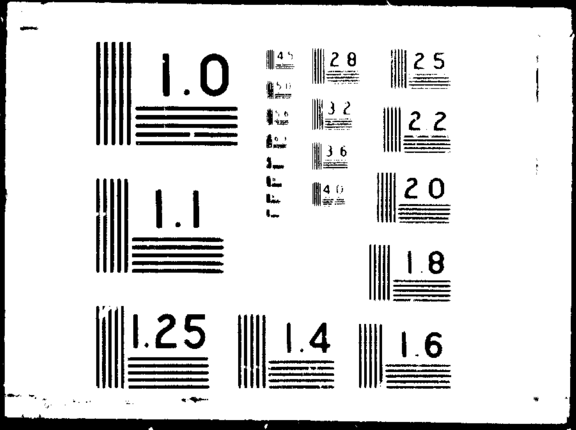

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Second Interregional Fertilizer Symposium

Kiev, USSR, 21 September - 1 October 1971
New Delhi, India, 2 - 13 October 1971

Agenda item IV/10

SUMMARY

ESTABLISHING A DOMESTIC FERTILIZER INDUSTRY BASED ON IMPORTED PHOSPHORIC ACID[1/]

by

T. Gans

Fertilizer & Chemical Development Council
Tel Aviv Israel

Within developing countries the urgent need for increased fertilizer supply can be satisfied by any one of three alternatives:

a) Import the basic raw materials and establish a grass-roots industry

b) Import the intermediate goods (e.g. phosphoric acid) and produce the final product

c) Import the final product

This paper seeks to demonstrate that, for many developing countries with different levels of economic growth, the importation of the intermediate product may prove to be the best alternative.

It is apparent that a commitment to an expanding fertilizer industry is likewise a commitment to additional marketing institutions, including transportation, handling and storage facilities. Hence, the investment decision must weigh the costs of supporting domestic production (through additional infrastructure) against the savings of foreign currency reserves.

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The technologies of fertilizer production are very sensitive to scale. Unit costs savings are only available at or near full capacities. Critical to the choice of grass-roots vs. intermediate production is the existence of a domestic market that will support high levels of output. Where effective demand for fertilizer does not exist and where the prospects for growth are great, a commitment to the intermediate plant may prove to be the least-cost alternative.

There are a variety of production alternatives within the intermediate goods industry. Developing countries are now able to select a series of plant sizes and processes that correspond to the progress of market growth and infrastructure capabilities. Recent developments in production, handling and transportation of fertilizers have enlarged the possibilities of preparing a tailor-made programme of industrial development.

A close examination of world-wide consumption and production patterns suggests that most developing countries lack the market to support a grass-roots fertilizer industry. Furthermore, where such industries have been established, output is characteristically below the minimum economically justifiable scale. Where demand is expected to grow, local consumption appears to justify grass-roots production only in the far distant future.

The key advantages of the intermediate-product alternative are the reduced investments, the limited foreign exchange expense and the capability of matching production possibilities to market realities.

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ESTABLISHING A DOMESTIC FERTILIZER INDUSTRY BASED ON IMPORTED PHOSPHORIC ACID[1]

by

T. Gans
D. Braude R. Brosh
Z. Itzkovitch P. Shapiro

Fertilizer & Chemical Development Council
Tel Aviv Israel

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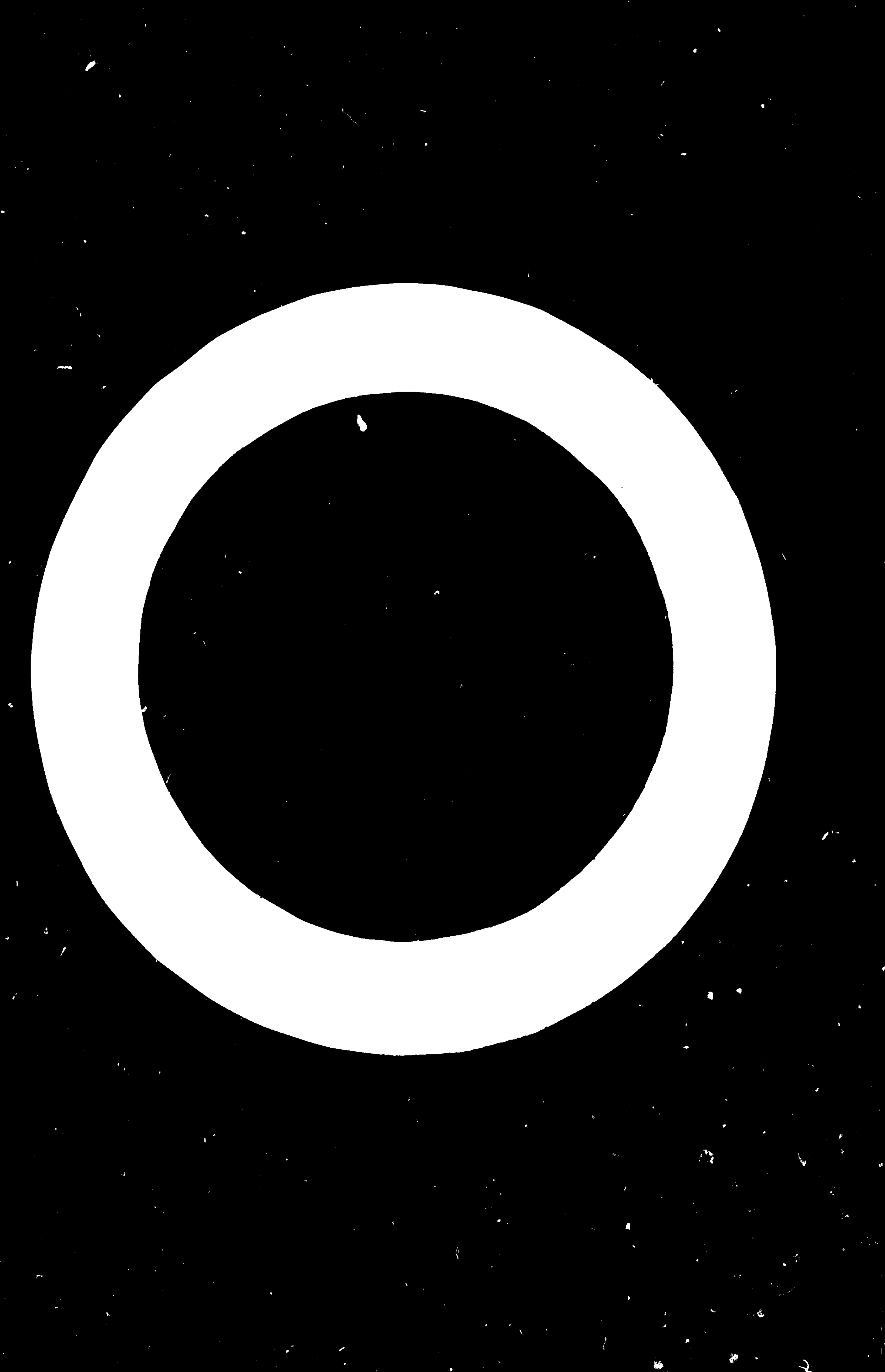

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INTRODUCTION

In many countries there is an urgent need for a fertilizer supply system capable of supplying fertilizers in appropriate quality and quantity at a reasonable price. This problem is especially severe in developing countries lacking the basic raw materials required for fertilizer production. Currently the following possibilities exist:

a) Import the basic raw materials and develop a complete fertilizer industry.

b) Import the intermediate goods for the production of finished fertilizers.

c) Import of fertilizers.

The choice among the three alternatives is consequential to the economic consideration of:

PART 1. Basic concepts in the fertilizer industry

a) The developing nation
b) The fertilizer industry
c) The current world-wide consumption and production patterns.

PART 2. A strategy of investment planning given the dynamics of market growth

a) A static model
b) A dynamic model

It is the purpose of this paper to demonstrate that the intermediate goods route may provide the greatest comparative economic advantage to a country with a developing fertilizer market.

SUMMARY

The first part of this paper develops the characteristics of the industry and the economic environment. The interrelationships of production scale, market size and infrastructure evolution are shown to be a critical factor in the TSP investment decision. Furthermore, the unique characteristics of the fertilizer industry encourage a process of industrial development that closely parallels the specific conditions of over-all economic growth. When the international economic environment is examined, we find that world-wide consumption and production patterns have generated industries with chronic overcapacities. This

is especially true of countries enjoying moderate levels of consumption. Our analysis further demonstrates that where initial levels of consumption are low, the spread between market growth and plant capacity may last for many years.

The second part of this paper signals the development of a strategy of investment planning given the dynamics of market growth. At the outset, the long-run evolution of fertilizer consumption is divided into three stages. The first stage is one of low growth and low consumption. The second stage is one of high growth and moderate consumption; while the last stage is characterized by low growth and high levels of consumption. The second part of the paper manifests the desirability of an intermediate industry within a Stage II environment. Two models are evidenced. The first is a static model assuming zero growth and single plant sizes throughout the planning horizion. The second model, the dynamic model, completes the analysis in a growing market with changing industrial complexes. Both models confirm our hypothesis that long run economies are realized if and only if an intermediate industry is constructed within the stage II market. The dynamic model is designed to offer a general approach to investment planning. The utility of this model can be expanded into other industries.

PART A: BASIC CONCEPTS IN THE FERTILIZER INDUSTRY

I. THE ECONOMICS OF DEVELOPING NATIONS

Developing nations are chronically pressured by the competing requirements of critical investment alternatives. Severely constrained by shortages of investment capital and foreign exchange, developing nations must weigh their plans for industrial growth against the larger priorities of a total, balanced economic development. However, the decision to enter the fertilizer industry is more a consequence of the increase in the immediate requirements for food. There are three options:

a) To import food
b) Employ land reclamation
c) To produce more food with the utilization of fertilizers.

The paper assumes that fertilizer use has already been recognized as the least-cost alternative, and the problem now remains to define the most efficient means of supplying the market with the fertilizer needs.

The decision to enter into the domestic production of fertilizer, entails rationing of not only the inputs of exchange, capital and expertise, but also the limited capabilities of the social infrastructure. It is evident that a commitment to an expanding fertilizer industry is likewise a commitment to additional marketing institutions, including the facilities of transportation, storage and handling. Hence, within the framework of scarcity, our thesis offers, what we feel to be the least-cost alternative of supplying fertilizer to the agricultural sector, based on the stage of fertilizer demand.

Most developing countries lack the infrastructure as required below:-

a) Sea transportation
b) Port facilities
c) Land transportation
d) Storage facilities
e) Skilled manpower
f) Capital (local or foreign currency)

A specific burden would be placed on the developing economy if foreign currency is used for the purchase of either the final product or raw material. Thus a growth in the consumption of fertilizer suggests a parallel growth in foreign exchange expenditures. The possibility of easing the balance of payments burden has encouraged the establishment of national fertilizer industries. It appeared that this approach offered the best solution of satisfying the future needs for fertilizer and at the same time, minimizing the foreign currency expense. The hypothesis was correct as long as the local market supported the smallest economic fertilizer production capacity.

II CHARACTERISTICS OF THE FERTILIZER INDUSTRY IN DEVELOPING COUNTRIES

A. Scale-markets-infrastructure

The basic fertilizer technology employs processes that are economically very sensitive to scale. Since advanced, cost-saving technologies can be applied only to larger scale production, the level of output has a decisive effect upon unit costs. Furthermore, investment in a complete fertilizer plant requires a high capital outlay, a considerable share of which is in hard currency.

The planners in the developing countries have to realize that if cost saving techniques are available only at higher output ranges, there must also be a commitment to create a market able to absorb an output near full capacity. Therefore, a grass-roots domestic fertilizer industry provides three challenges: large scale ventures; mature markets; and adequate infrastructures.

B. Fixed and variable costs components

The cost of production in the fertilizer industry can be divided into two main cost components:

1. The fixed investment
2. The cost of factor inputs including raw materials or intermediate goods.

The basic raw material is the critical component. At its source, the product is relatively inexpensive. However, the cost to the fertilizer industry is double due to the high expenses in handling, storage and transportation. The cost of raw materials at the fertilizer factory gate can be kept low by either locating the production unit near the source of raw material, or by taking full advantage of bulk rate savings in transportation and handling.

C. <u>The variety of processing alternatives enables tailoring of fertilizer industries</u>

The variety of production possibilities enables a developing country to select a series of plant sizes and processes that correspond to the progress of market growth and infrastructure capabilities. The problem of the importing nation is to determine the point of equilibrium where the supply system is efficient and the total costs of relevant production alternatives are the lowest. Evidently, the appropriate industrial process is a function of changing market and distribution situations.

The processing and upgrading of fertilizer can be done in various ways and methods, and can be segmented at different stages. The developing country is thus able to adapt its own industrial program to local realities. Recent developments in production, handling and transportation of fertilizers and raw materials have enlarged the possibilities of preparing a tailor-made program to include:

Bulk loading and unloading facilities, bulk road and rail transports, pumping and pipeline facilities for transportation of liquids etc.

D. <u>The choice to import intermediate goods as opposed to the raw material or final product</u>.

It is very difficult to quote a general consumption figure that indicates the point where local production is preferred to import, or vice-versa. The actual break-even point is different in each case, depending on the geographical situation of the country and the location of the plant.

Most common fertilizers are available today on the international market in ample quantities and at low prices. Often the fob price is lower than the wholesale price for the locally produced product. For a country with a low volume of consumption, the import of the final product may be the optimal least cost solution. Adjusting an import supply to a limited demand can keep the cost per unit of nutrient relatively low. Today, few countries base their supply policy entirely on the importation of fertilizers.

From the cost of production point of view, the following output scales are considered the minimum to justify domestic production. Low unit costs can be realized for ammonia at a minimum of 180,000 tons, and for phosphoric acid at the threshold of 80-100,000 metric tons P_2O_5 per annum at present day technology.

At the other extreme, is the possibility of developing a total fertilizer industry, (capable of processing raw materials into the finished goods), in spite of a limited market. This, evidently has been a common practice and has caused over-capacity in may countries. This appears to be especially true with ammonia production units. Furthermore, there are examples of projects that have not gone further than the final stages of construction, in spite of the heavy investment sunk in a productive capacity. In addition, there are plants that have remained idle after short periods of limited production.

New alternatives are currently available to developing countries aside from the two possibilities evidenced above. Recent developments in the production, handling and distribution of plant nutrients in liquid forms such as containing phosphoric acid and ammonia have signalled a fertilizer supply policy that is capable of realizing the economies of large scale production, without committing a heavy investment to underemployed, expensive units.

III PATTERNS OF WORLD WIDE CONSUMPTION AND PRODUCTION

Table I, demonstrates that world-wide consumption and production is concentrated among the few developed nations. Furthermore, it suggests that developing nations lack the market to support a grass-roots fertilizer industry and hence, must import their fertilizer supplies. Although a few local fertilizer industries have been established, market demand has usually fallen short of efficient productive capacity. Furthermore, where local industries have been developed, it appears that excess capacity will continue to exist for long periods of time.

A. Size of fertilizer markets

Consumption of fertilizers in a given country is a sum of many factors and conditions. Some of them are objective ones, such as: agriculture area, crops, type of soil and climatic conditions.

The other ones are subjective, such as: agricultural practices, economics of farming and the level of intensification.

There are only a few countries in the world where the upper limit of fertilizer use has been set by any of the objective factors mentioned. On the other hand, in many countries the use of fertilizer is kept below the optimal level, because of economic conditions and/or the prevailing agricultural practices. In developing countries actual consumption and increase in use, in the foreseeable future will still be very much below their consumption potential. In Table I, countries are grouped according to their annual consumption of nitrogen and phosphate fertilizers.

