# The Marble Industry in Egypt: A Microeconomic Analysis

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# THE MARBLE INDUSTRY IN EGYPT
# A MICROECONOMIC ANALYSIS

A Thesis Submitted to

The Department of Economics
in Partial Fulfillment of the Requirements for
the Degree of Master of Arts in Economics

By

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## DEDICATION

This work is dedicated in the first place to the soul and memory of my beloved father, my mentor, teacher and ideal in all times.

It is also dedicated to my mother, my sister Nehad and my brother Hossam, for being always there for me with support and advice.

This thesis is dedicated with respect and appreciation to Dr. Adel Beshai, my professor of Economics at AUC. His encouragement and motivation helped me to get through in difficult times. Dr. Beshai supervised my work and inspired me with very valuable thoughts and ideas.

My thesis is also dedicated with love to my husband, Ashraf, and my daughters Nermin, Noha and Sarah. I thank them for their support and help and for giving up, in many instances, their right on my time which was directed to this work and research. I enjoyed studying side by side with my daughters and I hope to have given them the inspiration that the true quest for knowledge and higher education would overcome any obstacle and has no limits.

Last, but not least, this is dedicated to my true friend and classmate since Kindergarten, Nivert. Her presence in my life and her moral support are instrumental in any success I achieve.

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## ABSTRACT

This thesis presents a microeconomic assessment of the marble industry in Egypt. It starts with an overview and analysis of the international marble industry, highlighting this industry as one of the oldest industries in the world. Historically, the industry moved from labor-intensive to capital-intensive with the advent of technological advancement, including development of automated production tools like cranes and diamond cutting wires. In Egypt, during the past 20 years, market entry into the industry was high, due to the high profit margins achieved. In addition, there was (and still is) lack of effective government regulation. Currently, the marble industry in Egypt could be described as that of monopolistic competition, where products are highly differentiated and there are relatively small barriers to entry. However, barriers to entry are becoming more tangible as the needed capital investment increased sharply with the devaluation of the Egyptian Pound. In order to study the dynamics of the industry more thoroughly, a case study (Watany Marble) was examined from two microeconomic perspectives: (1) an investment appraisal using economic cost-benefit analysis leading towards NPV, IRR, ERR and ROI calculations; and (2) application of the theory of the firm to the case study using Cobb Douglas production, profit maximization, cost minimization and returns to scale calculations. Results yield a ROI of 12.24% using weighted-average opportunity cost of capital considerations, a declining long-run average cost curve, and increasing returns to scale in production. Using isoquant-isocost analysis, the marginal rate of technical substitution between factors of production resulted in $1000 of capital corresponding to 7.5 units of labor. Future prospects for the industry is market segmentation, where value-driven and export-oriented firms will tend towards forming an oligopoly, whereas local-oriented, cost-driven firms with relatively low technology will tend towards operating under conditions of a monopolistic competition.

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# INTRODUCTORY CHAPTER

## Introduction

Marble is a precious ornamental stone used by man very early in history. Therefore, it could be said that Marble quarrying and processing industries belong to the oldest industries of the world. The ancient Egyptians, 5000 years ago, knew 40 different types of ornamental stones and worked chiefly with granite and some types of Marble like Alabaster. Some historians claim that the Greek and the Romans acquired the skills of quarrying and processing the Marble from the ancient Egyptians. For over a thousand years now, the economic activity of a city like Carara in Italy has been relying on and revolving mainly around Marble.

Today, marble is a highly differentiated product that is internationally traded. The price and value of marble depends on one hand on its natural characteristics like its quality, type and color as well as on processing of this marble, giving it a special shape, polish, size and thickness. Therefore, for a country to lead in this industry, it needs to be rich in the natural endowments of this precious stone as well as to possess a good industrial base, that allows it to properly extract the stone and process it for local and international trading..

## Objective

The objective of this thesis is to study the current status of the marble industry in Egypt using a microeconomic approach with a case study application. Specifically the thesis will be directed to study the Egyptian Marble industry with respect to its recent history, its characteristics, its prospects, impediments and needed regulations. A representative marble factory will be taken as a case study; first to assess the profitability of engaging in such an investment in Egypt, and second to utilize microeconomic tools to obtain production and cost characteristics of the representative firm.

**Research Methodology**

Various methodologies were used, depending on the nature of research conducted. On the industry level:

1. Research done on the International Marble Industry: Desk research covered an intensive use of research articles to collect data on the international Marble industry. Material related to the international marble industry and accessible through AUC library was screened for useful information.
2. Research done on the Egyptian Marble Industry: There is very little published information on the Egyptian Marble Industry, therefore lots of field research was conducted and several interviews were held with industry entrepreneurs, geologists as well as suppliers of equipment for the industry, in addition to credit and finance officers in banks.

Subsequently, the main challenge was to chose a representative firm of the industry. The following 2 main criteria were set to select a firm to be taken as a case study:

- Medium size enterprise with accessibility to both local and export markets. Most of the firms in the industry are medium size.

- Ideally established in the 1980; to represent the generation of the marble producers that evolved during that time and shaped this industrial sector over the past twenty years, in terms of the technology used.

On the firm level, using a case study; two methodologies were applied:

1. Economic cost benefit analysis to assess the profitability of investing in the marble industry. Indicators like ROI, IRR, ERR, NPV and payback were obtained.
2. Application of the theory of the firm to this enterprise, using a Cobb Douglas production function. By doing so, information on the micro level was obtained with respect to profit maximization, breakeven point, structure of the cost and revenue curves, cost minimization conditions as well as returns to scale. Other technical issues were analyzed such as marginal rate of technical substitution between factors of production and nature of the long run average cost curve.

**Flow of the Thesis**

The first chapter sheds some light on the international marble industry in general, its history, importance, uses, production and consumption patterns, as well as its main players and trade leaders. The second chapter focuses on the industry in Egypt and gives an overview on its current history and the recent developments as well as stages of production to highlight the nature of this industry and how the quarries relate to the factories. Then, characteristics of the industry are analyzed in more detail, as well as needed regulations (or more specifically, lack of regulations) for this sector in Egypt. The chapter ends with analyzing impediments facing the industry in addition to featuring prospects for the future.

After shedding some light on the dynamics of the industry in Egypt a case study of a marble factory "Watany Marble" that operates in this market environment is presented in the third chapter. The research in this chapter focuses on assessing the economic driving force behind this investment, namely profitability of the business using economic cost-benefit analysis. In the fourth chapter theory of the firm is applied to the case study using detailed microeconomic analysis to shed light on the production and cost characteristics of this industry. The fifth chapter summarizes the conclusion of the work done.

The flow of the thesis is developed from a general-to-specific perspective. It goes from the big picture, which is the international market of Marble, then focuses on the local Egyptian Market, and then zooms down on a case study in Egypt.

**Limitation of the Study**

This thesis is viewed as an eye opener to this very important industry in Egypt that deserves to receive much more attention than it currently does. Due to this fact, lots of research venues are open for further efforts to be directed to this sector. Interesting and tempting fields of research would have been resource depletion, externalities and associated social cost. Due to limitations on the scope of this study, these important economic issues were not tackled. Nevertheless, it is hoped that further research will be triggered to cover these important topics in future studies.

# CHAPTER II

## INTERNATIONAL MARBLE INDUSTRY

### Historical Developments of the Marble Industry

The industry of Marble and Granite is one of the oldest industries in the world. It is known since the ancient Egyptian, Greek and Roman civilizations as they used these stones to build their finest buildings and sculptures. Ancient Egyptians worked chiefly with Granite, while Greeks and Romans used more Marble. This was mainly related to the natural endowment of the country at that time and the ability of the ancients to extract and use the discovered stone.

Originally, the word "marble" stems from the Greek word "marmaros" and means a snow white and spotless stone, a rocky mass. The adjective "marmoreos" means "splendid" and the verb "marmairo" means "to shine".[1] Over the years, the meaning of the word marble changed gradually as the marble market expanded throughout the Western World. Historically, referring to marble meant an "ornamental stone taking polish", but for centuries, it was not possible to establish which ornamental stones were marble and which were not. In the 19th century, a new genetic classification of rocks was established and all crystalline calcareous colored rocks came under the heading of marble. Nowadays in the commercial and industrial world, all ornamental stones, silicates in particular and travertine stones that do not polish well, come under the same heading of Marble Products, while only crystalline calcareous rocks are considered marble in the strict sense

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[1] Panos Tomaras, Ancient Greek Marbles some still used today, p. 1

of the word. Under the general definition, all exploitation of marble, granite, serpentine, syenite, quartzite, porphyry, alabaster and diorite come under the heading of "marble industry".

Figure 1 gives an overview of the historical timelines for the development of the use of ornamental stones since 2650 B.C. till the present. During ancient times and due to the low degree of mechanization, this bulky industry called for the employment of huge quantities of manpower. According to the article "The Egyptian Pyramids", this problem was resolved economically by employing workers that accepted very low wages such as were earned by slaves and forced labor at those times. The ancient Egyptian civilization is the first known civilization to use the ornamental stones with great skills and to have their work sustained until today. The ancient Egyptians catalogued 40 different types of ornamental stones and used them for artistic and architectural purposes, among them limestone, sandstone, alabaster and granite (Arnold, 1991). The pyramids are a witness for that. The steps pyramid of King Zoser built in 2650 B.C. is the oldest monumental work in stone known to man. Its exterior walls are made of white limestone and its interior cladding of pink granite. The great pyramid of Cheops (2613 B.C) which is one of the seven wonders of the world, is the biggest monument of stone ever built. The blocks fit into each other with great precision, indicating high skills and accuracy. The interior corridors of the pyramid and the funerary chambers were constructed of granite which came from Assuan, 800 km away from the construction site of the pyramids. It is said "man fears time, but time fears the pyramids". [2]

[2] The Egyptian Pyramids, www.Litosonline.com, p1

The Greek civilization is very famous for working with Marble and left behind treasures of memorable monuments, sculptures and temples. The most famous temple is the Acropolis built around 462 BC which has columns and statues of antique Marble. The Greeks exported their Marble to the Roman Empire starting the 2nd century B.C. and the Romans, living in a home country very rich with marble, developed their own marble treasures starting 175 B.C. onwards. The widespread use of Marble began in the 1st century BC in Rome and by the time of Augustus, buildings were going up everywhere in Marble." I found a city of brick and left it a city of marble",[3] so said the Roman Emperor Cesar Augustus (64 B.C. – 14 A.D.) The Roman conquest of the Mediterranean Basin provided access to colored stones; yellow marble, red, green and black marbles from Greece. Egypt was the richest source of color; providing red, gray and black granite, basalts and sedimentary stones and even black volcanic glass (obsidian). By then, over fifty varieties of marble were known. The Romans were the first to use Marble in slabs, as a wall application. This is because it was the Romans who invented cement, which was needed to hold the marble tiles in place.[4]

The Christian Art and Architecture are generally very famous for using Marble. Most of the churches around the world, especially in Europe demonstrate the intense use of Marble for columns, sculptures, wall cladding, stairs and above all for the Altars. Examples extend over the different decades, like the Basilica of Santa Maria of Castello in Genoa (12th century), St. Peter in Rome (14th century) and the Church of Jesus in Genoa (17th Century).

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[3] Franco and Aldo Russo, Antique Marble History and Types,p.3
[4] Franco and Aldo Russo, Antique Marble History and Types,p.4

Islamic Architecture is also famous for using Marble. In Egypt, one of the oldest Mosques, the Ibn Tulun Mosque in Cairo was built in 879 A.D and contains very fine marble work. Also, in India Taj Mahel is one of the most profound Islamic Architectures made of marble built in 1627 A.D. Moreover, the two most important mosques in Saudi Arabia; the holy Mosque in Mekkah and the Mosque of Prophet Mohamed in Meddinah were built with the finest types of Marble in the world.

As illustrated, though the use of marble extended since early civilization and over the different epochs, yet there were factors that influenced the intensity of use. For example, the abolition of slavery in the ancient empires led the architecture to relinquish the use of those stones almost completely. The discovery of gunpowder in the fifteenth century was a means to help man extract the rock and was important to revive and help the development of the quarrying activity in Europe as well as in other parts of the world.

**Types and Characteristics of Marble Products**

Marble is either antique or modern. We refer to the antique Marble as the Marble extracted from quarries which have been exhausted and which are only known through the works of the ancients. According to quarries of the antique marble were in Greece. The "Lapis" is regarded as one of the finest of Antique Marbles. It is of deep blue color, stained with a clearer sky blue and intermixed with veins of gold. On account of its rarity, it was only used for inlaying. Several specimen of it may still be seen in castles. The most famous quarries for marble were in Carrara, Italy, which have been used since the time of Emperor Augustus. The finest quarries were discovered later and were made famous by great sculptors like Leonardo da Vinci ( 1452-1519 ) and Michelangelo ( 1475-1564 ).

| Egyptian Civilization | | Greek Civilization | Roman/ Christian Civilization | | Islamic Civilization | Modern |
|---|---|---|---|---|---|---|
| *Zoser Pyramid*, built in Sakkara of white limestone, in its interior lies the chamber of Pharao Snefru with cladding of *pink granite* and sealed with a block of stone 3 tons. This is the oldest *stone work known to man today*. It was built by architect Imhotep. It measures 545 m from North to South and 227 m from East to West and is 66m high. | *The Cheops Pyramid* of Gizeh,consisting of 2.3 million limestones, interior cladding of granite, is the *biggest monument of stone ever built.* The granite used in the construction of the corridors and the funerary chambers came from Assuan, 800 km away. The ancient Egyptians have thousands of statues, columns, obelisques and temples made of ornamental stones to demonstrate the intensive use of this resource by the ancient Egyptian civilization. | Only in the 6th century BC did Marble and Limestone buildings become common. Marble was used in the construction of the Parthenon, the Erchtheum, the Acropolis and the temple of Olympus Zeus. The famous quarries of Antique Marble were in Greece. The "Lapis" is regarded as one of the finest of antique Greek marble with its deep blue color intermixed with veins of gold. This could be found only in ancient castles. Also the white Marble of Paros of Greece is one of the most renowned of antique Marble. Statues and virgin blocks of Greek marble were imported to Rome in 2 & 1 century B.C. The Greek civilization intensively used the Marble to build statues, castles and temples. Many of them are preserved till date and demonstrate a very high skill especially in sculpture. | The oldest known specimen of Roman's Marble work dates back to 175-170 B.C and is a column to celebrate the victory of Marcius Claudius Marcellus. In 48 B.C marble was well-known throughout Rome and during the reign of Augustus huge quantities were used to modernize the city. During Roman Republic quarries were public property. | The *Christian Civilization* relates to the Roman Civilization especially in Art & Architecture. Lots of the Marble treasures produced during the Roman Empire are considered Christian Art, the churches, statues and Altars. The Vatican in Italy has a wealth of Marble heritage like St. Peters, 14th century. Christian Marble Art is found around the world in Egypt there is " Moalaka Church" , St. Gerguis and St Barbara 4th century. All over Europe, churches, castles and palaces are made of very fine Marble, like the Versailles in Paris and Schonbrun in Vienna. | Marble was widely used in Islamic Architecture. Mosques and palaces as well as mihrabs and minbars and in making columns and jars. *The holy mosque in Mekkah* and the *Mosque of the Prophet Mohamed in Madinah* were built with renowned Marble from the best types all over the world. One of the oldest Mosques is Ibn Tulun in Cairo built in 879 AD, a masterpiece of Architecture and marble designs. Azhar Mosque & University built in 972, the Citadel built in 1176 AD. In India, *Taj Mahel* built in 1627 as a tomb is a masterpiece of beauty | Thousands of buildings are being constructed every year with marble and granite floors, walls and decorations, whether for residential uses, as office buildings, governmental buildings, shopping malls or religious buildings like Mosques or churches. Using Marble in buildings reflects status, beauty and durability. Examples are the opera houses around the world and houses of Parliament. |
| **2650 B.C** | **2613 B.C.** | **462 – 1 BC** | **175 BC –zero** | **Zero-2003** | **879 AD - 2003** | **1900 - 2003** |

Figure (1): Historical Timeline for the Development of Ornamental Stone

The modern marble is the marble still being extracted from existing quarries. Today, there are at least 2500 known and registered Marble types, the prices of which vary according to their characteristics. The Carrara district in northern Italy still produces the world's most famous marble and is considered the capital of Marble in the World. Italy has over 300 types of known Marble, giving the country a distinguished place amongst the world's producers of Marble. The second richest country in Marble varieties is Greece which has slightly over 100 known types. Egypt produces over 25 different types of Marble and ranks as the ninth among the world's leading producers of Marble varieties.[5]

Marble is one of the rocks that make up the crust of the earth. The beds of Marble were formed, from the deposits of the sea, namely small quantities of stony substances, shells, gravel and pebbles being washed together and stratified. The formation of most of these beds of Marble seems to have preceded that of other beds of calcareous stones, as they are almost always found beneath such beds. In a hill composed of twenty or thirty beds of stone, there are usually only two or three beds of Marble. These always lie beneath the others and near the clay which forms the base of the hill, either resting upon it, or only separated from it by another bed which seems to be the residuum of all the others, being made up of Marble, and a large quantity of crystallizations.

Thus, by their situation beneath the other beds of calcareous earth, these Marbles have received the colors and petrifying fluids which the water always collects in its passage through the earth and the beds of stone which intervene between this

[5] Marble varieties, www.findstone.com

and the Marble beds. There are few Marbles, which are of a single color. Some fine black and white specimens and even these are often tinged with grey or brown. All other types are of various colors. It may rightly be said that every shade of color is visible in Marbles. There is red Marble with its various shades, orange yellow and yellowish, green and greenish, blues, more or less decided, and violet. These last two colors are the most rare, yet they are seen in the Violet Breccia, and in the Bleuturquin, a Marble obtained from Genoa and several other quarries. From the mingling of these colors results an infinitude of shades in the grey, dove, whitish, brown, and blackish Marbles.

Certain veined marbles are preferred by architects on aesthetic grounds. But generally speaking, the purer the chemical composition of the marble the whiter and more expensive it is. Usually Marble bears the name of the country in which its quarries are found or it bears the name of the mountain from where it was extracted such as the Pyrenean Marble or the Italian Carara.

The natural brilliancy and intensity of the colors of Marble can be increased by art. For this end it is only necessary to heat the Marble. The red will become more vivid, and the yellow will change into an orange or vermilion. The heat necessary to work this change is acquired by polishing Marble till it becomes hot, and the shades of color brought about in this simple manner are permanent and remain unchanged by weather or time; they are durable because they are deeply imprinted, and the entire mass of Marble would receive this increase of colors by an intense heat.

Apart from chemical characteristics and composition, other basic physical properties of Marble are also important in deciding its value as a deposit. Marble usually weighs from 2.5 to 3 tons for every cubic meter ($m^3$). Basic properties such as water absorption, bulk density, compressive strength, modulus of rupture (bending strength) and durability are important features of the stone, when a deposit of Marble is discovered and become an important determinant of its price and value. Usually, the marbles of a country resemble each other in chemical and physical features more strongly than those foreign to them. Nevertheless, it often happens that portions differently colored, and differently marked with spots and veins, are found in the same quarries, and sometimes in the same block.

Granite is a special type of Marble product and the name broadly applies to any crystalline quartz-bearing rock in which quartz makes up 10% to 50% of the felsic components, making granite extra hard. Granite has a very high density and weighs about 9 tons per $m^3$. It is light-coloured and its crystals are large enough to be seen with the naked eye. Granite can withstand a pressure of 15,000-20,000 pounds per square inch.

Only geologists can establish whether a deposit of Marble or Granite is usable or not and this has to be conducted on site. Then, a specimen of rock is taken from certain clearly marked places to mineralogical and petrographic laboratories and examined with special methods; including microscopic examination of transparent sections ($300^{th}$ of a millimeter thick) to trace each individual component mineral, dimension and ratio within the rock itself. Chemical analysis of all elements found takes place, even if these are merely traceable. Other specialized tests also take place. These tests are necessary to foresee the behavior of this particular type of marble during the working process, its resistance to stress, wear and tear and weather. The structure of an unknown piece of marble is examined to identify the original deposit to which this piece belongs, as the same types of marble are found in different parts of the world, far away from each other. Some quarrymen are so experienced, that they can tell at a glace which quarry each individual piece of stone comes from.

After addressing the types, characteristics and historical development of Marble use, recent trends of production, consumption and features of this viable industry in the world will be addressed in the following sections.

