

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE

FOR REFERENCE

NOT TO BE TAKEN FROM THIS ROOM

INTEGRATED PRODUCTION, INVENTORY, AND WORKFORCE PLANNING IN A

CERAMICS PLANT

Bogazici University Library



39001100541344

14

Fasih Öven

Submitted in partial fulfilment of the requirements for the
Degree of Master of Arts in the Faculty of
Industrial Administration School of
Business Administration and Economics

Robert College

1969

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE



124045

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE ii

ACKNOWLEDGEMENTS

The writer of this thesis is greatly indebted to Prof. Metin Göker for his invaluable advices and assistance during the course of preparation.

Also deserving special mention are Professors H. Tobey, Alper Orhon and Özer Ertuna with their precious ideas and criticism.

The author desires to express his gratitude to Mr. Rebi Gorbon, director and general manager of GORBON-IŞIL A.Ş. who has devoted his precious time and has helped at all stages of the study, and finally to Fatih Gorbon, Aziz Gorbon, who have properly undertaken their own shares of contribution.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 1

CONTENTS

Chapter		Page
I	INTRODUCTION	1
	Objectives of the Study	1
	Methodology	3
	A Brief History of the Firm	6
II	DEMAND	9
	Introduction	9
	Aggregate Demand for Tiles in Turkey	11
	Gorbon-İşıl's Market Share	21
III	DESCRIPTION OF THE EXISTING SYSTEM .	31
	Plant Location and Layout	31
	Organization of the Firm	33
	The Production Process	40
	Production Costs of the Firm	49
IV	PLANNING PRODUCTION, INVENTORY, AND WORKFORCE	55
	The Optimal Product Mix	56
	Aggregate Production, Workforce, and Inventory Planning	64
	Production Plan for October	73
	Production Control	77
V	CONCLUSION	81
	Recommendations	81
	Conclusion	83
	APPENDIX	86
	BIBLIOGRAPHY	93

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE

CHAPTER I

INTRODUCTION

Objectives of the Study

In this paper, an attempt has been made to develop a production plan using systems approach to the enterprise. Scientific programming techniques have been applied to a medium-size ceramics plant to show that these techniques lead to good results and that they can also be used by medium or small size companies.

Production Planning takes a given product or line of products and organizes in advance the manpower, materials, machines, and money required for a predetermined output in a given period of time.¹ Therefore, a production plan can be made only with the cooperation of production, personnel, sales, and finance departments because these departments must supply the data for capacities, manpower, demand, and costs.

Inventory planning must also be included into the scope of Production Planning. Sales and production rarely coincide, and most of the time one exceeds the other. In periods of low demand, goods are produced to be sold during periods of high demand where production can not meet the sales

¹Lawrence L. Bethel et al., Industrial Organization and Management (4th ed.; New York: McGraw-Hill Book Co., 1962), p. 152.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 2

requirements. Actually, a firm could adjust its production according to demand by employing an extra shift or overtime work during periods of high demand. When demand falls due to seasonal fluctuations, however, idle time will increase considerably. Such a practice could, of course, be too costly. Continuous hires and layoffs of labor are costly and are not favoured by the management because of labor grievances they can cause. Therefore, a production plan has to be made in order to organize these production factors beforehand.

Furthermore, if a company does not produce a single product but a line of products, the determination of the optimal product mix becomes necessary.

The reason of making a production plan is to achieve some predetermined objective, considering the environmental factors and the internal factors of the system such as manpower, machines, and raw material.

Currently few enterprises in Turkey use extensive production plans. Most of the companies develop a production plan which is based on past experience of their managers. So far, monopolistic conditions exist for most sectors of the industry so that most managers do not feel the pressure to apply improved methods of planning.

In companies, which face hard competition, still inefficient methods of production planning can be observed. This may be due to lack of knowledge or because of a belief

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 3

that scientific methods can only be applied in large-scale enterprises.

It must be admitted that scientific programming technique is not always the best method to use. For, there are many intangible factors affecting the production system and it is sometimes very difficult to express these intangible factors in mathematical terms. Therefore, often these factors are not included in the model. So, the model becomes a simplification of the actual state of nature.

Furthermore, a computer facilitates the use of mathematical models and Operations Research techniques. Especially in Turkey, where computers are not used extensively, these techniques can hardly be applied. One can hardly expect a medium size company, which does not have the financial means to acquire a computer for itself, to make use of these techniques, if real-time computer sharing is not exercised.

Methodology

This study was made through investigation in the plant and observation of the production processes. Reference has been made to literature related to this field.

The objective of a production plan may be anything the management decides upon. In this case the objective was to maximize the profits of the firm. Therefore, the data of costs, capacities, and sales have been found to make the production plan. After having the relevant data, a production plan was

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 4

made. Prior to this, however, the optimal product mix for the company under alternative capacities has been computed.

One of the main restraints affecting the production system, namely demand for the firm's products, is analysed in Chapter II. The analysis of demand was made in three steps. First, the estimate for constructional activities was taken; second, the amount of tiles used in various types of construction was found; and third, the market share of the company was determined. The demand for one year was found by this method. Then, based on past sales records of the company, seasonal indices were developed by taking the average of two years' monthly sales. Assuming that the sales mix of the company would not change, monthly sales figures for each product has been estimated.

In Chapter III the existing production system has been described. In the first section of this chapter the flow of information within the firm has been explained together with the formal organization of the firm. In the following section the production process is described. This section includes the operational characteristics and the time standards of the production system. The time standards have been approximately computed by making time studies in the plant and by past production records from which the rate of output for each production center was deduced. In the next part of this chapter the determination of the capacities of each production

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 5

center has been explained. Again, use of past production data and time standards were used to find the capacities. The last section of this chapter deals with the operating costs of the firm. Actual costs of production have been used to determine the costs of the operating units. In cases of variable overhead costs, allocations were based on estimates of the management and were revised by using available reports.

Chapter IV starts with the determination of the optimal product mix through Linear Programming techniques. This technique is not the only method to determine the most profitable product mix. As its name reveals, Linear Programming applies where linear relations between variables exist. For non-linear cost behaviour Convex Programming, which is an approximation to non-linear functions, would yield better results. The application of Linear Programming where the requirements of linearity is not met, misleading and even quite wrong results may be obtained. In this particular analysis, however, the linear behaviour of the variables constituted an ideal basis for the application of Linear Programming techniques. As the objective of the company was to maximize profits, an objective function with the products as variables was set up and maximized. The restraints were the production capacity of the system and the demand. A range of demand for each product was set by consulting the management about the sales mix. Alternative capacities were introduced to the

model and the most profitable product mixes for these alternatives were found. In the following section a monthly production schedule has been worked out, again by building a mathematical model and applying Linear Programming techniques. The last section of this chapter covers the topic of Production Control. In this part routing, dispatching, and follow-up have been designed to enable the management to have a more effective system of control.

In the last chapter recommendations which are to improve the system and the conclusions are made.

Data for the analysis were obtained from:

1. Financial Statements and Production Reports of the Company.
2. Investigations made in the Plant.
3. Previous Research made in this field.
4. Publications containing relevant information.

As the reports and statements used by the firm are not extensive, the data derived thereof were tried to be made as accurate as possible by consulting the management and responsible persons.

A Brief History of the Firm

Gorbon Seramik has been founded in 1958 as a private company to produce ceramics used in households and artistic ceramics. Its production capacity at that time was 167 kg per day. In the following years, however, the demand for the company's products was lower than expected, which forced the

company to operate under lower expected profits.

During the same period, the management decided to increase the production facilities in order to produce tiles for which there was a very high demand. At that time tiles were produced only by Eczacıbaşı, though much less than the actual demand. The residual of the demand was met through imports. Due to shortages of foreign exchange, imports were below desired level which, as a consequence, pushed the prices up. Tiles were sold in the black market for 1.60 T.L. per unit. After making an investment analysis the management found good profits in producing tiles.

In the meantime, the status of the firm had been changed and a corporation was founded under the name of Gorbón-Işıl A.Ş. with a capital stock of 3,000,000 T.L. By the end of 1966 the new facilities started to operate. In 1967 regular tile production had started. By that time another firm, Çanakkale Seramik, had been founded to produce tiles with a planned capacity to meet Turkey's demand by itself. Shortly after, another enterprise, Bozöyük started to operate with an estimated capacity of 12 million tiles per year. The competition of these two companies forced the prices to the current level of 1.10 T.L. per standard white tile.

The unanticipated decrease in price, however, made great impact on company expectations and as a result the profits for 1967 and 1968 turned out to be lower than expected.

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 8

Furthermore, the company has experienced difficulties in production. Occasionally the rate of defectives had been as high as 40 % whereas the average rate of defectives for the industry varies between 18 and 20 %. This high rate of defectives caused for lower output, more labor, and higher costs. The amount of first quality tiles had also been only 40 % versus 60 % second quality tiles. This technical problem has been solved by improving the presses and furnaces. Currently the rate of defectives is about 16 % and the percentage of first quality tiles to total production is 50 %.

* Currently more emphasis is given to ceramics products rather than tiles because the sale of ceramics require less effort, the terms of collection are more favourable, and finally because it is more profitable.

* During and after the new investment was undertaken, the company has experienced organizational difficulties. Until recently no clear line of authority and/or responsibility had been established.

* The channels of information were to a great extent informal and oral communication was used. No formal production planning had been practiced. The plant has always operated at full capacity, sometimes building up excess inventories. The practice of not using an optimal inventory policy, both for materials and finished goods, has caused customer rejection although high inventories were held.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 9

CHAPTER II

DEMAND

Introduction

Two major restrictions may be set to a production system. The first restriction is the capacity of the system itself. The other restriction may be regarded as an external restraint affecting the system indirectly. This restraint is the demand. To make a more precise statement, this restraint would be defined as the demand plus the level of inventories the firm wants to keep. The restraint of demand may decrease the optimality of the production system. To optimize the whole system, which is the firm in this case, suboptimization in the subsystems must occur. Therefore, the demand for the firm's products, which may have the effect of suboptimization, becomes a vital part of this analysis.

In this Chapter two main approaches were used to forecast the demand for the products of the company. One approach has been to forecast the demand by making a regression analysis between the company sales and constructional activities in Turkey, because tiles are only used in buildings. This particular analysis, however, did not give satisfactory results.

The second approach has been to estimate the aggregate

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 10

demand for tiles in Turkey, and to deduce the demand for the company's tiles by determining its market share.

It is apparent that the consumption of tiles depend on construction activities. Therefore, a forecast for tiles can be made only if the construction activities for that year are known. The first step then, was to determine the construction activities. A regression analysis was carried out between GNP and construction. The analysis revealed a significant result which was expected. But the forecast for tiles which was derived from the above analysis was not a good estimate. Therefore, the construction activities estimated in the Five Years' Development Plan were used in the analysis. Having the estimate for construction, there remained to find a relation between construction and the consumption of tiles to arrive at the aggregate demand for tiles in Turkey.

Based on past data, figures were derived as to how many tiles may be installed in various types of construction. Combining these figures with the estimated construction activities, the aggregate demand was found.

The market share of the company has been computed based on its share of total production because the yearly sales figure of the industry were not available.

Currently there is a high demand for other ceramics products. A forecast of demand for ceramics could not be done because of the variety of products involved, which appeal to

different markets. Therefore, considering the increasing demand for the company's ceramics products, an assumption has been made that the firm can sell all it produces.

Aggregate Demand for Tiles in Turkey

Historical Background

Until the production of tiles started in Turkey, demand was met through imports and it cannot be argued that imports and demand coincided. Rather, imports have been less than demand, for this can easily evidenced from the increase in the supply of tiles since 1960. The above statement can be supported by the fact that until 1966, in spite of the increase in the supply, tiles were sold in the black market.

TABLE 1

SUPPLY OF TILES IN TURKEY (IN THOUSAND UNITS)

Year	Imports	Production	Total Supply
1960	5,400	1,552	6,952
1961	10,044	6,633	16,677
1962	1,744	18,791	20,535
1963	7,008	23,604	30,612
1964	3,004	41,000	44,004
1965	156	36,000	36,156
1966	-	37,300	37,300
1967	-	51,300	51,300
1968	-	64,000 ¹	64,000

¹This figure is estimated by the Chamber of Industry in Istanbul.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 12

As can be seen in Table 1, demand was met through both local production and imports. Local production was started in 1958 by Eczacıbaşı Seramik Fabrikaları, and they have produced about 2.6 million units between 1958 and 1960. This enterprise stopped producing tiles in 1962. In 1961 Çanakkale Seramik İşletmesi started to produce tiles with an initial capacity of 25 million units per year. In the same year, the imports of tiles were abolished with the amendment of the Seventh Quota on July 4, 1961.¹

Notwithstanding, due to loopholes in the Law, imports have continued, though with a decreasing rate until 1965. Between 1961 and 1966 Çanakkale Seramik Fabrikaları was exercising monopoly power in the market for tiles, and in order to meet the orders, they had increased their production capacity to 60 million units per year. In 1966, however, two other enterprises, namely Bozöyük İşletmesi and Gorbun-İşıl A.Ş. have started to produce tiles with capacities of 12 million units per year and 6.4 million units per year respectively. Today the aggregate capacity of the industry adds up to 78.4 million units per year. In 1967 and in 1968 supply has exceeded the demand although all three plants were operating below full capacity. The finished goods inventory of the industry could not be obtained. The executives of the industry, however,

¹T.C. Resmi Gazete, 7. Kota ile ilgili ithalat Rejimi, 4 Temmuz 1961, Sayı: 10345

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 1

estimate the inventory at the end of 1968 to be between ten and twelve million units.

The sales price for tiles has been 120 kuruş per unit for first quality white tiles until early 1967. During 1967, in order to compete with Çanakkale Seramik İşletmesi, Bozöyük has decreased the prices so that the same product sells for 94 kuruş per unit.

Until late 1966, Çanakkale Seramik İşletmesi exercised monopoly in the production of tiles. In early 1967, with the entry of two other firms an oligopoly was established.

Before starting production, Bozöyük İşletmesi declared a price reduction for its products. This price decrease, which was about 20%, was a surprise for the other two firms who were favoring higher sales prices, although they had lower costs of production.

The price reduction has been immediately followed by Çanakkale Seramik Fabrikası and Gorbon-Işıl Seramik A.Ş. , and as a consequence, these two firms experienced lower incomes than they had expected during the following years.