B. Consumption production patterns

Table I, demonstrates that consumption is concentrated among a small percentage of nations (13.6% for Nitrogen and 9.8% for Phosphate) accounting for more than 80% of the total world consumption. The members of this group include the developed nations who produce not only for domestic consumption but also for export.

Within developing nations, the dominant criteria for establishing a domestic productive capacity should be the economically efficient plant size. Considering 180,000 ton/annum to be the smallest economic unit for the production of nitrogen, it appears then that 106 countries (or 75% of all the countries using fertilizer) are obliged to import rather than resort to local grass-roots productive capacity. Nevertheless, about 30 countries of this latter group have already established domestic industries. Output is characteristically below the 600 tons/day scale.

(However, there are a few exceptions, especially where production was originally export oriented.)

This situation is not limited to the Nitrogen market. The bulk of the phosphatic fertilizer supply is produced and demanded by developed countries. Many of them import the raw materials, produce fertilizers for their own needs, and are the main suppliers of phosphate to the international market.

On the other hand, developing countries cover their requirements through imports. Some of them base their supply on low nutrient content materials which can be produced economically in small production units. Fertilizers produced from phosphoric acid are more often imported, because local markets usually cannot support an economic unit, (75,000 mt P_2O_5). About 30 countries are currently in the position to import phosphoric acid. Another 50 countries represent the potential growth of the market in the future.

C. Chronic overcapacity

A number of developing countries have chosen to establish domestic fertilizer industries in the hope of developing local markets that will, in the future, satisfy full capacity. Table II, demonstrates that local consumption (given various growth rates) will justify local production only in the far distant future. In our analysis, the minimum economic scale for Nitrogen was assumed to be 150,000 mt per year and for P_2O_5, 75,000 mt per annum. For example, a country presently consuming 20,000 mt of both N and P_2O_5 (growing at a rate of 10%) would realise economies of domestic production in 14 years producing P_2O_5 and in 21 years producing Nitrogen.

TABLE I. CONSUMPTION AND PRODUCTION PATTERN BY COUNTRIES FOR NITROGEN AND PHOSPHATE FERTILIZERS.*

	NITROGEN			PHOSPHATE		
Annual consumption m.t.	Number of countries	Accumulated consumption m.t. '000	Number of producing countries	Number of countries	Accumulated consumption m.t. '000	Number of producing countries
Less than 5,000	56	122	4	47	71	--
5001 - 10,000	5	37	—	14	98	2
10001 - 20,000	16	218	4	12	176	7
20001 - 30,000	9	221	6	2	55	1
30001 - 50,000	8	292	7	9	387	7
50001 - 75,000	7	434	6	4	232	2
75001 - 100,000	1	77	1	3	272	1
100001 - 150,000	4	504	3	9	1092	9
150001 - 200,000	8	1385	7	5	865	5
200001 - 300,000	6	1498	6	5	1226	5
300001 - & more	19	21113	19	12	18201	12
TOTAL:	139	25901	63	122	22675	51
AS A PERCENTAGE						
Less than 5,000	40.3	0.47		38.52	0.31	
5001 - 10,000	3.6	0.14		11.47	0.43	
10001 - 20,000	11.5	0.84		9.83	0.78	
20001 - 30,000	6.5	0.85		1.64	0.24	
30001 - 50,000	5.75	1.13		7.38	1.71	
50001 - 150,000	8.6	4		13.11	7.04	
150001 - 200,000	5.75	5.35		4.1	3.81	
200001 - 300,000	4.3	5.8		4.1	5.41	
300001 - & above	13.6	81.5		9.3	80.27	
TOTAL %	100	100		100	100	

* Based on FAO data.

TABLE II. THE LENGTH OF TIME REQUIRED FOR A MARKET TO SUPPORT A FERTILIZER INDUSTRY AT GIVEN CAPACITIES AND AT VARIOUS GROWTH RATES

Present Consumption mt/year	Target output for P_2O_5 75,000			Target output for N 150,000		
	5%	10%	15%	5%	10%	15%
5,000	55 yrs	28 yrs	19 yrs	69 yrs	35 yrs	24 yrs
10,000	43 "	21 "	14 "	55 "	28 "	19 "
20,000	27 "	14 "	9 "	41 "	21 "	14 "
30,000	19 "	9 "	7 "	33 "	17 "	11 "
50,000	9 "	4 "	3 "	23 "	11 "	8 "
75,000				15 "	7 "	5 "

PART B: A STRATEGY OF INVESTMENT PLANNING GIVEN THE DYNAMICS OF MARKET GROWTH

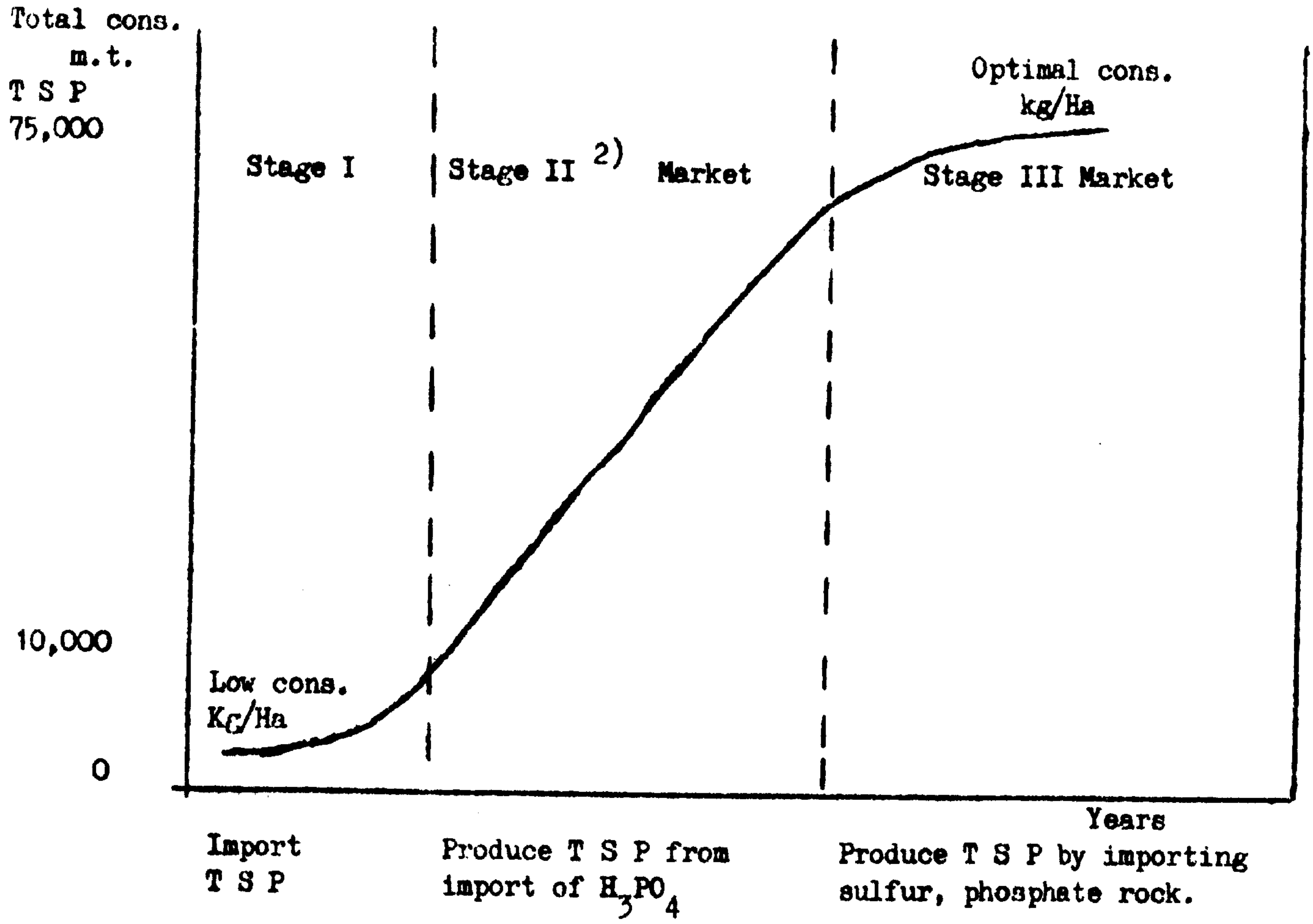
I. THE THEORY OF A DYNAMIC INVESTMENT STRATEGY

A. THE MACRO DYNAMICS OF MARKET GROWTH AND THE STRATEGIES OF LONG RUN INVESTMENT

Investment planning in the fertilizer industry is a function of the long run dynamics of fertilizer demand. It is presently possible to segment long run investment decisions into three major stages consequential to the overall growth of fertilizer consumption. A representation of long run market development is demonstrated in the graph below.

FIGURE 1.

Long run growth of fertilizer demand in a developing nation - prototype - [1)]



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1) The prototype assumes only optimal and low rates of fertilizer utilization. In our example we attributed 10,000 metric tons to low optimal use and 75,000 m.t. to optimal ratios of fertilizer consumption.

2) Stage II = growth rate of 15%

At the outset, we evidence a period of fertilizer utilization at levels far below the optimal ratio per unit area. The rate of growth in this stage is very low. Subsequently, we demonstrate a Stage II of accelerated growth resulting from the initial impact of extension services and federal assistance to fertilizer promotion. This is accompanied by massive efforts in marketing and distribution. A third period (Stage III) of declining growth rates signals the development of a mature market. The duration of each stage is dependent upon the degree of commitment to fertilizer utilization, including education, financing, price support programme, etc. The dynamics of industrial and domestic planning require:

1. That short run investment proposals coincide with current economic realities (market and infrastructure capabilities)

2. That all present decisions are consequential to the long run evolution of consumption and social infrastructure. Hence, present investment alternatives must fit an ongoing "system" of fertilizer development.

The following sections develop a prototype of investment decision making for the fertilizer industry. Demonstrated below is a model evidencing the logical linkage of investment analysis and long run economic planning.

Systematic economic planning realizes long term economies by:-

1. Matching a period of low growth and low levels of demand to the importation of final products. (Stage I.)

2. Supporting periods of high growth and moderate levels of consumption through "intermediates" industry (Stage II.)

3. Serving matured markets with declining growth rates and high levels of consumption through grass-roots industrialization. (sulphuric acid to phosphoric acid to triple superphosphate and compounds: (Stage III.)

The above strategy suggests that long run diseconomies will result if the timing and sequence of industrial development are not properly accomplished.

1. CURRENT PRODUCTION AND CONSUMPTION PATTERNS DEMONSTRATE SUB OPTIMAL STRATEGIES IN STAGE II MARKETS

Our market analysis (Table I) confirms that 61 nations, each consuming less than 5,000 mt of P_2O_5, are unable to efficiently support a domestic phosphoric industry. If total consumption falls below 5,000 mt their least cost alternative is the importation of final product. Where the demand exceeds 75,000 tons, the total grass-roots option proves to be satisfactory. Our theory tends to follow the general concensus; for most of the nations enjoying high levels of domestic demand (above 100,000 P_2O_5 phosphoric unit) are engaged in grass-roots production. In addition, many are exporting the finished product.

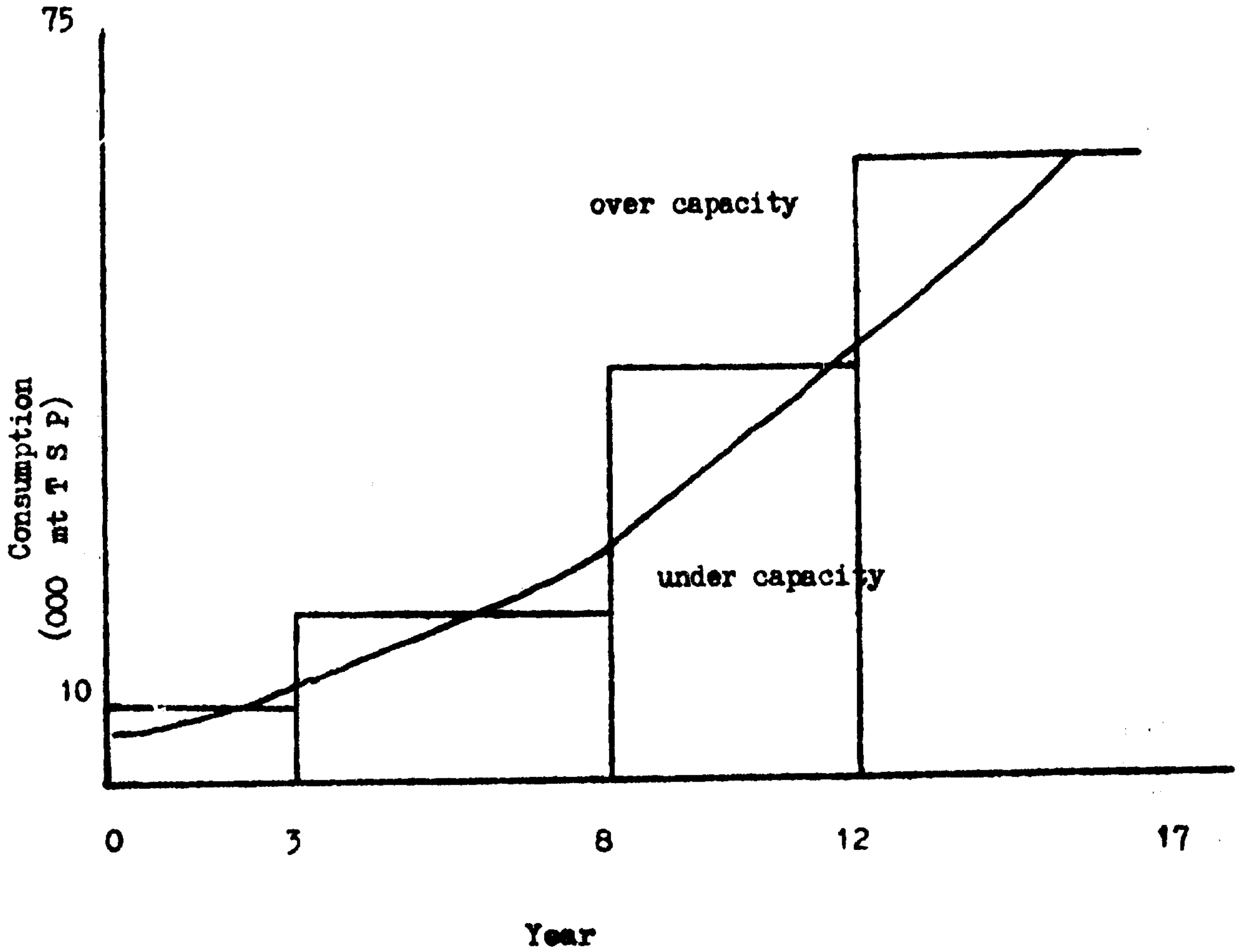
The concensus is not as clear within the intermediate ranges of consumption. There are many countries each consuming between 5,000 to 100,000 tons of P_2O_5 which belong to the high growth rate group. We feel that each should be committed to the intermediate industry. However, some countries have already developed a grass-roots production (with chronic overcapacity), or continue to produce low content fertilizers. On the other hand, the remaining countries are still importing the final product.