## World Consumption, Distribution and Share

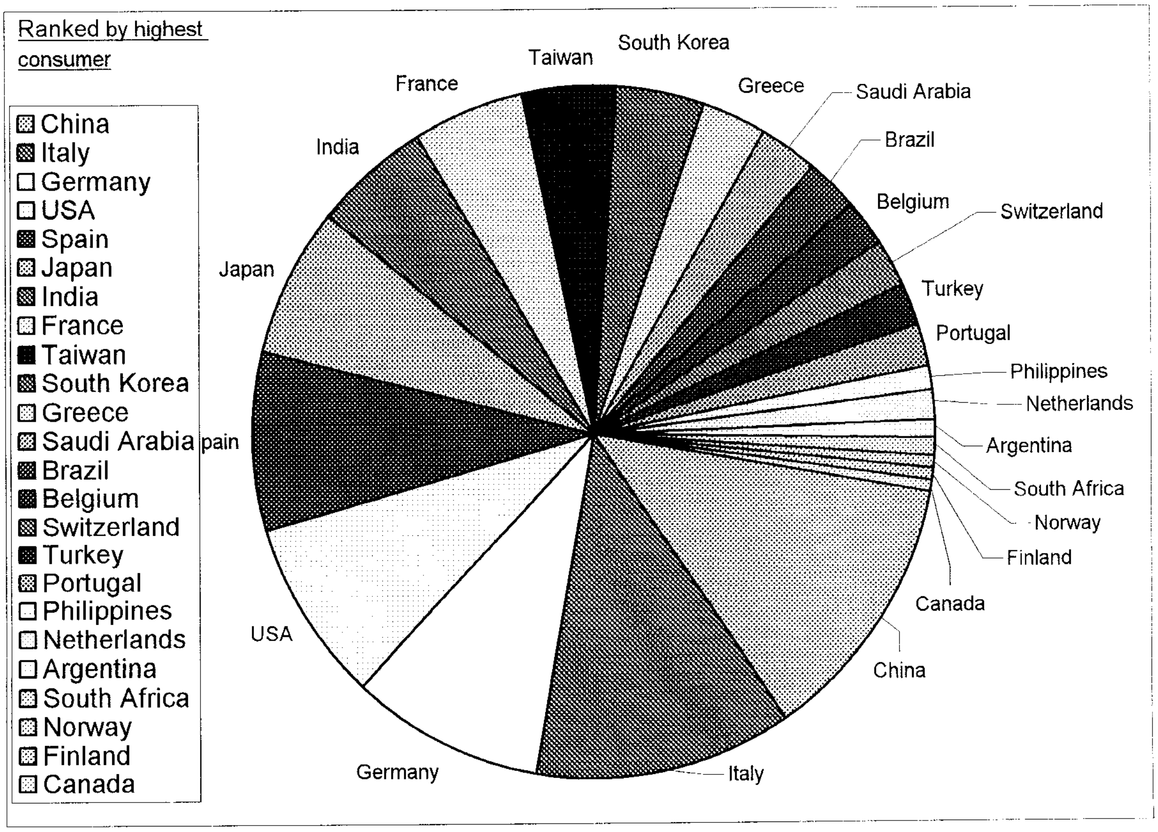



Figure (2): World Consumption of Marble
*Source: GDM Stone Industries Handbook 2000*

Figure (2) reflects the main consumer countries of Marble in the world in 1999. In that year, total world consumption of Marble was more than 477.74 mill $m^2$. As discussed before, man used to consume Marble since thousands of years. Today, the use of Marble has become very intensive and Marble became a well established industry with a wide base of consumers all over the world. The Table above reflects that in 1999 China was the biggest consumer with 10.3 % share of world consumption. In the second place came Italy with a world share of 9.8 %. Other leading consumer countries were Germany, U.S.A, Spain, Japan and India. On average, the world's consumption growth rate during 1998/1999 was 6%.

Table (1) includes another measure to compare the countries' consumption of marble which is the *per capita consumption of Marble*. Although China as a country is the biggest consumer of Marble, yet if we look at the intensity of Marble consumption reflected by the per capita consumption of Marble we find that it ranks as the second lowest consumer, where each citizen consumed on average 0.049 $m^2$ of Marble in 1999. Switzerland, on the other hand ranked number 15 with respect to its share of world consumption as a country. Looking at its per capita consumption of Marble, we find that it ranks as number one with the highest per capita consumption which is 1.438 $m^2$ of Marble. Right after Switzerland comes Greece taking the second highest per capita consumption with a rate of 1.429 $m^2$, slightly lagging behind Switzerland, but staying well ahead of world Marble leader Italy, where average per capita consumption is 1.01$m^2$. In comparison, per capita consumption in U.S.A is only slightly more than a tenth of Switzerland's and Germany slightly more than a third. India has the lowest per capita consumption of Marble with a rate of 0.027. Calculating the world's average per capita consumption of Marble, we find that it is 0.514 m2 per capita.

One major reason for Switzerland to be such an important Marble consumer is its very high-income level and standard of living. In absolute terms, the average household income in Switzerland is about 40% higher than in Germany. This comes in combination with the deep-rooted preference of the Swiss people for long lasting high quality goods, which favors the use of natural stones.

Over the past decade, natural stone (mainly marble and granite) has become the standard material used for luxurious homes and high price apartments. Marble and granite are used for cooking work places, bathrooms, entrance halls and living rooms. Also, service companies such as banks and insurance companies often apply this prestigious stone material for interior design and facade claddings.

Furthermore, dimensional stone is used by the public sector especially for road and public place paving and for important public buildings like halls and museums.

Table (1): Quantity of Marble consumed in mill m$^2$, Countries' Share and Per Capita Consumption in m$^2$ in 1999.

| Rank | Country | Quantity | World Share | Per Capita Consumption |
|---|---|---|---|---|
| 1 | China | 61.31 | 10.3% | 0.049 |
| 2 | Italy | 58.13 | 9.8% | 1.010 |
| 3 | Germany | 43.92 | 7.4% | 0.535 |
| 4 | USA | 41.92 | 7.0% | 0.150 |
| 5 | Spain | 39.33 | 6.6% | 0.980 |
| 6 | Japan | 33.36 | 5.6% | 0.263 |
| *7* | *India* | *26.88* | *4.5%* | *Lowest 0.027* |
| 8 | France | 24.51 | 4.1% | 0.415 |
| 9 | Taiwan | 21.92 | 3.7% | 0.996 |
| 10 | South Korea | 19.15 | 3.2% | 0.410 |
| 11 | Greece | 15.12 | 2.5% | 1.429 |
| 12 | Saudi Arabia | 13.89 | 2.3% | 0.650 |
| 13 | Brazil | 11.36 | 1.9% | 0.065 |
| 14 | Belgium | 11.03 | 1.9% | 1.080 |
| *15* | *Switzerland* | *10.42* | *1.8%* | *Highest 1.438* |
| 16 | Turkey | 9.27 | 1.6% | 0.143 |
| 17 | Portugal | 8.67 | 1.5% | 0.864 |
| 18 | Philippines | 6.03 | 1.0% | 0.077 |
| 19 | Netherlands | 5.87 | 1.0% | 0.371 |
| 20 | Argentina | 4.05 | 0.7% | 0.110 |
| 21 | South Africa | 4.01 | 0.7% | 0.095 |
| 22 | Norway | 2.74 | 0.5% | 0.614 |
| 23 | Finland | 2.61 | 0.4% | 0.500 |
| 24 | Canada | 2.24 | 0.4% | 0.072 |
| | Total | 477.74 | | *Average 0.514* |

*Source: GDM Stone Industries Handbook 2000*

The breakdown of the uses of natural stone internationally is summarized in Table (2). We find that 37% of consumed natural stone is used for flooring and 20% for total exterior and interior cladding, and 3.5 % for stairs. Uses of Marble for reasons other than construction include special works and structural works and funeral art which could all come under the general use of decorative art.

Table (2): Natural Stone Main uses in 1999

| Main uses of Natural Stone | % of Total |
|---|---|
| Flooring | 37.0% |
| Exterior cladding | 10.0% |
| Interior cladding | 10.0% |
| Stairs | 3.5% |
| Special works | 12.0% |
| Structural works | 10.0% |
| Funeral art | 15.0% |
| Others uses | 2.5% |
| Total | 100.0% |

*Source: Stone 2000*

Thus, the world's use of natural stones is roughly 60%-70% for construction purposes and 30%-40% for decorative art. Hence, one can generally say that uses of Marble are split between construction and decorative art with a ratio of two thirds to one third.

**Expected World Growth of Natural Stone Trade**

The world's consumption of natural stone has been increasing at an average rate of 6% in 1999 as illustrated before. The world's trade of natural stone has reflected a growing trend as well with an average expected growth rate of 7.5% over the coming 20 years.

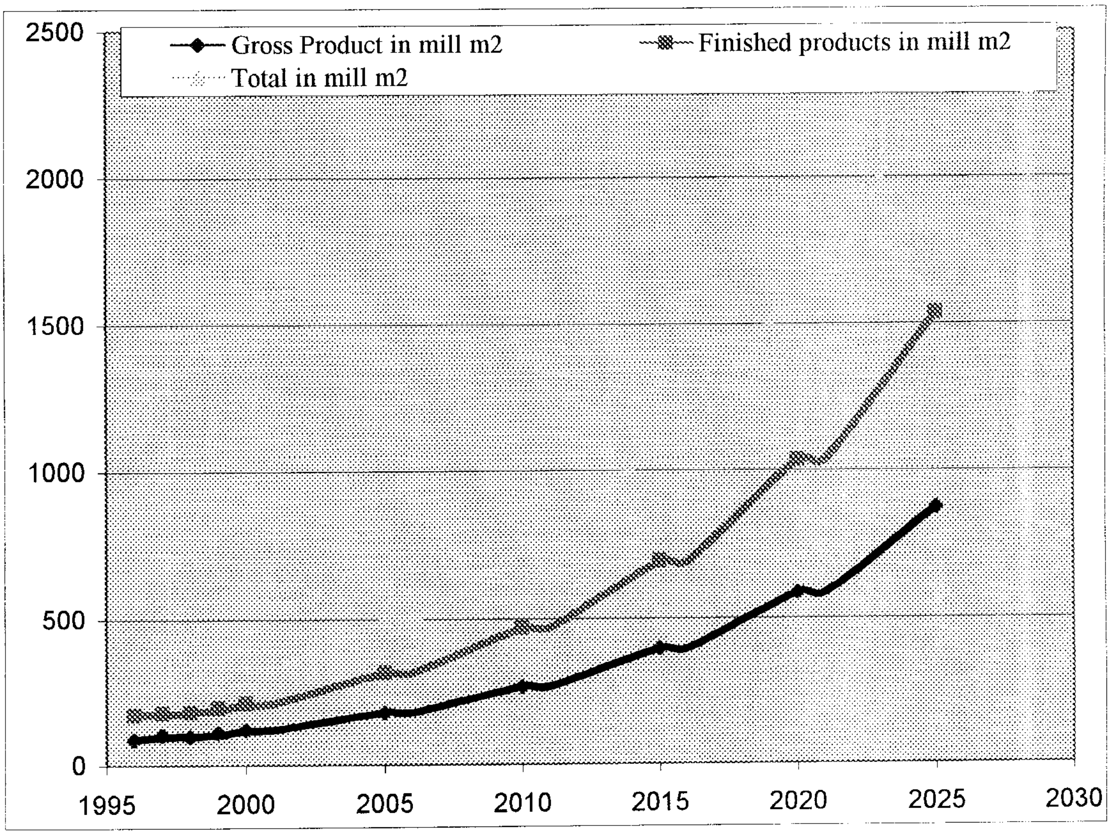



Figure (3): Expected World Growth of Natural Stone Trade
*Source: Stone 2000*

Figure (3) demonstrates the world's trade in the different types of Marble, whether raw or finished marble. This is represented in three graphs; the bottom graph represents the world's trade of raw Marble in $m^2$. This reflects constant levels of trade from 1996 till around the year 2005 at levels as low as 100 $m^2$. Starting the year 2005 world's trade in raw marble is expected to pick up and reach levels as high as 900 $m^2$ around the year 2020. The second graph represents trade in finished marble products and it reflects similar patterns of trade growth like the raw marble. Trade in finished Marble products was at levels higher than trade in raw marble and reached around 250 m2 in 1996. Yet it is expected to remain constant till the year 2005 when it is expected to pick up and reach levels as high as 1.5 billion $m^2$ in the year 2025. The third graph depicts the expected total growth of trade in finished and raw marble. It is expected that the total volume of international trade in natural stone in general will be around 2.4 billion $m^2$ by the year 2025.

Table (3): Expected World Growth of Natural Stone Trade

| Years | Gross Product in mill m2 | Finished products in mill m2 | Total in mill $m^2$ | annual growth rate | ratios |
|---|---|---|---|---|---|
| 1996 | 88.4 | 171.0 | 259.4 | 0.0% | 84.4% |
| 1997 | 103.7 | 179.2 | 282.9 | 9.1% | 92.1% |
| 1998 | 96.7 | 181.7 | 278.4 | -1.6% | 90.6% |
| 1999 | 111.5 | 195.8 | 307.3 | 10.4% | 100.0% |
| 2000 | 120.6 | 212.0 | 332.6 | 8.2% | 108.2% |
| 2005 | 179.2 | 315.1 | 494.3 | 9.7% | 160.9% |
| 2010 | 266.4 | 468.4 | 734.8 | 9.7% | 239.1% |
| 2015 | 396.1 | 696.2 | 1092.3 | 9.7% | 355.5% |
| 2020 | 588.8 | 1034.8 | 1623.6 | 9.7% | 528.3% |
| 2025 | 874.7 | 1538.3 | 2413.0 | 9.7% | 785.2% |
| **Average growth rate** | | | | **7.5%** | |

*Source: Stone 2000*

Table (3) reflects actual figures of natural stone trade from 1996 till 1999. From year 2000 till 2025, it is a projection of growth trends. It is expected that the trade in natural stones in the year 2025 will be about 8 times as high as the trade in 1999 and will reach a total trade volume of 2,413 billion $m^2$. It is obvious from Table (3) and Figure (3) that expectations foresee that the trade in finished stone will be almost as double as the trade in raw stone. But in general the trade in natural stone on the international level reflects an increasing trend.

**World Stone Industry; Leading Quarry Production**

As has been illustrated, the need for natural stone, both for construction and decorative purposes, never ceased since the times of the ancient civilizations and became more and more important over the years. This can easily be concluded from the steady increase observed in the stone production worldwide. In 1986 total production of ornamental stone was 21.7 million tons. This figure rose to 62.4 million tons in the year 2000, an increase of almost 300% in fourteen years.

To look at the production of *pure Marble and Travertine*, Table (4) represents data from the UN Statistical Yearbook on the production of industrial commodity by country and reflects a general increase in the production from the year 1991 till 1999. Whereas world production of Marble in 1990 was 17.3 mill $m^3$, in 1999 it increased ten folds to be 1.17 billion $m^3$.

Table (4): World Production of Marble and Travertine by continent

| Continent | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | Total |
|---|---|---|---|---|---|---|---|---|
| Africa | 55 | 608 | 846 | 750 | 817 | 739 | 301 | 4,424 |
| N. America | 1,830 | 1,943 | 1,035 | 782 | 656 | 800 | 40 | 11,851 |
| S. America | 305 | 329 | 387 | 434 | 448 | 447 | 9 | 3,569 |
| Asia | 6,947 | 8,878 | 9,484 | 10,868 | 10,788 | 9,227 | 1,455 | 83,237 |
| Euorpe | 125,352 | 134,003 | 145,766 | 146,465 | 149,975 | 172,270 | 175,053 | 1,071,810 |
| Total | 134,489 | 145,761 | 157,518 | 159,299 | 162,684 | 183,483 | 176,858 | 1,174,891 |

*Source: UN Statistical Yearbook on Production, Year 2000*

In 1993, Europe was the biggest producer of Marble with a total share of World Production of 93.2 %, whereas Asia came in the second place with a production share of 5.16%. The remaining 1.64 % were produced by the other three continents with North America taking the third place, South America the fourth and Africa the last. Looking at the 1999 data, we find that Europe remained the world's production leader of marble, with a share of 99% approximately, leaving only 1% of world's production to be supplied by the remaining 4 continents. The non-availability of data from some Marble producing countries in 1998 & 1999 led to the understatement of the aggregated world production level in these two years in the UN Statistical Yearbook. Annex (3) includes a detailed table with the volume of production of every country in each of the continents.

As for *Granite, porphyry and sandstone*, according to the UN Statistical Yearbook on the production of Commodities, world production witnessed slight increases over most of the past years from 1992 till 1999 with a decrease in 1998. Average yearly world production over the eight years was 192 mill $m^3$.

Table (5) World Production of Granite, Prophyry, Sandstone etc in thousand $m^3$.

| Continent | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | Total |
|---|---|---|---|---|---|---|---|---|
| Africa | 786 | 699 | 840 | 971 | 931 | 987 | 802 | 6,016 |
| N. America | 19,761 | 18,647 | 16,950 | 640 | 652 | 630 | 605 | 57,885 |
| S. America | 60,264 | 60,296 | 65,586 | 67,394 | 68,210 | 72,471 | 72,411 | 466,632 |
| Asia | 7,689 | 9,563 | 15,739 | 14,444 | 13,922 | 14,985 | 5,902 | 82,244 |
| Europe | 50,816 | 51,590 | 49,536 | 73,337 | 82,472 | 65,735 | 54,223 | 427,709 |
| Total | 139,316 | 140,795 | 148,651 | 156,786 | 166,187 | 154,808 | 133,943 | 1,344,067 |

*Source: UN Statistical Yearbook on Production, Year 2000*

South America had the leading position during that period, having a country like Brazil which belongs to the main producers of granite in the world. In the second place, as a continent, came Europe with a world production share of 36.4%. As for Europe, two countries were clearly dominating the arena in granite production: Spain and Portugal. With respect to the other three continents, Africa produced a negligible amount of world production hardly constituting 0.5 % at any one year. With respect to Asia and North America they exchanged the third and fourth place over the 7 years. Till 1994, North America had a higher production level. Starting 1995, Asia picked up and its production levels continued with an increasing trend, whereas North America suffered from decreased production one year after the other.

Table (6) below reflects the quarrying production of main producing countries of ornamental stones from 1997 till 2001. China has been a main producer with a world share of 25.6 % in 1997. Although China's share in world production decreased to 22.1% in 1998 and reached 20.3% in the year 2000, yet it picked up to 24.4% in 2001. Italy came in the second place as a world ornamental stone producer with a world production share of 19.2% in 1997. In 1998 its production share showed a decreasing trend and reached 15.2% in 2001, slightly more than India, which maintained the third place as a world producer of natural stones with a significant share of 14.7% of world production. The fourth and fifth places in 2001 were occupied by Iran and Spain with a world production share of 11% and 9% respectively.

Although Egypt is the oldest civilization that used ornamental stones with high skill and has until today a wide variety of marble product types, where the Egyptian Marble is well known and demanded, yet Egypt disappointingly holds the 27th position worldwide with a world production share ranging between 0.2% and 0.25%. According to Egyptian Marble producers, internal institutional bureaucracy and the fear from high taxation on the activity has resulted in lots of under registration of the business activity. Accordingly, Egypt's real volume of activity in the stone sector is not fairly reflected in official figures. Experts in the field of Marble and Granite in Egypt judge the position of Egypt to be ranking between the 15th and 20th country in the volume of natural stone production in the world.

Table (6): Leading Producing Countries of ornamental stones in $m^3$ tons 1997 - 2001.

| Country | 1997 | % share | 1998 | %share | 1999 | % share | 2000 | % share | 2001 | % share |
|---|---|---|---|---|---|---|---|---|---|---|
| China | 12,960 | 25.6% | 13,000 | 22.1% | 13,000 | 21.5% | 13,000 | 20.3% | 16,800 | 24.4% |
| Italy | 9,713 | 19.2% | 9,428 | 16.0% | 9,757 | 16.1% | 10,130 | 15.8% | 10,464 | 15.2% |
| India | 8,172 | 16.2% | 8,572 | 14.6% | 8,760 | 14.5% | 10,054 | 15.7% | 10,100 | 14.7% |
| Iran | 0 | 0.0% | 6,500 | 11.1% | 7,045 | 11.6% | 7,413 | 11.6% | 7,536 | 11.0% |
| Spain | 5,292 | 10.5% | 5,557 | 9.5% | 5,600 | 9.3% | 6,200 | 9.7% | 6,200 | 9.0% |
| Turkey | 2,000 | 4.0% | 2,400 | 4.1% | 2,304 | 3.8% | 2,453 | 3.8% | 2,625 | 3.8% |
| Brazil | 2,114 | 4.2% | 2,182 | 3.7% | 2,200 | 3.6% | 2,400 | 3.8% | 2,500 | 3.6% |
| Greece | 2,100 | 4.2% | 2,000 | 3.4% | 2,000 | 3.3% | 2,000 | 3.1% | 2,000 | 2.9% |
| Portugal | 1,200 | 2.4% | 1,878 | 3.2% | 1,900 | 3.1% | 1,900 | 3.0% | 2,000 | 2.9% |
| France | 1,198 | 2.4% | 1,100 | 1.9% | 1,300 | 2.1% | 1,300 | 2.0% | 1,500 | 2.2% |
| U.S.A | 1,180 | 2.3% | 1,130 | 1.9% | 1,250 | 2.1% | 1,250 | 2.0% | 1,300 | 1.9% |
| Mexico | 517 | 1.0% | 664 | 1.1% | 744 | 1.2% | 1,035 | 1.6% | 1,000 | 1.5% |
| S. Africa | 891 | 1.8% | 961 | 1.6% | 1,000 | 1.7% | 1,000 | 1.6% | 1,000 | 1.5% |
| Saudi Arabia | 600 | 1.2% | 600 | 1.0% | 600 | 1.0% | 580 | 0.9% | 600 | 0.9% |

*Source: Internazionale Marmi e Macchine Carrara S.p.A, 2002*

## Global Trade of Marble

Marble trade can be distinguished in three categories: raw marble, rough worked and finished marble. All these forms of marble have a reasonable share in world trade, but finished marble has the bulk share of about 50%. Obviously, most countries strive to export finished products as much as possible, since the value-added from working the raw marble into a finished product increases the country's profit margin.