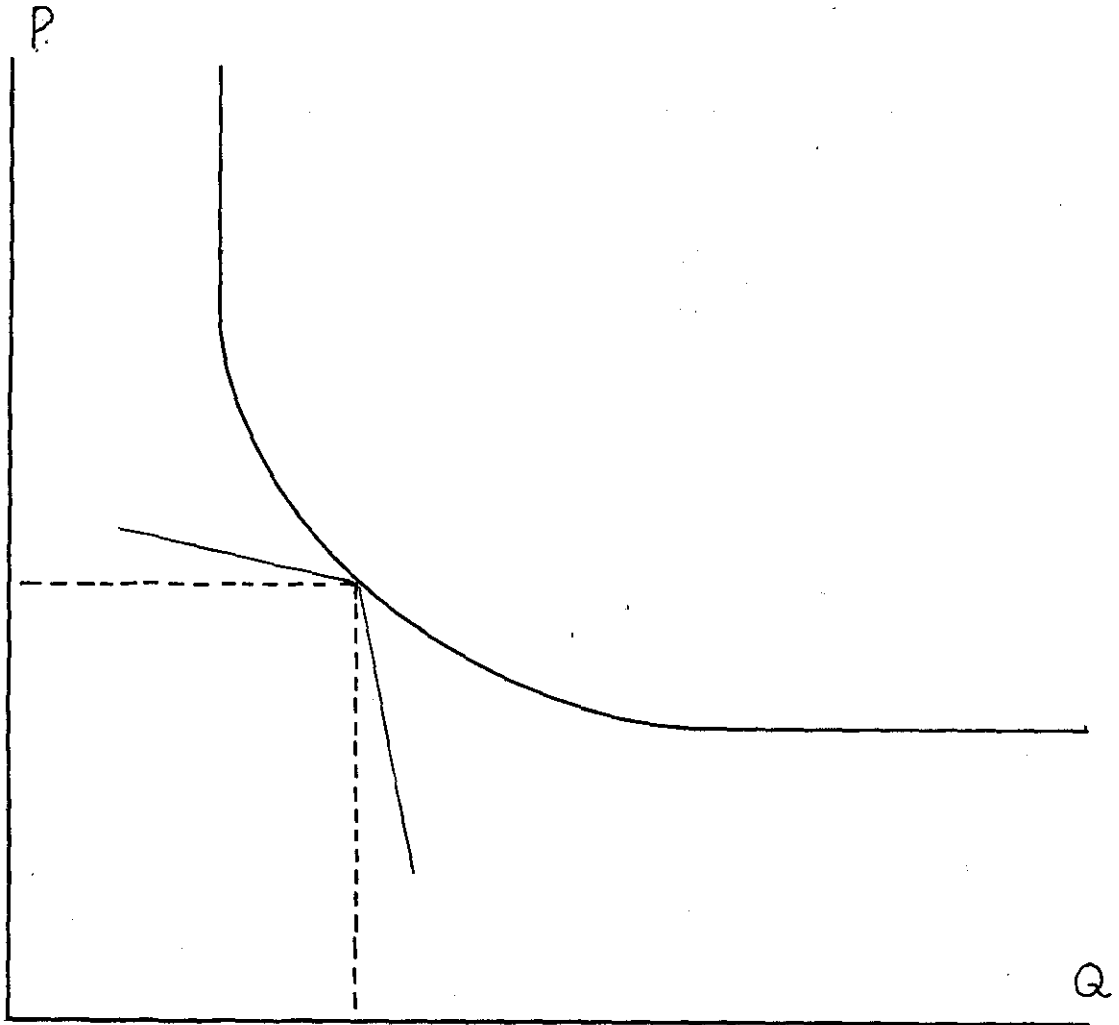
Observing that lowering the prices also decreased their profits, the firms in the industry concentrated their competitive actions on improving the quality of their products, granting better terms of credit to their customers, improving their sales organizations, and introducing new products to the market.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 1

THE DEMAND CURVE OF A FIRM IN THE INDUSTRY



Currently, the executives of the industry do not have any intentions of changing the established prices because they believe that they are facing a very kinked demand curve. If one of the firms would decrease the price of its products, the other firms would immediately adjust their prices accordingly, as it had been observed in 1966. On the other hand, if one firm would increase its prices, the other two firms would not necessarily follow the price increase. As a consequence, the firm which increases the prices will experience a loss in its market share. Therefore, a price increase can only occur if all three producers would collude, which seems to be quite unlikely for the present.

Furthermore, Gorbon-İşıl and Çanakkale Seramik do not have any intentions of decreasing the prices on a standard product for which there is an established market price. Bozöyük, on the other hand, would not attempt to decrease the prices for a second time because it has very high costs of production compared with the other two firms.¹

Forecast of Demand

Tiles are used in houses and apartments to cover the interior walls of the kitchens, bathrooms, and certain other

¹Ermukan Şengezer, İnce Seramik Sanayii İç Piyasa Etüdü, Türkiye Sınai Kalkınma Bankası A.Ş., İstanbul, Temmuz 1966, p. 27

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 16

surfaces. Furthermore, tiles are also used in laboratories, restaurants, hospitals, and other buildings. We can, therefore, safely assume that a close relation exists between the demand for tiles and construction. In order to determine the demand for tiles, a forecast for constructional activities becomes necessary. Construction, being a component of GNP, must vary according to changes in GNP. To verify this statement, a regression analysis has been carried out to test the correlation between National Income per capita, per capita GNP, and GNP versus construction. In the analysis, fourteen periods, the years between 1954 and 1967 have been considered.

TABLE II

GNP, NATIONAL INCOME, AND
CONSTRUCTION IN TURKEY

Year	per capita GNP (T.L.)	National Income per capita (TL)	GNP (billion T.L.)	Construction (in 1000 m ²)
1954	670	631	14.8	6,965
1955	875	757	18.2	6,898
1956	982	856	21.2	6,479
1957	1,197	1,044	27.4	6,940
1958	1,467	1,291	33.9	7,670
1959	1,767	1,545	41.8	6,546
1960	1,836	1,598	44.4	6,602
1961	1,888	1,636	46.5	6,681
1962	2,068	1,786	52.1	7,848
1963	2,310	1,994	59.6	7,719
1964	2,423	2,086	63.9	8,500
1965	2,541	2,177	68.3	10,907
1966	2,871	2,457	79.1	12,559
1967	3,141	2,655	87.7	12,728

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 17

The analysis revealed a correlation coefficient of 0.95 at 1 % level of significance, the coefficient of regression being 101,975.98. The growth rate of GNP was taken as 7 % per year as stated in the Five Years' Development Plan. Accordingly, the GNP for 1969 is estimated to be 101.3 billion T.L.. Based on the estimate of GNP for 1969, a forecast for construction has been carried out as follows:

$$Y = A + BX$$

where,

A = Construction in 1954

B = Coefficient of Regression

X = GNP 1969 - GNP 1954

Y = Construction in 1969

$$\begin{aligned} Y &= (101.3 - 14.8) \times 101,975.98 + 6,965,000 \\ &= 15,785,922 \text{ m}^2 \end{aligned}$$

Having obtained a construction forecast in terms of square meters for 1969, it still remains to find out how many tiles will be used in one square meter of construction.

Based on technical measurements, the use of tiles vary between 10 % and 25 % of area constructed as residences. Apartment houses consume on the average 7.99 tiles per square meters, houses consume 36 % of the amount, and other buildings 13 % of the amount or 2.88 and 1.12 tiles per square meter respectively. Furthermore, 81 % of the buildings are made of reinforced concrete, whereas 19 % is made of other materials.

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 1

Apartments, being multi-storey buildings, must be made of concrete. Commercial, industrial, and other larger buildings, being in cities, can also be assumed to be made concrete. Therefore, other materials are used for the building of houses¹.

TABLE 3

COMPUTATION OF TILE CONSUMPTION FOR
VARIOUS TYPES OF CONSTRUCTION

Type	(1) Concrete Build. (1000 m ²)	(2) Coef. of Consumption	(1) x (2)
Apartment	13,214	x	13,214 x
Houses	5,563	0.36 x	2,002 x
Other	9,388	0.13 x	1,220 x
Total	28,165	. .	16,436 x

During the same period 131,307 tiles have been consumed. Therefore, x would be equal to 7.99 tiles per square meter.

The average of construction figures of 1965, 1966, and 1967 revealed that 41 % of construction (in terms of m²) consisted of apartments, 33 % consisted of houses, and 26 % of total construction was built for other purposes. As indicated previously, 19 % of construction, mainly houses, do not use tiles. Therefore, only houses that cover 14 % of total construction area use tiles¹.

The distribution of constructional activities using

¹loc. cit., Şengezer

tiles according to various types of buildings is shown in Table 4.

TABLE 4

ESTIMATED CONCRETE CONSTRUCTION
IN TURKEY FOR 1969

Type	m ²
Apartments	6,472,228
Houses	2,210,029
Other	4,104,340

The demand for tiles is computed according to tile consumption per square meter in these types of buildings.

TABLE 5

ESTIMATED DEMAND FOR TILES IN 1969

Type	No. of Tiles
Apartments	51,713,102
Houses	6,364,884
Other	4,596,861
Total	62,674,847

In this forecast the estimated construction is 9 % higher than the estimate in the Second Five Years' Development Plan. The result reveals that both construction and demand for tiles have been overestimated. The executives of the industry do not believe the demand to be as high as 63 million units for 1969. Another reason for not using this analysis is the magnitude of the standard errors. The standard error of the estimate was 745,558 so that at a

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 20

confidence interval of 95 % or two standard deviations, the forecasted demand for tiles would lie in a region of ± 9.45 %, which makes the analysis inaccurate.

Another forecast has been made by taking the projected figures for construction, which is 14,637,500 m², from the Second Five Years' Development Plan. Based on this figure, the same method has been applied to find the demand for tiles. The distribution of construction using tiles according to various types of buildings and the demand for tiles is shown in Table 6.

TABLE 6
CONCRETE CONSTRUCTION AND DEMAND FOR
TILES IN 1969

Type	m ²	Tiles (units)
Apartments	6,001,375	47,950,986
Houses	2,049,250	5,901,840
Other	3,805,750	4,262,440
Total	11,856,375	58,115,266

The demand for tiles in 1969 is estimated to be about 58 million units. On the other hand, the production figure for 1968 is higher than the forecasted demand for 1969. Although this may seem irritating, it must be considered that the inventory of the industry is above ten million units.

TABLE 6A
COMPARISON OF FORECAST RESULTS

Type	Method I	Method II
Apartments	51,713,102	47,950,986
Houses	6,364,884	5,901,840
Other	4,596,861	4,262,440
Total	62,674,847	58,115,266

Gorbon-Işıl's Market Share

Sales Policy of the Firm

Gorbon-Işıl A.Ş. has a capacity of 6.4 million units of tiles per year, which is 8.16 % of aggregate capacity in Turkey. Due to its small size, its costs of production are higher than the costs of Çanakkale Seramik İşletmesi, which is the largest firm producing tiles.

The small sales organization of Gorbon-Işıl has not been as successful as its competitor in marketing its tiles. Knowing that they would not be able to compete in standard products, they have been trying to establish a new market through product differentiation. Therefore, in 1967 they have started to produce decorated and artistic tiles, both because these tiles had a higher profit margin and because they were not competitive. In 1968 the production of these

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 2

tiles have been increased, while the production of standard tiles have been decreased. Furthermore, these tiles require some additional know-how which the competitors do not possess completely and much flexibility in production which is easy for a small plant. In 1968 the management has decreased the amount of production of tiles in order to produce more ceramics which is more profitable to the firm. The aim of the company is to hold the production of tiles constant but produce higher quality tiles and increase the production of ceramics instead. In this respect, the market share of the company for tiles has been decreasing since the beginning of 1968. Furthermore, in order to produce the higher quality tiles, the company plans to invest in an additional electrical furnace which will enable to increase the plant's capacity for such tiles from 500 units per day to 2500 units per day.

The company does not have an organized sales department. Most sales are made through salesmen who work on a commission basis and sales are made to customers who purchase directly from the plant. No advertising is carried out by the company. As a consequence, many people are not aware of the products the firm produces. Furthermore, the flexibility of production enabled the company to produce a variety of products concerning color and design. Therefore, many constructors do not introduce the tiles of Gorbon-Işıl to

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 23

their customers because of the variety of tiles they would have to deal with while covering the walls and surfaces of bathrooms and kitchens. They prefer the standard products of the other companies which only have a limited number of colors and decorated tiles. Furthermore, the financial advantages of the other two companies enable the customer more favorable terms of payment.

The sales practice of the other two companies is to sell through wholesalers or through their own sales offices. Gorbon-Işıl, on the other hand, neither has its own sales offices nor wholesalers who act as agencies.

The absence of sales offices and agencies, accompanied with inadequate advertising prevents the company from being known in the market. Actually, Gorbon-Işıl, with its small scale of output could operate far above Break Even and it could even dominate the market in Istanbul with its high quality tiles which appeal to high income groups and luxurious construction. The management has accepted the policy of product differentiation, but no explicit effort has been observed to carry out the policy as yet.

A wrong policy is being exercised in the quality control of the tiles. The management claims that their tiles bear a better quality than the other ones produced in Turkey. Their second quality, however, is selected according to a higher quality standard than the second quality tiles

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 24

of the other producers. As a consequence, the demand for the second quality tiles of Gorbon-Işıl has been much higher than expected. The difference between first quality standard tiles of other producers and the second quality standard tiles of Gorbon-Işıl is claimed to be small, therefore, constructors prefer to purchase the second quality tiles of the company which is on the average 20 kuruş lower than the standard first quality tiles. But if the sales consisted of only second quality products, the company's profits would decrease considerably.

Forecast of Demand

As mentioned earlier, the production of tiles by Gorbon-Işıl is very recent. Production of tiles has started in the beginning of 1967 by this company. Since then, they have introduced new products in order to avoid the competition with other firms. Some of their production has ceased while other kinds of tiles have been produced that had a higher profit margin. Changes in the quality, style, and prices have taken place since then. Furthermore, the emphasis on product differentiation and higher output in the field of ceramics products has led the company not to produce according to market demand only, in case of tiles. Analysis on the part of the company has revealed that the production of ceramics was more profitable than the production of tiles. Ceramics have been sold easier without much marketing efforts for cash, while the sale of tiles have been made through

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 2

salesmen and against notes payable maturing on an average after six months. Consequently, a decrease in the market share of the company for tiles has been observed in 1968. Meanwhile, the production of artistic and decorated tiles has reached almost 40 % of total production of tiles in the plant. The tiles sales of the company is presented in Chart 1.

The inadequate records concerning customers' orders not met and customer rejections have forced the analysis to be based only on past sales records. To project future demand, a regression analysis has been carried out between sale of tiles and construction licences granted by local municipalities. The regression analysis has been made with one year, nine months, and six months time lag between construction and sales with white, colored, decorated, and the total sale of tiles respectively. In the first analysis the aggregate construction work in Turkey has been considered, in the second analysis only the sum of construction work in cities with populations above 100,000, and in the third analysis the construction in Istanbul has been used. Although correlation coefficients as high as 0.74 have been obtained, the results were not significant at 1 % and 5 % level; therefore, the analysis has not been used. The results are shown in Table 7.