2. MARKET GROWTH RATES AND EFFICIENT UTILIZATION OF CAPACITY

A key element in our investment strategy is choosing a production configuration that is able to match plant capacity with market growth. In markets of high growth rates (Stage II) the intermediate industrial option minimizes the losses of under and over capacities. Rapidly increasing consumption patterns make it exceedingly difficult to match continuous growth rates to discrete additions of output. Plant productivity in a rapidly growing market either lags or leads domestic consumption.

FIGURE 2.

Market growth and over/under plant capacities in Stage II.



Evidently, the least responsive production configuration, in a Stage II environment is the grass-roots option. It has the longest lead time. Adjustments to market fluctuations must be accomplished in all three production phases (sulphuric acid, phosphoric acid and TSP). In addition, where the demand for fertilizer is critical, economic planners are committed to minimize periods of excess productive ability in all three production phases. Furthermore, fluctuations in TSP demand manifests itself (via the accelerator) in diseconomies through the three-phase grass-roots production process, and through the social infrastructure.

For example, a change in demand for TSP of one mt implies an increase of 510 kg phosphoric acid and an increase of 900 kg of sulfuric acid. The disadvantages of grass-roots industrialization in a high growth market can be thus summarized as follows:-

Creation of a new capacity involves the complex alteration of three production phases, which, by extending the lead time until completion, aggravates discrepencies in market demand and supply. Furthermore, periods of production - market disequilibrium - are characterized by net outflows of foreign exchange and reduction in the efficiency of the capital investment.

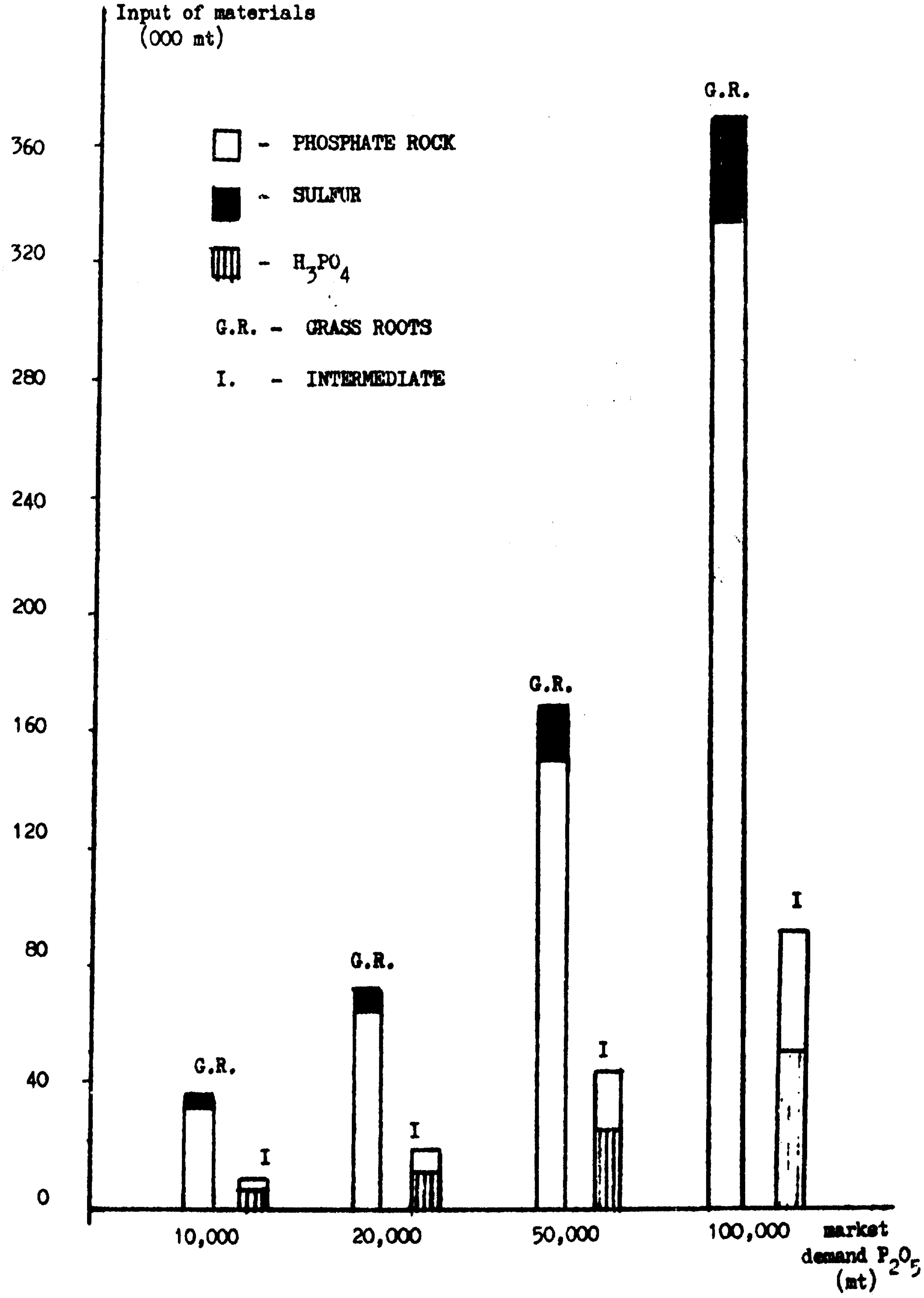
On the other hand, the intermediate production process rapidly adjusts to changing demand patterns with a minimum of additional capital outlay. Fully 40% of the investment in the intermediate process is taken by storage and handling facilities. The investment in storage provides additional flexibility since modular warehouses are able to act as buffers between consumption fluctuations and changes in productive capacity.

3. THE DYNAMICS OF MARKET GROWTH, INVESTMENT STRATEGIES AND INFRASTRUCTURE CAPABILITIES.

Coinciding with market growth is the evolution of transportation, storage and handling facilities. However, the lead time of investments in the social infrastructure usually exceeds the growth of fertilization consumption and productive capacity. In Stage II, production and consumption are usually growing faster than the capabilities of storage and transportation. An optimal Stage II fertilizer investment strategy must offer the least-cost method of distributing the desired output through limited supply channels. It appears that the intermediate goods alternative places fewer demands on the distribution system in the Stage II environment. The grass-roots option tends to "clog" the supply system with imported raw materials (sulphur, phosphate rock). In addition, the three-stage grass roots process increases storage requirements at each level of production. The chart Figure 3. shows that the intermediate goods alternative tends to bypass the limited infrastructure by reducing the tonnage of raw materials needed to produce a given output. During Stage II, the grass-roots industry requires almost 4 times as much product to be transported to and from the source of production.

FIGURE 3.*

A COMPARISON OF INPUT TONNAGES REQUIRED BY GRASS-ROOTS PRODUCTION vs. INTERMEDIATE GOODS INDUSTRY



NOTES: (Figure 3.)

1. 1.4 metric ton of phosphate rock are required by grass-roots industry for every metric ton of TSP produced

2. .344 " " of sulphur are required by grass-roots industry for every metric ton TSP produced

3. .51 " " of H_3PO_4 are required by intermediate industry for every metric ton TSP produced

4. .425 " " of phosphate rock are required by intermediate industry for every metric ton TSP produced.

Phosphate rock is: 31% P_2O_5

H_3PO_4 is : 69% P_2O_5.

Depending on the plant size, if the intermediate plant is located near a harbor it will use a "separate" (unloading facilities, tank storage, pipelines at $100,000) infrastructure further reducing the burden on the general infrastructure.

4. INVESTMENT SAVINGS CAN BE UTILIZED IN SUPPLY SUPPORTING ACTIVITIES.

One additional comment regarding investments, market size and infrastructure capabilities should be made. Recall, that we suggest that a commitment to domestic fertilizer industrialization is likewise a commitment to the development of marketing institutions. The growth of a domestic fertilizer industry, must also be paralleled by developments in:

1. Agricultural markets, price stability and credit systems.
2. Distribution systems of fertilizer and agricultural produce.

A realistic investment strategy must insure that the potential bottlenecks of distribution systems are avoided. The productivity of dollars committed to the growth of industrialization should be matched against the requirements of supply-supporting activities. Evidently, investment in the latter projects makes dollars committed to domestic industrialization more productive. Investment savings in a Stage II environment, through the intermediates alternative, frees additional capital to support marketing and distribution activities.

From our dynamic model in the concluding section of this paper, we find that investment savings in plant and equipment are indeed substantial.

B. THE MICRO ANALYSIS OF INVESTMENT ALTERNATIVES WITHIN THE STAGE II ENVIRONMENT: THE STATIC MODEL

Within the dynamic framework of market and infrastructure development, the relative advantages of intermediate goods processing, in Stage II, can be analyzed by considering:

1. The components of investment
2. The characteristics of foreign exchange expenditures
3. The comparative costs of final products.

1. THE COMPONENTS OF INVESTMENT: THE STATIC MODEL

The initial investment in plant, equipment and working capital is a non-linear function of capacity. From Table VI it is evident that the absolute spread of resources committed to the initial investment increases with output. The spread in plant, equipment and working capital in the grass-roots industry, increases from $2.5 m. (at 10,000 TSP) to $11.7 m. (at 135,000). Variable expenses are greater by about 6% in the grass-roots as compared with the intermediate goods process. The fixed cost component is more than twice as large in the grass-roots process.

See Figure 4. on Page 18.

FIGURE 4

Comparison of total fixed cost behaviour at various stages of output: grass roots versus intermediate production.

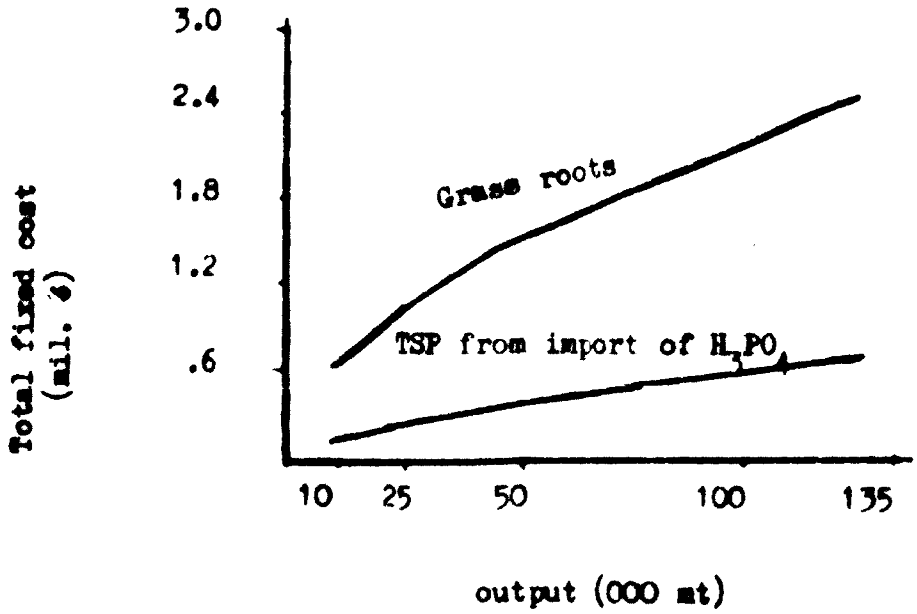
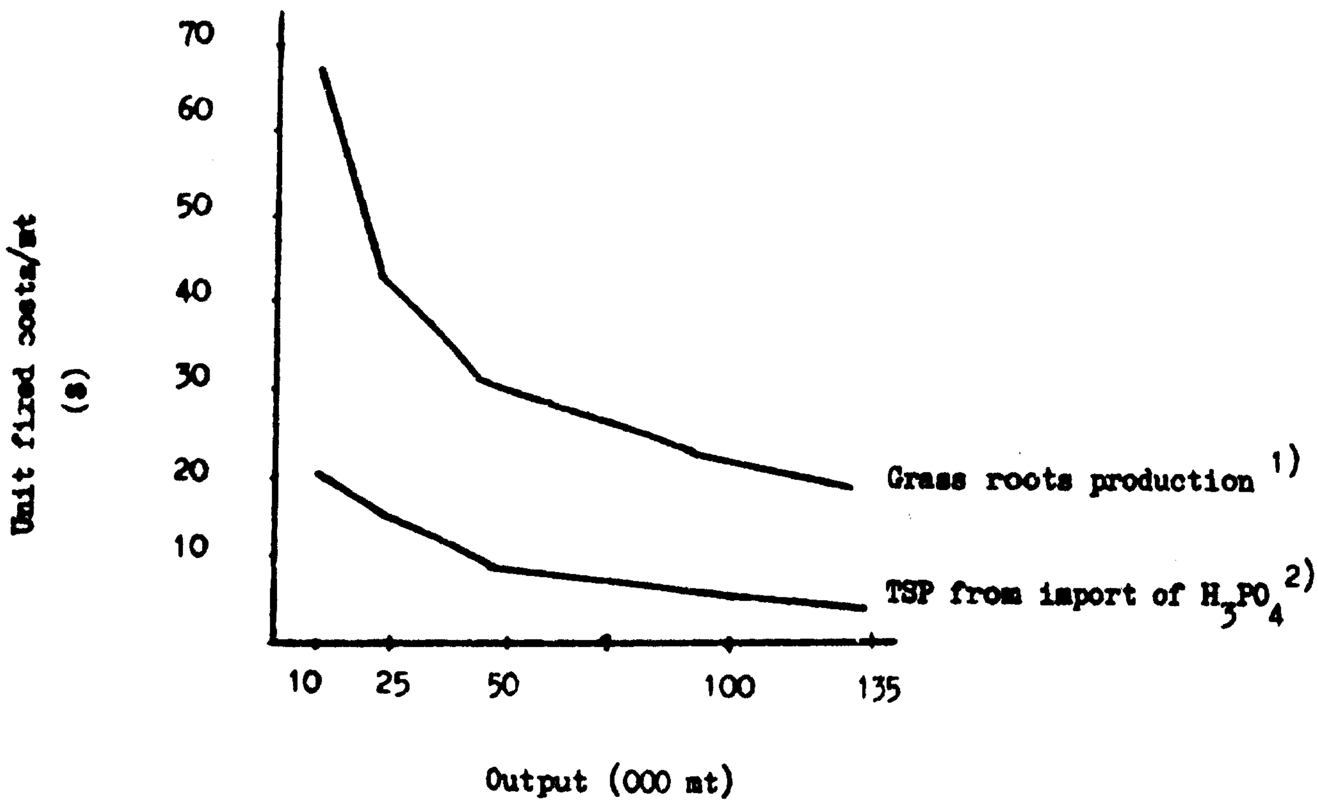


Figure 4, shows that fixed costs increase steadily across all output ranges, with the spread between the two alternatives growing from $725,000 p.a. (at 10,000 mt TSP) to $2,000,000 p.a. (at 135,000 mt TSP). Unit fixed costs for the entire industry behave in an inverse manner.

FIGURE 5

Comparison of two industry alternatives.
Grass roots vs. intermediate process.
Total fixed costs/unit output TSP.