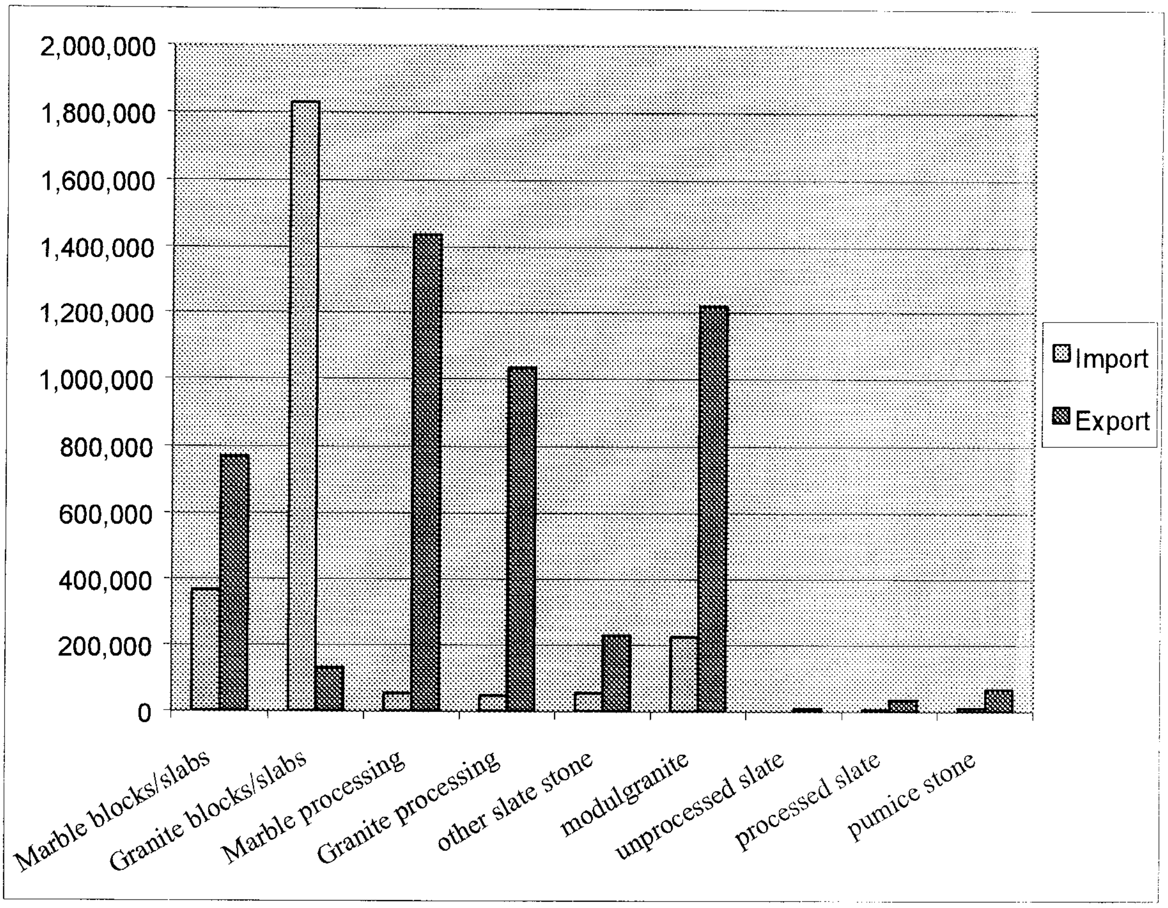



Figure (4): World Import and Export of ornamental stones for the year 2000
*Source: Internationale Marmi e Maccine Carrara Spa*

From Figure (4) above, we can see that, comparing the volume of world trade in ornamental stones, the highest volume of world imports are granite blocks and slabs which reached a benchmark of 1.8 mill tons in the year 2000. In second place comes exports of processed Marble which reached in that year 1.43 mill tons. The exports of finished marble blocks and slabs reached 769,000 tons, while imports were only 368,000 tons.

Table ( 7) Value of World's Exports in mill $

| Year | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| World Exports | 1758 | 1938 | 1974 | 1961 | 1863 |
| Growth rate | | 10.25% | 1.83% | -0.66% | -5.01% |

*Source: Sector Report on Granite & Marble, Industrial Information Network*

Looking at the value of world's exports of Marble and Granite in 1995, total world exports reached $ 1.758 billion. The value of exports witnessed an increase of 10% from 1995 to 1996. This high increase leveled off a year after to be 1.83% only. In 1998 & 1999 the total value of World's exports reflected first a slightly decreasing trend of 0.6% and then a decrease of 5%.

Italy has been number one exporter of Marble and Granite and has maintained this place for several years from 1995 till 1999. Italy's exports constitute over 59% of the world's exports of Marble totaling more than one billion dollars in 1995 of a world trade of $ 1.7 billion. Spain, the second biggest exporter exported only 10% .This illustrates the huge gap between Italy and any other country in the business of the export of Marble. Although Italy's exports showed a decreasing trend starting 1995, yet its share of total world exports were never less than 50%. Table (8) below displays the world's export volume of Marble Products and the main exporters in million dollars from 1995 to 1999.

Table (8): Major Exporters of Marble and Granite and their share in World's Exports in $ mill

| Country | 1996 | % share | 1997 | % share | 1998 | % share | 1999 | % share |
|---|---|---|---|---|---|---|---|---|
| Italy | 1,123.21 | 58% | 1,077.42 | 55% | 1,027.36 | 52% | 922.80 | 50% |
| Spain | 229.71 | 12% | 280.69 | 14% | 280.05 | 14% | 287.16 | 15% |
| Turkey | 82.80 | 4% | 99.83 | 5% | 113.98 | 6% | 143.64 | 8% |
| Portugal | 126.34 | 7% | 107.93 | 5% | 112.14 | 6% | 110.65 | 6% |
| Greece | 125.18 | 6% | 132.62 | 7% | 115.54 | 6% | 93.21 | 5% |
| Mexico | 22.11 | 1% | 36.53 | 2% | 43.55 | 2% | 59.20 | 3% |
| China | 32.39 | 2% | 38.46 | 2% | 47.94 | 2% | 44.98 | 2% |
| Other | 196.00 | 10% | 200.00 | 10% | 220.00 | 11% | 201.00 | 11% |
| Total | 1,937.74 | 100% | 1,973.48 | 100% | 1,960.56 | 100% | 1,862.64 | 100% |

*Source: Small and Medium Enterprise Development Authority, July 2002*

Looking at the import side, the United States has been the biggest importer of Marble during 1998/1999, reflecting an increasing volume of Marble imports which reached 39% of the world's import of Marble Products in 1999.

Table (9): Major Importers of Marble and Granite and their share in World's Imports (in $ mill)

| | 1996 | % share | 1997 | % share | 1998 | % share | 1999 | % share |
|---|---|---|---|---|---|---|---|---|
| USA | 200.88 | 24% | 245.11 | 25% | 316.03 | 33% | 366.45 | 39% |
| Hong Kong | 221.63 | 27% | 328.20 | 34% | 221.25 | 23% | 156.57 | 17% |
| China | 74.72 | 9% | 96.18 | 10% | 113.72 | 12% | 149.94 | 16% |
| Germany | 164.56 | 20% | 140.22 | 14% | 135.06 | 14% | 96.69 | 10% |
| Italy | 96.16 | 12% | 95.13 | 10% | 94.17 | 10% | 90.18 | 10% |
| Spain | 65.78 | 8% | 63.88 | 7% | 70.38 | 7% | 77.35 | 8% |
| Total | 823.73 | 100% | 968.72 | 100% | 950.61 | 100% | 937.18 | 100% |

*Source: Small and Medium Enterprise Development Authority, July 2002*

## Environmental Waste

The ornamental stone industry in general is characterized by the high level of waste generated during the quarrying as well as production process. The amount of waste generated could vary from amounts as low as 10% and as far as 65%, depending on the level of technology used during the extraction process in the quarries as well as during processing in the factories. The most economical technology is the diamond wire technology which allows cutting the stone with high precision which is like a knife cutting through according to specified dimensions. The most wasteful way of quarrying results from using explosives to extract the marble from the marble bed in the quarries. The explosion results in separation of pieces of Marble from the quarry, the dimension of which will vary according to the intensity of the explosion, resulting in an enormous waste, first from the explosion; second from leveling off the marble blocks into the required dimensions. The following chart displays the average amount of waste that has been produced worldwide from 1996 till 1999. This was 41% of production amount. That means of each 100 tons of Marble quarried, 41 tons were wasted. The waste figure could be as high as 65% in less developed countries.

This is not only an economic waste to the resources of the country, but it turns into an environmental problem later which has economic implications as well. The waste resulting from quarries and processing remains staked up at the quarrying sites and requires special attention as it turns into solid waste that has to be disposed of safely in order not to cause health hazards to the community. The problem of the waste at the quarrying site is less intense than the problem around the factories. If we take Egypt as an example, we find that the marble waste has formed hills of stones and dust around the factories in Shak El Thoban area. Very little effort is being made to safely dispose of this solid waste or reuse it in the production of ceramic tiles, for example, which enrich and add shine and value to the ceramic tiles produced. In the less developed countries, the solid waste resulting from marble quarrying and processing embodies a real economic loss to a valuable resource as well as a real environmental problem.

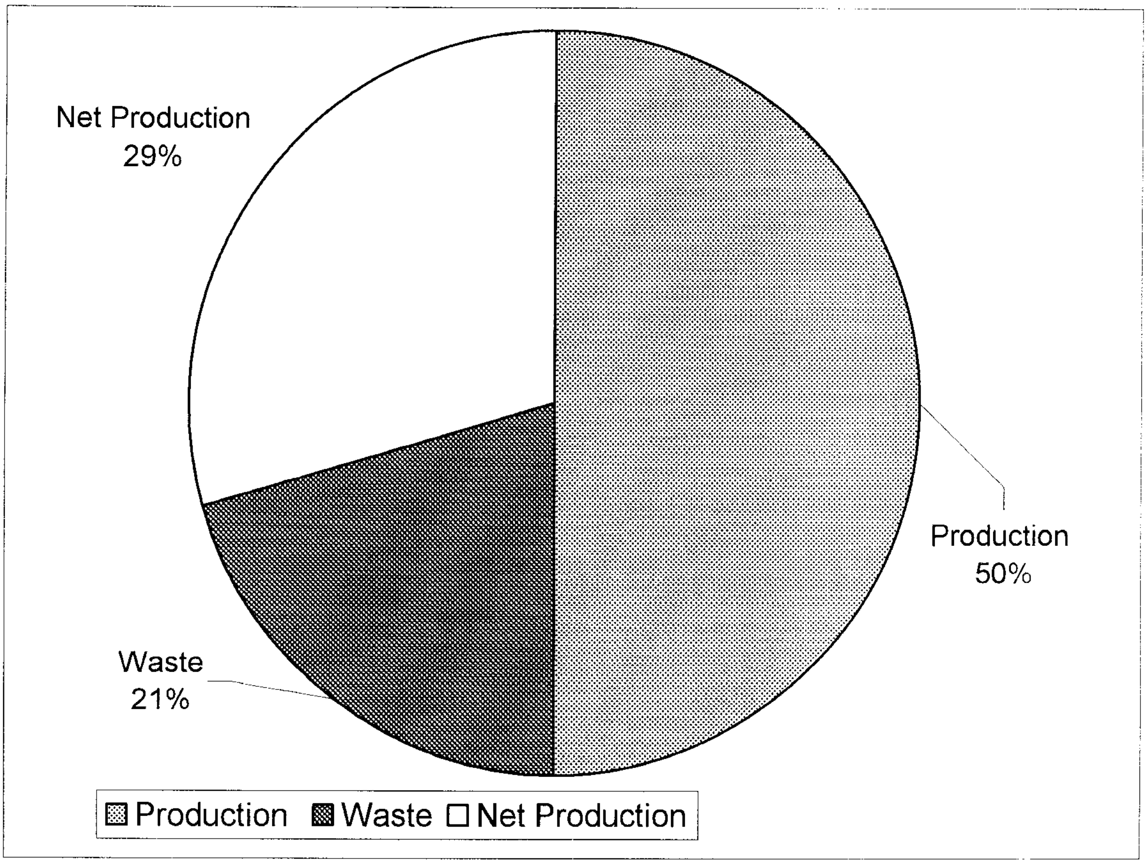



Figure (5): Environmental Waste resulting from Marble Production
*Source: Stone 2000*

# CHAPTER III

# THE MARBLE INDUSTRY IN EGYPT

## Evolution of the Industry in Egypt

Nature has gifted Egypt with large deposits and high quality marble and granite. Since 2700 B.C. ancient Egyptians used granite to build their important temples and buildings. It is claimed that the ancient Romans as early as the 3rd century B.C. acquired the Egyptian know how in quarrying and cutting the ornamental stones, especially granite. This technology was transferred back to Italy and due to the natural endowment of Italy with marble coupled with the acquired technical know how, the marble industry flourished in Italy and the Italians were able to further develop the industry of marble and granite until they became world leaders. On the other hand, the Egyptian ornamental stone industry was stagnant for centuries. With the flourishing of the Islamic civilization in Egypt, the marble and granite industry were revived again and several mosques and buildings reflect a fine skill of stone cutting and engraving of that era, though much of the marble used in the mosques was imported, as well.

During the nineteenth and most of the twentieth century marble and granite were used on a limited scale in Egypt for luxurious buildings like palaces and museums and were mainly imported. According to the geologist Mohamed Samih Afia (Afia, 1998) importation continued even after the revolution in 1952. Only occasionally directives were issued from the Egyptian Authorities to limit Marble imports as a measure to cut expenses. In 1948 there were two companies working in the quarrying activity: the Egyptian Company for the exploitation of mines and quarries whose issued capital was LE 20,000 and paid up capital LE 5,000. The other company was Egypt's Company for Mines and Quarries, whose capital was LE 400,000 and paid up capital was LE 40,000. These were the two main companies that worked in that field during this time. Though marble and granite were extracted, yet this activity was on a limited scale as shown in table (10) below. The table highlights amounts of Egyptian marble extracted between the years 1956 and 1961.

Table (10): Quantities of Marble quarried in Egypt during 1956 - 1961 in $m^3$

| Year | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 |
|---|---|---|---|---|---|---|
| Quantity | 1,500 | 1,780 | 3,811 | 1,938 | 4,410 | 3,979 |

*Source: Mohamed Samih Afia, Current Mining Development, 1998*

The production figures reflect generally an increasing trend which witnessed almost a doubling of production from one year to the other. Only in 1959 did the amount quarried decrease, but it immediately picked up the year after, indicating a real demand for the quantities supplied. Looking at the production of granite in table (11), we can see that its extraction witnessed a relative boom starting the late fifties. This boom was mainly related to the construction of the High Dam in Assuan, the construction of which required this very solid stone to build the body of the dam. In 1962, granite production in Egypt reached 219 tons and in 1963 it reached 256 tons. As illustrated, this sector suddenly gained importance and the

Table (11): Quantities of granite extracted from Egypt during 1956 - 1961 in $m^3$

| Year | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 |
|---|---|---|---|---|---|---|
| Quantity | 2,300 | 340 | 8,262 | 15,603 | 41,724 | 31,982 |

*Source: Mohamed Samih Afia, Current Mining Development, 1998*

government issued several directives to regulate and activate this industry. One of the most important regulations was the directive issued from the Vice President of Egypt no. 38 for the year 1962 to transfer all authorities related to marble and granite quarrying from the Egyptian General Survey and Measurement Authority (EGSMA) to the different governorates, while the EGSMA would be responsible for planning and conducting technical research and technical audit. The purpose of this directive was to help the decentralization of the decision taking related to this activity.

For the first time, Egypt's Five Year Plan (1960/1965) included projects related to the exploitation of ornamental stones (Afia, 1998). Results of this governmental attention to local production were reflected in the reduction in the imports of ornamental stones over the years. In 1973 imported ornamental stones reached 642 tons for the value of LE 20,000 which dropped to 96 tons in 1974 for a total value of LE 2800. Though the year 1973 that witnessed the October war is not necessarily the best benchmark to judge the drop in imports, yet Egypt's imports of ornamental stones did not pick up again and consumption of locally produced stones started to increase.

In the 1979 the Assuan Company for Marble and Granite "Marnit" was established with a capital of 1.2 million pounds which was increased in 1981 to LE 5 million. In 1983 Marnit established a factory to the East of the High Dam to process granite and marble with a total capacity of 65,000 $m^2$ of marble plates and 10 $m^2$ of granite. The total project cost was LE 3 mill. This company developed plans for the expansion of investments in the marble and granite sector, but these plans were never implemented.

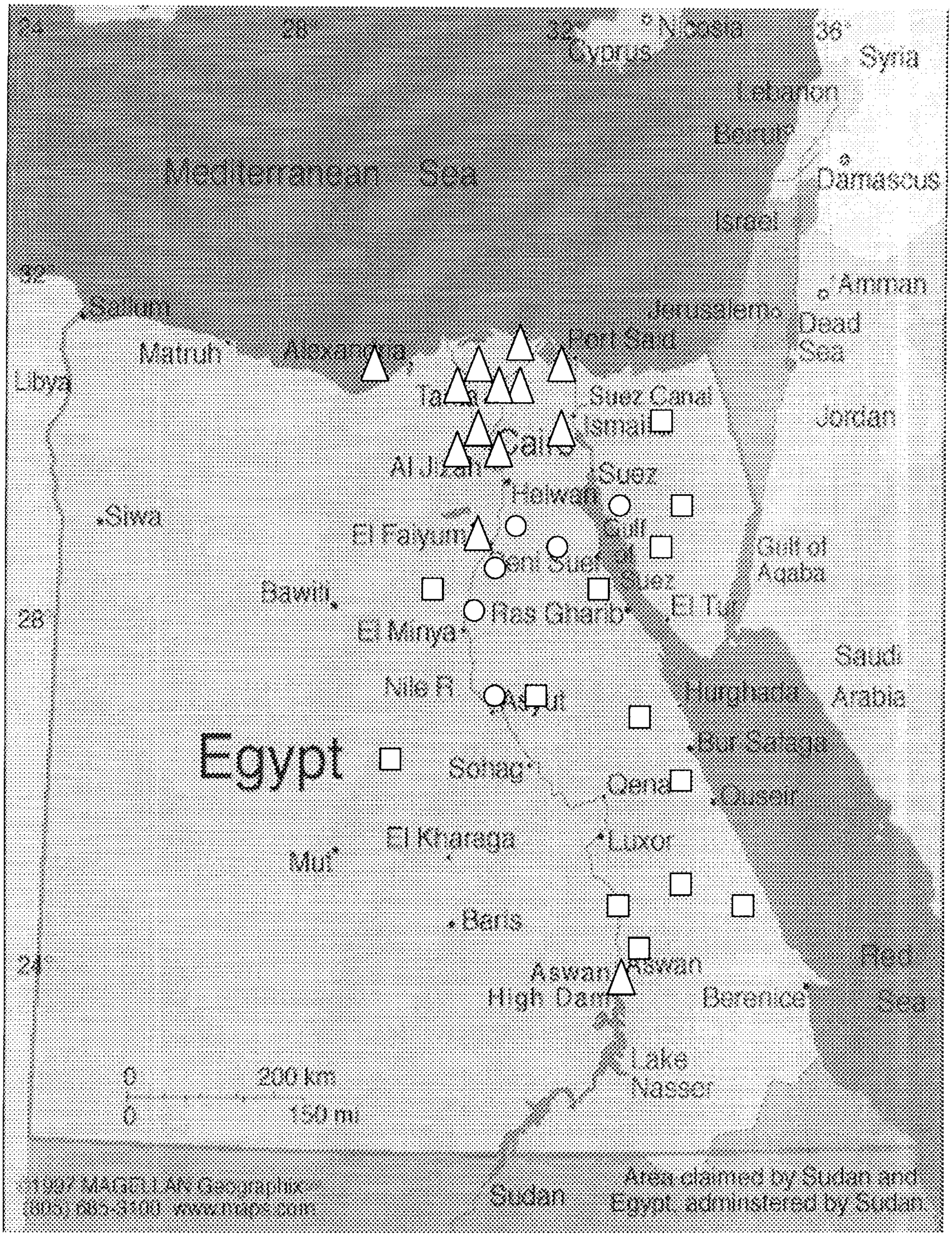
In the mid 1980s, the maximum capacity for the cutting machines in the country was 49,850$m^2$ for all types of ornamental stones. At the same time efforts were being undertaken to increase the cutting and stone processing capacity by 25,200 $m^2$, with a total planned capacity of 75,050 $m^2$. If we assume capacity to have been 80%, this means that 60,000 $m^2$ were being extracted in Egypt during this time. (Afia, 1998)

With the privatization trend in the eighties, investors started to be interested in the Marble and granite industry that was flourishing and seemed to have a good potential for growth. Moreover, cost of quarrying was not high, due to the use of cheap technology and cheap labor. As illustrated, there was a high demand for marble, while the supply was limited resulting in high profits. This high profit margin invited more and more businessmen to enter the industry. This became even easier with the decentralization of the permits for the quarrying activity. Granting permits became just a procedure and connection to higher authorities in the governorates facilitated the issuance of permits.

Between 1982 and 1995 the entry level into the industry accelerated, being encouraged by the high profit level. This further motivated investors to spend more for acquiring expensive and modern imported technologies. Over time, the massive market entry forced the prices down and the average cost up. Another important factor contributed to the increase in average cost, namely the constant devaluation of the Egyptian pound which drove the cost of imported modern machinery up. Also the labor market became competitive and the cost of skilled labor increased. All this resulted in turning this industry into an increasing cost industry.