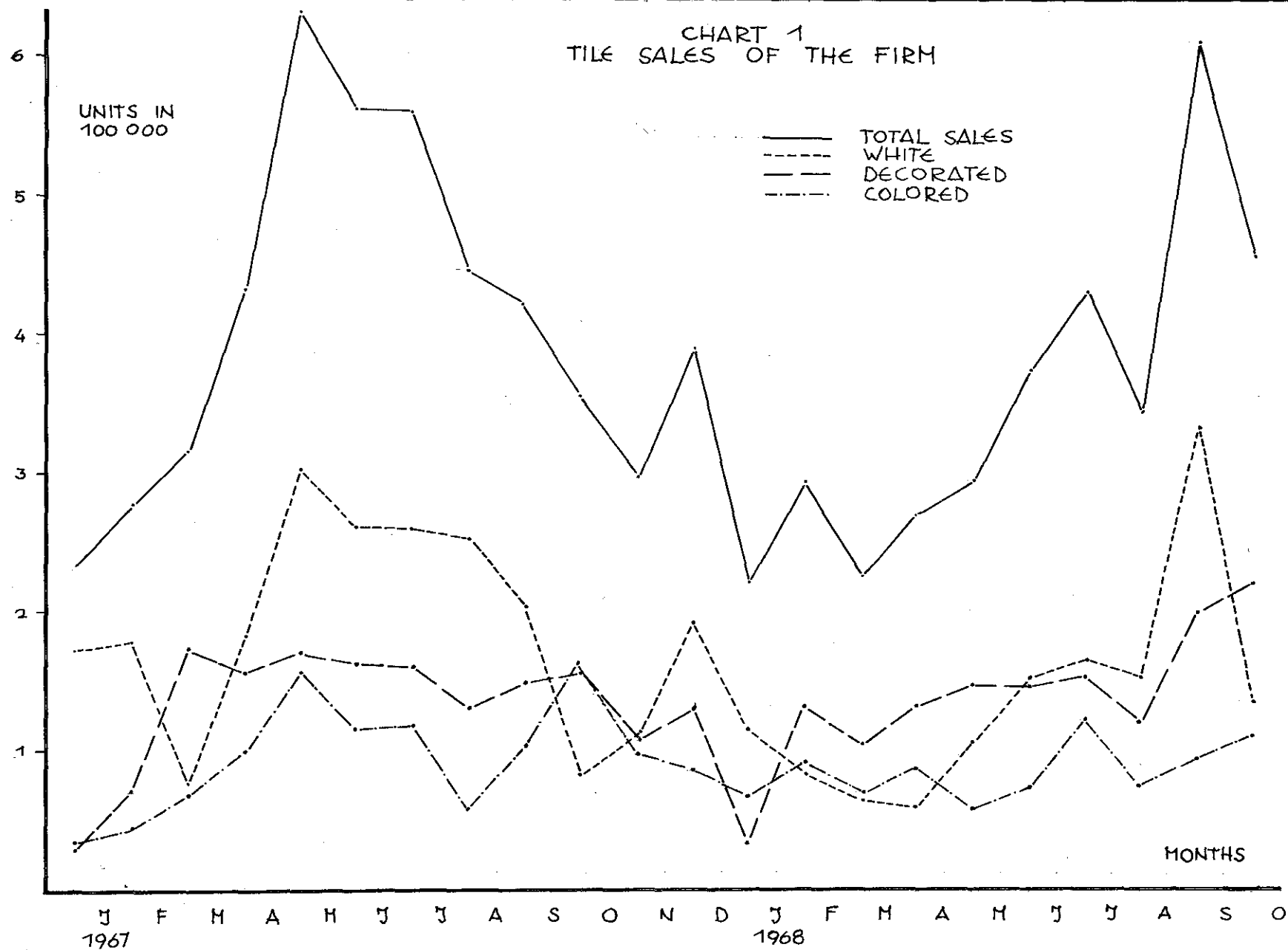
The estimate of the sale of tiles for 1969 was based on the aggregate forecast of tiles for Turkey. The market share of the company has been computed according to production

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEER, ISTANBUL

PAGE 26

CHART 1
TILE SALES OF THE FIRM



THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 27

TABLE 7
RESULTS OF REGRESSION ANALYSIS

Dep. Var.	Ind. VAR.	Time Lag (months)	Corr. C	F
1	A	12	.64	1.50
2	A	12	.60	1.33
3	A	12	.63	1.51
4	A	12	.74	2.77
1	A	9	.58	1.18
2	A	9	.73	2.66
3	A	9	.61	1.36
4	A	9	.64	1.60
1	A	6	.64	1.55
2	A	6	.61	1.36
3	A	6	.45	.59
4	A	6	.51	.79
1	B	12	.70	2.21
2	B	12	.61	1.38
3	B	12	.68	1.92
4	B	12	.64	1.62
1	B	9	.63	1.51
2	B	9	.44	.56
3	B	9	.59	1.21
4	B	9	.21	.11
1	B	6	.68	1.92
2	B	6	.39	.40
3	B	6	.60	1.30
4	B	6	.64	1.57
1	C	12	.72	2.47
2	C	12	.45	.57
3	C	12	.46	.62
4	C	12	.73	2.68
1	C	9	.62	1.39
2	C	9	.45	.59
3	C	9	.48	.68
4	C	9	.69	2.09
1	C	6	.68	2.02
2	C	6	.57	1.07
3	C	6	.61	1.33
4	C	6	.63	1.52

Notes:

(1) is the sales of white tiles, (2) is the sales of colored tiles, (3) is the sales of decorated tiles, and (4) is the total sales. (A) is the total construction in Turkey, containing seven variables: (a) apartments, (b) houses,

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 28

(c) commercial buildings, (d) industrial buildings, (e) cultural buildings, (f) other buildings, (g) total construction. (B) is the construction in cities with populations over 100,000 and contains the same variables as (A). (C) is the construction in Istanbul, also containing these seven variables.

figures because the sales data of the other companies were not available. The percentage of the company's production to total production has been used and the average of the years of 1967 and 1968 has been taken because it has been assumed that the purposeful decrease in the market share has not decreased the demand for the company's products effectively. The estimate market share of Gorbon-Işıl is accordingly 8.56 % or 4,974,000 units of tiles for 1969.

The sale of different types of tiles have been assumed to be as in the previous year. The only change is that the management believes to sell artistic tiles with printings on them more than in 1968 due to reduced prices and better method of production. The management anticipates to sell 275,000 units of such tiles in 1969 starting mainly after April. The printings are made on finished white or colored tiles. Therefore, a rough assumption has been made that 50 % of such printings will be made on white tiles and 50 % on colored tiles. Accordingly, the expected sales become as presented in Table 8.

The monthly sales of tiles has been computed according to seasonal indices as shown in Table 9. The monthly sales are estimated as in Table 10.

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 29

TABLE 8

EXPECTED SALES OF TILES

Type	%	Units
White	37.76	1,878,430
Colored	22.66	1,127,434
Decorated	34.05	1,693,736
Artistic	5.53	275,000
Total	100.00	4,974,600

TABLE 9

COMPANY SALES AND SEASONAL INDICES

Month	1967	1968	Total	Index
Jan.	229	219	448	4.85
Feb.	279	298	577	6.27
March	310	227	537	5.83
April	432	270	602	6.54
May	631	297	928	10.12
June	560	373	933	10.17
July	560	436	996	10.86
Aug.	445	345	790	8.60
Sept.	422	618	1,040	11.30
Oct.	353	458	811	9.60
Nov.	294	329	623	6.77
Dec.	394	441	835	9.09
Total	4,909	4,211	9,120	100.00

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 30

TABLE 10
MONTHLY SALES OF TILES

Month	White	Colored	Decorated	Artist. ¹	Total
Jan.	91,104	54,695	82,146	10,000	237,945
Feb.	117,778	70,677	106,197	11,000	305,652
March	109,512	65,729	98,745	11,000	284,986
April	122,849	73,734	110,770	27,000	334,353
May	190,097	114,096	171,406	27,000	502,599
June	191,036	114,660	172,253	27,000	504,949
July	203,997	122,439	183,940	27,000	537,376
Aug.	161,545	96,959	145,661	27,000	431,165
Sept.	212,263	127,400	191,392	27,000	558,055
Oct.	180,329	108,234	162,599	27,000	478,162
Nov.	127,170	76,327	114,666	27,000	345,163
Dec.	170,750	102,484	153,961	27,000	454,196
Total	1,878,430	1,127,434	1,693,736	275,000	4,974,600

¹The figures in the table are based on production capacities of the plant, because demand exceeds the output for this particular product.

In ceramics products the company has been expanding its production capacity and they are currently producing and selling about 197 kg per day which generates a sales revenue of about 6,300 T.L.. The company did not confront any marketing problem in this field as yet.

The maximum capacity for ceramics is estimated by the management to be approximately 447 kg per day and they believe that they can sell their products without difficulty. This anticipation will be accepted as an assumption in the analysis because a forecast can not be done due to the multitude of products involved in ceramics.

CHAPTER III

DESCRIPTION OF THE EXISTING SYSTEM

Plant Location and Layout

The plant is located in Levent and covers an area of approximately 5,000 m². Its location is excellent because it is in the boundaries of Istanbul, only 30 minutes from the center of the town. Customers often visit the plant and purchase directly from the company. Labor is easily available because the plant is surrounded by other factories which necessarily create a residence area for workers. Almost all workers live nearby so that the firm does not confront any problems of transporting their personnel. Furthermore, additional manpower can be hired very easily and almost without any time lag.

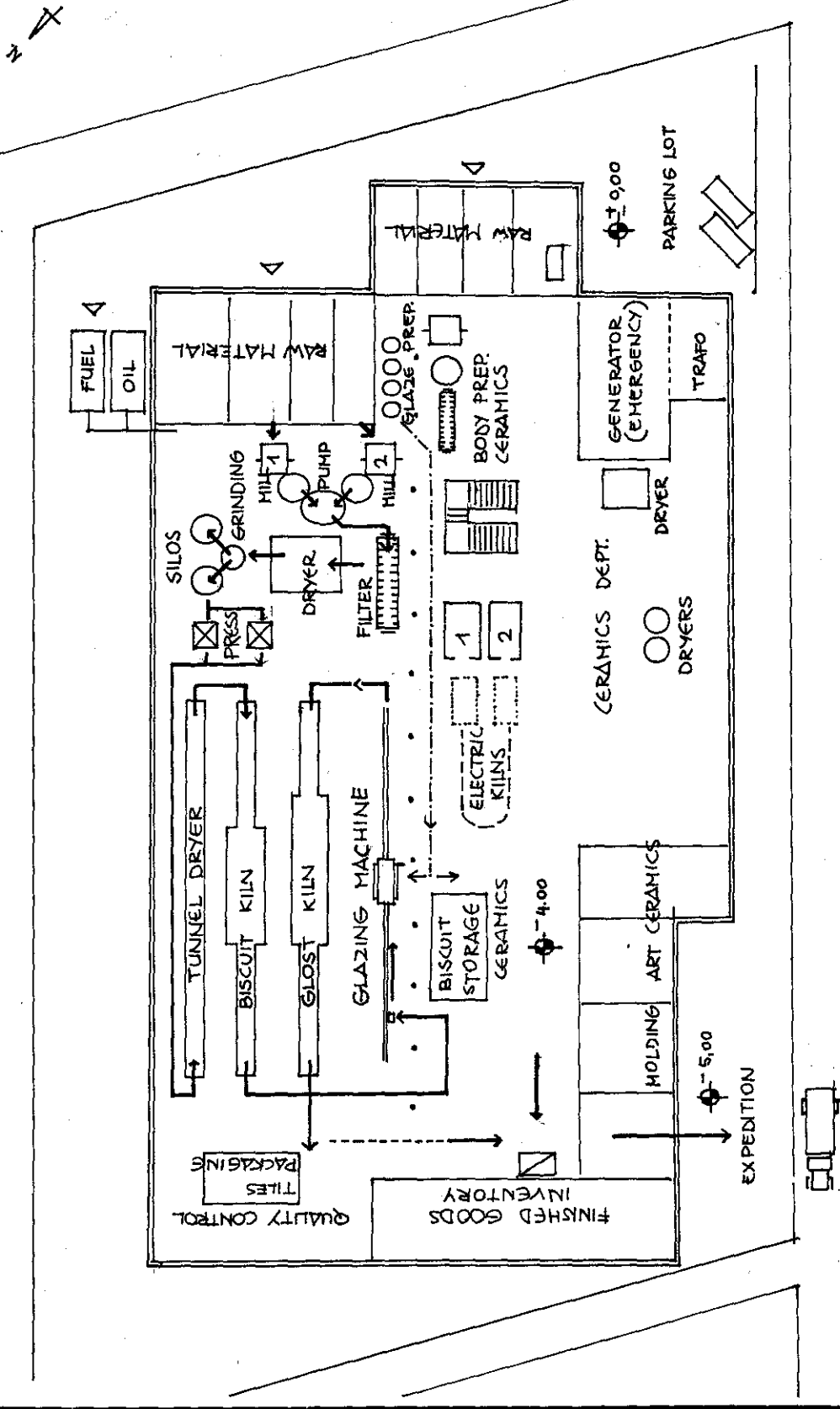
The plant is a three storey building situated on a sloped area. The plant has a parking lot for about six cars, from where an entrance leads to the top floor. The administrative offices, laboratories, eating facilities, finished ceramics inventory, and a small department for painting the artistic ceramics and tiles is on that floor. Beneath the parking lot is the storeroom or silo where the raw material is stored. This is the second floor with all other production departments and semi-finished goods storerooms. The first floor or rather the basement is used to store tiles and there

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 30

CHART 2A PLANT LAYOUT 1/500 m.



THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 32

is a small work-shop adjacent to the storeroom.

The layout of the plant cannot be considered to be ideal. This is due to the fact that initially the plant had not been designed to produce tiles.

The main pitfall of the plant's current location is that it has no possibility of expansion due to space limitations. Only few additions can be made in the plant so that only small capacity increases are possible.

Organization of the Firm

The firm employs 150 direct workers and 67 employees (including the management, maintenance department, and administrative personnel) totalling to 217. The firm operates on a one shift basis although some production centers, by the very nature of the operation, have to work three shifts a day.

Due to a relatively big expansion, the company has faced organizational and financial difficulties. Although some of the organizational problems have been solved by now, there still remain some administrative bottlenecks which require improvements. Channels of information are not clear and as a result many disturbances occur. Formal reporting is not exercised at a desired rate. Most information is transmitted informally.

The organization of the firm consists of a board of directors, a general manager, a planning committee, four consultants, and three major departments. One of the

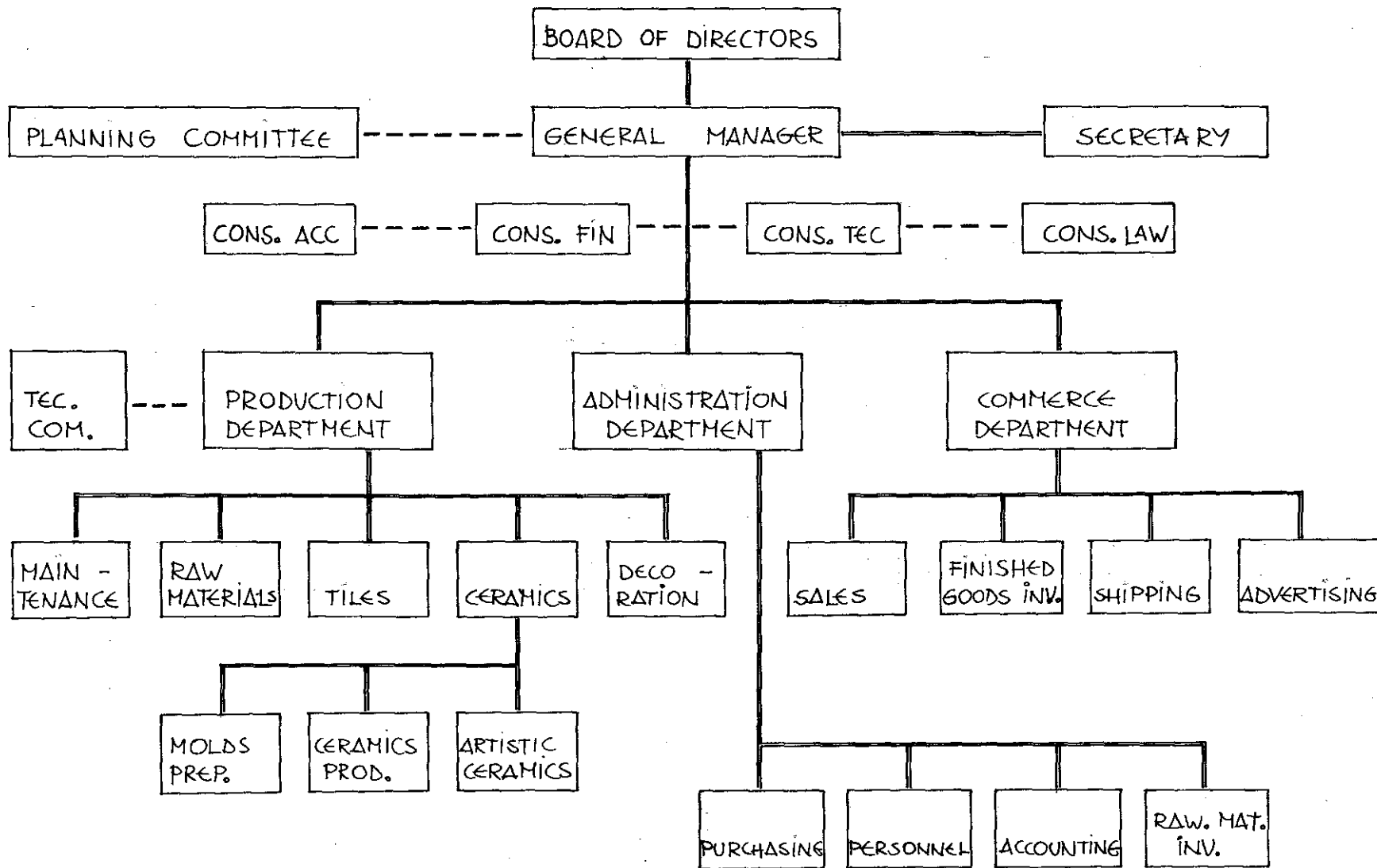


CHART 2 FORMAL ORGANIZATION OF THE FIRM

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 3

Shareholders, who is at the same time a member of the board of directors, is acting as general manager. He has a secretary who also performs all external communication. Attached to the general manager is a planning committee consisting of all department heads. This committee makes the yearly and quarterly plans and evaluates the results. The four consultants are also directly reporting to the general manager. Currently there are only three consultants because the general manager, due to his technical knowledge performs the task of technical consultant himself. The other three consultants deal with legal affairs, accounting, and financial problems. The three major departments, namely, production, administration, and sales departments, are also directly reporting to the general manager.