NOTE:

1. Unit fixed costs for grass-roots include total fixed costs of all stages of production/mt assuming full capacity.

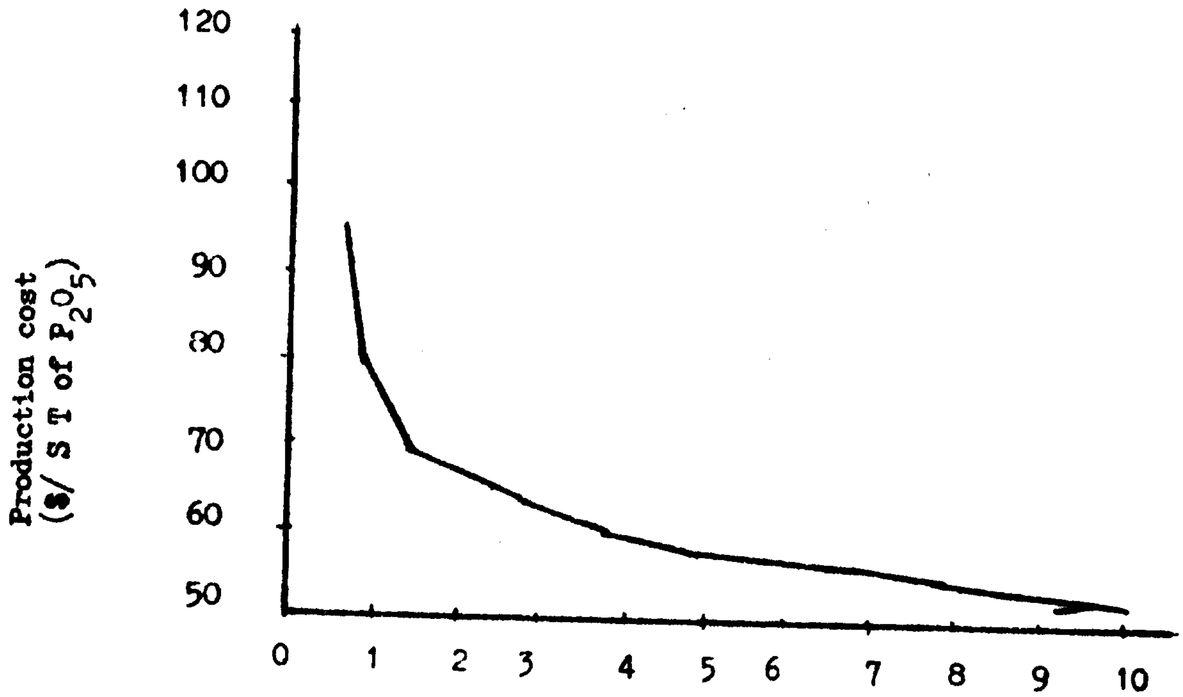
2. Unit fixed costs of intermediate process only includes costs in production of TSP from H_3PO_4.

a) SENSITIVITY TO COST FLUCTUATIONS AND PRODUCTION SCALE

Unit costs of phosphoric acid drop substantially through the production ranges appropriate to a Stage II market.

FIGURE 6

Wet process phosphoric acid (54% P_2O_5): plant capacity versus production costs.



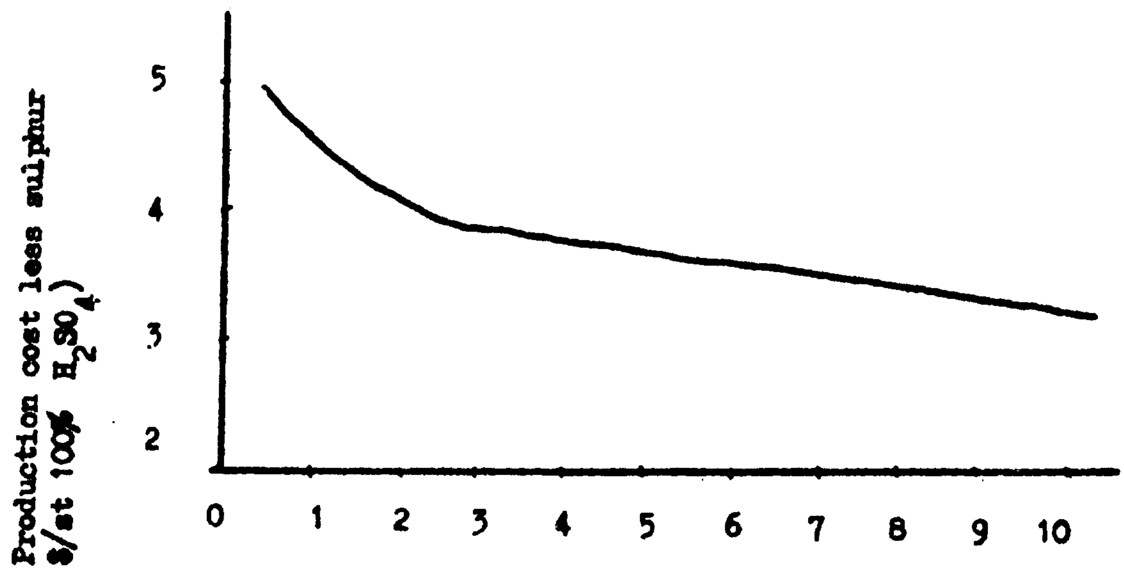
Plant capacity (00 s.t. of P_2O_5/day)

Source: UN Fertilizer Manual

Unit production costs of sulphuric acid are less sensitive to scale.

FIGURE 7

Sulphuric acid: production cost less sulphur cost versus plant capacity.



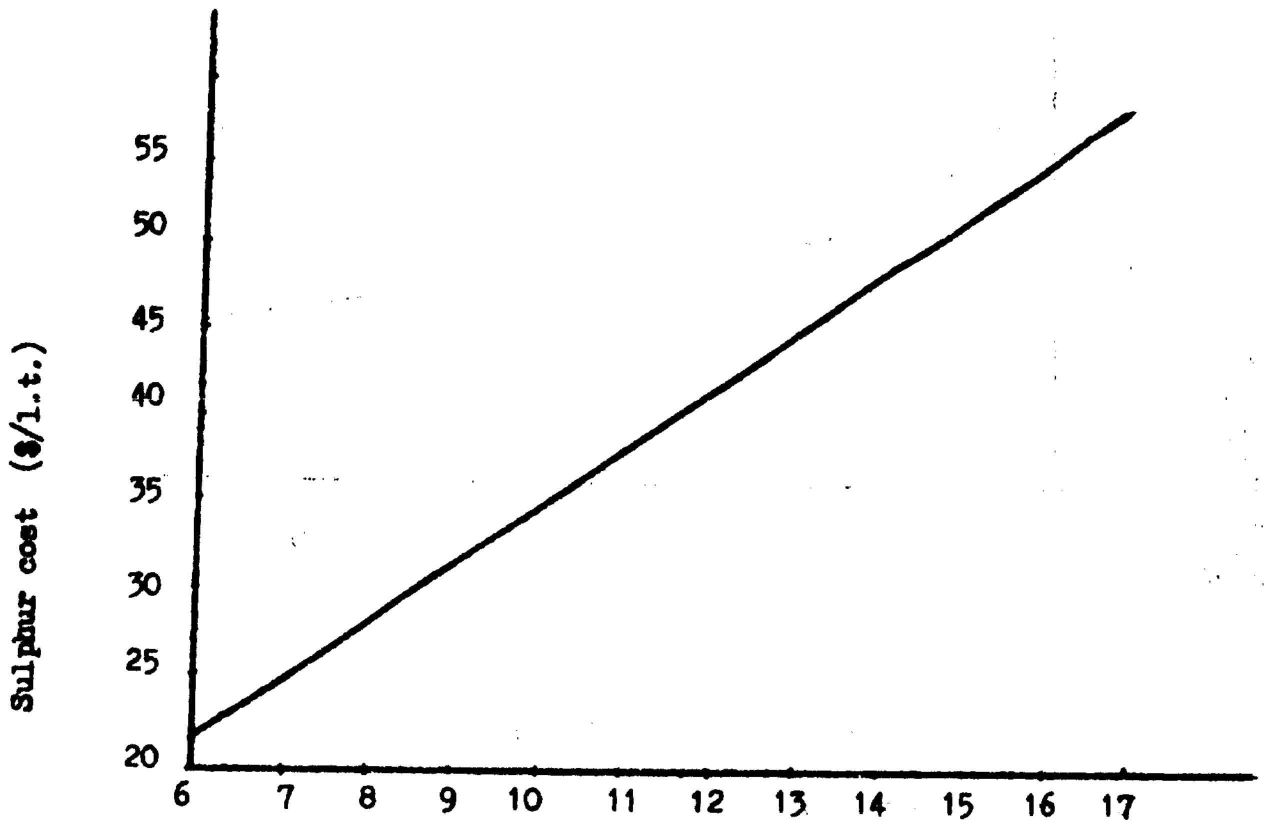
Plant capacity (00 st of 100% H_2SO_4/day)

Source: UN Fertilizer Manual.

But are directly responsive to changes in sulphur prices.

FIGURE 8

Sulphuric acid: Cost of sulphur in acid versus sulphur cost.



Sulphur portion of sulphuric acid cost
($/st of 100% H_2SO_4)

Source: UN Fertiliser Manual.

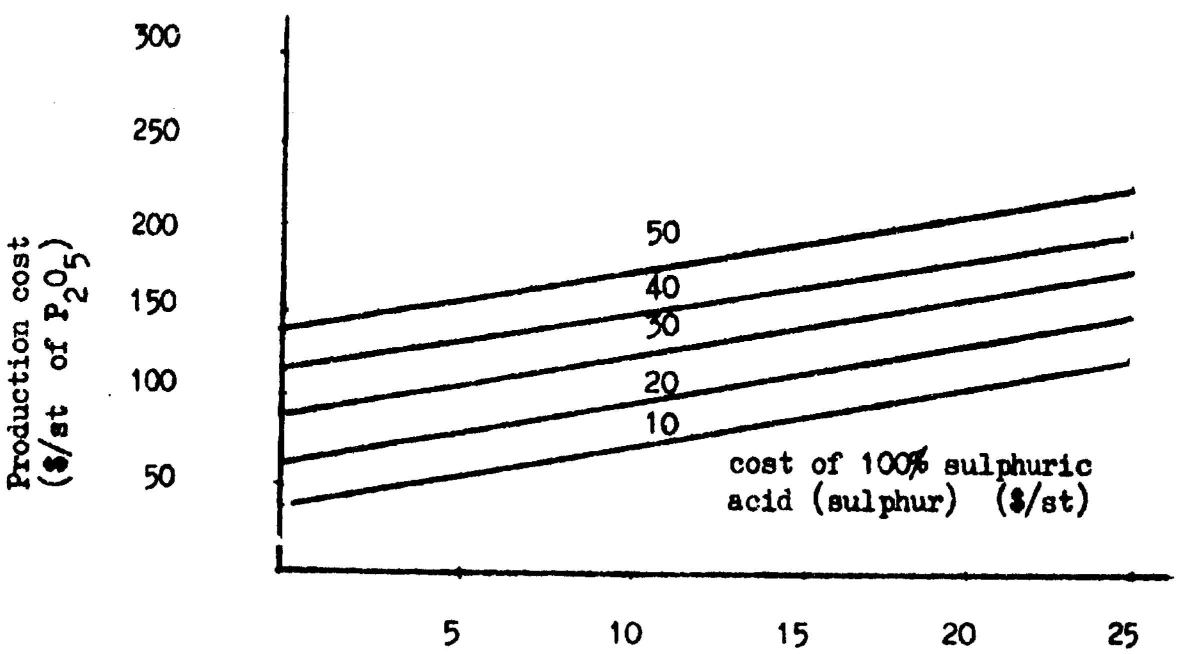
Changes in resources and/or product prices are evidenced directly in the variable unit costs. The greatest impact on variable costs is generated by fluctuations in the price of phosphate rock and sulphur. The influence of phosphate rock is felt most in the grass-roots industry where it is required at both the phosphoric acid and the TSP stages of production.

Unit production costs of phosphoric acid are related more to the price of phosphate rock than to the cost of producing sulphuric acid.

Phosphate rock makes up 54% of variable costs as opposed to sulphuric acid which comprises less than 42% of variable costs. (Assuming constant price ratios between phosphorus and sulphur).

FIGURE 9

Wet-process phosphoric acid (54% P_2O_5): production cost versus cost of phosphate at various sulphuric acid costs.



Cost of 66 bpl phosphate rock ($/st)

Source: UN Fertilizer Manual

On the other hand, TSP is least responsive to scale, even at low output ranges. However, production costs of TSP are related to changes in the price of (imported phosphoric acid and phosphate rock).

The major cost components of all three production stages are the costs of raw materials.

TABLE III

Raw material as a component of variable costs and total costs (50,000 output of TSP

Product	Raw material	% of variable costs	% of total costs
H_2SO_4	Sulphur	96	58
H_3PO_4	Phosphate rock	53	37
	Sulphuric acid	44	31
T S P	Phosphate rock	11	10
	Phosphoric acid	87	77

The price ratios of phosphate to sulphur is appropriate to countries importing raw material.

b) TERMINAL COSTS OF PHOSPHORIC ACID

A commitment to TSP production via phosphoric acid is likewise a commitment to additional storage and handling facilities. The tables indicate the unit costs per metric ton P_2O_5 of storage and handling. Similar storage and handling costs were calculated in other studies (e.g. TVA).

Exporters of phosphoric acid offer it cif. While trade of sulphur and phosphate rock is very often on fob basis. This eases supply arrangements for countries which import phosphoric acid.

TABLE IV

Terminal costs - phosphoric acid (69 T P_2O_5)

Production T S P	50,000	100,000	135,000
Phosphoric acid/annum	30,000	60,000	80,000
Cost ($) t. P_2O_5	5.-	3.5	3.-

Investment - $ 100,000.

Terminal costs include storage and handling in and out.

c) CONCLUSION OF INVESTMENT ANALYSIS WITHIN STAGE II.

The investment in plant and equipment is 4 times higher in the grass-roots process. Expansion costs are greatest in the grass-roots alternative given the commitment to sulphuric and phosphoric acid production.

Total variable costs are reduced in the intermediate goods industry by minimizing the requirement for raw materials. Furthermore, absolute fixed cost outlays can be minimized by producing TSP directly from phosphoric acid. The impact of resource price changes is most evident in the grass-roots process. The intermediate goods industry minimizes the risk (by minimizing the raw materials requirement) of unfavourable trends in unit cost - especially in the rapidly changing market of Stage II.

Investment in storage comprises about 40% of the capital committed to the production of TSP from imported phosphoric acid. Savings in investment can be further increased by constructing storage facilities as required by the growth in market demand. For example: it is possible to operate a plant with 45,000 mt capacity at half its designed output to match a market demand of 22,500.

Fixed costs are reduced by reducing the storage facilities needed to support such an output. The effective savings is almost 20% in plants producing at half capacity. Economies are realized via diminished operating costs and plant investment.

The savings in foreign exchange outflows is likewise evident when the following percentages are reviewed.

Of the total capital investment, 60% is for plant and equipment and 40% for storage. Of the 40% storage investment 60% is for building and 40% for machines. For the 60% in buildings, 50% is in local currency and 10% in foreign. For the 40% (machine outlay), 30% is in foreign currency and 10% in local.

2. THE CHARACTERISTICS OF FOREIGN EXCHANGE EXPENDITURE: THE STATIC MODEL

The following analysis of foreign exchange is a simplified version of a more complex dynamic model that will be presented in the lecture. Our presentation seeks here to demonstrate a method of analysis based on a number of simplifying assumptions. Later, we will release these assumptions and develop a complete method of dynamic investment analysis.

We adopted the following assumptions:-

1) Zero growth rate in consumption

2) Supply - one plant operates at full capacity, covering demand.

3) The analysis evinces the characteristics of foreign exchange at 6 different consumption levels, matched by plants of the same capacities.

4) Planning horizon is 15 years. (length of Stage II.)