If the marble industry is to be divided into marble quarrying and marble processing, we can find that the quarrying sector for the coming few years is likely to be more receptive to investments than the processing sector. The investment in modern quarrying machinery will improve the shape of the extracted block of marble and make stone cutting and transportation easier. It will also limit the cracks and damages that happen to the blocks of marble during extraction, which would add value to the quality of the extracted marble. Moreover and most importantly it will save this precious resource from being wasted through the traditional extraction methods which are wasteful. With respect to marble processing and polishing, this sector of the industry is almost saturated, as the number of factories operating in this sector is already high and the businessmen working in the field did not save any effort to acquire the most up-to-date technology. If comparisons between past investments in marble quarrying and processing is done, then investments in factories for marble processing have been much higher as it seems more secure to invest in one's factory than to invest in a quarries that one has a permit to operate for a year or a little more. Currently and according to Mr. Ibrahim Ghali, who is the dealer of several Italian companies for Marble processing and a distributor of this machinery all over Egypt, there are around 500 big enterprises in this industry and at least 3000 workshops. An important factor distinguishing a bigger entity from a workshop is the ownership of a crane.

The Map of Egypt, Figure (6) illustrates locations of Egyptian Marble and Granite quarries as well as locations of factories. Marble quarries are found in different locations all over the country, along the coast of the Red Sea (Zafarana), Sinai, Menia, Assiut, Asswan and the Eastern Dessert. Experts confirm that Egypt has also big reserves of undiscovered marble.




| | |
|---|---|
| □ | Marble and Marbleized Limestone |
| △ | Marble & Granite Factories |
| ○ | Alabaster |

Figure (6): location of Marble Quarries and Marble factories
*Source: Current Mining Development, Samih Afia, 1998*

Table (12): Location of the different types of Marble Quarries in Egypt

| Type | Location | Commercial Name | Specifications |
|---|---|---|---|
| White Marble | Wady el Elaky - Wady El Miyah | White Carrara | White with black and red veins |
| Black Marble | Wady el Elaky-North Albaramia-Wadi El Miyah | Black Carrara | Black with white veins |
| Calcic stone (Marble substitute) | Assiout and Kharga-Zafarana-- East of Sohag | Berlato | White & dark cream, yellowish cream |
| Calcic stone (Marble substitute) | Wadi Fyran, Sinai-Zaafarana-El Koraymat-El Galala | Botshino | Reddish pink |
| Green Serabantin | Wady Atallah AlKoser - Om Hassan Moutain, desert | Green Marble | Dark Green with veins |
| Calcic stone (Marble substitute) | Balk upper Egypt-Alhasna | Fleto Rosso | Cream with brownish veins |
| Green Brishia Ferdy | Wady el Hamamat -Gabal El Dokhan, | Green Brishia | Dark and light Green |
| Red Brishria | Assiout - Sohag | Red Brishia | Dark and light Red |
| Alalbastar | Menia- Asyout- Beni Sweif | Alalbastar | Golden yellow and white |
| Gray | Edfo- West of Menia | Teresta | Gray and smoked |

*Source: Mohamed Samih Afia, Current Mining Development, 1998*

Table (12) specifies the type of Marble available in different marble quarries and gives a description of each type. It also states the commercial name of the marble extracted which is not necessarily its scientific name. In business dealings marble types have their commercial name, which usually reflects a certain reference or indication. The names White and Black Carrara are an example for that. Carrara marble is one of the most famous Italian marble in the world. Giving Egyptian marble this name indicates that this Egyptian marble resembles the Italian Carrara. Adding a color to the commercial name indicates the color for the marble referred to. It is noteworthy to mention that Carrara is by default white. In Egypt, the commercial name of a marble type is "Black Carrara" to indicate that it has the same outlook and possibly the texture of the Italian Carrara Marble, but is black in color. Table (12) reflects also that Egyptian Marble has a variety of colors, whether white, creamy, black, green, red or grey and is heavily veined, which often adds beauty and originality to the natural stone.

The ornamental stone industry in Egypt has witnessed a boom in the past few years due to the boom in construction whether for residential purposes or for the building of touristic villages along the Red Sea and the Mediterranean, boosted by the high entry of businessmen into the industry as explained earlier. Mega projects like the underground metro have also contributed to the boom of the industry as well.

Not only the increased demand created a boom for the industry, but other factors contributed as well like improving the living conditions at the quarries, which facilitated the work there for 24 hours by applying shifts. Importing cheap electricity generators from Russia contributed to cutting the energy cost and facilitated the possibility of night shifts. The improvement in the quarrying technology made working in the quarries safer and invited more and more labor to work in the industry. Moreover, the advanced technology also decreased the waste generated during cutting and processing which increased the returns on the whole operation. Added to all that, advanced technology requires less administrative procedures unlike dynamite where permits and approvals are needed.

The area of "Shak El Thoban" in Katameyya has become a conglomeration of factories working in the Marble and granite industry. This area was first occupied by quarrymen quarrying the limestone in the hills and mountains of Katameyya. Over the time, interested investors in this area were granted about 10,000 $m^2$ for the price of LE 70/$m^2$ to build their stone factories. Quarrymen who started to work in the limestone hills, switched their stone factories to work in marble and granite, which was more profitable. Today, Shak El Thoban is a big area that is surrounded by a wall and has a main entrance gate. This big area is divided into a main stream of two streets, where the marble and granite factories are located the one besides the other. Shak El Thoban has the highest concentration of Marble and granite factories in Egypt reaching around 400 factories, constituting 60 % to 70 % of the factories in this industry in the whole country.[6]

Currently Egypt has about 500 marble and granite factories. According to specialists in the industry, there are 3 types of factories (1) factories that are just involved in cutting the blocks into plates of marble and then distribute them to workshops that handle further cutting and polishing. (2) factories that cut and polish the plates. (3) factories that do the whole process till the final product is produced, whether tiles or slaps.

A workshop operating in marble and granite does not own a crane, but works mainly in processing; cutting and polishing the already cut plates received from the factories into the final product as demanded by the end user. The workshops

[6] Interview, Mr. Ibrahim Ghaly, Supplier of Marble processing equipment.

are mainly those that deal with small orders for a flat or two. Factories that produce the final products take bigger orders for bigger entities like hotels or tourist villages.

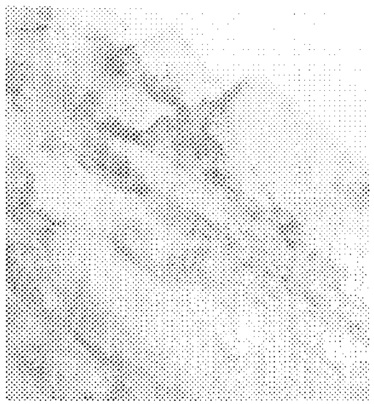
## Stages of Marble Production

The production of marble passes through several stages. The main stages are demonstrated in Figure (7). The first stage of production is (1) exploration which is the identification of the location of a productive marble quarry. After that comes (2) the stone cutting and then (3)Lifting and transportation, (4) stone-processing into plates, (5) polishing, (6) cutting into slabs and tiles and finally (7) distribution. Below is a detailed description of each of the production processes.

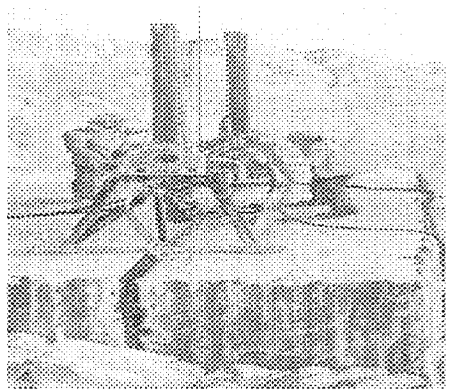
### (1) Exploration

Before extracting the stone, a quarry has to be discovered and identified. Quarries are discovered in Egypt in two phases:

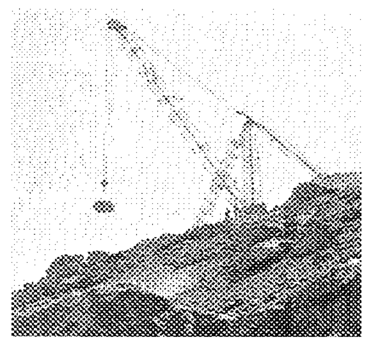
(a) Identification of location; this either happens ad hoc, or through modern technologies like GIS. "Search expeditions" are undertaken primarily by the EGSMA to areas where a potential for Marble quarries exist. Today,

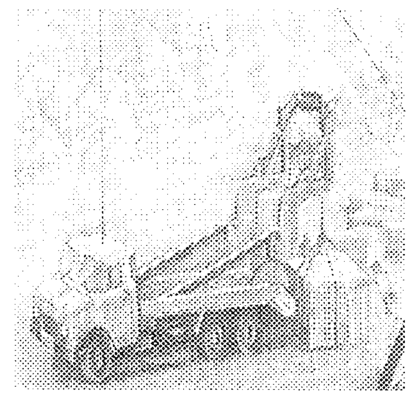


**Phase 1**: Marble exploration, a productive quarry is being identified

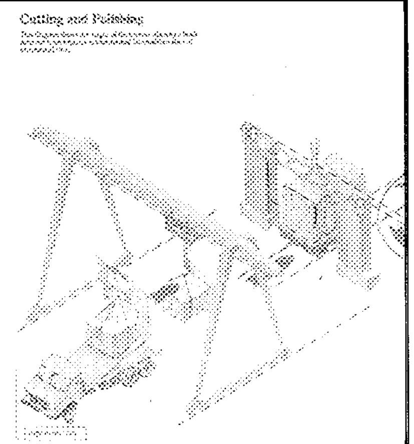


**Phase 2**: Marble extraction, which entails cutting the Marble rock into blocks.

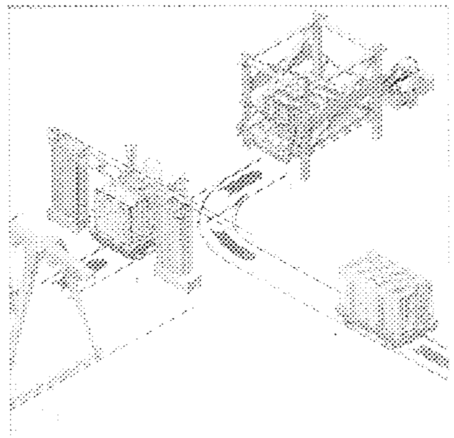




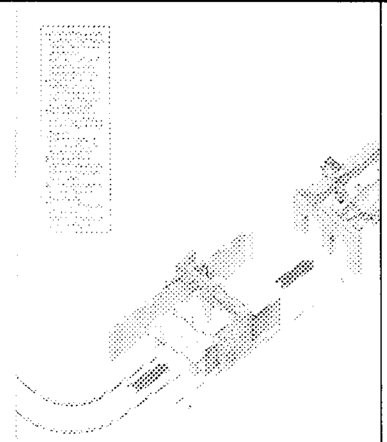
**Phase 3**: Lifting and Transportation. Lifting by hoist to reach inaccessible locations of the quarry or using a truck fitted with lifting equipment. The truck transports rocks to final destination.



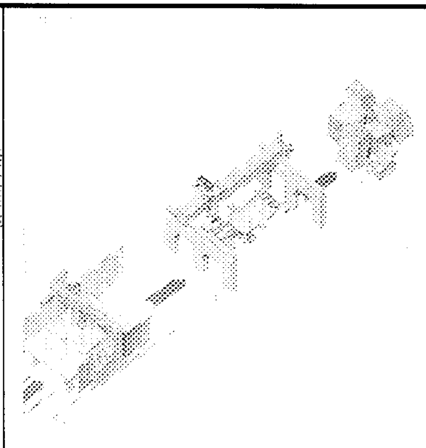
**Phase 4**: Arrival in Factory & inventory Management



**Phase 5**: Cutting of Marble Blocks into Plates.



**Phase 6**: Polishing the plates



**Phase 7**: Cutting plates into slabs and tiles for distribution

Figure (7): Marble Production Process

(b) advanced technology like the GIS is utilized as well for accuracy reasons and saving time. One important result of these search expeditions is drawing / updating maps clearly specifying location of quarries by specialists in the EGSMA. The private sector usually follows the maps and advice of the EGSMA and its search is more concerned with identifying the best location, and the most economical quarry

(c) Testing and verification of characteristics of the marble quarry: When a location of marble quarries is identified, a sample of the stone is taken to test its color and characteristics by the Egyptian General Survey and Measurement Authority. More precise calculations are done by entrepreneurs to assess the type, quality and reserves of the Marble in the quarry. This is undertaken with the main objective of evaluating the economic viability of the extraction operation. If, according to research quarrying proves a viable operation, the extraction process starts after obtaining necessary approvals.

It is noticeable that a number of retired police and army officers acquainted with the desert and region along the Red Sea where the marble quarries exist got involved in the industry during the past twenty years. They gained experience during their service as officers in these remote areas and developed the necessary network with the different stakeholders in the business. Another category of workmen that got involved in the industry are truck drivers that worked on transporting the rocks from the quarries to the factories. Over time, some of them gained the experience in the field, formed alliances with stakeholders and started a business operation in Marble or granite industry. Until today, almost no governmental restrictions or regulations exist, that put any prerequisites to new entrants into this industry.[7]

When operation in a certain quarry proves technically and economically feasible and viable, a license is obtained from the governorate where the quarry is located and fees for using the quarry are paid. Fees lie in a range between LE 4,500 and LE 20,000 according to the governorate and the type of quarry and quality of marble. It is argued that corruption or lack of experience on the side of some governorates leads often to the understatement of the fees for the quarry. Another approval from the ministry of interior is necessary for using the dynamite.

The license to operate a quarry is granted for one year only and is renewable. By definition a quarry's dimensions are 100 m * 50 m, and the license gives you the right to quarry this area for one year. When renewal time of license is due, fees have to be paid within 15 days or the right to use the quarry lapses. It lies in the authorities of the governorate to refuse granting a renewal to a quarrymen. A businessman in the industry is allowed to request more than one license and operate more than one quarry at the same time. When working in a certain quarry is approved, the quarry owner has the right to buy a certain quota of dynamite from the ministry of interior and is allowed to use the dynamite for the extraction of the marble and granite.

Amendments to quarrying regulations have been lately presented for approval to the parliament which suggest that; firstly permits to operate the quarries should be given after technical and financial assessment to the qualifications of the candidate

[7] Interviews with entrepreneurs in the Marble industry and geologists.

company. Secondly permits should be granted for a minimum period of at least one year and a maximum period of thirty years.

Discussions with quarrymen in the industry reveal that lots of marble resources were wasted in the past due to the lack of knowledge of proper extraction methods, especially by new entrants into the industry. It is claimed that mountains of marble were destroyed due to the misuse of dynamite and the lack of supervision of the authorities over the operation of a quarry.

**(2) Extraction**

Extraction of the Marble stone happens in several ways depending on the technology owned by the quarrymen. The most frequently used ways are:

a. Drilling vertical holes around the optimal block size by the use of hydraulic jacks or jackhammers and then splitting equipment is used to cut the block of marble. The splitting equipment could be (a), *wedges* which are placed in the horizontal row of vertically drilled holes. These are hammered in, until the rock splits.
b. A *twin-headed rig* which is used to drill a horizontal row of vertical holes and then to cut away the rock between them. The block size and shape of the rock are thus well controlled and the wastage is minimized.
c. A wire-saw cable may be used to cut the marble blocks. The wire-saw cable is driven by wheels and the continuous loop of the cable cuts the stone.
d. A flame cutter is used to blast a deep fissure into the quarry face. Attached to a long pole, the combustion chamber of the cutter burns fuel oil with

compressed air to produce a powerful flame. Like the exhaust of a rocket engine, the jet of hot gases is directed downwards to blast a narrow trench deep into the rock.

e. The use of explosives; after boring holes in the bedrock, these are then filled with explosives to blast the rock. This results not only in a waste sometimes as high as 90%, but also in smaller stone size which substantially reduces the price which is directly proportional to size. The misuse of explosives in marble extraction results in considerable waste.

The use of explosives is still present and often used in the industry due to the following:

a. very high cost of the modern imported machinery and equipment. This makes the extraction by the use of dynamite cheaper especially for new entrants into the industry. The majority of investors are more risk averse.
b. The lack of basic infrastructure such as roads, electricity, running water etc poses restrictions on the type of machinery used and requires the reliance on generators for electricity and tanks for water supply.
c. As the license for quarrying is granted for one year only, whereas the contents of one quarry could be exploited over decades, quarrymen are driven to think of the short term and exploit as much as possible with the least possible cost. Often, they do not consider the quarry as a long term resource or asset that they have to preserve.
d. Reluctance of banks to grant financing to quarrymen, due to their non-acquaintance with the quarrying industry and the economies of quarrying and the associated profit margins.

Other factors that determine the technology used in quarrying is the rarity of the stone found. If the stone found proves to be of rare color and texture, it becomes non-substitutable. This could drive the quarryman to refrain from using explosives, as for him the quarry starts to be considered a valuable resource. In this case the extraction happens using the most up-to-date technology to minimize the waste resulting from extraction.

Historically, the majority of the quarries were operated and controlled by the tribal chiefs who were given the extraction licenses purely for personal reasons and political considerations. It was almost impossible for a newcomer to get a marble quarrying license due to the power structure of the tribes living around the quarries are located. Nowadays, granting a license has become a much easier process as the right of granting the license lies in the authority of the governorates whereas it was granted earlier by the Egyptian General Survey and Measurement Authority.[8]

Registration of the extracted marble tonnage takes place after the truck that transports the marble is loaded. An officer appointed by the governorate registers the amount of stone extracted and collects a certain fee from the quarry owner for every $m^3$ extracted. (one $m^3$ of marble is approximately 3 tons). The fee varies from one governorate to the other. It also often happens that an agreement between the person in charge of operating the quarry and the governorate representative takes place to under-register the amount extracted and minimize the fee paid.

In an area like Sheikh Fadl 60 km away from Minia, there are from 80-90 operative quarries. Each quarry could produce between 100 and 200 $m^3$ per month, depending on the number of labor employed and the technology used. If we take this statistic as

[8] Interviews with geologists and marble quarry users.

an indicator, then on average, assuming that there are 85 quarries in this area, and each quarry is producing 150 $m^3$, then the region of Sheikh Fadl would be producing around 12,750 $m^3$ per month.[9]

The international size of marble blocks is 3.4*1.2*1.4 m. The single cubic meter of marble can result into 35 $m^2$ of slabs. The standard international size of slabs is 100/120*240/270 (the bigger the size, the greater the value of the slab).

With respect to extraction, according to experts in the industry, it is easier to extract the granite than the marble. The granite is very solid and has natural "separators" that make the cutting smoother and without quick fragmentation and much waste. The marble is easily fragmented and this makes the extraction more difficult and requires special skills.

**(3) Lifting and Transportation**

After cutting the rocks of marble, they need to be lifted to the truck for transportation to the factories. Lifting happens in two way; either by using a hoist which lifts the cut blocks from inaccessible parts of the quarry to where they can be loaded to the truck. Another means of lifting this heavy stone onto the truck is by using a truck fitted with lifting equipment, which lifts the blocks of stone from where they are to the truck.

Transportation is a very crucial step in this industry, as quarries are usually located far away from the factories where the stone is cut and processed. The truck can transport the raw marble to the factory, but it can also transport it to a port for further transportation to a third destination. Truck transportation is the initial transportation means, which could be followed by sea transportation, railway or air transportation in

[9] Interview with Mr. Tarek El Alfy.

very rare cases. The cost of transportation constitutes a high percentage of the cost of marble production and can reach as high as 60% of total cost, but because Marble is a high value product, it can stand transportation cost.

Trucks usually stay between 24 – 48 hours to transport the stone from the quarry to the factory, depending on the location of the quarry. It takes such a long time due to the heavy load carried by the trucks and also due to the long unpaved ways and roads the trucks have to drive through to transport the rocks from the quarries to the end destination.

Several quarries are located along the Red Sea, which makes transportation by sea for export purposes possible. Ports like; Marsa Alam, El Kosair, Safaga and Suez are suitable outlets for the direct sea transportation of marble to the different countries of the would.

Railway cargo could also be used for transportation. There is an efficient rail way network in Egypt that provides a wide coverage of the whole country. Yet the loading and unloading is not economical, as a crane at the railway station will be needed to load the rock from the truck to the train and vice versa.

Though air transportation could be very costly, yet it is available and could be used to ship any order to any part of the world, if the client is willing to bear this high cost of shipment which could exceed the cost of the stone itself.

**(4) Inventory Management**

The Inventory of raw stone blocks is very bulky and requires a very spacious area. The "inventory room" usually occupies the backyard of the factory. One of the characteristics of the stone is its durability which allows its storage as inventory in the open air with no special maintenance or security measures. Nevertheless the raw stone block is very heavy and this needs special skills and experience in storing the blocks: first to take the least possible space and second to allow the accessibility of all types of stored marble or granite and third to insure safety of the personnel working in the factory and safety of the blocks from any damage.

Once the raw blocks of stone arrive at the factory, they are loaded from the trucks with the crane in the backyard of the factory, where usually the storage area for the raw material is located. Usually the backyard space is divided in vertical lanes to store the different types of rocks and make them accessible when these are needed for processing. The raw blocks of marble are usually placed one block on top of each other, separated by wooden "chair" or separator to comfortably separate one block from the other which facilitates its lifting by the hoist or crane. A maximum of three blocks could be placed on top of each other.

Inventory Management in Egypt is mainly through manual bookkeeping. Though the processing in this industry has reached a high level of automation, yet inventory management is done in most of the factories manually, by registering the date, number and dimensions and quality of blocks received. Only very few factories have a computerized inventory management system.