The sales department is engaged in sales, advertising, and controlling finished goods inventories (both ceramics and tiles). The administration department deals with accounting, personnel problems, purchases, and raw materials inventory.

The production department is divided into five smaller departments. There are two assistant production managers who are responsible for tile and ceramics production respectively. The other three departments are directly attached to the production manager. These departments are: (1) Earth, glaze, and dye preparation department, (2) Maintenance department, and (3) Decoration department.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 2

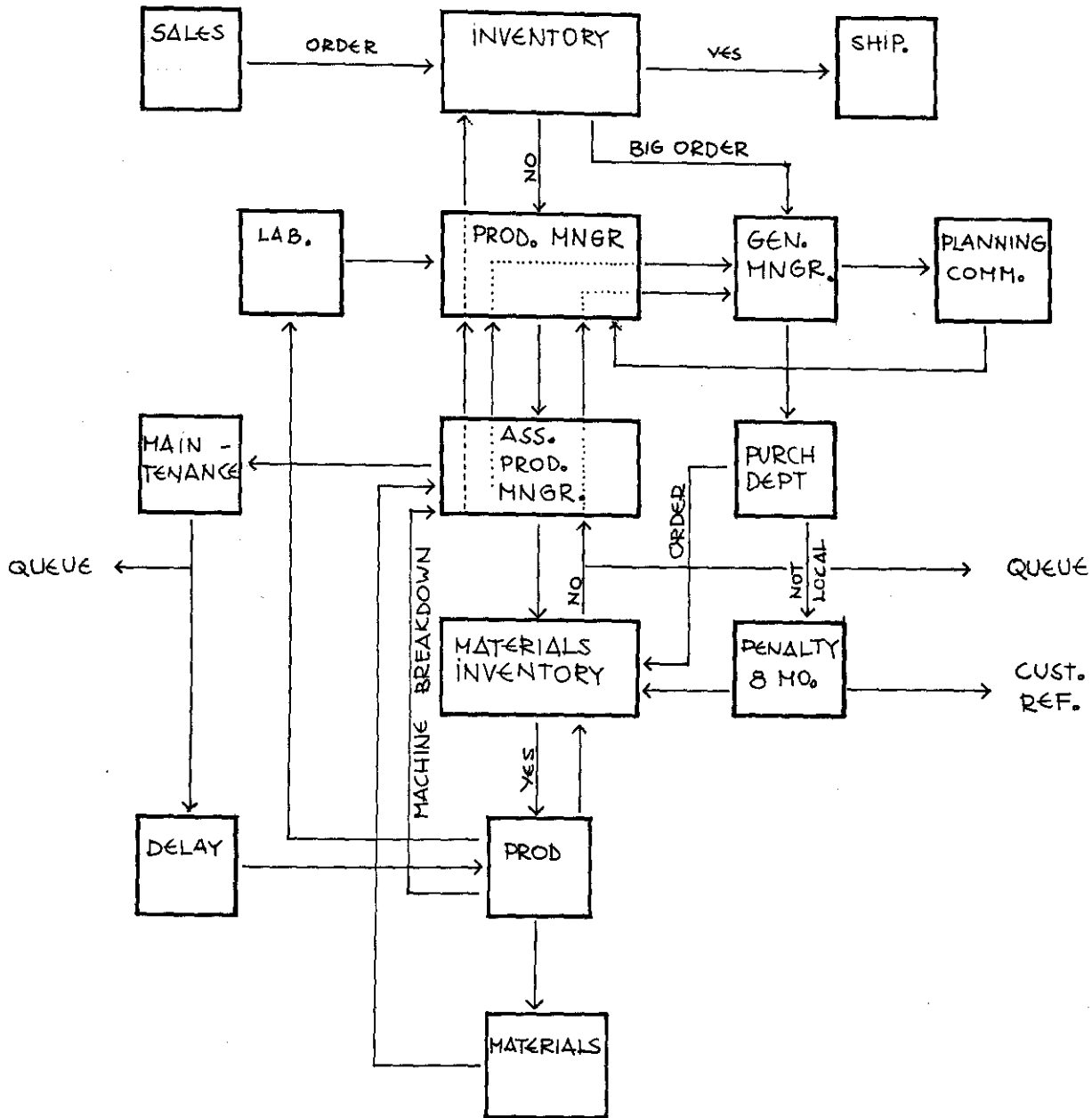


CHART 3
INFORMATION FLOW OF THE PRODUCTION SYSTEM.

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 37

As it can be observed from the organization chart, the company does not have enough staff departments. The effects of the absence of such departments is felt especially in the production system. The standard methods of production control are not exercised extensively, and as the managers say, follow up becomes very difficult.

Production control is currently exercised through oral communication and to some extent through the use of formal reports. This practice may be due to standard procedures in the production system. Earth preparation and tile production has been standardized to a great extent. Various products are produced in the ceramics department and except some products that are produced in big lots, the remaining products cannot be standardized because they are usually produced on specific orders. The problems encountered in the production of such goods are solved by the head of department, production manager, or jointly by the general manager and the other two managers mentioned above.

This system forces the management to exercise a production oriented management style, and the general manager does not find enough time to deal with other problems.

Although few formal reports are used to transmit the information, the flow of information is clearly defined and follows a very logical pattern. The information is clearly defined but its flow could be made more effective by using written reports because it is easier to follow up. The flow

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 3

of information in the Production System is shown in Chart 3.

The orders are accepted by the Sales Department. The order is forwarded to Finished Goods Inventory. If the goods ordered are available in the inventories, the order is shipped. If not, the order is given to the production manager, who forwards it to the responsible assistant production manager. Necessary materials are checked in the inventories and the production is started.

The production data are transmitted to the production manager through assistant production manager. Furthermore, a sample of the products is tested in the laboratory and the result is reported to the production manager. Upon the termination of the production, the goods are sent to inventories and subsequently shipped.

If the required materials are not readily available, they are produced in the plant, if possible, and reported to the production manager. On the other hand, if these materials are to be purchased, the purchase request is submitted through the production manager to the general manager, who gives the order to the purchasing department. In this case the orders are queued. The purchasing department purchases the necessary materials and gives it to materials inventory and the production starts. In some cases the materials (such as dies) have to be purchased from overseas; if so, about eight months elapse before the goods arrive, therefore the order is rejected.

In case of machine breakdown, the production manager is informed, and he requires from the maintenance department to repair the machinery. Again a delay occurs and the orders are queued.

Current Production System

The management has decided to produce more ceramics and decrease the output of tiles instead. This decision was given due to an increased demand for ceramics and its relatively high contribution margin.

The company's primary bottleneck lies in the furnaces. Therefore, the increased ceramics production has to be partially treated in the tunnel furnaces initially established for tiles. As a matter of fact, it is easy to increase the output of ceramics because its production, excluding the furnaces, is directly related to workforce. The equipments required to produce it is inexpensive and can be purchased in Turkey. Only the capacity of furnaces and the space required for its production impose a restriction on ceramics output.

The production system consists of two subsystems; namely the preparation of raw material and the production of marketable goods. More modern plants that produce similar products do not prepare their own raw material but purchase it. In Turkey, the difficulty of obtaining raw material with a standard quality has forced the industry to produce it itself. An accomplishment of the production department was

to prepare the raw material such that it can be used for both tiles and ceramics. This raw material is prepared in a separate department which is adjacent to both tile and ceramics departments.

The Production Process

Raw Material

The purchased elements of the raw material (primarily earth), are grinded and then stored in silos. According to the need for raw material, this earth is mixed with water and grinded again. The resulting mud is mixed with other chemicals in two big mixers and the water is separated partially in a filter-press. If the raw material is to be used for ceramics production, it is immediately transported to that department. If the raw material is to be used to produce tiles, additional treatment is required. The mud is exposed to high temperature in the drying-room until its humidity reaches a desired level. The resulting earth is grinded again and reduced to powder, then it is transported to silos by mechanical conveyors, where it is stored for about three days to homogenize the humidity of the raw material. At this stage the raw material is ready for use.

Tiles

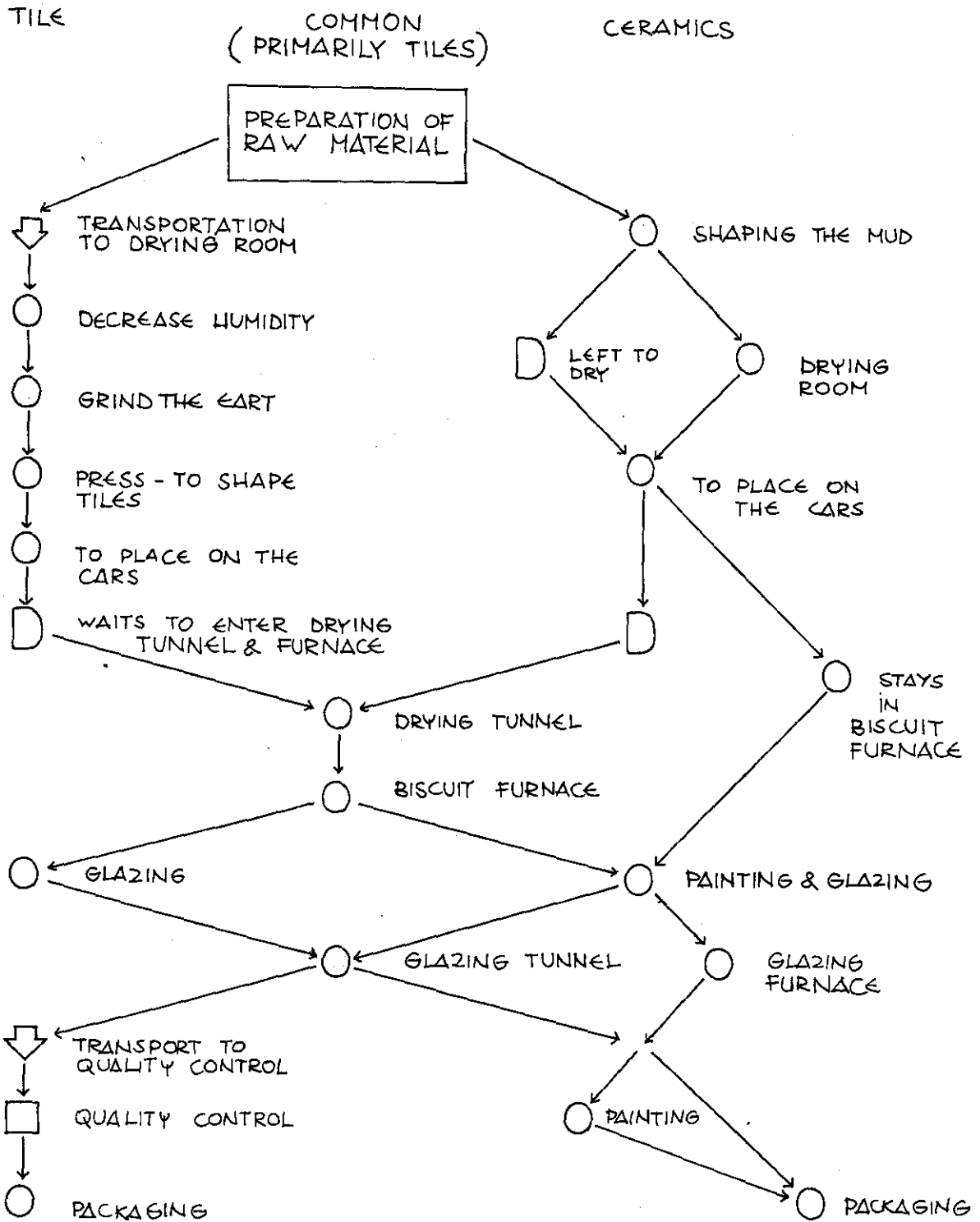
Tiles and ceramics are treated simultaneously during the process of production. Ideally, these two different products should not be subject to common treatment, but the desire to increase the output of ceramics does not leave any

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 4

CHART 4
FLOW PROCESS CHART



THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 42

other alternative for the present. The common treatment occurs only in the tunnel furnaces which are actually designed for tiles. The treatment of ceramics in these furnaces complicates the production because ceramics require a lower temperature than tiles. Much effort is spent to adjust the temperature of the tunnel furnaces so that the products are not damaged and the rate of defectives not increased. Chart 4 shows the process flow of tiles and ceramics simultaneously.

The production of tiles is a routine process. Raw material flows automatically to the process which operate mechanically and give a square form to the raw material, called biscuit. These biscuits are loaded to small cars and they are treated in two tunnel furnaces subsequently. After the treatment in the furnaces, the defectives are separated. The remainder is glazed in the glazing machine either white or in any color that is marketed. Additional treatment is applied in the decoration department to semi-finished tiles which are sold as decorated. After being glazed, the tiles are loaded again on the cars and they are treated in another tunnel furnace from where the final product is obtained. The process flow for white tiles is shown in Chart 5.

Ceramics

The production of ceramics is more complicated. The plant currently produces three or four ceramics products in relatively large lots. The rest of the production consists of specific consumers' orders. The production of goods which

THE S I S

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 43

CHART 5

PROCESS FLOW CHART

Op.No.	Units	Explanation	Operation	No. of worker	Op. time
1	ton	Prepare earth for grinding		4	1 ¹⁵ hrs.
2	ton	Grind earth in grinding mills			2 ⁴⁰ hrs.
3	ton	Storage of earth			3 months
4	ton	Weigh the earth, add water and grind		5	1 ³⁰ hrs.
5		Mud inspection			30 min.
6	ton	Mech. transport. of mud to mixers			2 ⁴⁰ hrs.
7	ton	Mixing			2 ⁴⁰ hrs.
8	ton	Filter-press op.			1 ²⁰ hrs.
9	ton	Dryer			3 ²⁶ hrs.
10	ton	Transp. dry earth to grinders and then to silos		2	48 min.
11	units	Storage of earth			3 days
12	units	Press to shape biscuits		10	3.12 sec.
13		Waits to enter drying tunnel		6	16 hrs.
14	car	Treatment in drying tunnel			2 hrs.
15	car	Treatment in biscuit kiln			2 hrs.
16	units	Inspection		4	1.56 sec.
17		Glazing		9	1.15 sec.
18	car	Glazing kiln			22 min.
19	units	Transport., control, and packing.		4	5 sec.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 4

are sold through wholesalers are standardized. Specific orders, however, are mostly non-recurrent, and are, therefore, more difficult to put into production. For this reason, the ceramics department is divided to two smaller departments. One department produces the standard goods and the other department produces the so called "artistic" ceramics. A third department produces the necessary molds for casting which is one method of shaping the mud in a desired way. The other method is to shape the mud on lathes. After this process the semi-finished goods are either treated in electrical furnaces, tunnel furnaces, or they are stored on shelves and left to dry. After glazing these products, they are either treated in a special electrical furnace or they are treated in the post-glaze tunnel-furnace together with tiles. After this process the final product is obtained.