5) Constant resource prices and foreign exchange rates. Furthermore, no changes in the cost of capital or the required return on investment are anticipated.

6) Constant yearly foreign exchange cash flows.

The foreign investment component is a constant percentage of the initial outlay in plant and equipment. Table V, traces the path and the spread of foreign exchange cash flows per Stage II capacities. The largest component of variable costs are raw materials and phosphoric acid. The foreign exchange (FEC) componen for sulphur, phosphate rock and phosphoric acid is 100%. Other inputs of variabl costs include power, (50% FEC) water (10% FEC) and fuel (90% FEC). However, the latter is less than 5% of total variable costs. The foreign exchange component of initial investment (at 10,000 TSP) is about 3 times higher in the grass-roots process. The initial advantage declines to 2.7 times at 135,000 mt TSP capacity The grass-roots alternative enjoys a net operating advantage. (Table V.)

The cost of phosphoric acid to the TSP production process accounts for its comparative operating disadvantage.

TABLE V.

THE FOREIGN EXCHANGE COMPONENTS OF INITIAL INVESTMENTS AND YEARLY OPERATING COSTS.

A STATIC COMPARISON

('000 $)

	10,000 A	10,000 B	50,000 A	50,000 B	100,000 A	100,000 B	135,000 A	135,000 B
1) Fixed capital inv.								
H_2SO_4)								
H_3PO_4)								
TSP)								
Total fixed inv.	2,510	700	6,300	1,943	9,600	3,223	11,700	4,100
Foreign exchange	1,757	490	4,410	1,360	6,720	2,286	8,190	2,870
2) Net	1,267		3,050		4,464		5,320	
Fixed costs								
3) Foreign exchange	283	64	696	155	1,045	232	1,262	283
Net	219		543		813		979	
4) **Variable costs**								
Foreign exchange								
Sulphur	93		475		949		1,259	
Phosphate rock	268	72	1,342	382	2,685	765	3,630	1,039
Phosphoric acid		442		2,210		4,420		5,960
Net		153		775		1,551		2,110
ADVANTAGE IN TOTAL OPERATING COST		66		232		738		1,131

A = Grass-root
B = Intermediate industry

1) Includes investment in plants, equipment and working capital.
2) Foreign exchange component is 70% of F.C.I. + W.C.
3) Foreign exchange component is 60% of fixed costs, or 12.9% of F.C.I. (not including W.C.)
4) Raw material or H_2PO_4 import = 100% foreign exchange outlay.

TABLE VI

Payback periods of G.R. vs. intermediate industry (F.E. Component)

Plant size	10	25	50	75	100	135
Payback period	100 + y.	100 + y.	100 + y.	11 y.	9 y.	6 y.

Table VI and Figure 10 demonstrate the payback period required for the G.R. to equal the present value of total outlay to that of the intermediate industry route.

The figure shows that at low capacity the payout period is much longer than the actual life of the plant. It becomes shorter with the increase of size.

FIGURE 10

Payback periods of G.R. vs. Intermediate (B) industry (F.E. Component)

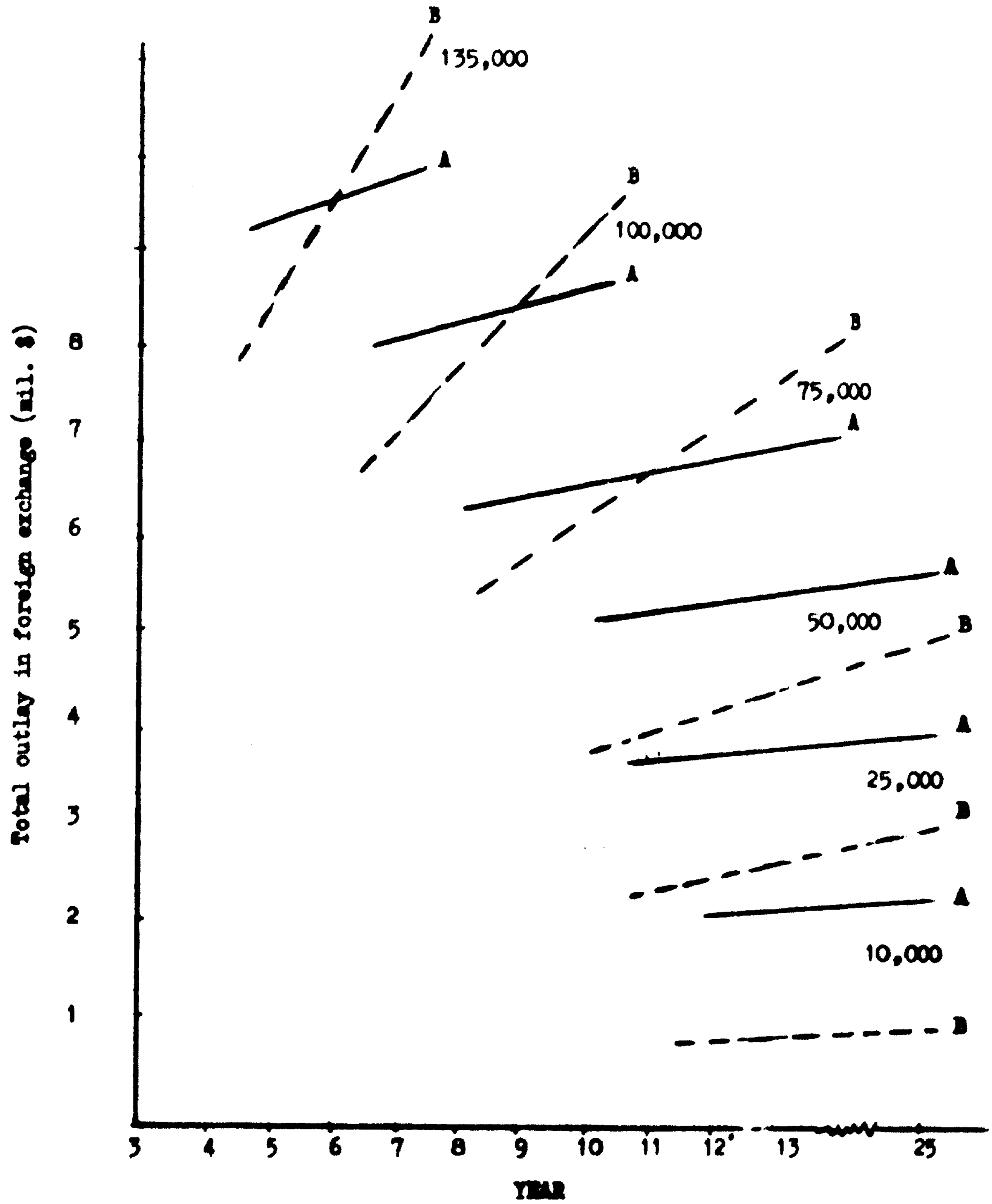


Table VII, shows total cost of production for triple superphosphate when all plants operate at full capacity.

The intermediate route enjoys an advantage in the total cost of production whic diminishes with increased capacity and loses its advantage at capacities greate than 100,000 tons.

The grass-roots industry enjoys an advantage in the foreign currency expenditur from 25,000 tons capacity.

Since production is often below installed capacity in the dynamic market the differences in total cost of production will still be greater, while the advant in foreign exchange expenditure enjoyed by the grass-roots operation, will be smaller and may be reversed.

TABLE VII

Cost of production of TSP

Plant capacities	Intermediate Cost of Production mt/TSP		Grass Roots Cost of Production mt/TSP	
	Unit	FEC	Unit	FEC
10,000	72.40	57.88	109.70	65.30
25,000	64.97	55.56	82.19	55.41
50,000	60.75	54.53	68.47	48.74
75,000	59.46	54.14	64.03	47.97
100,000	58.18	53.75	59.59	47.20
135,000	57.43	53.53	56.85	46.09

3. CONCLUSIONS OF THE STATIC MODEL

The static model above tends to confirm our hypothesis. It suggests that a production configuration operating in a stage II environment (assuming zero growth) will realize economies by operating as an intermediate's industry. Note that all plant sizes relative to the Stage II market 19,000 - 75,000 mt evidence savings in foreign exchange. Only at the upper limits of Stage II (lower range of Stage III) does the PV of foreign change expenditures break-even (given the grass roots option) at a time within the life of the project. This is as we would expect, for our theory recommends the grass roots alternative at output ranges characteristic of Stage II markets.

Therefore, we have demonstrated within our static framework, that the intermediate industry is the best possibility given the macro analysis of market growth and the micro analysis of investment alternatives.

The dynamic model presented in the next section designs a strategy for a growing market demand. Furthermore, the model in the section develops a mix of plant sizes at each year for 17 years. Comparisons are then drawn between the six alternatives of grass-roots and intermediate production.

II. THE DYNAMIC MODEL

A. DESCRIPTION OF THE DYNAMIC MODEL

1. THE STATIC MODEL REVIEWED

We have introduced a macro theory of investment strategy given the dynamics of market demand and a micro analysis of investment considering the components and the behaviour of foreign exchange. The micro analysis of the previous section compared the investment alternatives of grass-roots and intermediate processes in a zero growth market. The supply side of the market was assumed to be supported by either a single plant or a single complex. For example, if 100,000 mt TSP was demanded per year, then we compared a TSP plant of 100,000 mt TSP (importing H_3PO_4) to the grass-roots complex; A TSP plant capacity of 100,000 mt TSP, a phosphoric acid plant producing 64,000 mt H_3PO_4 and a sulphuric acid plant producing 92,000 mt H_2SO_4. In each case we assumed full capacity.

2. THE DYNAMIC MODEL

In this section we attempt to drop many of our static assumptions and link our micro methods of investment analysis to the dynamics of market growth. We present a comparison of three investment strategies, introducing the intermediate and (two) grass roots alternatives as a series of plant mixes through a TSP market growing at 15% per year. The analysis demonstrates first, that the three strategies are resonable (i.e. they closely follow market demand at low cost.) In addition, the conclusion of our analysis prove to be correct regardless of changes in our assumptions.

The working model is a series of investments in a Stage II market. It links our recommendation to import TSP in a Stage I market with our suggestion to integrate into grass-roots production at the onset of Stage III. It shows that there is a period of approximately 15 years (Stage II) where the optimal plant strategy is the intermediate configuration. By defining the least-cost options through this 15 year period, we, in effect, have defined (for this example) the upper and lower limits of a Stage II market.

This section seeks to show the comparative costs to the entire economy by selecting a least cost alternative from the strategies of grass-roots and intermediate production. The cash flows presented are total cash flows for the entire economy (Operating cost plus investment minus depreciation). Unit costs (of local and foreign exchange) include the costs of importation. Our calculations of expenditures and cash flows include the costs of operating at less than full capacity. Our analysis thus challenges the notion that savings on unit costs and foreign exchange outlays are mutually exclusive (as evidenced in our static presentation) It also refutes the theory that higher expenses (i.e. high unit costs) must be tolerated to save foreign currency.

Hence, the model demonstrates limits of Stage I and Stage III. It shows that by comparing the present values and unit costs of three strategies, the intermediate process enjoys the smallest present value of total investment and foreign exchange outflows. It further demonstrates not only the effectiveness of intermediate strategies, but also the existence of a Stage II phenomenon.

B. THE MARKET LIMITS OF STAGE II DEFINED

The lower limit of Stage II is not determined by the relative advantages of various plant sizes. Indeed, the low market consumption at bottom ranges of Stage II precludes comparative production analysises. Our definition of the Stage II lower boundry recognizes the minimal economic shipping costs of H_3PO_4 as the critical constraint. For our analysis, we have found that the costs of imported H_3PO_4 is not significantly related to the quantity purchased. Furthermore, the minimal economic shipping quantity (H_3PO_4) can be indirectly translated into a minimal plant size of TSP. The required output in the grass roots option of H_2SO_4 and H_3PO_4 is obviously directly related to the desired TSP capacity. Thus, the lower Stage II limit is a function of shipload quantities and storage. In our example, shipping and storage costs determine that 6 shiploads of 2000 metric tons (each) H_3PO_4 per year, plus the storage required to support the imported H_3PO_4, define a minimum plant size of 10,000 m.t. TSP per annum.

On the other hand, the upper limit of Stage II (by definition) is that locus of market growth where the alternative of grass roots production offers greater savings than the intermediate process. Had the grass-roots option been immediately successful, or had the break-even point of grass roots and intermediate production fallen shortly after the lower boundry, then our notion of a Stage II stra-tegy would hardly justify further consideration. However, both the static and dynamic models conclusively signal the existence of a 15 year Stage II market. Stated another way, (in our example) there exists at a 15% rate of growth, a Stage II market of consumption evolving from 10,000 m.t. TSP to approximately 100,000 m.t. TSP per annum.

C. THE STRATEGIES DEFINED

Our market strategy is designed to select three courses of action, two of which manifest the grass roots metnod of production. The first strategy is a combination of plants which are based entirely on the notion of employing H_3PO_4 to produce domestic TSP. The strategy closely matches the growth of market demand and plant capacity. At the same time it seeks to minimize total costs.

The strategy for the production of TSP from either imported or locally produced H_3PO_4 has intentionally been kept constant to serve as a common ground for comparing the next two grass-root alternatives.

The first strategy for grass roots production seeks to parallel the growth of TSP output (and demand) with the production of H_2SO_4 and H_3PO_4. Evidently, the first grass roots option adds acid plants in small increments, matching the 25,000 and 50,000 m.t. TSP additions in the strategy. The second grass roots option adds acid production later in Stage II., when TSP consumption is large enough to support the introduction of 75,000 m.t. (TSP) capacity.

Our choice of grass root strategies tests the extreme two cases of investing early in acid production as opposed to investing later, and in larger capacities.

Both these grass root options have been compared with the possibility of producing TSP from imported phosphoric acid. (The intermediate option).