Deciding on the inventory of the different marble types to be stored depends on several factors. The most important factor is the contracted client demand. That means if an agreement is signed between the factory and a client, the factory tries to store as much of the required blocks as inventory to secure the order and hedge against possible risks. This order is then processed in due time. Another important factor is market demand. Types that enjoy a high demand in the market are kept in inventory stakes. Another important reason to store raw marble blocks in the factory backyard as inventory is the originality and rarity of the stone. Such a stone is kept until the right customer who would rightly value the stone is interested.

**(5) Stone Cutting**

When a certain order is placed, the raw stone block is transported to the factory to be cut as demanded either into tiles or slabs of various thickness usually 2 cm or 4 cm. Stone-cutting is a lengthy process that can take more than a continuous 12-16 hours of operation to complete the cutting process, depending on the model of the cutting machine as well as on the status of its diamond wire or diamond blades. In this operation the block is hoisted on a trolley. Irregular blocks are trimmed with a wire saw. The trolley is fixed on four steel columns. A 'gang saw' unit comprising multiple cutting tools, recently diamond blades, anchored to the columns, cuts the stone into slabs of prescribed thickness. The wire has diamond impregnated, metal matrix segments. This allows the wire to literally scratch its way through the marble. Instantly a shower of water is drifted on the marble and the diamond wire all the time to prevent overheating. The water also washes away debris. A 60-blade gang saw produces an average of 58 slabs while the two end pieces are wasted. The shape and size of the slabs vary according to the shape of the original stone. Freshly cut slabs are taken on the trolley to the polishing machines.

Though less expensive than imported machinery, locally manufactured cutting machines have only 40-45 blades which are usually not very accurate and produce inconsistent thickness, particularly of marble tiles which fail to measure up to international standards. Moreover the productivity of local machines is less than the modern imported machines. This is a major deterrent to the marble processing industry in Egypt as well as to the expansion of the export base in two ways:

- The quality of finished Marble and granite processed in that way is not competitive internationally which makes it sell cheaper and adversely affects the reputation of the Egyptian Marble.
- It continues to drive demand for Egyptian Marble and granite to be for raw marble blocks which is the cheapest form of exports, depriving the country from the value added that could result from processing the Marble into a high value finished product.

For the industry to pick-up local manufacturing has to meet the strict quality standards of the affluent international markets, especially that this product is geared to meet the demand of high level consumers that have a taste for quality.

**(6) Polishing**

After the stone has been cut to the specific dimensions, there are different techniques towards reaching a "finished" product. The most known of these techniques is: (a) Polishing. The polishing operation is in many factories fully automated and is basically through the use of powdered abrasives that keeps on scrubbing the surface of the marble until it becomes smooth and shiny. The smoother the abrasive used, the shiner and smoother the surface of the marble. Here again the water showers are essential to prevent overheating. The process of polishing allows the full color, depth and crystal structure of the stone to be visible which reflects the beauty of the stone.
(b) Tumbling: creates a rough finish to the surface of the stone. This is achieved by turning the stone at slow speed, in a rotating barrel with abrasives and water for extended hours. (c) thermal / flame; this type of finish is given to the marble by

applying a high temperature flame to the surface of the stone. The flame fractures crystals on the top, leaving a rough-textured finish. This is highly resistant and perfect as a walking surface.

A rotating saw is used to trim the edges of each polished slab. After that the finished product is ready for transportation and delivery to the end user.

**(7) Distribution**

The distribution channels depends very much on the end product produced by the factory. If the factory produces finished tiles and slabs, then this is a finished order, processed according to the customer requirements and a delivery rather than distribution takes place. The final product is delivered to the customer according to an agreed upon time and place. As a finished marble product is very fragile and needs special care in handling, it is usually packaged, loaded on a truck and delivered to the client. The same factory could be producing marble plates. These require distribution efforts. .Distribution often goes (a) to workshops, which are usually the middleman between the supplier and the end user. These workshops receive the cut plates of marble and store them in their shops for the end user to choose from. These workshops usually have showrooms where they display the wide choice of colors and types of marble to the end user. These smaller workshops constitute a good percentage of the clientele base for the bigger factories. Usually workshops deal with the smaller orders and process the cut and polished plates into slabs and tiles, as well as for kitchens as cutting and working surfaces and or any other uses.

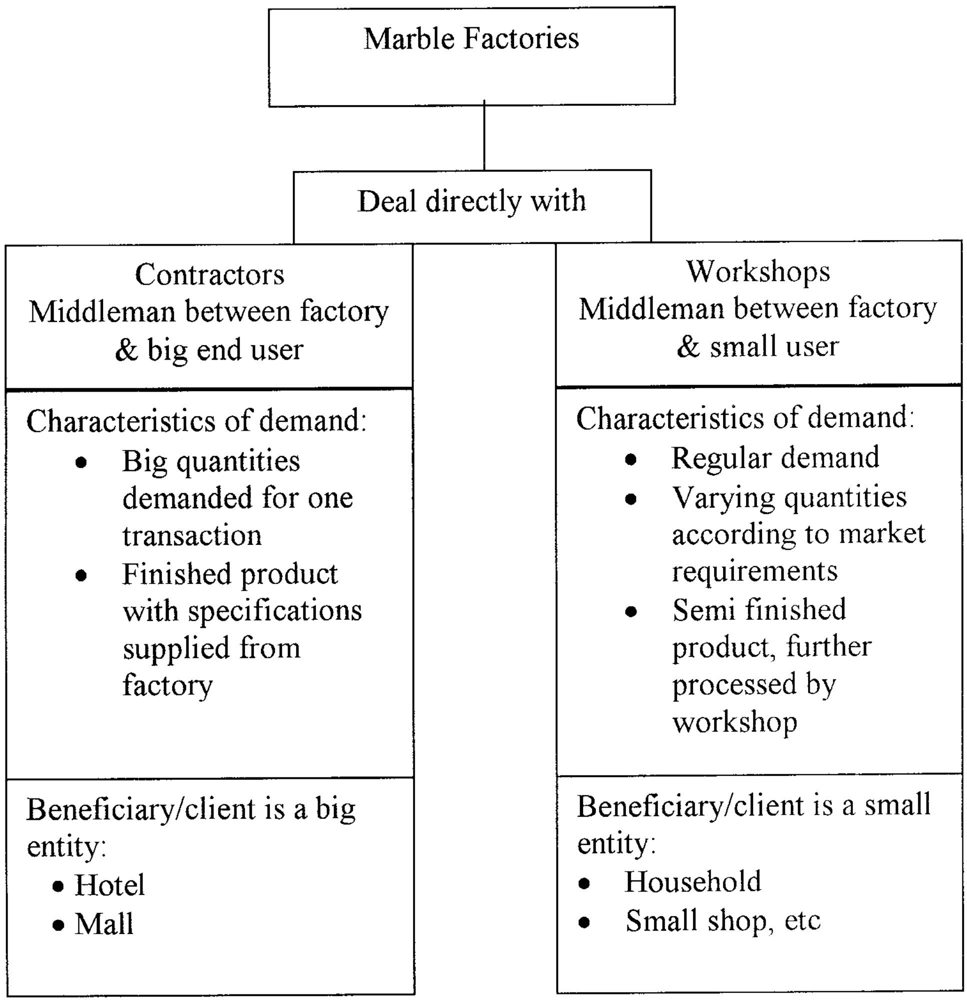
Factories that are involved in cutting the plates of marble into tiles and slabs deal usually with bigger orders where the marble is required for a whole big building and a contract is signed between the Marble supplier and the building contractor for the quantity supplied, the dimensions and the quality of marble.

## Characteristics of the Industry

The Marble Industry has its unique characteristics that differentiate it from any other industry. This industry deals with a natural stone that is appreciated worldwide and has such a high level of product differentiation inside the same country as well as from one country to the other. In this industry what differentiates the raw material from the final product is the cutting and polishing that is exercised on the raw material which refines it into a final product. Egypt enjoys abundance and high quality of the raw material, yet the production process in Egypt has still a way to go to reach the advanced levels enjoyed by the top producing countries. Nevertheless the industry is growing from one day to the other and it is worthwhile studying and analyzing the characteristics of this industry in Egypt.

### 1. Nature of competition

The Marble industry in Egypt is very competitive and has matured over the years after the massive entry into this industry since the early 1980s. As mentioned earlier about 500 factories and 3000 workshops compete on the consumer to offer a product that is highly differentiated. The interaction between supply and demand could be best illustrated by the diagram below:




On the demand side, customers of marble factories are either contractors who implement construction works for a big project and are both price and quantity sensitive with varying degrees. Marble workshops deal also directly with factories and receive marble plates of different types to further sell them to small client and cater for smaller orders. They do the cutting of these plates according to request whether tiles, working areas or according to order. There are also cases where the factories deal directly with the end user.

In this market we have varying types of competition: Quantity competition, where the suppliers that can provide big quantities and usually operate their own quarries have a clear edge over others. There is also a tough price competition, where small suppliers sometimes dump the market by lowering their prices severely, just for the sake of selling their product and generating cash. We also have quality, type and color competition, where the quality, type and color of the finished product is of vital importance. This is for suppliers who target the elite market.

For suppliers to be competitive in this market, they have to deal with imported marble as well. Imported marble has an established customer base in Egypt and a supplier that targets the upper class of Egyptian, he has to be able to provide requested supplies of imported marble.

There is hardly any seasonality of demand. Marble is required all year long, though is follows very much the construction sector. If the construction sector witnesses a boom, the marble industry is always expected to follow and vice versa. Moreover, demand is usually higher in summer, as construction work is more intense in summer than in winter, for several reasons among which are that days are longer and the weather is more predictable.

Competition in this industry depends on several factors and on the market niche that the supplier serves. Producers that dominate the Market were able to develop the following qualities to gain a competitive edge:

Table (13): Gaining a competitive Edge in the Industry

| Competitive Edge | Means to gain it |
|---|---|
| Ready availability of the product demanded and the ability to respond quickly to higher quantities. | Own the right to operate a number of quarries. |
| Ability to produce high quality standardized product according to specifications. | Ownership of high technology, if not in extraction, than at least in the factories. |
| Ability to maintain a constant price level, despite variations in quantities demanded. | Operating cost is either constant or decreasing with higher quantities produced |
| Ability to minimize the waste during the production process to increase the returns on the whole operation. | The ownership of high technology and skilled labor. |
| Ability to offer rare types of Marble with unusual colors to cater to the tastes of a highly selective niche of clients. | Active in exploring and acquiring rare types in local and international Markets |
| Access to the international markets and the ability to export and open new markets internationally. | • Source of income in foreign currency, facilitating the acquisition of updated imported technologies.<br>• Awareness of international standards |

## 2. Barriers to Entry

If we talk about the barriers to entry to the Marble industry we have to differentiate between barriers to the stone quarrying and to the stone processing, as entering each of the sectors in this industry has different barriers.

a. Stone quarrying: No real barriers exist currently as the license is granted upon placing a request and following necessary procedures to obtain the license, however entry to specific quarries of rare types or with special characteristics will not be possibly open to a new entrants. Licensing expenses and extraction cost vary from one quarry to the other, but generally speaking, this does not form a real barrier as it is usually on the low side. Acquiring the dynamite needed for extraction is a quota granted after a license is obtained. Unless certain modern and expensive extraction methods are imposed on marble quarrying activity in Egypt, no real barriers to entry exist on the quarrying of Marble.

It has been noticed lately that several Korean and Asian Agencies became very interested in the Egyptian raw marble. For that purpose they used Egyptian Middlemen to acquire the licenses in their names and then exploit the quarries freely to extract the Marble and export it to Asia. This reflects how good the quality of the Egyptian stone is, and at the same time this example demonstrates the easiness of acquiring a license. In the marble market, the Asians sometimes pay a price much higher than the ongoing market rate to get the quantity of stone they demand. After being processed in China or Korea, this stone is re-exported from China to the international Markets. Becoming specialized in exporting raw marble is a real economic waste to a value added that could be obtained by the internal processing of raw marble, that could also generate employment opportunities as well as activating the sector as a whole.[10]

According to experts, the industry is very receptive to new entrants that are willing to invest real money in the quarrying industry, reducing in this way the waste and

[10] Interview with entrepreneurs in the Marble Industry

producing a good quality that complies to international standards with respect to dimensions and quality. Therefore the market is far from being saturated if new entrants can bring along differentiation in the quality produced and technology employed.

b. Marble processing: A barrier exists to enter this industry in the form of a high investment cost needed to prepare the infrastructure for the factories and to acquire the processing machinery which is mainly imported machinery and is very expensive.

Apart from the high fixed cost to start a marble processing facility, the quasi fixed cost is also very high. The stone is cut with diamond blades which need to be replaced on average every three month. This is another high regular quasi fixed cost that needs to be taken into consideration when starting the business. To establish a factory in Egypt for Marble processing an investment of LE 8 to LE 10 Million is needed.

There are other "indirect or hidden" general barriers to entering this industry in Egypt like:

(1) Lack of skilled labor: there are no colleges or schools that qualify workers to work in this industry. In the University of Engineering there are mining studies, but this only qualify students to work in marble quarrying as mining/quarrying engineers. In Asswan, there was a college that taught the skills of cutting and craving marble and granite, but this college no longer offers this specialization. Therefore to get skilled labors, you have to either hire a worker with previous experience in another factory,

i.e. you have to attract other competitors' staff which could be quite expensive. The other option would be to provide on the job training to new labor, which is time consuming and not cost effective if you can't maintain their loyalty.

(2) Cheap imports; cheap imports constitute another hidden barrier to entry as imports can satisfy local demand with relatively competitive prices. This fills in the gap in demand and closes the markets in the face of new entrants.

(3) Size and location of the factory; the industry is very space consuming and the optimum area for a marble processing unit is preferably not less than 5,000 $m^2$. Moreover the industry is characterized by the regional concentration of the factories in the same area. Acquiring such a big area in a region already settled by marble factories is not easy. Being located somewhere else could drive the new entrant out of competition.

(4) Foreign exchange: the access to foreign currency is a necessity for importing the machinery for a new factory. Lack of hard currency could deter the acquisition of the needed technology.

### 3. Fixed Costs

Fixed costs in this industry constitute the following:

- Cost of Land for factory which could be high, as the industry requires a spacious facility. This would vary from one location to the other, but would be in the range of LE 500,000 assuming an area of 5000$m^2$ and LE 100 for the $m^2$.
- Infrastructure installation: a complicated infrastructure is fitted to reinforce the ground with concrete to make sure that it would carry the weight of the

heavy machinery. Moreover the installation needed for electricity and water supply and waste water treatment is in the range of LE 1,000,000.

- The basic machinery for a marble production line is:

  Chasse machine:

  1. The Italian type would cost between LE 900,000 and LE 950,000.
  2. The German machine would cost between LE 1,000,000 and LE 1,200,000.

- Cutting machine
- El Fariza (one head): It would cost between LE 70,000 and LE 80,000 depending on whether it is Italian or German made.
- Polishing Machine: It would cost between LE 30,000 – LE 40,000 depending on whether Italian or German.
- Crane: the cost of a crane lies in the range of LE 500,000.
- Trolley; A trolley would cost between 120,000 – 150,000.

Equipment prices quoted above are usually paid in foreign currency and are accordingly subject to increases if the foreign exchange market is subject to any pressures of any type. A devaluation of the Egyptian pound can increase the prices of imported items at a rate as high as 30%. This uncertainty factor is another reason why an investor is sometimes reluctant to enter this industry, even if common barriers to entry are overcome.

## 4. Major Players

This industry used to be characterized in Egypt as well as abroad by being a family business, where the business got inherited from one generation to the other. In Egypt a number of the current major players in the market have inherited this business from their families. Currently, major players in the market are:

**George & Raouf Abdulla**: This is a family business that started in the 1960s. They are involved in quarrying and processing of marble and granite into finished products. The company operates several quarries that produce varying types of marble. They almost have a monopoly over certain types of Marble. In the mean time they own and subcontract ten factories that process marble and granite extracted from the company's operated quarries. In that way, this company insures a constant supply of the raw product from the quarries and at the same time insures the quality of finished product that is produced in its factories. This gives them the advantage of supplying large quantities easily. The factories are equipped with the latest technology and comply to international standards with respect to production and output. The factories are oriented towards serving the export market than the local market. On the other hand, the company has several offices in the major marble markets around the world They have an office and showroom in Carrara, Italy as well as offices in China and the USA. This keeps them most up-to-date with industry developments. Through exportation, the company has a regular cash flow of hard currency. This facilitates the importation of all needed equipment to Egypt, which is again needed to maintain the company's level of performance and quality.

Products of this company have become a trade mark which allowed the company to sell for prices higher than ongoing market rates. The name is like a guarantee against any defaults in quality or delays in delivery and for this intangible asset their clients are willing to pay more. It is difficult to assess the company's local market share, but it is assumed that this company controls around 50% of the Egyptian exports of marble to the world.

**Sinai Company; Medhat and Ezz:** This company is a partnership. It operates quarries in Sinai and is heavily involved in the exportation of Marble. This company enjoys several features as Raouf Abdalla, though Raouf is stronger internationally. The company's market share can not be assessed accurately for the purpose of this study, but the company is influential in the foreign as well as local Market in terms of its establishment, reputation and quality and size of deals it undertakes, locally and internationally.

**El Hasana Company; Ahmed Hagag**: He operates his quarries and owns his factories for processing the different types of marble and granite. He has succeeded in opening several markets worldwide and is heavily involved in exportation and is known for producing good quality.

Other companies are well established like El Sa'ayda,, Mr. Ayman Hamdoun as well as Sahary Company and Eng Hassan Salama Co. These companies are also key players in the market for marble and granite. They produce good quality, have an established reputation in the market and possess a reasonable market share.

## 5. Technology

The technology for Marble quarrying and processing is very advanced internationally. Factories in developed countries are fully automated which makes the industry highly capital intensive. Though few factories in Egypt tend to acquire the latest technology, yet several factories still import second hand outdated machinery which is much lower in price. The main process that is highly automated in this industry is block cutting into plates, as doing this manually does not facilitate mass production. All other processes including polishing could be done either with fully automated equipment or with semi-automated or manual machines.

Technologies for the marble industry in Egypt are bought from Italy, Germany, Spain, India or Turkey. There are also some Egyptian machines that are produced in workshops copying the patent design of some of the imported machinery. These machines, though performing the required function, yet they are comparatively inefficient and produce a non-standardized product that does not comply to internationally accepted standards. The Italian and German technologies are known to be the best. The Indian and Turkish technologies are less competitive, but are much lower in price. Technology and computerization allow the factory owner to easily update the machinery, as usually only the software and few outdated parts in the machines are replaced with new up-to-date parts. This is due to the nature of the industry that needs very heavy and expensive machinery which is updated rather than replaced. This makes the semi quasi cost for a factory that follows the most up-to-date technology very high.

An important feature of the machinery for this industry is the usage of diamond blades or wire to cut the hard stone. Diamond blades are relatively expensive and are quickly fully utilized after about three month of operation which again imposes a high quasi fixed cost on the factory owner. Another feature of the industry is the intensive use of water. Water is used for cooling of saws, dust suppression and lubrication. The average water consumption for a middle size factory can go up to $60m^3/hr$.

## 6. Pricing Strategy

A unique characteristic that influences this industry is the varying cost structure of the different marble suppliers. Cost of extracting the stone and processing could vary severely from one supplier to the other, depending on the type of technology and tools the supplier uses, as well as nature of the quarry he is operating or getting his marble supplies from. There are quarries that are relatively easily exploited, while other quarries have a complicated nature that often requires extra effort to extract the stone. This adds to their total cost and drives their pricing upwards. Apart from the nature of the quarry is the technology used in quarrying. Some investors in the industry use relatively expensive technology and incur high costs to extract the stone, while their competitors have the flexibility to lower their cost due to using lower technology resulting in relatively lower cost. At the extreme end of pricing comes suppliers who intentionally use the cheapest and most wasteful way of extraction like explosives for example to be able to sell cheap. Of course, in that case, the social cost of losing the valuable marble resources is not accounted for. This dumps prices in the market and causes a real distortion, while the difference in pricing is pushed on the society by wasting its limited resources.

The more investments are directed to high technology, especially in stone quarrying and cutting, the higher is the cost to the supplier and the lower is the cost to the society, as it saves on resources. Unfortunately there is no way to reflect that in the market, because there are no regulations in force that control the stone cutting process or the percentage of waste acceptable to the authorities from the quarrying operation.

In principle, the pricing of marble depends on the following criteria:

- Type, quality and rareness of the marble; the higher the quality of marble and rare the type is, the more expensive it becomes. Rare types that are not frequently available are priced according to demand, and how much the consumer is willing to pay for it. According to a marble trader, he was able to sell a shipment of imported marble that had rare colors relative to the types available in Egypt at a price five times higher than the bottom price he initially set for the shipment. Rare colors are automatically priced higher and usually are demanded as they are an important means of differentiation.
- Local or imported marble: in principle imported marble is higher in price than locally produced marble.
- Surface area and thickness: Surface area is an important factor in pricing. Any surface area bigger than 2 m will start to be priced differently and there is a direct relationship between surface area and price. There is also a direct relationship between thickness and price. The default thickness is 2 cm or 4 cm. It is a rule that the 4 cm thick marble piece is priced 1.8 times higher than a 2 cm piece.

According to the Factory Owners interviewed, prices that are announced in the market consist of actual cost and a mark-up as a profit margin. Due to the varying cost structure of the different suppliers, prices do vary. Some suppliers who have a low cost structure, apparently at the expense of social cost, sell for whatever prices are offered by demand if they need to generate some cash flow into their business. This distorts the market, not only the local market, but the export market as well as, as they offer relatively low prices to international orders in order to sell in hard currency, without accounting for the repercussions on the market. This is due to the high valuation of the hard currency and the need to acquire it in order to be able to import raw material and production equipment.