Determination of Capacities

The capacities have been calculated according to past production data and these calculations have been revised by making time studies. In some production centers, like the furnaces, no time study has been made. Because of continuous operation, only the reports indicating the output have been used. The same method has been applied in determining the capacity of ceramics department.

The determination of capacity where the production could be easily observed, stop-watch time study has been applied. The time study was made on different days randomly

each with an interval of five minutes. Fifteen such stop-watch time studies have been made. It may be argued that such a small sample will not give a very accurate result. But comparing these results with the actual production indicated that the results obtained from the time study was fairly correct.

Capacity of Raw Materials Department

The raw material department has two production centers. In the first production center, the raw material can be produced for the ceramics department and in the second section the raw material is prepared for making tiles. But as mentioned earlier, the raw material prepared for tiles can also be used to produce ceramics. Its capacity is enough to supply both departments so that currently the production center, which is to prepare raw material for the ceramics department, is not used. The capacity of raw materials preparation for the ceramics department is said to be one metric ton per day.

The capacities of raw material preparation department for tiles is according to production records as follows:

1. Mud preparation: It takes 90 min. to prepare 1 ton, daily capacity being 16 tons.
2. Grinding wheels: 1 ton is grinded in 2 hrs. and 40 min., so that the daily capacity is 9 tons.
3. Mixers: The capacities of the mixers are exactly the same as the capacity of the grinding wheels.
4. Filter Press operation: 80 min. are required to treat 1 ton so that 18 tons can be treated in a day.

5. Drying Room: The drying room treats 1 ton in 3 hrs. and 26 minutes, or 6.9 tons per day.

It is evident that this department can produce more raw material than actually needed. The only bottle-neck may be observed in the drying room which would be relevant only if the plant would produce tiles at higher capacity levels which is not possible without additional investment.

Capacity of the Ceramics Department

The variety of products and most of all the magnitude of non-recurring items in the ceramics department has made it impossible to determine a capacity in terms of units. Therefore, the capacity has been defined in terms of kilograms of output that can be produced. This is, of course, a rough method because the weights of products that require same labor hours and same machine time may differ. The output has been determined in terms of weight according to current product mix.

The capacity in terms of kilograms is not a meaningful figure by itself. A relevant definition of capacity should be in terms of equivalent units of tiles, so that joint capacity restrictions for tiles and ceramics could be established. The equivalent units have been found according to space occupation in the furnaces. One car entering the post-glaze tunnel furnace can either be loaded with 567 units of tiles or, on the average 40.5 kg of ceramics. Therefore, one kilogram of ceramics is equivalent to $567/40.5$ or 14 units of tiles.

According to the estimate of the management, the maximum capacity of this department would be at 447 kg/day which is equivalent to 6257 tiles per day. The furnaces installed for ceramics, however, can only treat 167 kg or 2338 equivalent units of tiles per day. Therefore, the production above 167 kg/day must be subject to common treatment with tiles, which necessarily has the effect of reducing the output of tiles.

Capacity of Tile Department

The production units of the tile department are the presses, furnaces, and the glazing machine. The glaze and colors are prepared in the laboratory; the separation of defectives and the decoration of tiles are carried out manually so that no capacity restrictions can be imposed to these operations. Therefore, the capacities have been determined for the above mentioned production units.

Capacities of the Presses

There are two mechanical presses which have a theoretical capacity of producing 28 units/min. each. This capacity, however, is never reached. Time studies revealed that actual production varied between 16 and 24 units/min. during different times of the day averaging to 21 units/min.. The machine down-time is 42 minutes per shift or 10 % on an average. Furthermore, one shift is seven hours due to noon-break and daily maintenance of the presses. Therefore, the efficiency of production, including the down-time of the presses, is 65 % in seven operation hours.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 48

The theoretical capacity of the presses are 56 units/min. or 23520 units per shift. Working at 65 % efficiency produces an output of 15,288 units per shift for two presses or 7,644 units per shift for one press. The presses work six days a week and the furnaces for seven days. Therefore, the actual production per shift, considering seven days need is $6/7 \times 7644$ or 6552 units per shift. Maximum capacity for presses is 39,312 units per day, operating both presses on a three shift basis.

Biscuit Kiln Capacity

The biscuits or raw tiles are treated in two subsequent furnaces which are synchronized. The capacities of the furnaces are to treat 14 cars a day (24hrs.). Every two days, one car loaded with ceramics shelves is treated in this furnace, which are used to place the glazed tiles to enter the other tunnel furnace. Therefore, the average capacity of this furnace is to treat 13.5 cars a day. One car is loaded with 1,680 tiles, so that 22,680 tiles can be treated in a day.

Glazing Machine Capacity

The theoretical capacity of this machine is to glaze 4,800 units per hour or 80 units per minute. Time study has revealed that on the average 42 tiles were glazed in a minute. Previously 59 tiles were glazed in a minute; but due to reduction in the output of tiles, the workers do not spend effort to glaze more because they can meet the required production under current conditions in about five hours. Actually, a production of 80 units per minute is not exercised because then many defectives

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 49

occur due to inadequate attention. In the analysis, however, the capacity was taken to be 59 units per minute.

Post-Glazing Tunnel Furnace Capacity

The glazing tunnel has a capacity of treating 38 loaded cars per day (24 hrs.). A car can be loaded with 567 tiles or the equivalent amount of ceramics, so that the capacity of this furnace is to treat 21,546 tiles in 24 hours.

These capacities indicate the maximum outputs of the production centers. The defective products, however, must be subtracted at the end, to arrive at the actual production capacity of the firm. The defectives occur in two production centers; namely in the furnaces. Actually, it is not exactly known where the products become defective, but they can easily be detected after leaving the furnaces. The rate of defectives after being treated in the biscuit tunnel furnace is 9 %. The rate of defectives observed after the treatment in the post-glazing tunnel furnace is 5 % so that if 1,000 units of tiles are to be produced, on the average 1,157 biscuits must be produced by the presses and treated in the furnace, 1,053 of these must be glazed and treated in the post-glazing tunnel furnace.

Production Costs of the Firm

In the analysis, fixed and variable costs have been separated. Fixed costs include items such as depreciation, administrative expenses, interest paid, sales expenses, and salaries of the administrative personnel. The variable overhead of the

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 50

ceramics department could not be allocated correctly, therefore, they have been added to fixed costs. Although this is not a correct procedure, it will not have any adverse effects in the analysis because an average cost of 2.54 T.L./kg of ceramics will not change its degree of profitability compared with other products.

Labor, material, raw material, and the variable overhead of the tile department have been considered as variable costs. Although these cost figures are not very detailed, more accurate cost data could not be developed due to reports which were not more informative.

Fixed Costs

The fixed costs have been assumed to be exactly as they were in the preceeding year, and the figures have been taken from the Balance Sheet of the firm. The items mentioned in the previous section are considered as fixed costs. Furthermore, the labor cost of the presses are also considered to be fixed because this cost increases stepwise and the labor cost of one shift is constant whether they produce 1 unit or 6552 units. Not having the knowledge as how many shifts to employ, this cost will be subtracted from the final profit figure. The fixed costs (except the cost of labor for presses) are expected to be as follows:

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 51

Salaries	438,055.78 T.L.
Administrative Exp.	426,448.47
Depreciation	351,604.36
Interest Paid	586,692.21
Sales Expenses	421,704.88
Var. Overhead (Cer.)	414,098.98
Total F. C.	<u>2,638,604.68 T.L.</u>

In 1968 the Variable Overhead cost of the ceramics department has been 182,500 T.L., but with an increased output of 447 kg per day, this cost is estimated to be T.L. 414,098.98. The administrative expenses include both fixed overhead costs and office expenses. Sales Expenses is made up of commissions paid to salesmen, discounts, shipping expenses, and advertising expenses.

Although fixed costs are assumed to remain constant, Sales Expenses may increase due to an advertising campaign which the management plans to do in 1969, and Interest Paid may decrease because the company will pay some of its debts that bear interest.

Variable Costs

Ceramics

Generally, the variable costs of the firm show a linear behaviour. For the ceramics department, however, it has been argued that the increase in workforce is less than the increase of the output. But the relation of labor to output could not be exactly determined. Therefore, the labor costs of the ceramics department has been assumed to increase linear with output.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 52

The material expenses vary directly with output. The cost of one kilogram ceramics was computed according to last year's data. The ceramics output in 1968 was 71,905 kg, produced at a total variable cost (excluding variable overhead costs) of 816,121.75 T.L.. Therefore, the cost of producing 1 kg of ceramics was found to be T.L. 11.35.

Tiles

The costs of this department vary directly with output (except the labor costs for presses). It has been observed that variable cost per unit does not change at different levels of output, as long as the production of tiles and ceramics are more than 12,000 equivalent units of tiles per day. In capacities below 12,000, the variable cost per unit increases as output decreases.

The variable cost per unit was found through average costs and/or computed for each production center.

1. Raw Material. Considering the rate of defectives, 332.5 grams of raw material become necessary, which has a cost of 18 kuruş per kilogram. The raw material required to produce one tile has a cost of 5.98 kuruş/tile.
2. Glaze. One tile consumes 20 g of glaze. Considering 5 % rate of defectives, the amount of glaze used for one tile becomes 21 g, which has a cost of 4.50 T.L./kg. Accordingly, the cost of glazing one tile is 9.45 kuruş.
3. Fuel Oil. The fuel oil expense is 1000 T.L./day. When 13,500 tiles/day are produced, 66 % of this cost is identified

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 53

with tiles according to glazing kiln loadings. Therefore,

$(660 \text{ T.L./day}) : (13,500 \text{ tiles/day}) = 4.89 \text{ kuruş per tile.}$

4. Variable Overhead Cost. On the average, the variable overhead cost is 1,000 T.L. for 12,000 tiles so that the variable overhead per unit becomes 8.33 kuruş.
5. Water. For an output of 12,000 tiles, water amounting to 40 T.L. is spent. This is used in preparing the raw material and during glazing. Accordingly, the cost of water for one tile is 0.33 kuruş.
6. Electricity. 666 T.L. worth of electricity is consumed in one day when 12,000 tiles are produced. Only 40 % of the amount is allocated to tiles because the greater portion is consumed by the electrical furnaces in the ceramics department. The amount allocated to tiles is T.L. 266.40 . The electricity to produce one tile is, $266.40 : 12,000$ or 2.22 kuruş.
7. Labor. Cost of labor, excluding the presses and the decoration department, for the tile production department is 1278 T.L. when 12,000 units are produced. Accordingly, the labor cost is 10.65 kuruş/tile.

By adding these costs, the unit cost of standard white tile is obtained, which turns out to be 41.85 kuruş. The unit costs of colored, decorated, and artistic tiles are, of course, higher depending on the particular color used. The incremental costs of producing colored tiles is shown in Table 11.

Decorated tiles have an additional cost of 2.5 kuruş/tile having a labor cost of 2 kuruş/tile and the material usage is

TABLE 11

INCREMENTAL COSTS OF COLORED TILES

Color	Cost (kuruş)
Yellow	6.016
Pink	3.296
Blue and Green	2.944
Black and Dark Blue	4.080
Red	13.368

0.5 kuruş/tile. Artistic tiles, on the other hand, are produced at a higher cost. The labor cost for such tiles is 3.45 kuruş per unit and the cost of materials is 7 kuruş/unit totalling to 10.45 kuruş per artistic tile.

CHAPTER IV

PLANNING PRODUCTION, INVENTORY AND WORKFORCE

In the first part of this chapter, before proceeding with production planning, the optimal product mix for the company is computed. The restraints imposed on the system were the capacities and demand. The optimal product mix has been found for alternative capacities. In some of the alternatives the demand was assumed to be as computed in Chapter II, whereas in some cases a higher demand for ceramics products was used. Together with the optimal product mix, the expected profits before tax were determined for alternative capacities, which may indicate whether additional investment would be profitable if the demand increases as it had been assumed.

After having obtained the optimal product mix under current capacity and demand restrictions, an aggregate production and inventory planning was carried out with Linear Programming techniques on an IBM 1620 computer.

Based on this monthly production plan, a detailed plan was designed for the company. In this part, routing, dispatching, scheduling and follow-up are discussed under the heading of production control. Furthermore, manpower, materials, and machine time requirements have been determined.

The Optimal Product Mix

Linear Programming techniques was applied to find the optimal product mix. The reason for using Linear Programming was that (1) costs show a linear behaviour and (2) sales revenue is linear. Furthermore, this technique also reveals the bottlenecks of the system. The optimal product mix is the combination of products which maximize the profits of the firm. Therefore, the objective function was to be maximized.

A mathematical model was built with capacity and demand restraints, the variables being the products. Therefore, the profitability of the products, or their contribution margins had to be known.

The prices have been calculated by taking the weighted average of the sales of first and second quality products. The variable cost of each product was subtracted from its respective revenue, and the contribution margin was found.

TABLE 12

REVENUE, COST, AND CONTRIBUTION MARGIN OF PRODUCTS

Type	Cost	Price	C. M.
White	41.85	72.14	30.29
Yellow	47.87	75.50	27.63
Green and Blue	44.79	77.60	32.81
Pink	45.19	90.18	44.99
Black and Dark Blue	45.93	81.79	35.86
Red	55.22	96.47	41.25
Decorated Yellow	50.37	92.50	42.13
Dec. Green and Blue	47.29	95.00	47.71
Decorated Pink	47.69	107.50	59.81
Artistic tiles	52.30	130.00	77.70
Ceramics (eq. units)			137.28

Capacity restrictions were set for each production unit, and only the relevant restrictions were introduced to the model. In setting the restrictions, the sequence of production flow has been used according to the flow process chart. The capacity restrictions are as follows:

1. $4.86 (x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10}) + 1.05 x_{11} \leq 241,920$
2. $4.86 (x_1 + x_2 + \dots + x_{10}) + 1.05 x_{11} \leq 126,000$
3. $4.86 (x_1 + x_2 + \dots + x_{10}) + 1.05 x_{11} \leq 222,600$
4. $4.86 (x_1 + x_2 + \dots + x_{10}) + 1.05 x_{11} \leq 252,000$
5. $4.86 (x_1 + x_2 + \dots + x_{10}) \leq 23,000 \times 4.2$
6. $1.157 (x_1 + x_2 + \dots + x_{10}) \leq 39,312$
7. $1.157 (x_1 + x_2 + \dots + x_{10}) \leq 22,680$
8. $1.157 (x_1 + x_2 + \dots + x_{10}) + 1.05 x_{11} \leq 25,140$
9. $1.053 (x_1 + x_2 + \dots + x_{10}) \leq 24,000$
10. $1.053 (x_1 + x_2 + \dots + x_{10}) \leq 21,546$
11. $1.053 (x_1 + x_2 + \dots + x_{10}) + 1.02 x_{11} \leq 23,932$
12. $1.05 x_{11} \leq 6,583$
13. $x_{10} \leq 500$

Some of the capacity restrictions are not significant because they are dominated by other restraints. Among the first four restrictions, Restriction (2) dominates the other three. By eliminating the restraints that are not significant, seven capacity restraints remain. These restraints are: (2), (7), (8), (10), (11), (12), and (13).