Table VIII below summarizes yearly forecasted market demand, our three strategies, and yearly production capacities. Our replacement philosophy seeks to minimize the possibility of undercapacity (i.e. importing TSP) while, at the same time, providing for the least-cost method of matching demand and supply. Important factors matching output to consumption include: the lead times of construction, the progress towards full capacity, the normal life of acid and TSP plants, and the feasible size of plant increments

D. THE ASSUMPTIONS OF THIS MODEL

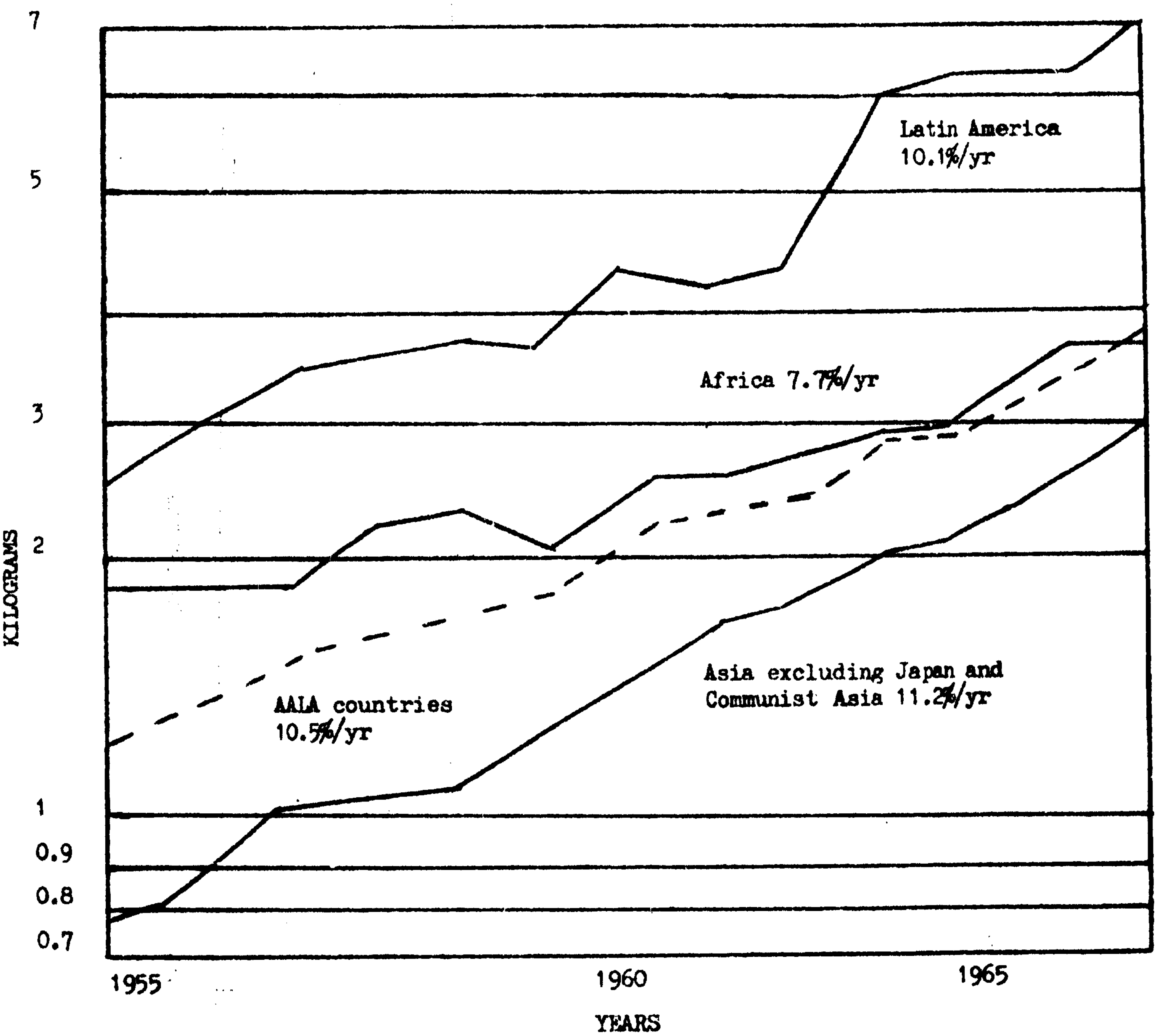
Our assumptions were made with three goals in mind. First, we attempted to simplify the mechanics of the model. Next, we attempted to match our computations with current economic realities and with studies that have been accomplished prior to this one. (Where the assumptions are critical, sources have been quoted in justification.) And finally, we attempted to minimize the changes in our conclusions as a result of changes in our assumptions. Furthermore, if at all possible, our model has selected the most conservative and realistic assumptions.

1. MARKET ASSUMPTIONS:

A market growing at the rate of 15% was used to demonstrate the best possible growth that can be expected for a developing nation. TVA publication "Estimated World Fertilizer Production Capacity as Related to Future Needs suggests that upper limit of market growth is usually no more than 10%. See figure However, in order to add to advantage of grass-roots production, we selected a higher rate of growth. Obviously the higher the rate of growth, the shorter the duration of a Stage II market and the weaker our argument is for intermediate production. Furthermore, we have assumed that the cost of importing sulphur, phosphate rock, and phosphoric acid will remain constant throughout the Stage II horizon. The cost of these resources were chosen to be \$130.- mt H_3PO_4, \$30.- c&f mt sulphur, and \$17.- c&f phosphate rock. (34% P_2O_5). Source:

FIGURE 10a

THE GROWTH OF FERTILIZER CONSUMPTION PER CAPITA - AALA COUNTRIES WITH 1960-67 TRENDS



YEAR No.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Total TSP consump. (product)	7,600	8,700	10,000	11,500	13,200	15,200	17,500	20,100	23,100	26,600	30,600	35,200	40,400	45,500	53,500	61,500	70,700	75,000
P_2O_5 requirement (content)			2,580	3,956	4,540	5,230	6,020	6,914	7,946	8,600	8,600	12,108	13,760	16,000	18,400	21,150	24,320	25,800
<u>H_3PO_4 req.</u>																		
Import at 69%			3,742	5,736	6,[illegible]83	7,583	8,729	10,025	11,522	12,470	12,470	17,557	19,952	23,200	26,680	30,[illegible]67	35,264	37,410
Local prod. at 54%			4,773	7,319	8,399	9,675	11,137	12,791	14,700	15,910	15,910	22,440	25,456	29,600	34,040	39,127	45,000	47,730
H_2SO_4 - s.t. H_3PO_4 51%			6,966	10,681	12,258	14,121	16,250	18,668	21,454	23,220	23,220	32,692	37,522	43,190	49,691	57,120	65,664	69,660
<u>T.S.P. Plant</u>																		
1. 25,000 T.P.A. (prod.)	Start 30% P.C.I.	Comp. 70% P.C.	30% c. 7500	11,500	13,200	15,200	17,500	20,100	23,100	25,000	25,000	25,000	20,200	closed down				
2. 25,000 T.P.A "										Start 30% P.C.I.	Compl. 70% P.C.I.	at 80% C. 10,200	20,200	25,000	13,500	[illegible]1,500	20,700	25,000
3. 50,000 T.P.A "												Start 30% P.C.I.	Compl. 70% P.C.I.	21,500	40,000	50,000	50,000	50,000
Import T.S.P. "	7,600	8,700	2,500							1,600	5,600							
<u>Option 2 for G.M.</u> H_3PO_4 & H_2SO_4 at 75,000 TSP											Start 30% P.C.I	Compl. 70% P.C.I.						
<u>Option 1 for G.M.</u>																		
H_3PO_4 & H_2SO_4 - s.t. No.1. TSP	Start 30% P.C.I	Compl 70% P.C.I	at 30% of cap.															
H_3PO_4 & H_2SO_4 - s.t No. 2. TSP										Start const.	Compl. const.	30% cap.		100% cap.				
H_3PO_4 & H_2SO_4 - s.t No. 3. TSP												Start const.	Compl. const.					

TABLE VIII. CONSUMPTION PATTERN OF 3 PRODUCTION STRATEGIES.

2. STRATEGY ASSUMPTIONS:

We have assumed that our plants produce only for domestic production, and that excess capacities are not exported if market demand should be less than productive ability. In addition, we have assumed that current excess capacity cannot be employed to produce products that will be stored for more than one year in order to satisfy future increases in demand. This, we feel, is a reasonable assumption given the difficulty and high cost of storing these products over long periods of time.

We have now brought new plans on line(anticipating the lead time for construction and capacity build-up) when market demand is approximately 80% of productive capacity. Where two plants of the same size are operating in a market unable to support the full capacity of both, total demand has been equally divided among the two plants. Where one plant is larger than the other, we have assumed the largest will produce at full capacity, while the smaller plants will produce at less than full capacity. Salvage values will not be computed into cash flows, for we assume that the cost to dismantle a plant is equal to the cash return from salvage. Depreciation is assumed to be a straight line. The minimum economically viable acid plant size is assumed to be 25,000 mt TSP equivalent. Start-up capacities are a function of experience with plants of this nature and the number of years of plant operation. The construction lead time is constant at two years for all plants and all capacities employed in this model. (Table IX).

TABLE IX: START UP CAPACITIES AS A % OF TOTAL CAPACITY

Plant Description	Years After the Completion of Construction				
	1	2	3	4	5
TSP					
25,000 Plant No. 1	30	70	80	90	100%
25,000 Plant No. 2	80	100%			
50,000	80	100%			
H_2SO_4 and H_3PO_4					
Plant No. 1	30	70	80	90	100%
Plant No. 2	80	100%			
75,000 Plant	80	100%			

The lead time of capacity to production is calculated by adding time for construction plus the time required to reach full capacity, such that actual production will equal 80% of market demand during the first year of operation.

The fixed investment cash flow is assumed to follow a constant outlay sequence: Working capital is expended 40% in the first year and 60% in the second year of construction. Investment cash flow is completed by 30% during the first year, and 70% in the remaining year. The foreign exchange component is assumed to be constant at all levels of capacity: At 70% (FEC) for both working capital and fixed investment. The foreign exchange percentage of fixed costs is 12.9% of the total fixed investment, or 60% of fixed costs.

Cash flows include the total outlay of cash for any particular period. The discount rate used is 9%, which we feel to be a reasonable cost of capital.

E. RESULTS OF THE DYNAMIC MODEL

The major comparisons were accomplished among the three options. The first compared the cash flows for 17 years; the second compared the expenses for that same period; and the third compared average costs. For each comparison foreign exchange expenditures were computed. In addition, both cash flows and expenses (including the foreign exchange components) were discounted at 9%. The results of this model are summarized in the following series of figures. Actual and discounted values are presented so that the reader can extrapolate additional conclusions for various rates.

1. CASH FLOW ANALYSIS

FIGURE 11:

A COMPARISON OF ACTUAL AND DISCOUNTED CASH FLOWS BETWEEN GRASS ROOTS OPTION ONE AND BETWEEN THE INTERMEDIATE STRATEGY

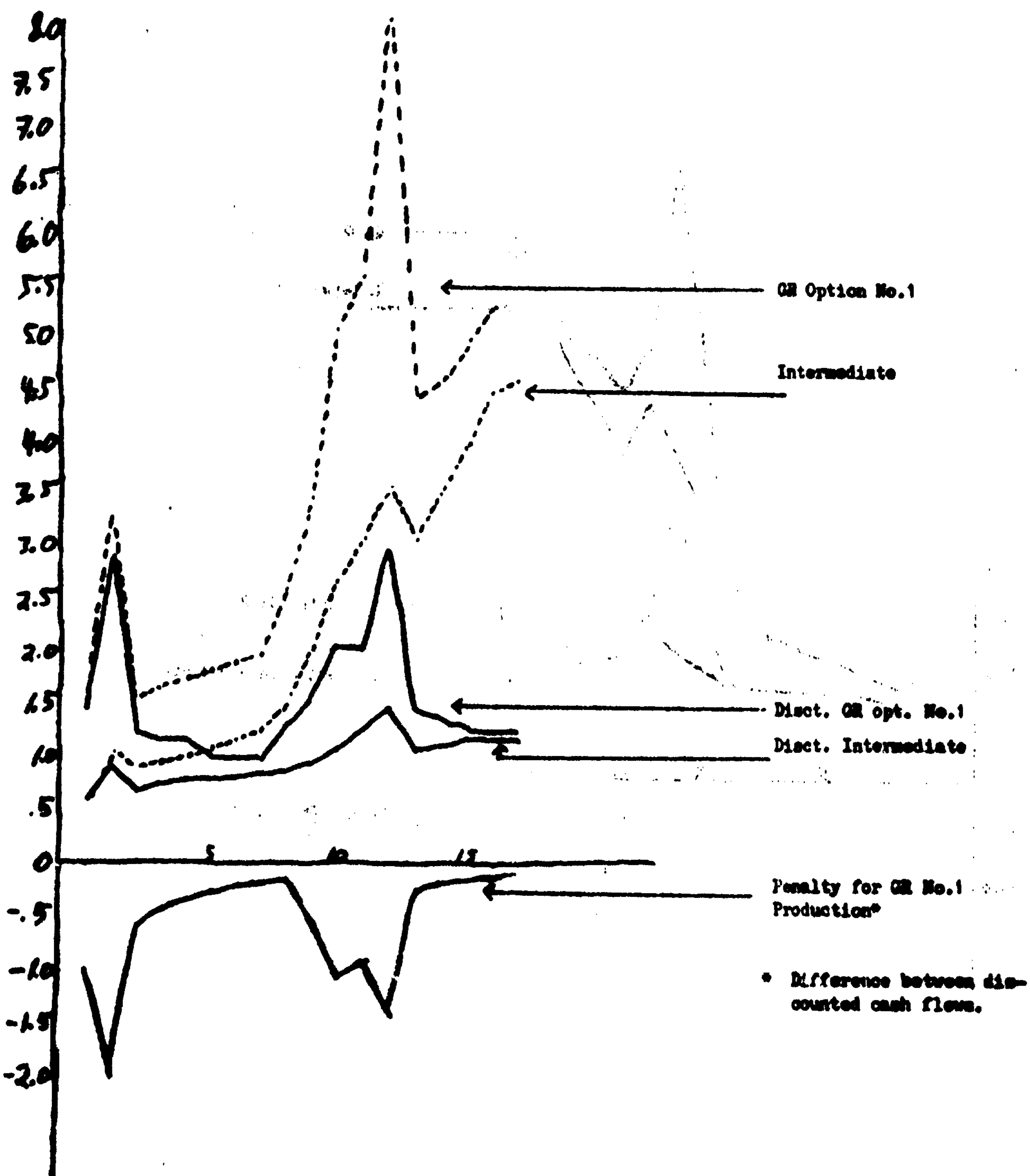


FIGURE 11a

A COMPARISON OF ACTUAL AND DISCOUNTED CASH FLOWS BETWEEN GRASS ROOTS OPTION TWO AND BETWEEN THE INTERMEDIATE STRATEGY.