**7. Differentiation**

Marble is a good that enjoys a very high level of differentiation due to the varying natural characteristics that it enjoys. There are types of Marble that could be described as being snobbish goods as they are very rare and reflect a high living standard and wealth. On the other hand there are Marble types that are very common and are affordable and are considered normal goods. Not only type and quality create the differentiation when talking about Marble, but the color as well as the cut and polish and shape of the stone. As described earlier, there are Marbles that are antique, which stem from quarries that have already depleted. These are very precious and in some cases compare to the precious stones.

Horizontally marble types are differentiated through size of surface area, thickness and type of polish applied. You can have a work place that consists of one piece of solid marble where the surface area could be as big as 4m2 or more. Marble can have varying thicknesses which are produced according to request. When addressing vertical differentiation, we would say that the type of the marble block and the quality of the stone constitute the main elements for vertical differentiation.

The issue of differentiation makes issues like pricing of Marble very complicated.

## 8. Geographic and Size Concentration

According to Mr. Ibrahim Ghaly, who is a main dealer of Italian and German suppliers of marble production lines in Egypt, Egypt has currently about 500 factories working in this industry. 400 factories or about 70% of the industry is located in Shak El Thoban in Katameyya, Cairo as mentioned earlier. The remaining 100 factories are scattered all over Egypt, primarily in the main cities or the capital of the governorates.

Looking at official statistics produced by specialized bodies, we find that the statistic produced by the General Arab Organization for Industrialization in 1998/1999 indicates that only 119 Companies are working in this field in Egypt. Table (14) describes the size and regional distribution of the firms engaged in this industry in Egypt according to this statistic. Looking at the size of enterprises, we find that out of the 119 enterprises, 103 are categorized as medium size enterprises, which compromise about 85% of the enterprises in Egypt. The enterprises described as being big are mainly located in Cairo, where there are 6 bigger size enterprises. Giza, Sharkia and Alexandria have also 2 big marble factories each. While Kaliobia, Menufia, Ismailia and Aswan, each has big marble enterprise. The medium size enterprises are located in Cairo as well as in Giza, Damietta and Alexandria. It is noticeable that only 2 Marble enterprises are located in upper Egypt, one big enterprise in Aswan and one in Beni Suwaif.

Results of interviews with experts in the industry confirm the regional distribution of factories across Egypt, but confirm that the statistic highly underestimates the number of factories operating in the industry. According to Mr. Ibrahim Ghaly, who as a distributor of marble processing machinery, considers all the marble producers as either current clients or potential clients, all the marble producers are concentrated in Cairo. This is easily explained by the fact that the Capital of Egypt has the highest concentration of business. Here also lives the highest per capita income Egyptians. It is often the case that the work is being processed in Cairo, but is then transported all over the country, possibly to governorates that lie near to the quarry. This is a consequence to the fact the demand is mainly initiated, with head offices of the different businesses located in Cairo and hence suppliers are concentrated in Cairo as well. The city of Cairo can be described as the centre and main market for Marble Trading in Egypt.

According to several marble factory owners interviewed, factories can not be located besides the quarries, as quarries are usually located in remote areas. Accordingly if factories are located right besides the quarries, this will necessitate several requirements that are not feasible; namely the supply of water and electricity as well as infrastructure and a certain level of living standard to persuade the factory labor to settle in areas near the quarries. On the other hand, the transportation of the finished product is much more complicated and risky, as the processed marble becomes very fragile, while the solid raw marble stone can be transported without concerns of fragility. Nevertheless and according to Mr. Calutchi, owner of Tesimag a well established supplier of marble producing equipment, the biggest marble factory in the world is located in Oman, out near the quarries and has 118 production lines for the production of marble and granite.

Table : (14) Number and Regional Distribution of Marble Enterprises in Egypt

| Governorate | Number of enterprises working in Marble and Granite | | |
|---|---|---|---|
| | Big Enterprises | Meduim size enterprises | Total |
| Cairo | 6 | 59 | 65 |
| Giza | 2 | 12 | 14 |
| Kaliobia | 1 | 1 | 2 |
| Sharkia | 2 | 2 | 4 |
| Alexandria | 2 | 8 | 10 |
| Monofeya | 1 | 1 | 2 |
| Ismailia | 1 | 1 | 2 |
| Aswan | 1 | | 1 |
| Damietta | | 11 | 11 |
| Gharbia | | 4 | 4 |
| Dakahlia | | 1 | 1 |
| Port Said | | 2 | 2 |
| Beni Sewef | | 1 | 1 |
| Total | 16 | 103 | 119 |

*Source: General Arab Organization For Industrialization, 1998*

Another important feature of the industry in Egypt is not only the concentration in cities, but it is also noticeable that Marble producers in Cairo are mainly concentrated in three regions:

- Shak El Thoban, which is located in Kattameya. It consists of several roads, each about 2 km long that has Marble factories on the left and right sides.

- El Basatin region, where marble factoriesas well as smaller marble workshops, are located the one besides the other.
- Bab El Khalk, where there are mainly smaller workshops located with one or two factories in the area.

A recent SME study also confirms that there are about 500 enterprises working in the field of Marble production in Egypt. With respect to the workshops, their number exceeds 3000 workshops and they are also regionally concentrated like marble factories.

**<u>Current Local Regulations</u>**

There are regulations that organize the marble industry in Egypt. Unfortunately these are confined mainly to systematize the process of acquiring a license to operate a marble quarry. Beyond that, we find that regulations did not extend to cover and properly manage the extraction process and the operational aspects of the industry itself. This lack of regulations with respect to the extraction process for example results in lots of waste to this valuable resource, as has been illustrated earlier.

The following are regulations that organize the quarrying licensing:

1. The quarrying license is obtained from the governorate, where the quarry is located. The license to operate a quarry is granted for one year and is renewable. When renewal is due, renewal fees have to be paid within 20 days, otherwise the license lapses. A standard measurement for any quarry is 100m *50 m. A businessman can operate more than one quarry and obtain more than one license.

2. The fees for a quarrying license vary between LE 4,500 and LE 25,000 , depending on the governorate and location of the quarry.
3. A license to operate a quarry gives the license holder the right to get a certain quota of dynamite for marble extraction from the quarry.
4. The governorate is not responsible to supply the quarry with any infrastructure. It is the responsibility of the applicant to provide necessary basic needs to workers in the quarry, as well as needed water and electricity.
5. On every truck loaded from the quarries, the tonnage is registered and a fee is paid on the amount of extracted marble. Fess paid vary from one governorate to the other.

**Current impediments facing the industry**

The marble industry in Egypt could be one of the most rewarding industries, in terms of export potential, contribution to GNP and forward and backward linkages to the other sectors of the economy, yet some impediments still face the development of this industry in Egypt, like:

- Lack of comprehensive regulations that organize and foster the industry.
- Misuse of the quarries, which results in lots of waste.
- Lack of technical data on types of quarries in Egypt and existing deposits of marble.
- Lack of organized training of manpower to service this industry.
- Lack of organized research and development that serves the industry.
- Lack of information on the international marble markets and required international standards.

- Lack of infrastructure and attention given to the existing marble factories. An area like shak El Thobaan, where over 80% of the marble industry is concentrated in Egypt, does not have basic infrastructure, such as the supply of water, whereas the marble industry uses water intensively. Accordingly tanks of water are sold to the factories to be able to run their operation.
- Distortions in the market caused by the different extraction techniques which vary in efficiency. An inefficient marble producer who causes lots of waste to the country's resources by using cheap extraction techniques based on explosives can afford to offer the products much cheaper on the market causing price distortion, not only locally, but in the export markets as well.
- Distortions caused by inefficient producers who supply bad quality to the international markets at lower prices, thus destroying the reputation of the Egyptian Marble and marble producers.
- Concentration of factories in Cairo with no efforts to promote this industry in cities which lie closer to the quarries, like cities located at the Red Sea where the marble quarries are close. This increases the cost of the final product through high transportation cost and well as concentrates the expertise in limited places.

**Prospects for the Industry in Egypt**

If we look at the contribution of the industry to the Egyptian Economy, we find that this sector has grown tremendously over the past years. Egypt has the natural endowments and the experienced experts in the field that allows Egypt to lead a very successful Marble industry. According to Eng. Medhat Mostafa,[11] President of Sinai

[11] El Ahram Newspaper, Friday June 27th, 2003

International Company, one of the biggest Marble producers in Egypt and also Vice President of the Association of Marble and Granite producers; Investments in Marble and Granite quarries and factories have reached LE 5 billion lately and more than half a million persons work in this sector. Egyptian Exports of Marble reached in value LE 275 million in 2002 and achieved in the first quarter of 2003 more than LE 125 mill. It is expected that exports will increase during the coming three years to reach one billion Egyptian Pounds.

To compare data announced by Mr. Medhat Mostafa to officially published data, we find that statistics issued by the Egyptian Survey and Measurement Authority reflect a lesser volume of marble exports than the volume announced by Mr. Mostafa by about 36%. This might be due to the under-registration of the exported volume of Marble, as is the case with extracted marble.

Table (15) reflects the development of Egyptian exports of marble over the past six years as announced by the Egyptian General Survey and Measurement Authority and published by C.A.P.M.A.S.. It shows a continuously increasing volume of exports. Between 2001 and 2002 a real boom was witnessed, as exports increased by 217%. This reflects good prospects for the marble industry with respect to export markets. It also indicates the acceptance of the product on the international level and the increased demand placed on it.

Table (15): Value of Exports of Egyptian Marble in mill LE; 1997 to 2002

| Year | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|
| Value of exported Egyptian Marble | 36 | 72 | 59 | 67 | 93 | 202 |

*Source: C.A.P.M.A.S. Annual Bulletin of Foreign Trade, 1997-2003*

It should be noted that these volumes of exported marble were listed under raw exports, i.e. are exported as raw stones. Increasing the volume of exported marble in a finished form will create a real value added for the Egyptian Economy, in the form of employment generation, as well as higher export proceeds in hard currency.

Egypt owns a very rich reservoir of Marble, according to Mr. Medhat Mostafa. The Italians, after research expeditions in Egypt, affirmed that Egypt posses the biggest deposits of beige and off-white marble. For example the marble reservoir of "Khashm El Rakaba" extends over an area of 70km*70km and El Galala reservoir; 80 km*80 km and Sinai reservoir 50 km*50 km. Moreover regions like Assuan, Sohag, El Menia and El Wadi El Gedid contain extended reservoirs.

It is hoped that more efficient extraction techniques and equipment will be employed on a wider scale in Egypt. This will greatly improve prospects for the Marble industry to compete on the international level, by improving the properties and quality of the marble extracted. It will also decrease the waste created during extraction saving by that this precious stone for the future generations.

# CHAPTER IV

## THE CASE STUDY OF WATANY MARBLE: APPRAISAL OF THE INVESTMENT DECISION

Watany Factory for Marble and Granite was established in 1986 as a limited Partnership Company among the Watany Family. The Factory is located in the Industrial City of Ismalia on a total area of 8,000 $m^2$. The initial equity capital was LE 100,000 at time of establishment in 1986. In 1997 the factory shifted to work under Investment Law no.8 as a private free zone enterprise geared towards exportation. Accordingly, the status of the company became a shareholders company and the issued and registered capital was increased to USS 2,222,900. Under the new status, the company was subcontracted to deliver marble and granite to several customers inside and outside Egypt. An example of projects performed in Egypt is the Airport of Sharm El Sheikh and Suez Canal University. For projects outside Egypt, examples are the new Airport of Dubai, the Prince's Office in Dubai and the Holy Mosques Expansions in Mecca and Medina.

The factory is managed by Dr. Magdy Watany who has been working in this field since the late seventies in the Capital of Marble in Italy, Carrara. With this rich experience, he decided to return to Egypt to establish his own factory in Ismalia, while maintaining his business links in Italy as well as in other neighboring countries. His expertise in the field and his international contacts were key to the success of the factory. Dr. Magdy Watany is a member of the Marble and Granite World Federation.

The factory uses the Italian Technology. Italian experts participated in the design of the factory and were involved in the start up phase for installation and training of the employees on the machinery used. Watany Factory produces finished Marble and Granite products. The factory receives the hard raw stones from different quarries all over Egypt where sawing machines in the factory cut them into slabs. The slabs are then polished and are either sold as a final product or are cut further into different shapes according to the customer's demand. Thickness of the slabs is usually either 20 or 40 mm and slabs are measured and sold by square meter.

The factory strives to follow international standards in its operation, as 50 % of its products are export oriented. This allows the company to benefit from the comparative advantage of low wages and inexpensive utilities in Egypt and to sell in foreign markets at competitive prices. Another advantage of exportation stems from generating an income in foreign currency for the company which is important to secure imports of raw materials and spare parts needed and paid for in foreign currency. Regarding the remaining 50% of sales, about 35% is addressed to the public tenders, while 15% are distributed locally to the private sector and are accordingly priced in line with current market prices. Distribution is to follow direct channels locally and internationally through the internet, publications and fairs. The company has also 2 agents; in Italy and in Dubai.

**Investment Decision for Factory Expansion**

During the past years, the company has been able to develop a very good commercial local and international network. It regularly participated in important fairs for the industry and was able to present a competitive product in terms of quality and pricing.

This resulted in a flow of orders, which the factory could not keep up to due to its limited production capacity, losing by that good contracts from countries like UAE, Saudi Arabia as well as China, Southeast Asia, USA and Canada. With respect to the local market, forecasts performed by the company reflected promising prospects as well. Construction and touristic resorts are continuously established creating a continous demand for varying types of marble and granite.

In the year 1999, and according to the Company's financial Statements, the level of the Factory's production and sales reached in value LE 12,570,300 ($ 3,698,000 at the rate of $/LE = 3.4 prevailing at that time). An expert's assessment for a possible increase in production capacity was estimated to be 192,000 $m^2$, which meant doubling the production capacity. Local and international market forecasts projected that in case of expansion 75% of the factory's production would be exported, while 25% of it would be sold locally. A unit price estimation of $8.8/m for the marble slabs and $ 29.4 for the granite slabs was projected. In the light of the illustrated situation, the shareholders of Watany Factory took the decision to invest and double the production capacity of Watany Marble Factory.

**<u>Assessment of Investment Decision</u>**

After this brief on the factory, its operation and expansion, the rest of the chapter will deal with the assessment of the Investment decision using economic and financial assessment tools and taking into account the changes that happened during the past four years in the Egyptian economic environment. Several economic and non economic factors have changed affecting the Investment climate in varying degrees. Changes on the economic sphere were not always in accordance with predictions made four years ago. The validity of the assumptions made by the company will be assessed in the context of this analysis and as the chapter develops unrealistic assumptions will be relaxed and replaced by actual data until 2004 and recent predictions until 2009. In the light of the previous chapters, the purpose of the current chapter is to present the operation of a marble factory in terms of costs and revenues as well as assumptions guiding the factory's operation with respect to its investment decisions. The analysis will assess the returns to the investment made using economic and financial analysis tools to determine how wise the investment decision at that time was and how changes in the country's economic variables impacted this marble factory operation, whether positively or negatively.

Capital investments are key to the growth and prosperity of an economy through possible innovations, employment creation, profitability and development that these investments result in. Wise Investment decisions create a better living standard and higher social welfare for the nation as a whole, (Selim, 2004). To assess the expected profitability of an investment, financial indicators are used which reflect a projected picture of possible gains that could be achieved. In the case of Watany Marble the investment decision was to double the production capacity. This investment decision was taken based on the prediction of some financial statements for ten years, using in several instances unrealistic assumptions, nevertheless the projected financial statements reflected a profitable operation. These Financial Statements included:

- Balance Sheet & Income Statement
- Needed Capital Investments
- Labor and materials breakdown

- It is worthwhile mentioning that all financial statements had the US$ as the denominated currency for the whole period of 10 years. Assumptions used to project those financial statements were:
- A fixed exchange rate US$/LE= 3.4 (used to prevail in 1999) was used for the 10 years-projection.
- 75% of total production is exported and 25% sold locally.
- No allowance for inflation was made.
- About 30% of total investment cost is to be financed through a bank loan amounting to $ 1.75 mill. Accordingly, the investor would self finance 70% of total project cost.
- An agreement with the bank for the terms and conditions of the loan allows a grace period of 3 years, repayment over ten years and a fixed interest rate of 10% over the whole period.
- Expansion would double the production capacity, as time passes, the contribution of the old line will decrease, while the contribution of the new line will reach full capacity.

**The Approach and Methodology to Evaluate the Investment Decision**

As this investment decision was taken four years ago, assessing the investment decision today will require compiling the needed data from the files of the company. Thereafter a set of adjustments to the financials predicted by the company will have to be applied. Adjustments will be based partially on real data as well as on recently projected data. Using this adjusted data, a set of economic and financial indicators like; Money Worth Indicators, Rate of Return Indicators and Pay back Indicators will be calculated. The following steps demonstrate the methodology implemented and the tools used to assess Watany's investment decision using these tools.

**Step 1: Assessment of Investment Cost**

Table (1) aggregates cost of investments in US$ at the exchange rate of $/LE=3.4. Old investment cost of the factory was incurred during the period from 1988 to 1999 and is included as a net value for the purpose of the current analysis. The new expansion cost was incurred in the year 1999. As shown in Figure 1, a major portion of the investment cost, about 66% was absorbed in buying factory equipment and covered, overhead traveling crane, crane truck 9 tons, fork lift 2.5 tons, block cutter, block carrying trolley, cutting machine and polishing machine. This reflects the important role played by equipment in this industry. All equipment items were imported from Italy and were accordingly paid for in foreign currency. Another cost incurred in foreign currency was the design and engineering cost, as the factory owner had to use Italian expertise to reach an optimum design for his new factory which was relatively a new business in Egypt at that time. Total investments for Infrastructure reached $ 983.7 thousand. Cost of infrastructure included cost for Concrete Foundations for the machines, foundation and rail for movable crane, sewage, water, electricity, air compressor and fuel connection. This infrastructure is unique to the marble and granite industry. Due to this unique feature, professional implementation of the infrastructure design needs specialized expertise to fix the solid concrete ground and is key to the success of the factory operation. On the other hand, the cost of buildings reached about $ 909.77 thousand and covered the building of the fence and gate, the administrative building and building of the stores for raw materials. Plant equipment absorbed more than 66% of total investment cost Other minor costs included, office furniture, design & engineering and site preparation.

Total investment cost incurred includes payments done in $ as well as in Egyptian Pounds and amounted to $ 6,009.77 mill, the equivalent of which was LE 20.433 mill at the rate of $/LE = 3.4 which was the prevailing rate in 1999.

Figure (8): Breakdown of Investment Cost

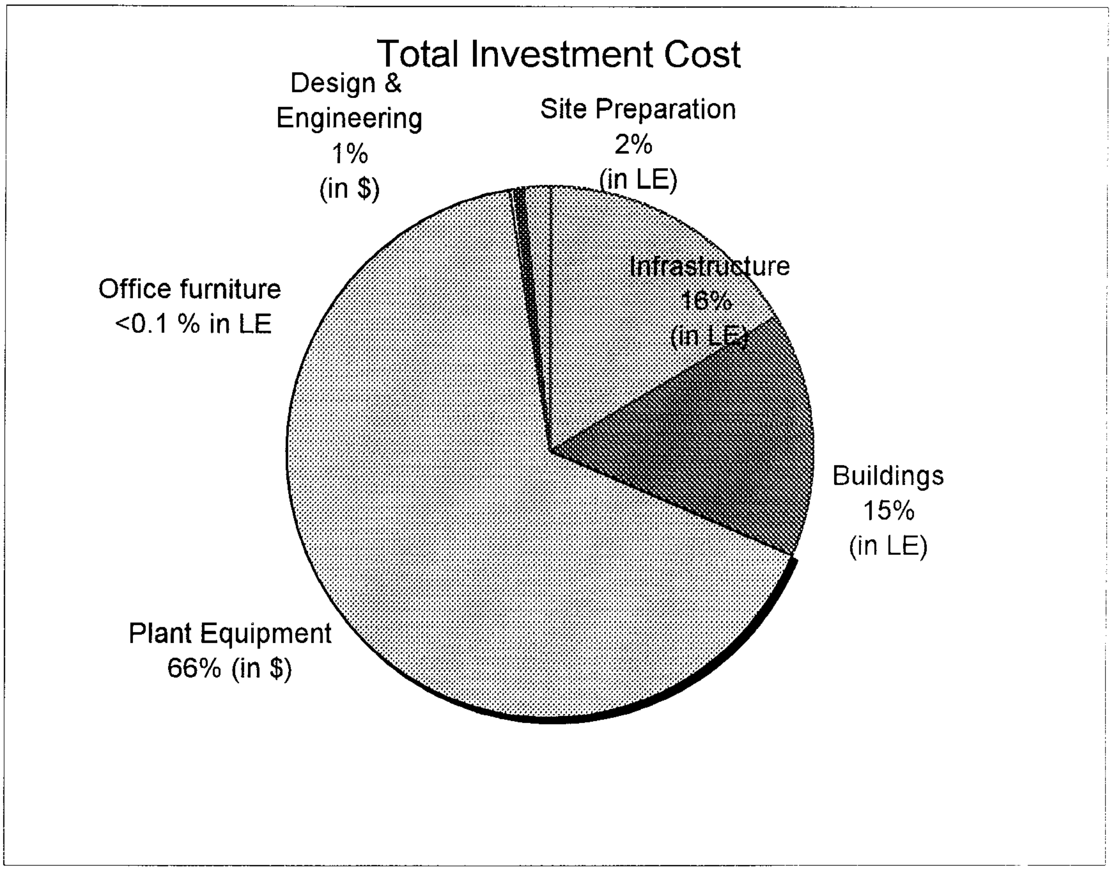



Figure (8) illustrates the breakdown of the Investment cost into the different cost components and the percentage of each cost to total cost. The currency in which the cost item was incurred, whether LE or $ is highlighted as well, as it will impact the analysis as will be illustrated later on.