In setting the demand restrictions, the sales mix of 1968 has been considered. The maximum demand was taken as calculated

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 58

in Chapter III. Then, in consultation with the management, a range of sales for each individual product have been determined in terms of percentages of total sales. Accordingly, the sales sales restrictions are as follows:

1. $-2x_1 + (x_2 + x_3 + \dots + x_{10}) \leq 0$
2. $10 x_1 - 153.1 x_2 + 10 (x_3 + x_4 + \dots + x_{10}) \leq 0$
3. $x_1 + x_2 - 12.09 x_3 + (x_4 + x_5 + \dots + x_{10}) \leq 0$
4. $x_1 + x_2 + x_3 - 19.2 x_4 + (x_5 + x_6 + \dots + x_{10}) \leq 0$
5. $x_1 + x_2 + x_3 + x_4 - 39.17 x_5 + (x_6 + x_7 + \dots + x_{10}) \leq 0$
6. $x_1 + x_2 + \dots + x_5 - 67.99 x_6 + x_7 + \dots + x_{10} \leq 0$
7. $x_1 + \dots + x_6 - 11.09 x_7 + x_8 + x_9 + x_{10} \leq 0$
8. $x_1 + \dots + x_7 - 5.07 x_8 + x_9 + x_{10} \leq 0$
9. $x_1 + \dots + x_8 - 15.53 x_9 + x_{10} \leq 0$

Whereby, x_1 = white, x_2 = yellow, x_3 = green and blue, x_4 = pink, x_5 = black and dark blue, x_6 = red, x_7 = decorated yellow, x_8 = decorated green and blue, x_9 = decorated pink, x_{10} = artistic tiles, and x_{11} = ceramics products.

The upper sales limit for ceramics products is equal to maximum attainable output, so that no demand restriction had to be imposed.

The objective function becomes, $E_{\max} = 30.29 x_1 + 27.63 x_2 + 32.81 x_3 + 44.99 x_4 + 35.86 x_5 + 41.25 x_6 + 42.13 x_7 + 47.71 x_8 + 59.81 x_9 + 77.70 x_{10} + 137.28 x_{11}$

The Linear Programming problems were solved in the computer using the program LP-20. Six alternatives were analyzed,

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 59

the alternatives being:

1. Current capacity, presses working one shift each.
2. Current capacity, one press working two shifts and one press working one shift.
3. Capacity of artistic tiles increased to 2,500 units per day.
4. Capacity increase of ceramics to 800 kg/day, the other capacities being as in alternative (3).
5. Capacity increase of ceramics to 800 kg/day without additional furnaces, others remaining as in alternative (3).
6. Capacity increase of ceramics to 800 kg /day, the other capacities being as in alternative (1).

The output data of Alternative (2) is shown in Table 14.

The computer output reveals that the revenue will be 14,156 T.L. a day. The capacities and sales were computed according to seven days week. Therefore, first the labor cost of the presses must be subtracted, and the remaining figure must be multiplied with 365. The expected profit will be obtained after subtracting the fixed costs.

The labor cost of presses under this alternative is 307.50 T.L./day. Spreading this cost over seven days, it becomes 263.57 T.L./day so that the value of the objective function reduces to T.L. 13,892.43 . Accordingly, the yearly revenue is 5,070,736.98 T.L. . Subtracting the fixed costs from this figure, the expected profit will be obtained, which turns out to be T.L. 2,432,132.27 .

In order to realize this profit, on the average the daily

THESIS

TABLE 13. LINEAR PROGRAMMING MATRIX OF ALTERNATIVE 2

[illegible]

ITER	FUNCTIONAL	VAR IN	VAR OUT
0001	1145040006	0008047710	0035000000
0002	1508520006	0001030290	0019000000
0003	2081270006	0007042130	0034000000
0004	2464910006	0003032810	0030000000
0005	3049559006	0009059310	0036000000
0006	3306209006	0002027630	0029000000
0007	3642965006	0004044990	0031000000
0008	3770477506	0005035860	0032000000
0009	3826372506	0006041250	0033000000
0010	1241731107	001113728	0017000000
0011	1288153607	0010077700	0018000000
0012	1315886907	0036000000	0028000000
0013	1358628307	0035000000	0027000000
0014	1372158607	0031000000	0023000000
0015	1387050107	0034000000	0026000000
0016	1394945407	0033000000	0025000000
0017	1403616207	0032000000	0024000000
0018	1415684807	0030000000	0020000000

FUNCTIONAL = 07 .14156

BASIC SOLUTION

ID	CJ	LEVEL
0012	000.000	06 .53187
0013	000.000	06 .69100
0014	000.000	06 .27870
0015	000.000	06 .71876
0016	000.000	06 .31968
0011	137.280	6257.60450
0010	077.700	500.00000
0001	030.290	4543.33330
0030	000.000	251.66666
0021	000.000	300.00000
0022	000.000	188.33334
0031	000.000	225.00000
0032	000.000	170.00000
0033	000.000	140.00000
0034	000.000	260.00000
0035	000.000	680.00000
0036	000.000	370.00000
0002	027.630	600.00000
0003	032.810	1051.66660
0004	044.990	785.00000
0005	035.860	420.00000
0006	041.250	240.00000
0007	042.130	1260.00000
0008	047.710	3080.00000
0009	059.810	1150.00000

ID	CJ	SHADOW PRICES
0019	000.000	.83999
0029	000.000	5.17999
0020	000.000	31.96999
0023	000.000	12.18000
0024	000.000	3.05000
0025	000.000	8.44000
0026	000.000	9.32000
0027	000.000	14.90000

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 6

production must consist of 4543 white, 600 yellow, 1051 green and blue, 785 pink, 420 black and dark blue, 240 red, 1260 decorated yellow, 3090 decorated green and blue, 1150 decorated pink, 500 artistic tiles, and 6258 equivalent units of ceramics. The outcomes of the remaining five alternatives are tabulated below.

TABLE 15

OPTIMAL PRODUCT MIX UNDER
DIFFERENT ALTERNATIVES

Prod.	A l t e r n a t i v e s				
	1	3	4	5	6
x_1	3,775	4,543	4,543	3,848	4,543
x_2	600	600	600	707	600
x_3	800	800	800	881	1,051
x_4	560	560	560	571	785
x_5	250	250	250	287	420
x_6	100	100	100	167	240
x_7	1,000	1,000	1,000	954	1,260
x_8	2,590	2,400	2,400	1,901	3,080
x_9	1,150	876	876	698	1,150
x_{10}	500	2,500	2,500	1,525	500

If the capacity of ceramics is increased to 800 kg/day, incremental variable overhead to be added to fixed costs is T.L. 558,617.90 and the depreciation expense is estimated to be T.L. 40,000 , If, on the other hand, the capacity of the artistic tiles are increased to 2,500 units/day, the incremental fixed cost is very small and even negligible. Such a furnace is expected to cost 20,000 T.L. with an expected life of five years, having a yearly maintenance expense of 500 T.L. . Assuming

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 6

straight line depreciation, the fixed costs would increase by 4,500 T.L..

The revenue under Alternative 1, computed as in Alternative 2, becomes 4,779,018 T.L.. The labor cost of presses was 184.80 T.L. in this case. Subtracting the fixed costs, an expected profit of 2,140,413.32 T.L. was obtained.

In Alternative 3 the costs are as in Alternative 2 except an additional fixed cost of 4,500 T.L. due to maintenance and depreciation of a new furnace. The revenue, on the other hand, is 5,309,446.98 T.L. so that the profit is estimated to be 2,666,342.27 T.L..

For Alternative 4 due to increased ceramics production and sales, the expected profit turns out to be 4,577,500.40 T.L.. In this case the presses work one shift each, and the incremental variable overhead becomes 598,617.90 T.L.

In Alternative 5 the same condition for costs prevail, only that less depreciation is applied, and that revenue is less. The expected profit is 4,169,235.42 T.L..

The data for the last alternative are: 20,941 T.L. revenue per day; 598,617.90 T.L. variable overhead and depreciation, and finally 4,338,790.42 T.L. expected profit.

The outcome also reveals the restrictions which do not permit the objective function or profits to be larger. The most effectives are five restraints. The profits would increase at the maximum rate under the given conditions, if more ceramics could be produced and sold. The next profitable product would

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 64

be an additional unit of artistic tiles. As it can be seen from the results, except for these two products, the restraints that affect the objective function are to a great extent demand restrictions. It means that the company could increase its profits considerably if it could sell its products with higher contribution margins. Capacity restrictions do not seem to be the "most" effective restraints.

Aggregate Production, Workforce, and Inventory Planning

An aggregate production, inventory, and workforce planning has been made with the use of Linear Programming. The problem was to determine how much to produce, when to produce, and how many workers to employ in order to meet the estimated demand, at a minimum cost. Therefore, a monthly production scheduling was made using the computer. The restraints were:

- (1) The amount of buffer inventories and expected sales, and
- (2) The manpower requirements to produce at the desired level of output.

The minimum buffer inventories desired by the management is the expected sales of the subsequent month, which varies between 250,000 and 560,000 tiles. A buffer inventory for ceramics products is not regarded as necessary. The inventories of the company consisted of 834,797 tiles at the end of the year 1968. Some part of this inventory is made up of products that are not produced any longer, the exact amount of which could not

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 65

be determined. Furthermore, some tiles exist in small lots, so that without any additional production these products are not marketable. Therefore, the beginning inventory was assumed to be 300,000 units believing that incorrect decisions of past years should not be burdened to this year. It is expected that optimal inventory quantities will be obtained after several years, if no unusually high sales occur or if the output of tiles is not reduced.

The manpower requirement has been calculated on a less accurate way. Current output in units of tiles and equivalent units of ceramics was taken and divided by the number of workers, who are working in the production department. An argument may be raised that the output produced by a worker in the tile department is more than the output of a worker employed in the ceramics department, because of relative capital intensity in tile production. In spite of this fact, a better relationship between manpower and output could not be established.

The necessary data for the monthly production scheduling were: (1) the number of direct workers, (2) cost of hiring one worker, (3) cost of layoff, (4) cost of overtime work per unit, (5) beginning inventory of the period, (6) desired amount of buffer inventories, (7) expected sales, (8) inventory carrying cost, and (9) the regular payroll cost of a worker per month.

The number of direct workers currently employed is 150. Cost of hiring one man is almost zero except the costs associated with the time consumption of a personnel clerk. But this cost

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 66

is estimated to be so small that it may be neglected. On the other hand, an unskilled worker has on the average a learning time of two months. During this period he does not work efficiently. The cost associated with the learning time of a worker is considered as a cost of hiring, which amounts to 400 T.L. .

When a worker is laid off, he has a legal right of getting one month's salary as compensation. The workers who are to be laid off due to alternate production levels are the unskilled workers who, on the average, have a salary of 450 T.L. per month. Therefore, this figure is considered to be the cost of laying off one worker.

By law, a worker must receive 50 % additional premium to work overtime. On the average, a worker gets 20 T.L. a day and produces 132.6 units of ceramics and tiles. The labor cost per unit is then, 15.08 kuruş. While working overtime, he receives 150 % of the amount or 22.62 kuruş per unit.

Beginning inventory was assumed to be 300,000 units and desired buffer inventories were the expected sales of the subsequent month. Expected sales were shown in Chapter II.

The inventory carrying cost is 3.73 kuruş per unit per month. The financial cost of having one unit of inventory is 1.50 kuruş per month and the other costs associated with it such as cost of workers in the storeroom and cost of deterioration is approximately 2.23 kuruş per month mer unit.

The regular payroll cost of a worker per month is 450 T.L.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 67

The restrictions of this model are as follows:

$$P_1 \geq Q_2 + D_1 - I$$

$$P_1 + P_2 \geq Q_3 + D_1 + D_2 - I$$

$$P_1 + P_2 + P_3 \geq Q_4 + D_1 + D_2 + D_3 - I$$

$$P_1 + \dots + P_4 \geq Q_5 + D_1 + \dots + D_4 - I$$

$$P_1 + \dots + P_5 \geq Q_6 + D_1 + \dots + D_5 - I$$

$$P_1 + \dots + P_6 \geq Q_7 + D_1 + \dots + D_6 - I$$

$$P_1 + \dots + P_7 \geq Q_8 + D_1 + \dots + D_7 - I$$

$$P_1 + \dots + P_8 \geq Q_9 + D_1 + \dots + D_8 - I$$

$$P_1 + \dots + P_9 \geq Q_{10} + D_1 + \dots + D_9 - I$$

$$P_1 + \dots + P_{10} \geq Q_{11} + D_1 + \dots + D_{10} - I$$

$$P_1 + \dots + P_{11} \geq Q_{12} + D_1 + \dots + D_{11} - I$$

$$P_1 + \dots + P_{12} \geq Q_{13} + D_1 + \dots + D_{12} - I$$

$$P_1 - C_p W_1 \geq 0$$

$$P_2 - C_p (W_1 - X_1 + Y_1) \geq 0$$

$$P_3 - C_p (W_1 - X_1 + Y_1 + Y_2) \geq 0$$

$$P_4 - C_p (W_1 - X_1 - X_2 - X_3 + Y_1 + Y_2 + Y_3) \geq 0$$

$$P_5 - C_p (W_1 - X_1 - \dots - X_4 + Y_1 + \dots + Y_4) \geq 0$$

$$P_6 - C_p (W_1 - X_1 - \dots - X_5 + Y_1 + \dots + Y_5) \geq 0$$

$$P_7 - C_p (W_1 - X_1 - \dots - X_6 + Y_1 + \dots + Y_6) \geq 0$$

$$P_8 - C_p (W_1 - X_1 - \dots - X_7 + Y_1 + \dots + Y_7) \geq 0$$

$$P_9 - C_p (W_1 - X_1 - \dots - X_8 + Y_1 + \dots + Y_8) \geq 0$$

$$P_{10} - C_p (W_1 - X_1 - \dots - X_9 + Y_1 + \dots + Y_9) \geq 0$$

$$P_{11} - C_p (W_1 - X_1 - \dots - X_{10} + Y_1 + \dots + Y_{10}) \geq 0$$

$$P_{12} - C_p (W_1 - X_1 - \dots - X_{11} + Y_1 + \dots + Y_{11}) \geq 0$$

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 68

Where,

P_i = No. of units to produce during month i

X_i = No. of workers laid off

Y_i = No. of workers hired

W_i = Total workforce

D_i = Demand

Q_i = Minimum inventories

I_1 = Beginning inventory

C_p = Regular Payroll cost per worker per month

C_f = Cost of lay off

C_h = Cost of hiring

C_o = Direct labor to produce a unit overtime

C_i = Inventory carrying cost

C_p = No. of units produced by a worker in one month

The objective function which is to minimize Total Cost, is as follows:

$$\begin{aligned} TC = & \left\{ \sum_{i=1}^{12} W_i C_p + C_h Y_i + C_f X_i + C_o (P_i - C_p W_i) \right\} + C_i (12I_1 + 11P_1 \\ & + 10P_2 + 9P_3 + 8P_4 + 7P_5 + 6P_6 + 5P_7 + 4P_8 + 3P_9 + 2P_{10} \\ & + P_{11} - 11D_1 - 10D_2 - 9D_3 - 8D_4 - 7D_5 - 6D_6 - 5D_7 - 4D_8 \\ & - 3D_9 - 2D_{10} - D_{11}) \end{aligned}$$

The Matrix is shown in Table 16

After running the program on the computer, a monthly schedule was obtained which is tabulated in Table 17.