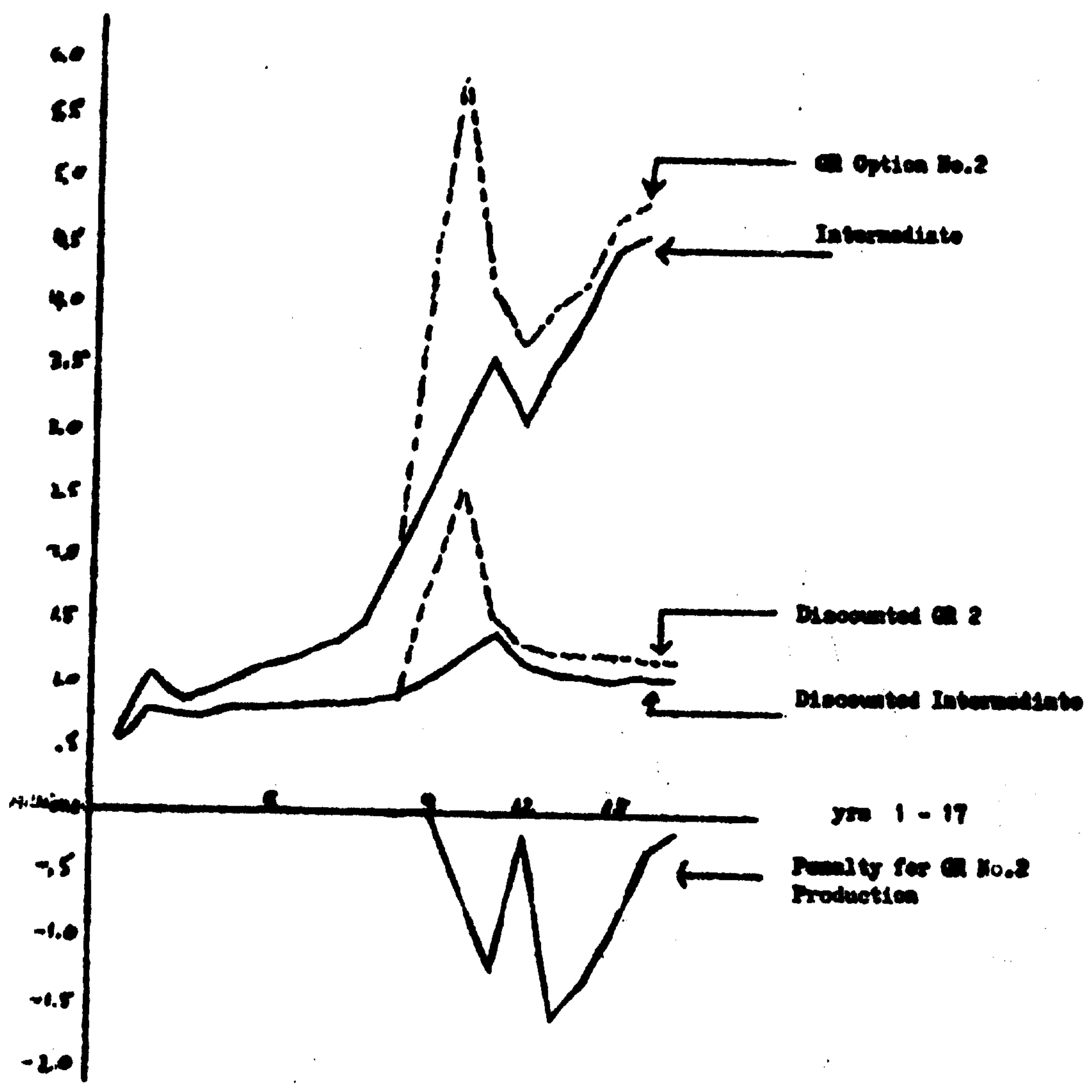
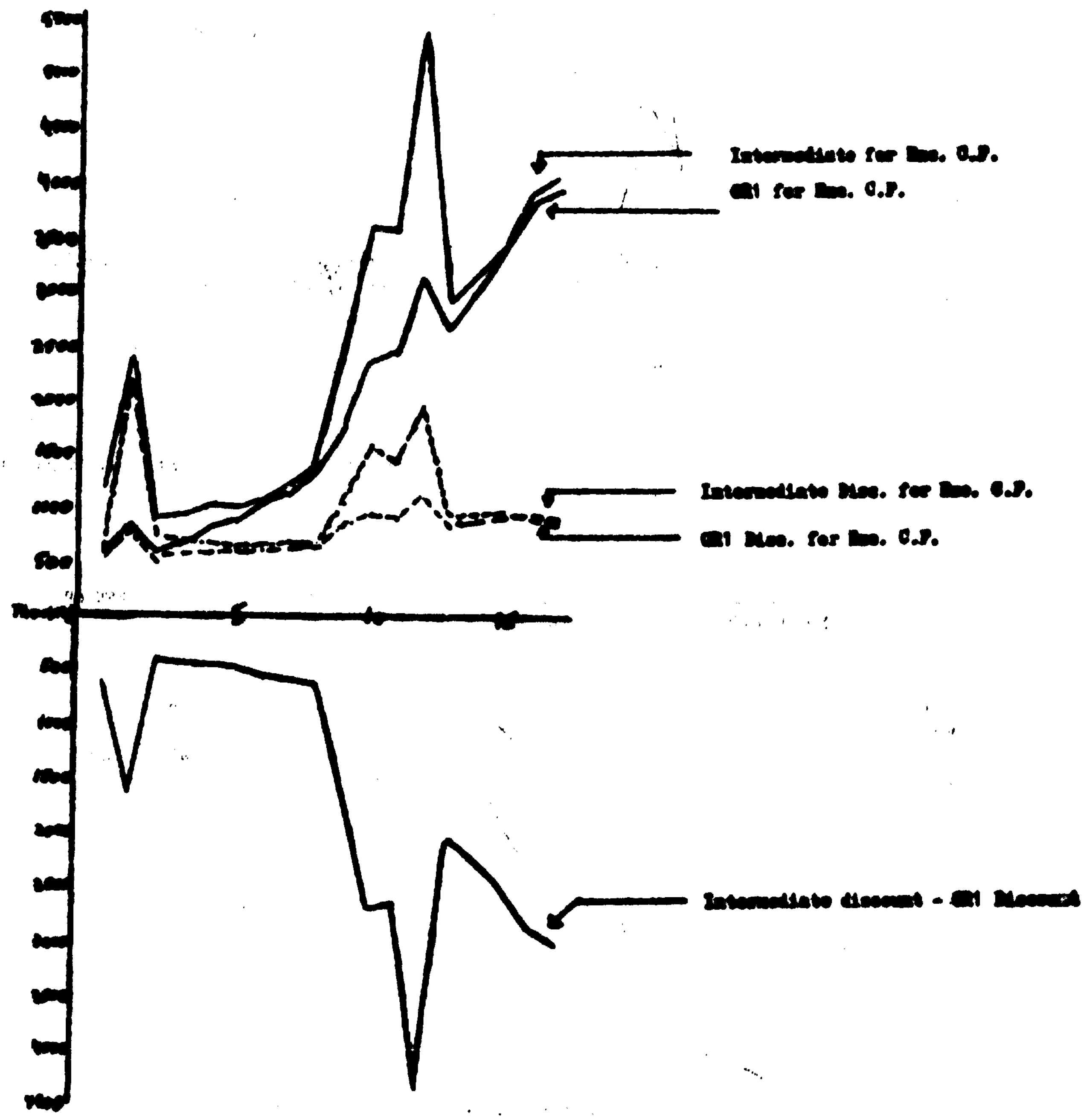


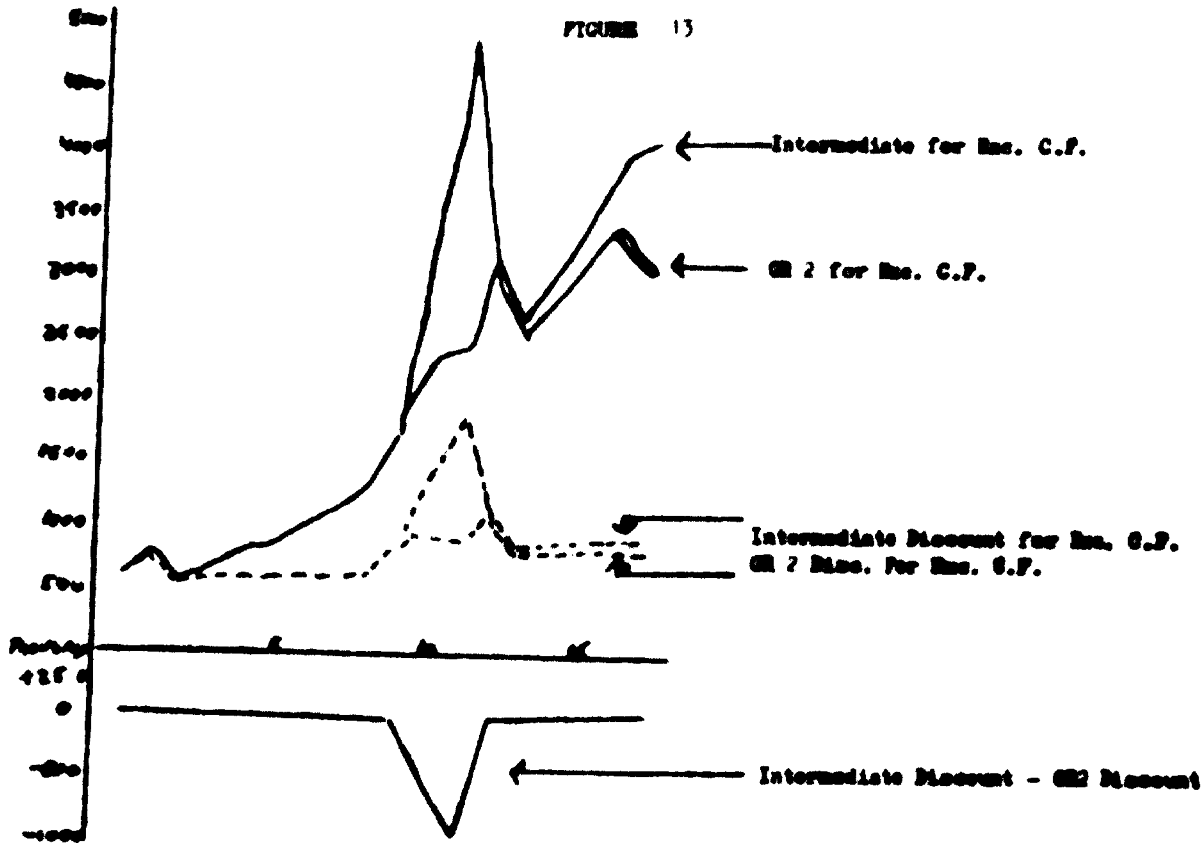
FIGURE: 12

A COMPARISON OF ACTUAL AND DISCOUNTED CASH FLOWS (FOREIGN EXCHANGE COMPONENT) BETWEEN GRASS ROOT. OPTION ONE AND THE INTERMEDIATE STRATEGY



A COMPARISON OF ACTUAL AND DISCOUNTED CASH FLOWS (FOREIGN EXCHANGE COMPONENT) BETWEEN OPTION TWO AND INTERMEDIATE STRATEGY.

FIGURE 13



2 EXPENSE ANALYSIS: A COMPARISON OF ACTUAL AND DISCOUNTED EXPENSES BETWEEN GR OPTION ONE AND BETWEEN THE INTERMEDIATE STRATEGY

FIGURE 14

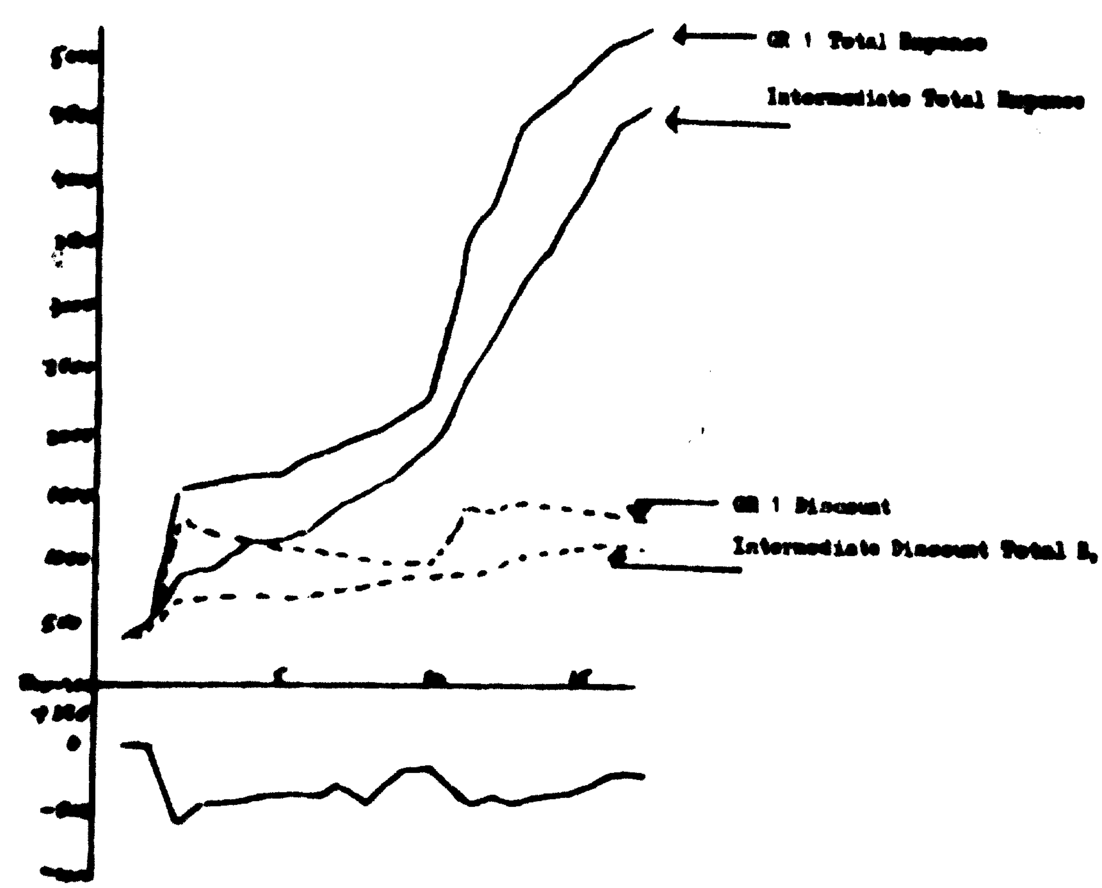


FIGURE 15:

A COMPARISON OF ACTUAL AND DISCOUNTED EXPENSES BETWEEN GR OPTION TWO AND BETWEEN THE INTERMEDIATE STRATEGY

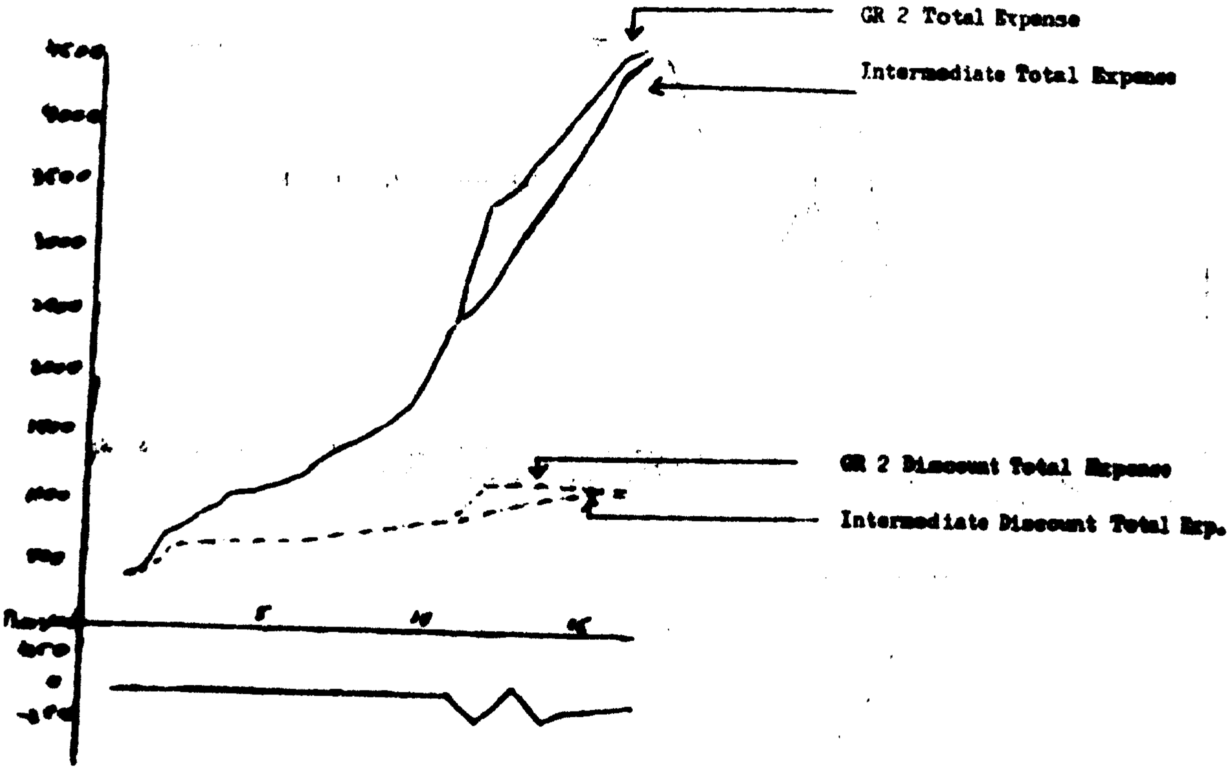


FIGURE 16:

A COMPARISON OF ACTUAL AND DISCOUNTED EXPENSES (FOREIGN EXCHANGE COMPONENT) BETWEEN GR OPTION ONE AND BETWEEN THE INTERMEDIATE STRATEGY

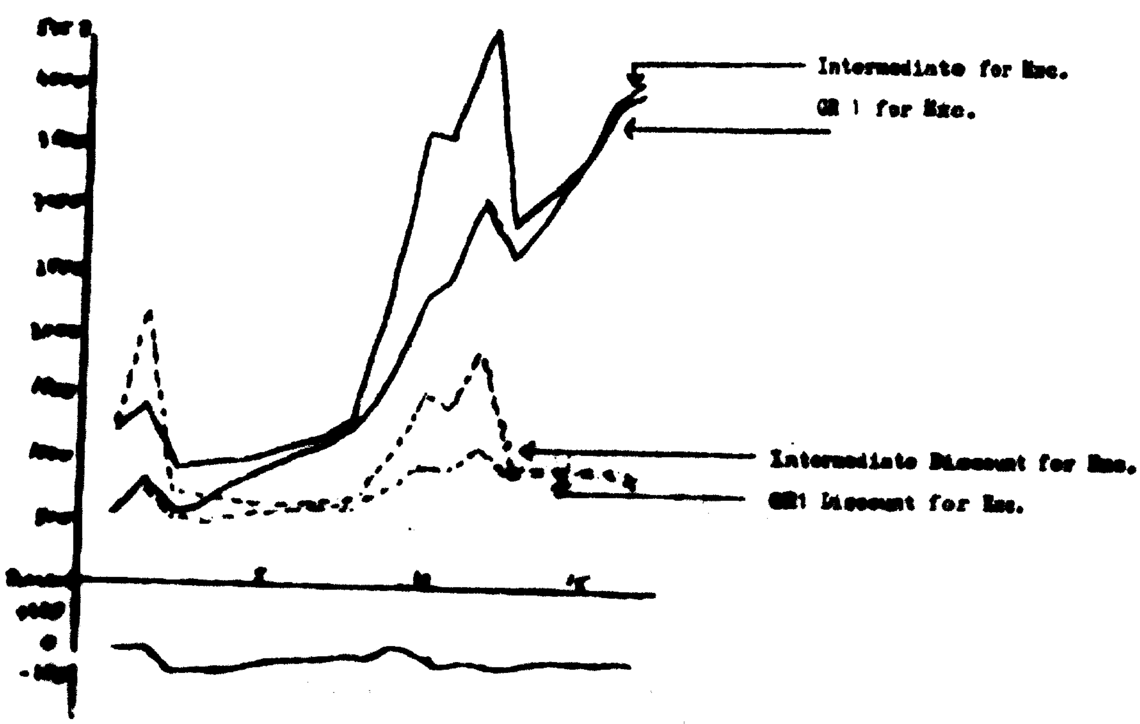
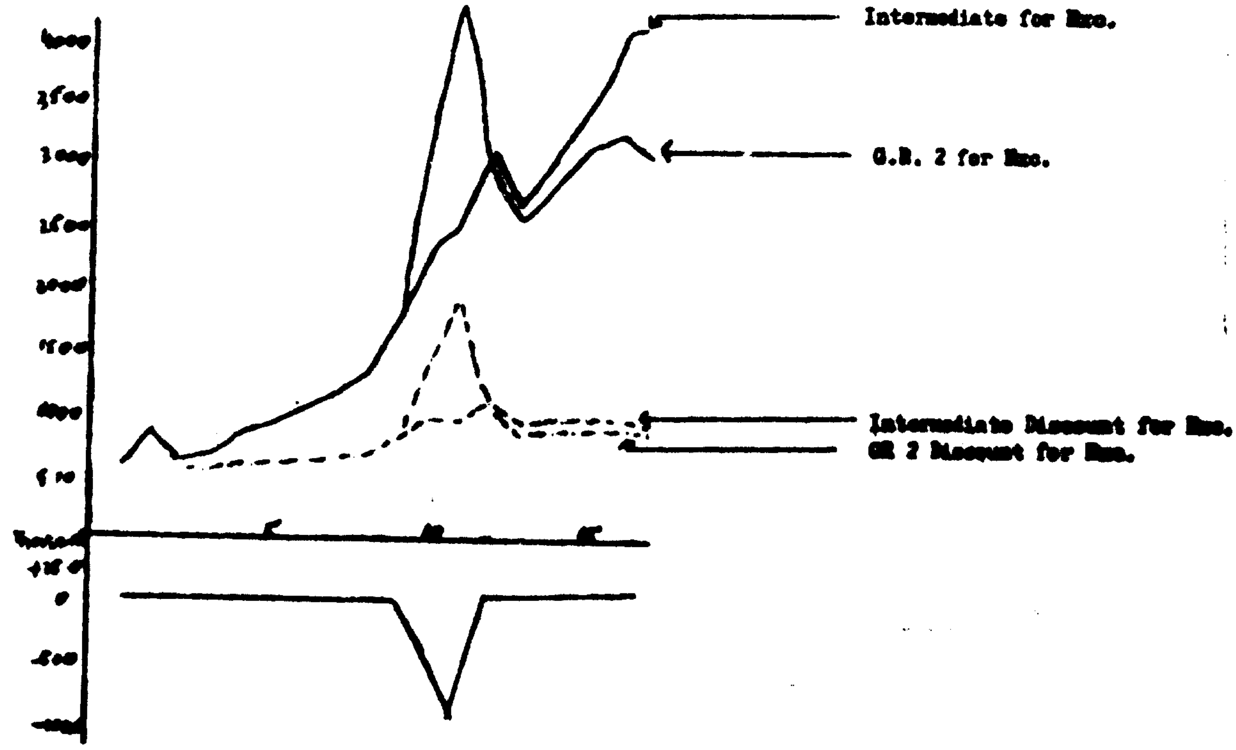


FIGURE: 17

A COMPARISON OF ACTUAL AND DISCOUNTED EXPENSES (FOREIGN EXCHANGE COMPONENT) BETWEEN GR OPTION TWO AND BETWEEN THE INTERMEDIATE STRATEGY.



3. AVERAGE COST ANALYSIS

AVERAGE COST COMPARISONS WERE LIKEWISE COMPUTED FOR FOREIGN EXCHANGE EXPENSES AND TOTAL EXPENSES.

FIGURE: 18

A COMPARISON OF AVERAGE COSTS BETWEEN ALL THREE INVESTMENT STRATEGIES

ACTUAL

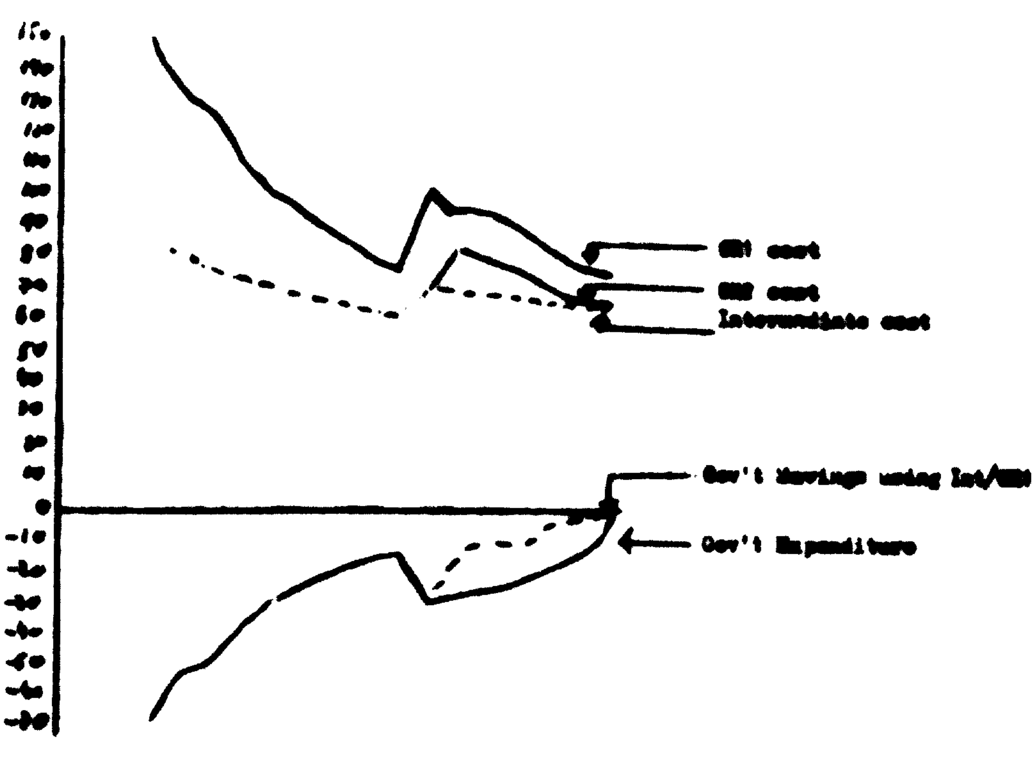
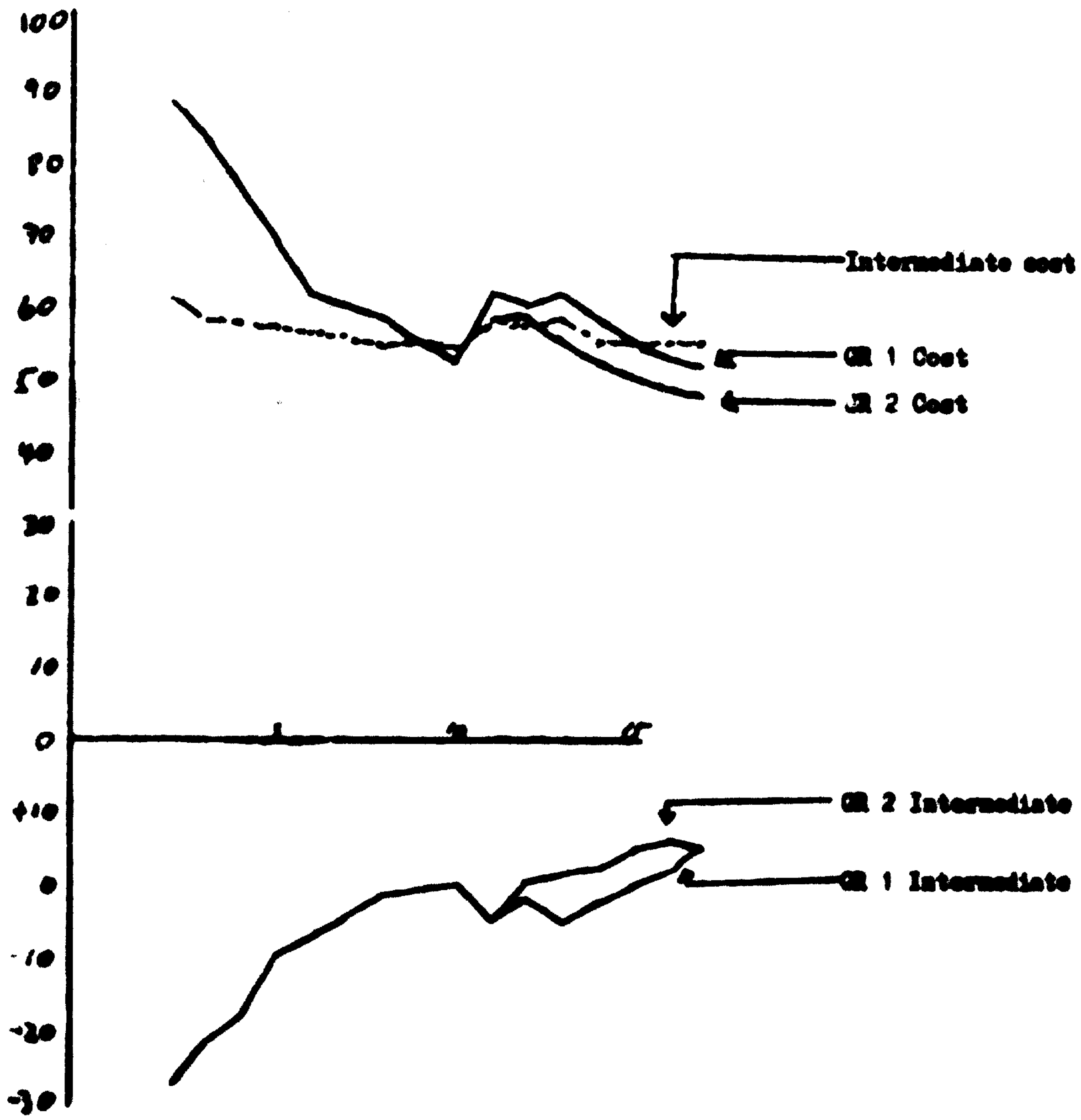


FIGURE 19:

A COMPARISON OF AVERAGE COSTS (FOREIGN EXCHANGE COMPONENT) BETWEEN ALL THREE STRATEGIES



G. CONCLUSIONS

The conclusions of this section reinforce the remarks that were made in our static model. However, the dynamics of market growth coupled with changing plant capacities (and industry configurations) adds further credence to our notion of a Stage II strategy. The table below Table 10 demonstrates that:

1. The intermediate process minimizes (substantially) the present value of total cash flows.

2. The intermediate process minimizes the present value of the foreign exchange component of total cash flows.

3. The intermediate option minimizes the average costs of foreign exchange and total (discounted) expenses. (Table 11)

TABLE 10: A SUMMARY COMPARISON OF PRESENT VALUES OF TOTAL CASH FLOWS AND EXPENSES BETWEEN THE THREE INVESTMENT STRATEGIES

Plant Description	Present Value of Total Cash Flows	Index	Present Value of the Foreign Exchange component of cash flows	Index
Intermediate Plant	16,892,500	100	13,969,800	100
Grass Roots Option 1	28,062,200	166	19,014,000	136
Grass Roots Option 2	19,062,650	115	14,893,500	106

TABLE 11: A COMPARISON OF PRESENT VALUES AND AVERAGE PRESENT VALUES OF TOTAL EXPENSES FOR THE THREE STRATEGIES

Industrial Strategy	Total Expenses Discounted	Total Expenses in Foreign Exchange Discounted
Intermediate	14,806,810	12,471,368
Grass Roots No.1	20,143,370	13,480,307
Grass Roots No.2	16,481,510	12,106,068

	Average Total Discounted Expense per Ton of TSP		Average Total Discounted Foreign Exchange Component per Ton of TSP	
		%		%
Intermediate	26.11	100	21.99	100
Grass Roots No. 2	27.30	104	21.35	97
Grass Roots No. 1	35.52	135	32.77	149

Total consumption of TSP in 17 years is 567,000 metric tons.

H. THE UTILITY OF A GENERAL WORKING MODEL

The primary purpose of our model is to demonstrate a theory of investment within the TSP industry. We have chosen, what we feel to be realistic examples as evidence of that theory. The model presented, is a general one - one that can be adapted to any specific market or industrial reality. How the reader employs this model is only a function of local political situations, local costs, and plant size options. We firmly believe that the dynamics of investment planning should be applied to other industrial sectors, and, as in the case of Triple-superphosphate, the intermediate options may prove to be the most successful.

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