**Step 2: Assessment of the Production Capacity**

As mentioned earlier, this is an expansion of an existing production capacity. For that purpose, a new production line has been installed. Table 2 highlights the expected production capacity of both production lines, the old and new line over The period of ten years. As highlighted in the table, the old production line will not be producing with a capacity better than 90% and its production capacity will deteriorate over time to reach 60% in year 10. On the other hand, the new production line will start with a capacity of 30% which will reach 100% starting the 3rd year of operation. Over the period of the ten years, the factory will be reaching its highest production level in the 3rd and 4th years of operation.

**Step 3: Assessment of Total Production Cost**

The financial statements from 2000 to 2009 projected by the company were all denominated in US $ at the fixed rate of $/LE = 3.4. Table 2 sums up quasi fixed cost, variable and total production cost in dollars and the percentage share of each cost item in total production cost. As payments for the project were made in $ as well as in Egyptian Pounds, the currency of payment of each item is shown in the table. This is very important as the exchange rate varies considerably over the years. The table also shows the projected production capacities during the different years of operation.

Table (16): Total Production Capacity of the Old Production Line and the Expansion

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| Production Capacity/ Timeline | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t8 | t9 | t10 |
| Old Production Line | 90% | 90% | 80% | 80% | 70% | 70% | 60% | 60% | 60% | 60% |
| New Production Line | 30% | 60% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Total for Factory after expansion | 60% | 75% | 90% | 90% | 85% | 85% | 80% | 80% | 80% | 80% |

Table (17) clearly highlights that the cost of acquiring the raw material is the main operating cost for production in this industry as it constitutes about 79% of total production cost. Raw material consists mainly of raw marble blocs which are on average 70% acquired from local quarries and 30% imported. Other cost associated with acquiring the raw marble like cost of transportation and handling is included in the cost estimate quoted in the table below. Most of the cost items are incurred in local currency. The cost items paid in foreign currencies are associated with spare parts for the production equipment as well as specialized maintenance which is periodically needed for the machinery.

It is assumed from the beginning that the production capacity of the old production line will decrease, whereas the capacity of the new line will pick up to compensate for the deterioration in the capacity of the old line. We will see that on average the production capacity will be around 80%. The table shows also total cash outflow pertaining to each cost item over the ten years of the study and also the cumulative cash outflow for the same period.

Table 16: Total Production cost including Quasi Fixed Cost, Variable Cost( in **'000 US$** ) & production capacity with currency of payment

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Undiscounted cash outflow | % of total | Currency of pay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item / time | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t8 | t9 | t10 | | | |
| Indirect labor | 39 | 41 | 43 | 45 | 47 | 50 | 52 | 55 | 58 | 61 | 491 | 0.98% | LE |
| Factory o/h | 72 | 76 | 79 | 83 | 88 | 92 | 96 | 101 | 106 | 112 | 906 | 1.82% | LE |
| Rent | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 100 | 0.20% | LE |
| Marketing o/h | 35 | 37 | 39 | 41 | 43 | 45 | 47 | 49 | 52 | 54 | 440 | 0.88% | LE |
| **Quasi Fixed Cost** | **156** | **163** | **171** | **179** | **187** | **196** | **206** | **215** | **226** | **236** | **1,936** | **3.89%** | LE |
| Raw Materials | 3,115 | 3,271 | 3,434 | 3,606 | 3,786 | 3,976 | 4,174 | 4,383 | 4,602 | 4,832 | 39,180 | 78.66% | 30%$&70%LE |
| Raw Marble Blocs | | | | | | | | | | | | | LE & $ |
| Raw Granite Blocs | | | | | | | | | | | | | LE |
| Steel Shots | | | | | | | | | | | | | $ |
| Limestone | | | | | | | | | | | | | LE |
| Direct labor | 78 | 82 | 86 | 90 | 95 | 100 | 105 | 110 | 115 | 121 | 981 | 1.97% | LE |
| Utilities | 27 | 27 | 27 | 27 | 27 | 30 | 30 | 30 | 30 | 30 | 285 | 0.57% | LE |
| Water | Underground water is used and no cost of water charged | | | | | | | | | | | | |
| Electricity | | | | | | | | | | | | | LE |
| Spare parts | 10 | 11 | 11 | 12 | 13 | 14 | 15 | 17 | 18 | 20 | 141 | 0.28% | $ |
| Grandly Stones | | | | | | | | | | | | | |
| Diamond steel | | | | | | | | | | | | | |
| Diamond disk | | | | | | | | | | | | | |
| steel grit | | | | | | | | | | | | | |
| Maintenance | 62 | 62 | 65 | 68 | 73 | 78 | 84 | 90 | 99 | 108 | 789 | 1.58% | 70%$&30%LE |
| Total variable cost | 3,292 | 3,452 | 3,623 | 3,804 | 3,994 | 4,197 | 4,408 | 4,629 | 4,865 | 5,112 | 41,376 | 83.07% | in$ & LE |
| **Total Quasi Fixed & Variable Cost** | **3,448** | **3,615** | **3,794** | **3,983** | **4,182** | **4,394** | **4,614** | **4,845** | **5,090** | **5,349** | **43,313** | **86.96%** | |
| 15% contingency | 517 | 542 | 569 | 597 | 627 | 659 | 692 | 727 | 764 | 802 | 6,497 | **13.04%** | |
| **Total production cost** | **3,965** | **4,158** | **4,364** | **4,580** | **4,809** | **5,053** | **5,306** | **5,571** | **5,854** | **6,151** | **49,810** | **100.00%** | in$ & LE |

**Step 4: Converting the Ten-Year Total Production Cost into Local Currency**

As shown in Table (17), the production cost is mainly incurred in Egyptian Pounds. For analysis purposes, the Company's financials will be presented in local currency. Here one of the major assumptions mentioned earlier which is the stabilization of the exchange rate between the $ and the LE at 3.4 will be relaxed as it proved to be very unrealistic. Table (18) shows total costs in Egyptian pounds after allowing for the readjustment by utilizing the average ongoing exchange rate during the years from 2000 to 2004 and the recently projected exchange rate until 2009. It is worthwhile mentioning that most of the reports on future projections of economic indicators for Egypt refrained from including an exchange rate projection for $/LE for more than 2 years (until 2005) due to the high volatility of this relationship during the past years.

It should be noted that costs incurred in Egyptian Pounds were reverted to local currency by multiplying times 3.4, the same conversion rate used earlier in the year 2000. Only cost items incurred in $, like the cost of imported raw materials and the cost of equipment spare parts have been converted at the announced market exchange rates as highlighted in Table 3.

**Step 5: Ten Years Revenues Assessment**

After the identification of all cost items pertaining to operation, revenues generated from the factory's operation needed to be identified and assessed as well.

Table (18): Total Production Cost in **('000 LE)** readjusted to actual exchange rate till 2004 & to projected rate till 2009

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Total un-discounted Cashflow | % of Total | Currency of Pay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item / Time | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t8 | t9 | t10 | | | |
| Prevailing/ Projected Exchange Rate | 3.54 | 4.05 | 4.63 | 5.87 | 6.21 | 6.44 | 6.69 | 6.94 | 7.19 | 7.44 | | | |
| Indirect Labor | 133 | 139 | 146 | 154 | 161 | 169 | 178 | 187 | 196 | 206 | 1,668 | 0.85% | LE |
| Factory o/h | 245 | 257 | 270 | 283 | 298 | 312 | 328 | 344 | 362 | 380 | 3,079 | 1.57% | LE |
| Rent | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 340 | 0.17% | LE |
| Marketing o/h | 119 | 125 | 131 | 138 | 145 | 152 | 159 | 167 | 176 | 185 | 1,497 | 0.77% | LE |
| **Total Quasi Fixed Cost** | **530** | **555** | **581** | **609** | **637** | **668** | **699** | **732** | **767** | **804** | **6,584** | **3.37%** | **LE** |
| Raw Materials | 10,678 | 11,546 | 12,521 | 14,042 | 15,001 | 15,934 | 16,940 | 18,006 | 19,136 | 20,335 | 154,139 | 78.80% | 30%$,70%LE |
| Raw Marble Blocs | | | | | | | | | | | | | LE & $ |
| Raw Granite Blocs | | | | | | | | | | | | | LE |
| Steel Shots | | | | | | | | | | | | | $ |
| Limestone | | | | | | | | | | | | | LE |
| Direct Labor | 265 | 278 | 292 | 307 | 322 | 338 | 355 | 373 | 392 | 411 | 3,336 | 1.71% | LE |
| Utilities | 92 | 92 | 92 | 92 | 92 | 102 | 102 | 102 | 102 | 102 | 969 | 0.50% | LE |
| Water | Underground water is used and no cost of water charged | | | | | | | | | | | | |
| Electricity | | | | | | | | | | | | | LE |
| Spare parts | 35 | 43 | 51 | 70 | 80 | 89 | 102 | 117 | 133 | 151 | 871 | 0.45% | $ |
| Maintenance | 217 | 239 | 277 | 351 | 393 | 433 | 478 | 527 | 597 | 675 | 4,185 | 2.14% | 70%$,30%LE |
| Grandly Stones | | | | | | | | | | | | | |
| Diamond Steel | | | | | | | | | | | | | |
| Diamond Disk | | | | | | | | | | | | | |
| Steel Grit | | | | | | | | | | | | | |
| **Total Variable Cost** | **11,287** | **12,198** | **13,234** | **14,861** | **15,888** | **16,897** | **17,977** | **19,124** | **20,360** | **21,675** | **163,500** | **83.59%** | |
| **Total Quasi Fixed & Variable Cost** | **11,818** | **12,753** | **13,815** | **15,470** | **16,525** | **17,564** | **18,676** | **19,857** | **21,127** | **22,479** | **170,084** | **86.96%** | |
| 15% Contingency | 1,773 | 1,913 | 2,072 | 2,320 | 2,479 | 2,635 | 2,801 | 2,979 | 3,169 | 3,372 | 25,513 | 13.04% | |
| **Total Production Cost** | **13,591** | **14,666** | **15,888** | **17,790** | **19,004** | **20,199** | **21,477** | **22,835** | **24,296** | **25,850** | **195,596** | **100.00%** | |
| **Production Capacity** | **60%** | **75%** | **90%** | **90%** | **85%** | **85%** | **80%** | **80%** | **80%** | **80%** | | | |

Table (19) reflects projected revenues of the factory over the period of 10 years in US$ as initially estimated using the exchange rate of $/LE as 3.4. According to the Company's market assessment and plans, 75% of production capacity would be exported, while the remaining 25% would be sold locally.

To convert the $ revenues into Egyptian Pounds, the same concept of local currency readjustment previously applied to the costs will be applied to revenues, i.e. revenue proceeds in $ will be converted using market / recently projected exchange rate, revenues received in LE will be converted at the rate of $/LE 3.4. Table 4 presents this final adjustment to revenues.

**Step 6: Appraisal of the Investment decision**

After estimating the Company's total costs and total revenues in Egyptian Pounds, the appraisal for the Company's investment decision can done using a set of financial evaluation techniques. Financial evaluation is a tool that predicts the profitability outcomes and net commercial gains expected from engaging in a given project. The financial appraisal of Watany investment decision will involve the estimation of the discounted annual cash flow. It will also involve the calculation of project appraisal indicators like; Money Worth Indicators, Rate of Return Indicators, and Payback Indicators.

Table (19): Total revenues expressed (in **'000 $)** at the exchange rate of $/LE 3.4 and then converted into **'000 LE** at the prevailing market rate / projected exchange rate

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Cumilative undiscounted CF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t8 | t9 | t10 | |
| Prevailing/ Projected Yearly Average Exchange Rate | 3.54 | 4.05 | 4.63 | 5.87 | 6.21 | 6.44 | 6.69 | 6.94 | 7.19 | 7.44 | |
| **Total Revenues in $ at fixed exchange rate of 3.4** | **4,744** | **5,919** | **7,088** | **7,088** | **6,691** | **6,691** | **6,294** | **6,294** | **6,294** | **6,294** | **63,397** |
| 75% of Total Revenues received in $ | 3,558 | 4,439 | 5,316 | 5,316 | 5,018 | 5,018 | 4,720 | 4,720 | 4,720 | 4,720 | 47,545 |
| 25% of Total Revenue received in LE expressed in | 1,186 | 1,480 | 1,772 | 1,772 | 1,673 | 1,673 | 1,574 | 1,574 | 1,574 | 1,574 | 15,852 |
| **Total Revenues expressed in LE at actual/projected exchange rates** | **16,628** | **23,010** | **30,638** | **37,230** | **37,085** | **38,239** | **37,150** | **38,330** | **39,511** | **40,691** | **338,512** |

## Calculation of the Discounted Cash Flow

To arrive at the undiscounted cash flow, all outflows were subtracted from the Company's cash inflows as reflected in Table (19). To discount the CF and accommodate inflation, a suitable discount rate needs to be calculated that takes into account the ongoing deposit rate as well as the ongoing lending rate, as the Company finances about 30% of its expansion through a loan amounting to US$ 1,750,000 with a grace period of three years.

## Choice and Calculation of an Opportunity Cost of Capital

To obtain a realistic discount rate, during the grace period, the weighted average cost of capital would be the market interest rate. For the remaining years, the lending rate, the Central Bank's of Egypt discount rate and the inflation rate need to be projected until 2009. After checking several economic reports that specialize in forecasting country's economic indicators like the International Financial Statistics, the Economist Intelligence Country Report and the World Bank's Global Economic Prospects Report, as well as the Egyptian CAPMAS it is obvious that forecasting for the Egyptian Economy is currently difficult and expected to be inaccurate due to the constant change witnessed in the economic environment relating to the volatility of the Egyptian pound against the other currencies which affects the level of imports, exports, inflation rate and the country's economic performance in general. Accordingly, it was decided to stabilize the economic indicator for which no reliable forecast was presented by international statistics data books. Table (20) summarizes the country's economic indicators used.

Table (20):Actual/Expected Deposit Rate, Lending Rate and CBE Discount Rate in %.

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| Prevailing/expected deposit rate | 9.5 | 9.5 | 9.3 | 9.5 | 9.4 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| Lending rate | 13.2 | 13.3 | 13.8 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Central Bank Discount Rate | 12 | 11 | 11 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Inflation Rate | 2.7 | 4.5 | 4.1 | 4.5 | 5 | 5.5 | 4.5 | 4.5 | 4.5 | 4.5 |

*Source: 2003 International Monetary Fund, International Financial Statistics Yearbook*

Let $f$ = inflation, $r_l$ = effective lending rate with grace period, $r_m$ =market interest rate, $r_d$ = discount rate and $r_e$ = effective rate with allowance for f.

As 30% of the project's cost is financed through a bank loan with a fixed interest rate of 10%, a duration of ten years and a grace period of three years, the effective discount rate would be:

$$r_d = 30\% r_l + 70\% r_m \quad (4.1)$$

To calculate the effective lending rate $r_d$ with allowance for the grace period; let

$$(r_{l1}) + (r_{l2})(r_{l3})(r_{l4})(\ldots)(r_{l10}) = k \quad (4.2)$$

$$(1 + r_l)^7 = k \quad (4.3)$$

$$\ln(1 + r_l)^7 = \ln k \quad (4.4)$$

$$7 \ln(1 + r_l) = \ln k \quad (4.5)$$

$$1 + r_l = e^{\ln k / 7} \quad (4.6)$$

$$r_l = e^{\ln k / 7} - 1 \quad (4.7)$$

$$k = (1.132)(1.133)(1.138)(1.12)^7 = 3.226597 \quad (4.8)$$

$$r_l = 18.216\% \quad (4.9)$$

During the grace period, where no repayment is required from the factory, the effective lending rate or the opportunity cost of capital would be 18.216%. This would prevail for a period of three years, which is the duration of the grace period. To calculate the discount rate, or the opportunity cost of capital for the ten years, $r_d$:

$$r_d = 30\% r_l + 70\% r_m \quad (4.10)$$

$$r_d = 30\%(18.216) + 70\%(10\%) = 5.464\% + 7\% = 12.46\% \quad (4.11)$$

The calculate the opportunity cost of capital, while allowing for a grace period of three years and a special interest rate of 10%, then the discount rate would be 12.46%. In order to account for inflation, f, the inflation rate will be incorporated into the equation to arrive at the effective discount rate, $r_e$

$$r_e = (1 + f)(1 + r_d) - 1 \quad (4.12)$$

Table (21) reflects f which is the inflation rate over the period of ten years, $r_d$ which is the discount rate with allowance for the grace period and $r_e$ which is the effective discount rate combining the effect of the inflation rate and grace period over the duration of the loan facility.

Table (21): Effective discount rate adjusted to inflation

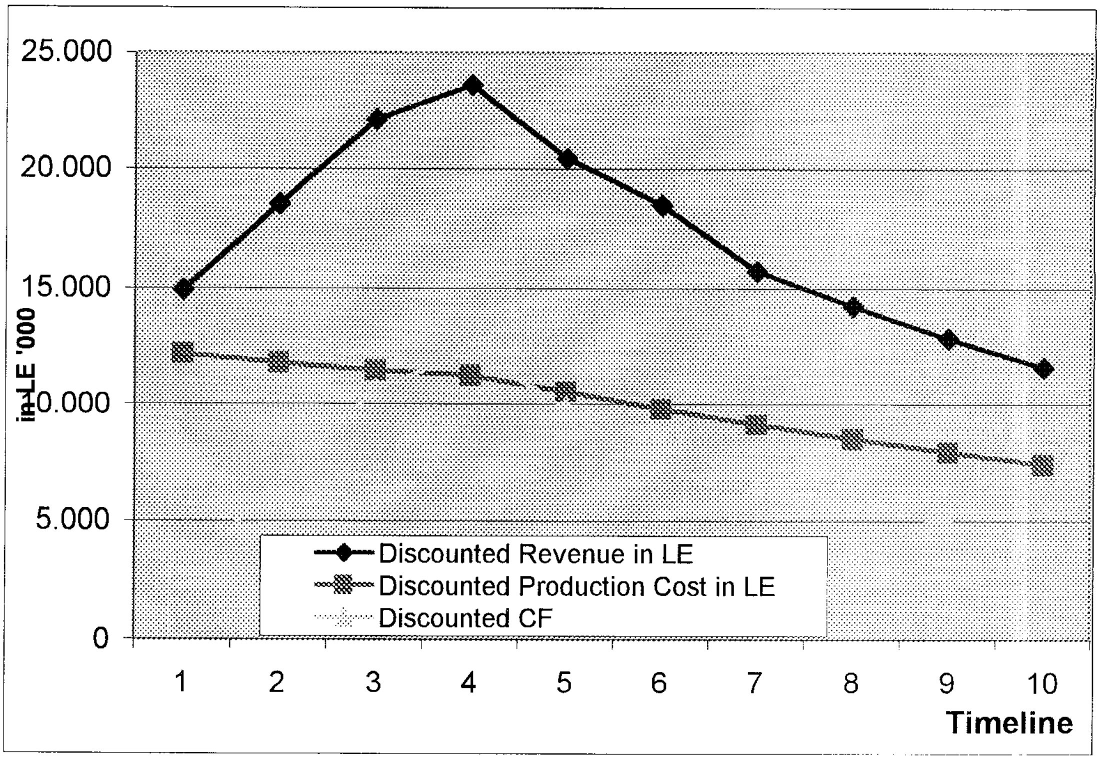
| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $f$% | 2.7 | 4.5 | 4.1 | 4.5 | 5.0 | 5.5% | 4.5% | 4.5% | 4.5% | 4.5% | 4.4% |
| $r_d$% | 10 | 10 | 10 | 12.46 | 12.46 | 12.46 | 12.46 | 12.46 | 12.46 | 12.46 | 11.722 |
| $r_e$% | **11.30** | **11.50** | **11.45** | **14.07** | **14.13** | **14.20** | **14.07** | **14.07** | **14.07** | **14.07** | **13.29** |

As highlighted in table (21), the effective discount rate showed an increasing trend from one year to the other due to the increase in inflation rate and the end of the grace period of the loan by the end of 2002.

**<u>Calculation of the Company's Discounted Cash Flow</u>**

After obtaining the effective discount rate, it was applied to total revenues and total costs to obtain discounted revenues, discounted costs and discounted Cash Flow which are illustrated in Figure (9) below. The graph of the total cost reflects a decreasing cost function, where operating costs decreases over time. On the other hand yearly discounted revenues and yearly discounted CF reached their peak in the fourth year reflecting the highest profitability levels during that year.

Figure (9): Discounted Revenues, Discounted Costs and Discounted Cash Flow.




On the other hand Figure (9) reflects besides the discounted and undiscounted cash flow, the cumulative undiscounted and cumulative discounted cash flow over the period of ten years. The project achieved a cumulative cash flow of LE 140 mill over the period of ten years. Discounting this figure reflected a cash flow of LE 72.4 mill only.