X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}
-3977,0											3977,0										
-3977,0	-3977,0										3977,0	3977,0									
-3977,0	-3977,0	-3977,0									3977,0	3977,0	3977,0								
-3977,0	-3977,0	-3977,0	-3977,0								3977,0	3977,0	3977,0	3977,0							
-3977,0	-3977,0	-3977,0	-3977,0	-3977,0							3977,0	3977,0	3977,0	3977,0	3977,0						
-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0						3977,0	3977,0	3977,0	3977,0	3977,0	3977,0					
-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0					3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0				
-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0				3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0			
-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0			3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0		
-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0		3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	
-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0
-539557	-494597	-449638	-404678	-359718	-314758	-269799	-224839	-179879	-134919	-89960	+494557	+449597	+404638	+359678	+314718	+269758	+224799	+179839	+134879	+89919	+44960

E _q No	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	P ₇	P ₈	P ₉	P ₁₀	P ₁₁	P ₁₂	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	Y ₁	Y ₂	Y ₃	Y ₄	Y ₅	Y ₆	Y ₇	Y ₈	Y ₉	Y ₁₀	Y ₁₁			
1	-1,0	-1,0																																			
2	-1,0	-1,0	-1,0																																		
3	-1,0	-1,0	-1,0	-1,0																																	
4	-1,0	-1,0	-1,0	-1,0	-1,0																																
5	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0																															
6	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0																														
7	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0																													
8	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0																												
9	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0																											
10	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0																										
11	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0	-1,0																									
12	-1,0																																				
13		-1,0											-3977,0												3977,0												
14			-1,0										-3977,0	-3977,0											3977,0	3977,0											
15				-1,0									-3977,0	-3977,0	-3977,0										3977,0	3977,0	3977,0										
16					-1,0								-3977,0	-3977,0	-3977,0	-3977,0									3977,0	3977,0	3977,0	3977,0									
17						-1,0							-3977,0	-3977,0	-3977,0	-3977,0	-3977,0								3977,0	3977,0	3977,0	3977,0	3977,0								
18							-1,0						-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0							3977,0	3977,0	3977,0	3977,0	3977,0	3977,0							
19								-1,0					-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0						3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0					
20									-1,0				-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0					3977,0	3977,0	3977,0	9977,0	3977,0	3977,0	3977,0	3977,0	3977,0				
21										-1,0			-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0					3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0		
22											-1,0		-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0				3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	
23												-1,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0	-3977,0			3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0	3977,0
VALUE	-64	-60	-56	-52	-49	-45	-41	-38	-34	-30	-26	-23	-539557	-494597	-449638	-404678	-359718	-314758	-269799	-224839	-179879	-134919	-89960	+494557	+449597	+404638	+359678	+314718	+269758	+224799	+179839	+134879	+89919	+44960			

[illegible]

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 70

TABLE 17
MONTHLY PRODUCTION SCHEDULE

Month	Units to produce	Hire	Lay_off
1	596,580	-	72
2	307,480	90	-
3	665,740	-	-
4	665,740	-	-
5	665,740	-	-
6	665,900	-	-
7	665,900	-	-
8	665,900	-	-
9	665,900	-	-
10	587,410	-	19
11	587,410	-	-
12	448,290	-	34

The objective function to be minimized, or the total cost is 300,320 T.L..

Planning Labor, Machines and Materials

According to the Production Schedule, 4,935,110 units of tiles and 2,252,880 equivalent units of ceramics have to be produced. In this case, the ceramics department operates at full capacity, whereas the tile department operates at 68 % capacity.

A plan concerning labor, machine time and materials could not be done for the ceramics department. The operation time of the lathers depend on the shape and size of the product. For goods that are shaped in molds, the number of molds depend on the time required to dry the mud. Usually, however, for

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 71

production of large lots on the lathers, at least fifty molds are required. Furthermore, 1 % of these molds must be renewed every day. The products which are shaped in the molds, do not permit the establishing of a relationship. The requirement of the molds depends on the size of the order and on the date of shipment. For example, if 1,000 units are ordered which is to be produced within 20 days, 10 molds may be prepared and five units obtained during one day from one mold, amounting to 50 units per day. If, on the other hand, the order is to be produced in ten days, 20 molds have to be prepared. The number of molds required also depends on how many units may be produced with one mold in a day, which is determined heuristically. Furthermore, the color and glaze requirements do also depend on the types of products finished. To produce the desired amount of ceramics, 470 kg of raw material (earth) is required.

Raw Material

In order to produce 2,252,880 equivalent units of ceramics and 7,187,990 tiles, the raw material requirement is 171,640 kg and 1,711,500 kg respectively, which is 6 metric tons per day. The labor required for this amount is 7³⁰ hrs. for eleven workers. The machine loadings vary from 16 hours to 20 hours 36 minutes per day. As it can be seen, machine loadings are more than labor hours. This is because once the machine is loaded, no labor is required and the machine is turned off at night by the night-watchman.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 72

Tiles

Due to defectives occurring during the production process, 5,704,987 units must be shaped in the presses. Expressed in daily output, 15,630 units must be formed. The normal capacity of a press is to shape 936 units per hour. Therefore, 6,096 machine hours per year are required, which is equivalent to 16 hours 42 minutes per day. There are two presses working seven hours in a eight hours shift, so that one press must work for two shifts, and one press for one shift. It is inevitable that labor will be idle for two hours 58 minutes per day. It would seem to be a good practice to minimize the idle time by hiring and laying off workers. For this operation, however, this is not possible because skilled labor is required. But the skill is acquired by working on the machine, and this method is very costly.

Considering the defectives, 14,238 units per day must be treated in the glazing machine, which takes 5 hours 10 min. working at a normal rate. The cleaning and set-up time is 1 hr. 30 min., so that 1 hr. 20 min. idle time remains. The set-up time is about 45 minutes which makes two set-ups with zero costs possible.

The selection of biscuits is done manually by four workers. On the average, they will have to work almost without interruption. The calculated labor hours leave an idle time of 12 minutes per worker per shift, which is not significant.

Three workers are employed in quality control and packaging.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 73

In order to control and prepare the desired amount for shipment, they will have to work 24,675,550 seconds during the year. The cumulative time available for one year is 27,594,000 sec., so that during the year the workers will have an idle time of 2,918,450 sec., which reduces to 48 min. per shift per worker, which is not a big deviation.

Material Requirements

On the average, the molds of the presses can be used to shape 136,000 biscuits. Accordingly, 42 molds are required to produce the scheduled amount of tiles. In other words, once in every 50 days, the molds of the presses have to be renewed.

The tile cases in the glazing kiln are deteriorated after going through the furnace for sixty times. The yearly requirement is 9,125 units which is equivalent to 25 units per day.

One tile consumes 20 g of glaze. Considering 5 % rate of defectives, the required amount of glaze to produce 4,935,110 tiles is 103,640 kg.

To produce colored tiles, 0.8 g of dye are needed per tile. Furthermore, 56.71 % of total production is computed to consist of colored tiles. Therefore 4.157 kg of various dyes will be needed.

Production Plan for October

A one month production plan for October was carried out. This month has been chosen randomly and does not have any special characteristics. According to the monthly production schedule,

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 74

587,410 units must be produced during that month, which is equivalent to 13,322 tiles and 6,258 equivalent units of ceramics per day. According to the optimal product mix under alternative (2), the production requirement becomes as in Table 18.

TABLE 18

PRODUCT REQUIREMENTS FOR OCTOBER

Product	Units/Month
White	133,290
Yellow	18,000
Blue and Green	31,530
Pink	23,550
Black and Dark Blue	12,600
Red	7,200
D. Yellow	37,800
D. Blue and Green	86,190
D. Pink	34,500
Artistic	15,000
Ceramics	187,740

Considering the production requirements for that month, it can be seen that the ceramics department works at full capacity. A production plan for this department could not be made because the plan would have to change according to the types of products ordered.

The tile department, on the other hand, will have to produce 13,322 tiles per day on an average.

The requirement for raw material becomes approximately 6 tons per day, the machine loading and labor hours being as calculated in the previous section. The presses must work three

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 75

shifts altogether, one shift being idle for 58 % of the time. Overtime cannot be practiced instead, because its use is restricted by law.

Although the furnaces or kilns are loaded at 88.6 % capacity, they cannot be extinguished because of the characteristics of the kilns. Such a practice would stop the production for at least one week, and it would also damage the products.

The only production center that requires scheduling is the glazing machine. Decorated tiles receive the same treatment as colored tiles do in the glazing machine.

A possible schedule for the glazing machine could be as indicated in Table 19.

Material Requirements

According to the computations made in the previous section the requirement for materials would be as follows.

1. Press molds. Three press molds will be used during October to shape 462,000 biscuits. If, on the other hand, the mold installed to the press was not new in the beginning of the month, four molds will be required.
2. Tile Cases. 752 molds will have to be replaced to produce the desired amount.
3. Glaze. 8,838 kg of glaze will be consumed to produce 399,670 units of tiles.
4. Dyes. The dye requirement has been computed according to the amount produced in that color, and the dye it requires.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 76

- a) Yellow: 44.640 kg
- b) Blue and Green: 94.176 kg
- c) Pink: 46.440 kg
- d) Dark Blue and Black: 10.08 kg
- e) Red: 17.280 kg

TABLE 19

GLAZING MACHINE SCHEDULE

Day	Production
1	Yellow
2	Blue+Green
3	White
4	Red+White (9942)
6	White
7	Pink
8	Yellow
9	Blue+Green
10	White
11	White
13	Blue+Green
14	White
15	Pink
16	Blue+Green
17	White
18	Blue+Green (10116, Yellow 5684)
20	Yellow
21	White
22	Blue+Green
23	Pink
24	White
25	Blue+Green
27	Pink (11954, Yellow 4000)
28	White
30	Blue+Green

Note:

If no number is given, it means that the average daily output will be produced.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 77

Production Control

As mentioned before, the company does not exercise production control extensively. To some extent this may be justifiable because the tile department is standardized to such an extent that except the follow-up, the current practice very efficient. The ceramics department, however, is much more difficult to control. The difficulty of designing a production control system lies in the multitude of non-recurring orders. As stated in the previous section of this paper, the times and methods of production for some orders are made heuristically and there is currently no better way than to do so.

Currently, the company's routing can be considered as perfect. The route sheets of all standard products and most of the non-recurrent products are filed. If a new order arrives for a product not produced before, the estimate of cost, date of delivery, and the method of production is based on previous routings.

The management uses a sales order form for dispatching and scheduling. This form bears the date of order receipt, date of delivery, and quantities demanded. This is issued in four copies. The first copy remains in the sales department, the second copy is forwarded to tile production department, the third copy to the assistant production manager in charge of ceramics, and the fourth to the finished goods inventory. A similar form is used for ceramics orders, the only difference being that a

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 78

copy of this form is given to the production manager. In this case, the assistant production manager in charge of ceramics, performs the work of follow-up for the tile production.

Routing

Routing determines what operation will be done on a product as well as where and how. A suggested Route Sheet for a white tile is shown below.

ROUTE SHEET

1. Materials needed.

- a) Raw material: 332.5 g
- b) Glaze : 21 g
- c) Dye (if any): .8 to 2.4 g

Specification of the quality of materials (2)

- 3. Sequence of production and time standards (as in chart 5)
- 4. Set-up time: 45 minutes for the glazing machine, zero cost for two set-ups a day.
- 5. Scrap Factor: 1.157 after leaving the biscuit kiln, 1.053 after leaving the glazing kiln.
- 6. Cost: 41.85 kuruş
- 7. Quality Control: No defectiveness should be seen at a distance of one meter. The result of the Harkord test (heating the tile to 80 degrees Celcius and dropping it to cold water) must be satisfactory; the glaze must not split.

The route sheet above is, of course, not complete. The quality specifications and the way of preparing the materials should also be included. In the route sheets of the company,

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 79

these specifications are given.

Routing is made by the production department, especially by the assistant production manager. If any technical problems arise which cannot be solved by the responsible assistant production manager, the technical committee meets and discusses the problem. Thereafter, the routing is determined.

The costs and operation times of the products are not indicated in the route sheets the firm uses. In case of tiles, the costs and operation times are approximately known by the management. Especially, the process flow and time requirements of the tile department are exactly known. Only some deviations occur in operations where labor is involved. Due to semi-finished goods inventory, however, such fluctuations in the operations do not affect the production. In the ceramics department, on the other hand, no time study analysis was carried out. Until recently, the firm did not have many goods that were demanded continuously and that could be produced in large lots. Furthermore, it is very costly and time consuming to make time studies for several hundred different products.

Production Control Forms

The control forms currently used are not adequate for follow-up, although it is claimed that they are satisfactory for routing and dispatching. An attempt has been made to design production control forms such that follow-up will be more simple than it currently is, without introducing much bureaucracy.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 80

The aim was to set an efficient control system, using few reports.

For tile production, the currently used form is extended. Three columns were added, indicating when the production should start, and when it should end, and the delays that occur. This form will be issued in three copies; the one remaining there, the others going to finished goods storeroom and production manager respectively. If there is no inventory on hand, the production manager will issue a production order to the department and, at the end of the day he will receive production reports and he will be able to follow-up his own orders.

A similar procedure would be suggested to the ceramics department. Actually more detailed information would be desirable but instead of facilitating control, such a practice increases bureaucracy.

By applying the suggested method, control will be exercised by sales, inventory, and production managers.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 81

CHAPTER V

CONCLUSION

Reccomendations

After leaving the biscuit kiln, the tiles were selected and the defectives separated before they were treated in the glazing machine. This machine, however, worked at about 50 % capacity. Therefore, the defectives could be separated just before the biscuits were glazed on the machine, abolishing a separate operation of selection. This suggestion has been considered by the management and the selection section abolished. Its effect was a saving of four workers and a gain of about 80 m² of floor space which enabled the company to shift the packaging section to this space and increase the floor space of ceramics department.

Once the demand is known or estimated, the optimal product mix reveals many useful information. First, under prevailing conditions, it can be determined what to produce in order to attain the maximum profit. Second, if there is demand for the products, the expected profits can be calculated and compared with the necessary incremental investment whether it is worthwhile to invest.

If the output of artistic tiles were increased to 2,500 units per day, the incremental revenue per day becomes 654 T.L.. The investment required to increase the output is 26,000 T.L.. The additional kiln is expected to have a life of five years and

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 82

maintenance cost of 500 T.L. per year.

The monthly cash inflow is T.L. 19,620 for sixty months, and the cash outflows are T.L. 26,000 in period zero and T.L. 500 in periods 12, 24, 36, and 48 . The interest rate is 1.5 % per month, which is equivalent to approximately 18 % per year. The Net Present Value of the cash flows become as follows:

$$\begin{aligned} \text{NPV} &= -26,000 - 418.19 - 349.77 - 292.54 - 244.68 \\ &\quad + 772,640.03 \\ &= 745,334.85 \text{ T.L.} \end{aligned}$$

Therefore, it would be a very good investment decision to take the investment, in order to increase the output of artistic tiles to 2,500 units per day.

Still another alternative may be to increase the capacity of the ceramics department. This, however, would be a hypothetical case because it is questionable whether a still higher output of ceramics could be absorbed by the market. If the demand for ceramics would be as high as 800 kg per day, the incremental revenue for the company would be 6,785 T.L. per day for an investment of about 250,000 T.L.. After subtracting the incremental variable overhead, the incremental revenue reduces to 5,828 T.L. . Assuming a life of five years for the investment, the Net Present Value of the investment at a discount rate of 18 % would be:

$$\begin{aligned} \text{NPV} &= -250,000 + 6,920,000 \\ &= 6,670,000 \text{ T.L.} \end{aligned}$$

As both analysis reveal, capacity increases are always profitable for the company as long as the sales of the products

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 83

can be secured. The least efficient part of the system is the sales department. A better organization of this department is inevitable. The sales policy must be such that the product mix will consist of products with higher contribution margins. This can be done by producing decorated and artistic tiles and stop the production of standard tiles. The execution of such a policy would, of course, require much effort on the part of the sales department.

The absence of a cost accounting system in the firm does not make any cost control system possible. Therefore, it would be beneficial to use the cost figures determined in Chapter III as standard costs. These figures, not being too accurate, can be revised when more representative figures are obtained.

A monthly production schedule which also plans inventories and workforce will give better results if practiced continuously. Such schedules must be prepared every month, revising the data according to previous month's results.

The production control forms designed in the previous Chapter is expected to facilitate follow-up and make the reporting more formal.

Conclusion

As explained in the first Chapter, an attempt was made to apply scientific programming techniques to a medium-size plant. Linear Programming Models to determine the optimal product mix and monthly production scheduling have revealed relevant results. Especially in computing the optimal product mix, a perfect result

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE

84

was obtained. Compared with the actual results, the profit figure obtained through the use of Linear Programming technique was higher than the plant's managers actually expect. This difference can arise from two independent factors. The first factor is that the calculated costs were not very accurate and, therefore, the calculated expected profits turned out to be higher than expected by the management. The second factor causing the difference may be that much material is wasted due to inadequate control in the plant. Most probably, both factors together would make up for the observed difference.

In case of production scheduling, the outcomes were not as satisfactory as in the previous analysis. Although mathematically the analysis revealed good results, the intangible factors were not considered because they could not be quantified. No management would like to lay off 30 workers at a time because costs will be reduced. It must be noted, however, that these results should not be used rigidly. Rather, they should be used as guidelines or tools that contribute to decision making. The users of such programs should know its pitfalls and decide accordingly. Furthermore, this model can be sophisticated, if the intangible factors could be defined in some quantitative terms. But it is very difficult, if not impossible, to assign some cost figure to a lay off. Therefore, the model should be used as it is, only trying to make tangible costs and/or benefits more accurate.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 85

The absence of a widely exercised computer time-sharing system makes the use of scientific programming techniques difficult. The main reason for not using such methods, however, is that most managers are not familiar with such tools of management. For, some educational institutions which are in possession of a computer, rent it to outsiders on an hourly basis. Therefore, it would not be too costly to run a scheduling program every month. The cost factor lies, rather, in the high salary of a manager or OR man who can develop a scientific programming model for a firm. Therefore, scientific programming techniques will gain popularity if the management will be familiar with such management tools, and the relatively successful application of Linear Programming has proved that the statement 'Scientific Programming Techniques applies to only big firms' is not always valid.

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 86

APPENDIX

PRODUCTION PLANNING FOR GORBON ISIL

OPTIMAL PRODUCT MIX ALTERNATIVE 1

ITER	FUNCTIONAL	VAR IN	VAR OUT
0001	1145040006	0008047710	0035000000
0002	1508520006	0001030290	0019000000
0003	2081270006	0007042130	0034000000
0004	2464910006	0003032810	0030000000
0005	3049559006	0009059810	0036000000
0006	3306209006	0002027630	0029000000
0007	3642965006	0004044990	0031000000
0008	3770477506	0005035860	0032000000
0009	3826872506	0006041250	0033000000
0010	1241731107	001113728	0017000000
0011	1288153607	0010077700	0018000000
0012	1315886907	0036000000	0028000000
0013	1327864607	0035000000	0013000000

FUNCTIONAL = 07 .13278

BASIC SOLUTION

ID	CJ	LEVEL
0012	000.000	06 .64385
0035	000.000	190.56179
0014	000.000	06 .54530
0015	000.000	06 .96138
0016	000.000	06 .56231
0011	137.280	6257.60450
0010	077.700	500.00000
0001	030.290	3775.28080
0020	000.000	2304.15740
0021	000.000	300.00000
0022	000.000	440.00000
0023	000.000	225.00000
0024	000.000	170.00000
0025	000.000	140.00000
0026	000.000	260.00000
0027	000.000	489.43821
0036	000.000	370.00000
0002	027.630	600.00000
0003	032.810	800.00000
0004	044.990	560.00000
0005	035.860	250.00000
0006	041.250	100.00000
0007	042.130	1000.00000
0008	047.710	2590.56170
0009	059.810	1150.00000

ID	CJ	SHADOW PRICES
0019	000.000	5.80666
0029	000.000	20.07999
0030	000.000	14.89999
0031	000.000	2.71999
0032	000.000	11.84999
0033	000.000	6.45999
0034	000.000	5.57999
0013	000.000	.36217
0028	000.000	12.10000

PRODUCTION PLANNING FOR GORBON ISIL

OPTIMAL PRODUCT MIX ALTERNATIVE 3

ITER	FUNCTIONAL	VAR IN	VAR OUT
0001	1145040006	0008047710	0035000000
0002	1508520006	0001030290	0019000000
0003	2081270006	0007042130	0034000000
0004	2464910006	0003032810	0030000000
0005	3049559006	0009059810	0036000000
0006	3306209006	0002027630	0029000000
0007	3642965006	0004044990	0031000000
0008	3770477506	0005035860	0032000000
0009	3826872506	0006041250	0033000000
0010	1241731107	0011137280	0017000000
0011	1473843607	0010077700	0018000000
0012	1481089207	0036000000	0020000000

FUNCTIONAL = 07 .14810

BASIC SOLUTION

ID	CJ	LEVEL
0012	000.000	06 .53187
0013	000.000	06 .38860
0014	000.000	06 .27870
0015	000.000	06 .71876
0016	000.000	06 .31968
0011	137.280	6257.60450
0010	077.700	2500.00000
0001	030.290	4543.33330
0036	000.000	96.66666
0021	000.000	300.00000
0022	000.000	440.00000
0023	000.000	225.00000
0024	000.000	170.00000
0025	000.000	140.00000
0026	000.000	260.00000
0027	000.000	680.00000
0028	000.000	273.33334
0002	027.630	600.00000
0003	032.810	800.00000
0004	044.990	560.00000
0005	035.860	250.00000
0006	041.250	100.00000
0007	042.130	1000.00000
0008	047.710	2400.00000
0009	059.810	876.66666

SHADOW PRICES

ID	CJ	SHADOW PRICES
0019	000.000	9.83999
0029	000.000	32.17999
0030	000.000	26.99999
0031	000.000	14.81999
0032	000.000	23.94999
0033	000.000	18.55999
0034	000.000	17.67999
0035	000.000	12.09999
0020	000.000	49.96999
0018	000.000	17.89000

PRODUCTION PLANNING FOR GORPON ISIL

OPTIMAL PRODUCT MIX ALTERNATIVE 4

ITER	FUNCTIONAL	VAR IN	VAR OUT
0001	1145040006	0008047710	0035000000
0002	1508520006	0001030290	0019000000
0003	2031270006	0007042130	0034000000
0004	2464910006	0003032810	0030000000
0005	3049559006	0009059810	0036000000
0006	3306209006	0002027630	0029000000
0007	3642965006	0004044990	0031000000
0008	3770477506	0005035860	0032000000
0009	3326872506	0006041250	0033000000
0010	1920170307	0011137280	0017000000
0011	2152283307	0010077700	0013000000
0012	2159523907	0036000000	0020000000

FUNCTIONAL = 07 .21595

BASIC SOLUTION

ID	CJ	LEVEL
0012	000.000	06 .47998
0013	000.000	06 .38860
0014	000.000	4809.10100
0015	000.000	06 .71876
0016	000.000	05 .54099
0011	137.280	05 .11199
0010	077.700	2500.00000
0001	030.290	4543.33330
0036	000.000	96.66666
0021	000.000	300.00000
0022	000.000	440.00000
0023	000.000	225.00000
0024	000.000	170.00000
0025	000.000	140.00000
0026	000.000	260.00000
0027	000.000	680.00000
0028	000.000	273.33334
0002	027.630	600.00000
0003	032.810	800.00000
0004	044.990	560.00000
0005	035.860	250.00000
0006	041.250	100.00000
0007	042.130	1000.00000
0008	047.710	2400.00000
0009	059.810	876.66666

ID	CJ	SHADOW PRICES
0019	000.000	9.83999
0029	000.000	32.17999
0030	000.000	26.99999
0031	000.000	14.81999
0032	000.000	23.94999
0033	000.000	18.55999
0034	000.000	17.67999
0035	000.000	12.09999
0020	000.000	49.96999
0018	000.000	17.89000
0017	000.000	1.30494

OPTIMAL PRODUCT MIX ALTERNATIVE 5

ITER	FUNCTIONAL	VAR IN	VAR OUT
0001	1537536007	001113728	0017000000
0002	1537536007	0010077700	0020000000
0003	1537536007	0002027630	0021000000
0004	1537536007	0003032810	0023000000
0005	1537536007	0005035860	0024000000
0006	1537536007	0006041250	0025000000
0007	1537536007	0007042130	0026000000
0008	1537536007	0008047710	0027000000
0009	1537536007	0009059810	0019000000
0010	1537536007	0001030290	0022000000
0011	2036777707	0004044990	0014000000

FUNCTIONAL = 07 .20367

BASIC SOLUTION

ID	CJ	LEVEL
0012	000.000	06 .58131
0013	000.000	06 .93224
0004	044.990	571.53617
0015	000.000	06 .93830
0016	000.000	05 .35108
0011	137.280	05 .11200
0018	000.000	974.80390
0009	059.810	698.42897
0010	077.700	1525.19610
0002	027.630	707.84983
0001	030.290	3848.34350
0003	032.810	881.97329
0005	035.860	287.40431
0006	041.250	167.39207
0007	042.130	954.92400
0008	047.710	1901.98190

ID	CJ	SHADOW PRICES
0022	000.000	1.61931
0021	000.000	.34293
0023	000.000	.10415
0014	000.000	.37375
0024	000.000	.05284
0025	000.000	.29421
0026	000.000	.49406
0027	000.000	.10822
0019	000.000	15.80333
0020	000.000	.30698
0017	000.000	97.96139

0024	000.000	5.05000
0025	000.000	8.44000
0026	000.000	9.32000
0027	000.000	14.90000
0028	000.000	27.00000
0018	000.000	44.89000

OPTIMAL PRODUCT MIX ALTERNATIVE 6

ITER	FUNCTIONAL	VAR IN	VAR OUT
0001	1145040006	0008047710	0035000000
0002	1508520006	0001030290	0019000000
0003	2081270006	0007042130	0034000000
0004	2464910006	0003032810	0030000000
0005	3049559006	0009059310	0036000000
0006	3306209006	0002027630	0029000000
0007	3642965006	0004044990	0031000000
0008	3770477506	0005035860	0032000000
0009	3826872506	0006041250	0033000000
0010	1920170807	0011137280	0017000000
0011	1966593307	0010077700	0018000000
0012	1994326607	0036000000	0028 000000
0013	2037068007	0035000000	0027000000
0014	2050593307	0031000000	0023000000
0015	2065489807	0034000000	0026000000
0016	2073385107	0033000000	0025000000
0017	2082055907	0032000000	0024000000
0018	2094124507	0030000000	0020000000

FUNCTIONAL = 07 .20941

BASIC SOLUTION

ID	CJ	LEVEL
0012	000.000	06 .47998
0013	000.000	06 .38860
0014	000.000	4809.10200
0015	000.000	06 .71876
0016	000.000	05 .54099
0011	137.280	05 .11199
0010	077.700	500.00000
0001	030.290	4543.33330
0030	000.000	251.66666
0021	000.000	300.00000
0022	000.000	188.33334
0031	000.000	225.00000
0032	000.000	170.00000
0033	000.000	140.00000
0034	000.000	260.00000
0035	000.000	680.00000
0036	000.000	370.00000
0002	027.630	600.00000
0003	032.810	1051.66660
0004	044.990	785.00000
0005	035.860	420.00000
0006	041.250	240.00000
0007	042.130	1260.00000
0008	047.710	3080.00000
0009	059.810	1150.00000

ID	CJ	SHADOW PRICES
0019	000.000	.83999
0029	000.000	5.17999
0020	000.000	31.96999
0023	000.000	12.18000
0024	000.000	3.05000
0025	000.000	8.44000
0026	000.000	9.32000
0027	000.000	14.90000
0028	000.000	27.00000
0018	000.000	44.89000

ITER	FUNCTIONAL	VAR IN	VAR OUT
0001	1653246906	0012000023	0045000000
0002	1855439106	0011000026	0044000000
0003	2099351306	0010000030	0043000000
0004	2321947306	0009000034	0042000000
0005	2321947306	0003000034	0041000000
0006	2557003606	0002000060	0035000000
0007	2580866806	0001000064	0046000000
0008	2688251206	0004000052	0049000000
0009	2777733206	0005000049	0050000000
0010	2843362006	0006000045	0051000000
0011	2885122606	0007000041	0052000000
0012	2908985806	0008000038	0053000000
0013	2984151006	0035000000	0047000000
0014	3017694206	0023089960	0057000000
0015	3020241206	0043000000	0055000000
0016	3021946006	0021179379	0056000000
0017	3019246306	0025449597	0048000000
0018	3014617406	0029269758	0025449597
0019	3013851906	0013539557	0054000000
0020	3003289606	0025449597	0035000000
0021	3003289606	0028314718	0029269758

FUNCTIONAL = 06 -.30032

BASIC SOLUTION

ID	CJ	LEVEL
0002	-000.060	06 .30748
0036	000.000	06 .14365
0037	000.000	06 .11905
0038	000.000	05 .92110
0039	000.000	05 .32896
0040	000.000	05 .79893
0003	-000.034	06 .66574
0009	-000.034	06 .66590
0010	-000.030	06 .58741
0011	-000.026	06 .58741
0012	-000.023	06 .44829
0001	-000.064	06 .59658
0025	449.597	90.08315
0028	314.718	.03977
0004	-000.052	06 .66574
0005	-000.049	06 .66574
0006	-000.045	06 .66590
0007	-000.041	06 .66590
0008	-000.038	06 .66590
0013	-539.557	72.69222
0043	000.000	05 .54516
0021	-179.379	19.73420
0023	-089.960	34.98340

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, İSTANBUL

PAGE 93

BIBLIOGRAPHY

THESIS

ROBERT COLLEGE GRADUATE SCHOOL
BEBEK, ISTANBUL

PAGE 9

Public Documents

- T.C. Başbakanlık, Devlet İstatistik Genel Müdürlüğü, Aylık İstatistik Bülteni, Ankara 1955-1968
- T.C. Resmî Gazete, Ankara, 4 Temmuz 1961, Sayı 10845
- T.C. Başbakanlık Devlet Planlama Teşkilatı, İkinci Beş Yıllık Kalkınma Planı, Ankara, 1967

Books

- Holt, Charles C. et al., Planning Production, Inventories and Workforce. Englewood Cliffs, N.J.:Prentice-Hall, Inc.,1960
- Stigler, George J., The Theory of Price, New York: The McMillan Co., 1968
- Vazsonyi, Andrew, Scientific Programming in Business and Industry, New York, Wiley, 1958
- Baumol, William J., Economic Theoty and Operations Analysis, 2nd ed., Englewood Cliffs, N.J.: Prentice-Hall, 1965
- Churchman, Charles West, etal., Introduction to Operations Research, New York: wiley, 1957