**Net Present Value**

The Net Present Value (NPV) measures the net gain of the project over its life in a single figure. This indicator is the most common criteria in evaluating projects from the financial cash flow viewpoint. A positive NPV represents an expected net gain and project feasibility, whereas a negative value reflects an expected loss

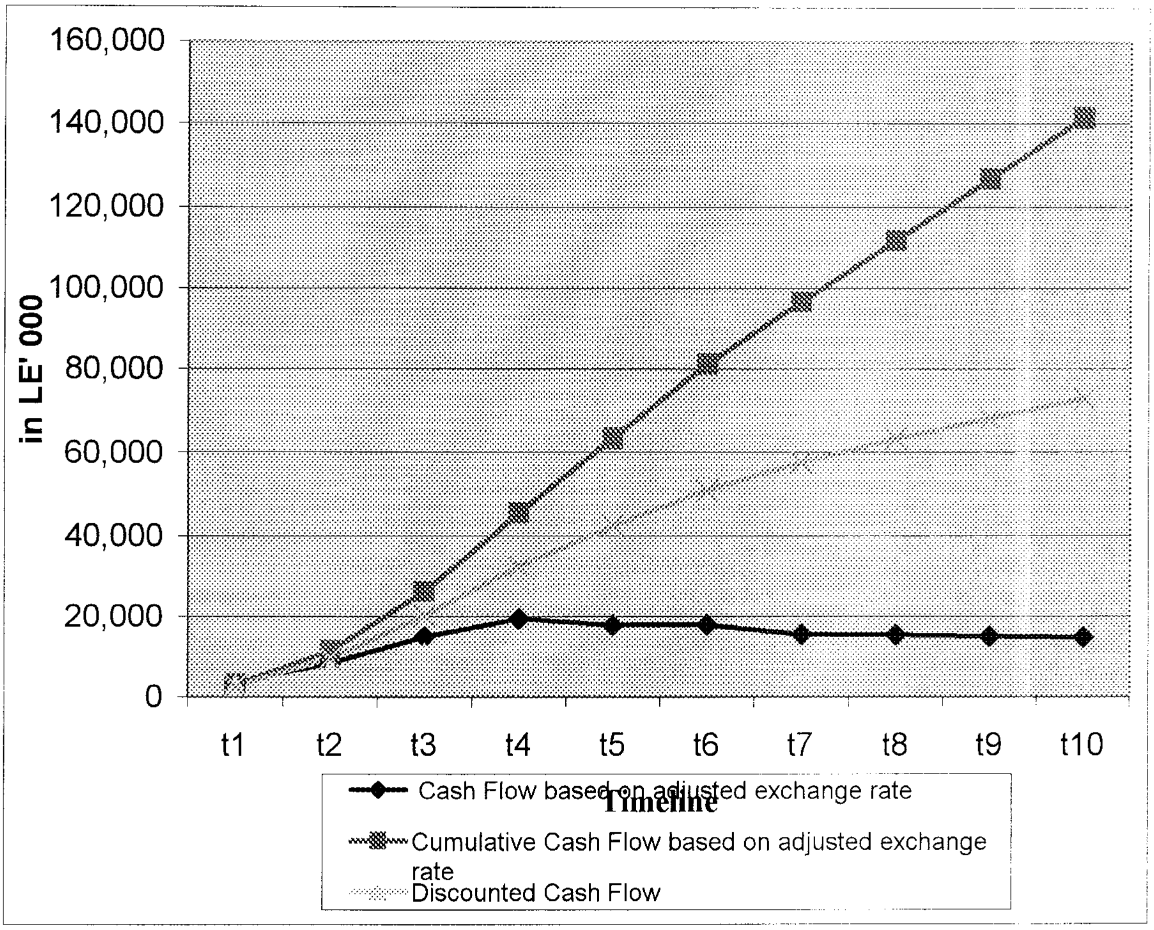
Table (22): CF, discounted CF, Cumulative CF & Cumulative discounted CF

| Timeline | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t8 | t9 | t10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cash Flow based on adjusted exchange rate | 3,037 | 8,344 | 14,750 | 19,440 | 17,847 | 17,806 | 15,453 | 15,275 | 14,994 | 14,620 |
| Cumulative Cash Flow based on adjusted exchange rate | 3,037 | 11,382 | 26,132 | 45,571 | 63,418 | 81,224 | 96,676 | 111,951 | 126,946 | 141,566 |
| Discounted Cash Flow | 2,729 | 6,724 | 10,665 | 12,323 | 9,912 | 8,660 | 6,589 | 5,710 | 4,914 | 4,675 |
| Cumulative Discounted Cash Flow | 2729 | 9,453 | 20,119 | 32,442 | 42,354 | 51,013 | 57,602 | 63,312 | 68,225 | 72,900 |
| Cumulative Contribution | 3.74% | 12.97% | 27.60% | 44.50% | 58.10% | 69.98% | 79.02% | 86.85% | 93.59% | 100.00% |

and indicates that the project is economically unviable. The NPV of a project over a period of n years can be calculated by using the following equation:

$$PV = -I + \sum_{t=1}^{n} \frac{B_t - C_t}{\prod_{1}^{t}(1+r_t)} \qquad (4.13)$$

Figure (10): Comparison between CF, discounted CF, Cumulative CF & Cumulative discounted CF

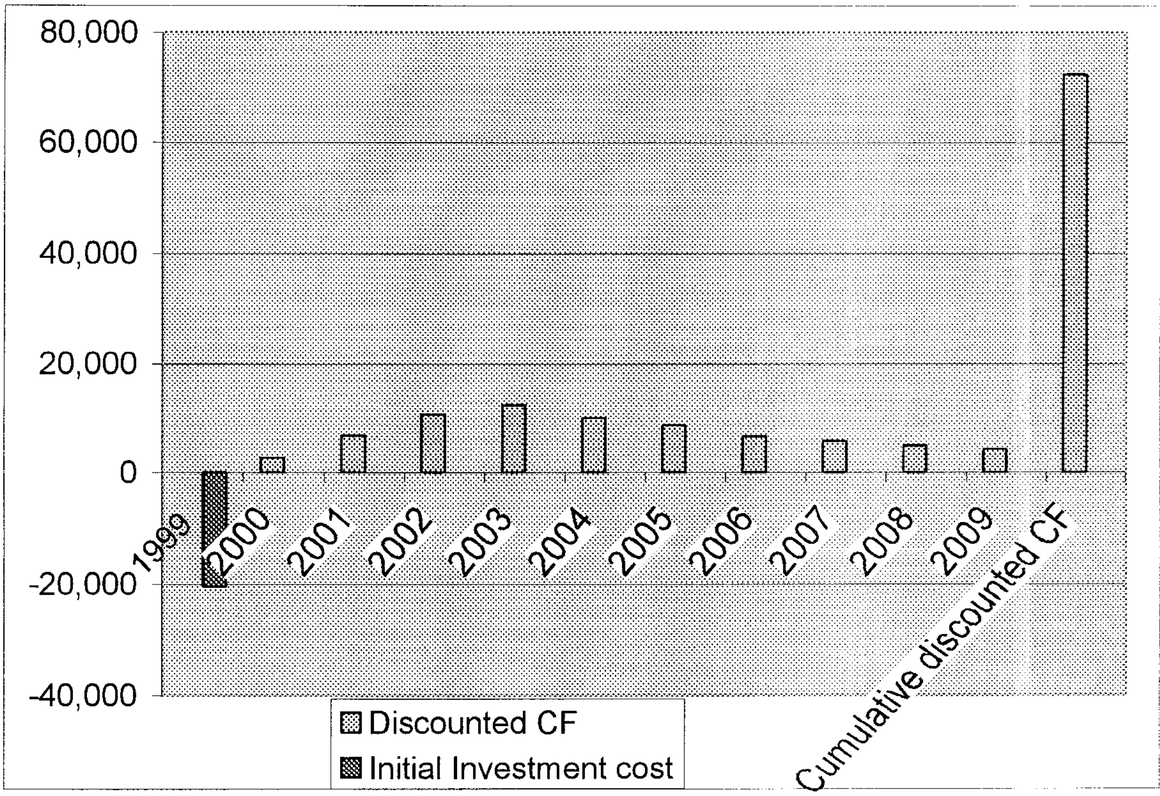



In the case of Watany Marble, having derived the discounted Cash Flow, Obtaining the NPV would be by subtracting total investment cost from the cumulative discounted cash flow;

NPV = - 20,433,000 + 72,418,000 = <u>51,985,000</u> (4.14)

The NPV indicator to assess Watany Marble investment decision reflected positive net gains of LE 51,985 mill and a feasible project. Figure (11) illustrates total investments which reached about LE 20.4 mill, yearly discounted Cash Flow and cumulative Cash flow after the tenth year of operation.

Figure (11): Total Investment Cost, Yearly discounted Cash Flow and Cumulative discounted Cash Flow




## Annual Worth

The annual worth of a project yields the net annual cash amount produced by the project's activities. This involves either the conversion of net benefits to their equivalent annual amounts or equivalently the conversion of the NPV into an annual worth by the use of a capital recovery factor.

$$AW = (PV)(C_r) \qquad (4.15)$$

where $C_r$ is the capital recovery factor and is determined by

$$C_r = \frac{r(1+r)^n}{(1+r)^n - 1} \qquad (4.16)$$

$$C_r = \frac{r\,(1+r)^n}{(1+r)^n - 1} = \frac{0.1329\,(1+0.1329)^{10}}{(1+0.1329)^{10} - 1} = \frac{0.4629}{2.4827} = 0.1864 \qquad (4.17)$$

$$AW = 51{,}985{,}000 * 0.1864 = \underline{9{,}690{,}000} \qquad (4.18)$$

The AW indicator for Watany Marble yielded a positive figure of LE 9,690 mill indicating a feasible project.

**Future Worth**

Future Worth measures the future value of the project in money terms of the future. It can be seen as the equivalent cash amount of the project's net benefits that have accumulated over its entire horizon of operation which is to be given to the investor at the project's end year, n. Rather than discounting, FW includes the money value of net benefits discounted further to the future. Therefore with the use of NPV indicator and the effective discount rate $r_e$, FW could be calculated as follows:

$$FW = (PV)(1+r)^n \qquad (4.19)$$

$$FW = (PV)(1+r)^n = 51{,}985 * (1+0.1329)^{10} = 181{,}047{,}000 \qquad (4.20)$$

The high positive value of the FW implies an economically feasible project.

**Capitalized Worth**

The Capitalized Worth method is the annual worth method over an indefinite period. CW can be calculated by applying the equation;

$$CW = (PV)(r) \qquad (4.21)$$

$$CW = 51{,}985 * 0.1329 = 6{,}908{,}000 \qquad (4.22)$$

The positive CW implies a high degree of feasibility.

**Rate of Return Indicators**

These are financial indicators based on an implied interest rate for the project over its entire life span. The interest yield is calculated based on an assumed model and then compared with the market interest rate to determine project feasibility. Internal, external and growth rate of return model are three different indicators of project yield

**Internal Rate of Return**

IRR is denoted by $\rho$ and reflects the net yield of the project. It is obtained by the solution of the following equation:

$$-I+\sum_{t=1}^{n}\frac{B_t-C_t}{(1+\rho)^t}=0 \qquad (4.23)$$

Where I equals the original capital investment.

The IRR can be described as the discount rate at which the present worth of the project's benefits equals that of its costs. It is also the discount rate at which the present worth of the project equals zero. A major advantage of the IRR is that it can be calculated on the basis of perceived benefit and cost data for the project alone without any consideration for the opportunity cost of capital or other external variables. Its major drawback lies when there are multiple solutions for its value for the exact same project. This occurs if the time profile of net benefits crosses zero more than once. This could be the case where major items of equipment of the project must be replaced very couple of years. For the Watany Factory this is not a relevant issue, as the heavy equipment for marble production lasts for very long times. The IRR is a preferred indicator for assessing project feasibility as it translates the cash flow of the project into a single internal profitability rate and compares this rate with the available opportunity cost of capital.

The calculation of IRR for Watany Marble yielded a value of **49.16 %**. This is a very high rate compared to the market interest rate of about 10%, which indicates that the project is highly profitable.

**External Rate of Return**

The ERR method assumes that all cash flows are re-invested at an external rate comparable to that of the prevailing market interest rate. It therefore calculates an interest yield for which the future worth of the initial capital investment equals the future worth of the projected cash flows based on the market interest rate. The ERR is calculated based on the following equation:

$$(-I)(1+r_e)^n = \left( \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} \right)(1+r)^n \qquad (4.24)$$

For Watany Marble; **ERR = 26.19 %**

This is a high ERR value and indicates a feasible and highly profitable project.

**Payback Period**

Payback indicators represent the period of time needed to regain the initial capital invested in the project. This is also the period needed to achieve the break-even situation. The conventional payback and the project balance are two indicators that achieve that purpose.

The payback or breakeven period can be defined as the time-frame required for the value of the initial capital investment to be fully recovered, based on the forecasted net benefits of the project's operation. The formula for this calculation is as follows:

$$I = \sum_{t=1}^{p} (B_t - C_t) \qquad (4.25)$$

The payback period is denoted by p and is a single indicator with units of time, usually expressed in years. It can be set against a predetermined norm or against that of competing projects to arrive at project feasibility or infeasibility. The payback period for Watany Marble Project was calculated to be p= 3.03 years

This means that the initial investment could be recovered in a period of about three years. Comparatively this is a short period of capital recovery, especially with this size of investments.

**Return on Investment**

Return on investment is an accounting technique that uses the ratio between average yearly profit and average-year investment to arrive at its criteria for evaluation. The average yearly profit is the average undiscounted net benefits over the life of the project, and is found by:

$$\frac{1}{n}\sum_{t=1}^{n}(B_t - C_t) \qquad (4.26)$$

Average yearly investment uses straight depreciation allowance to account for the initial investment minus the expected salvage value of the project, and is calculated by the following expression:

$$\frac{\sum_{t=0}^{n}\left[I-\frac{t}{n}(I-S_v)\right]}{n+1} \tag{4.27}$$

where $S_v$ is the expected salvage value for the project and $I$ is the initial capital investment.

The return on investment, $R_I$, is then the ratio between the above two expressions:

$$R_I = \frac{\frac{n+1}{n}\sum_{t=1}^{n}(B_t - C_t)}{\sum_{t=0}^{n}\left[I-\frac{t}{n}(I-S_v)\right]} \tag{4.28}$$

Return on investment has no set criteria for project feasibility. Yet, in choosing between different projects, the project with the highest ROI value is chosen. For Watany Marble ROI was calculated to be 12.24% which is relatively subtle. Actually the ROI is considered the most indicative measure of the project's return on capital.

Table (23): Summary Table of Valuation Tools used in Chapter 5

| Valuation | Equation | Description | Value | Notes |
|---|---|---|---|---|
| **NPV** | $PV = -I + \sum_{t=1}^{n} \frac{B_t - C_t}{\prod_{1}^{t}(1+r_t)}$ where $B_t$ & $C_t$ are estimated benefits and costs for year t, NPV measured for n years | Measures the net gain of the project over its life in a single figure, based on the discount rate used. | LE 51.985 mill | High positive value representing an expected gain for the project and high project feasibility. |
| **AW** | $AW = (PV)(C_r)$ $C_r = \frac{r(1+r)^n}{(1+r)^n - 1}$, where Cr is the capital recovery factor | Yields the annual net cash amount produced by the project's activities. It converges NPV into an annual worth by the use of the Capital Recovery factor. | LE 9.690 mill | Positive value, an indicator of project's feasibility and profitability. |
| **FW** | $FW = (PV)(1+r)^n$ | Yields the equivalent cash amount of the project's net benefits, that have accumulated over its entire horizon of operation at project's end year $n$. | LE 181.047 mill | High positive value implying project's feasibility. |
| **CW** | $(PV)/r$ | Is the equivalent of giving to the investor an annual equal amount of capital worth indefinitely. | LE 6.908 mill | Positive value indicating project's feasibility based on perpetual valuation. |

| Valuation | Equation | Description | Value | Notes |
|---|---|---|---|---|
| **IRR** | $-I+\sum_{t=1}^{n}\frac{B_t-C_t}{(1+\rho)^t}=0$ <br> IRR is denoted by $\rho$ & $I$ equals the original capital investment. | Is the discount rate at which the present worth of the project's benefits equals that of its costs. At this discount rate, the present worth of the project is zero. | 49.16 % | IRR is higher than the ongoing market interest rate which is around 10%. This indicates that the return on re-investment is higher than cost of capital. |
| **ERR** | $(-I)(1+r_e)^n=\left(\sum_{t=1}^{n}\frac{B_t-C_t}{(1+r)^t}\right)(1+r)^n$ | A measure of the minimum guaranteed return on the capital investment of the project. | 26.19 % | ERR < IRR <br> As ERR is a more conservative approach in investment valuation. |
| **Payback** | $I=\sum_{t=1}^{p}(B_t-C_t)$ | Is the timeframe required for the value of the initial capital investment to be fully recovered. | 3.03 years | A reasonable time frame for capital investment recovery, especially for this size of projects. |
| **ROI** | $R_I=\frac{\frac{n+1}{n}\sum_{t=1}^{n}(B_t-C_t)}{\sum_{t=0}^{n}\left[I-\frac{t}{n}(I-S_v)\right]}$ | Is the ratio between average yearly profit and average-year investment. | 12.24 % | A relatively subtle ROI. |

## General Remarks

Several factors have contributed to the result of the valuation, some of them relating to the nature of the industry, others to the economic conditions in Egypt and some other to the operation of the factory itself. A major factor that has influenced the operation of the factory is the exchange rate between the Egyptian pound and the US$. In a way, the factory's operation is dependent on the international markets, first as an importer of the machinery, second as an importer of raw materials and spare parts and third as an exporter of marble. In the case of Watany marble, the overall conditions were very favorable. The factory imported all its equipment before the year 2000. Till that year, the exchange rate between the $ and the LE was 3.4. The beginning of year 2000 witnessed the start of the devaluation of the Egyptian Pound until three years later, in 2003, the Egyptian pound lost almost 50% of its value. So the fact that all the equipment for the expansion was imported before the devaluation of the LE saved the factory a much higher cost to pay in terms of Egyptian. On the other hand, the factory's expansion was completed in the year 2000 and in this way increased its export share at a time when access to export markets was a real advantage. With the devaluation of the Egyptian currency, all export proceeds in foreign currency were translated into a higher profit margin in LE.

Other factors pertaining to the Factory and contributing to the successful performance of its operation is its ability to conclude an agreement with the bank for a loan facility with three years grace period and a fixed interest rate of 10%. This lowered the cost of capital for the company and the discount rate used. This contributed to the attainment of the positive indicators when the company's investment decision was assessed because as the cost of capital for the factory was relatively low, it reflected on the valuation indicators to be high. The IRR was 49.16%, higher than the interest rate indicating that the return on re-investment was higher than the cost of capital. However the IRR is the most guaranteed rate of return. A more conservative indicator, the ERR which reflects the minimum attainable return on capital investment, was also as high 26.19%. The high values for the financial indicators are mainly attributable to the low cost of capital and accordingly the low discount rate. It is worthwhile mentioning that both indicators whether IRR OR ERR do not take depreciation into account. The indicator that accounts for depreciation is the ROI, which is the ratio between average yearly profits and average yearly investment. The ROI which is 12.24% is probably the true indicator of the return on Investment.

As illustrated in the chapter on the Egyptian Marble Industry, the market structure of the industry ranges between oligopoly and monopolistic competition. Watany Marble is not a major player in the market. It does not operate its own quarries and has to pay a relatively high cost of raw material if compared to major players that own quarries. Accordingly, it will have to manage carefully its profit margin generated through the difference between costs and revenues. Nevertheless, the factory's ability to be present in the international market and export its products will remain a positive aspect adding to its profitable operation as long as the hard currency in Egypt remains to be gaining the floor against the Egyptian Pound. The factory will continue to perform well, so long as its export channels are active.

When calculating the ROI, the salvage value used for the factory was very low. This is justified by the fact that the market for Marble in Egypt is an emerging market and will still face lots of changes in technology used. This could lead to turning the current machinery used in Watany Factory to become outdated or obsolete. Therefore putting a low salvage value is reasonable.

With respect to pricing, it is understandable that the factory would not be able to increase its revenues over the years, whether in the export market or in the local market. In the export markets, Watany strives to remain competitive and accordingly increasing its prices in the international market is not possible without losing its market share. Moreover locally, the factory does not have the position in the market that would allow it to increase prices without losing revenues. Not only its small size in the market would imply a conservative approach towards pricing, but also the presence of many substitutes for marble in the market like ceramics and tiles makes the price elasticity of marble high and leaving almost no room for price increases without losing grounds to competitive substitutes.

## A Final Comment

Watany Marble is a family business with a medium size investment. The expansion decision taking to almost double the production capacity proved to be wise by all performance indicators used. The valuation of the investment was done by calculating the different feasibility indicators; like the IRR which reached 49.16% and the ERR which reached 26.19%. The ROI proved to be subtle and ranged around 12.24%. It is arguably the true indicator of the returns achieved by the Watany Marble Factory. Payback period for this investment was calculated to be 3.03 years, which is relatively a reasonable timeframe. NPV is estimated to be LE 52 mill relative to an initial capital investment of LE 20.4 mill. The low cost of capital that was attainable to the company as well as the resulting low discount rate used contributed to the high valuation of the company in terms of NPV. By all indicators used, investments undertaken for Watany Marble proved to be profitable and viable, even though the company possesses little market power and produces a highly substitutable (price elastic) product. Watany's early presence in the Egyptian marble industry which is still considered an emerging market seems to have benefited its operation economically and created a competitive edge relative to late comers.

# CHAPTER V

# WATANY MARBLE: APPLIED MICROECONOMIC ANALYSIS AND THEORY OF THE FIRM

After assessing the economic feasibility of the investments undertaken by Watany Marble and proving that the factory's operation is economically viable, it is the purpose of this chapter to conduct applied analysis of the theory of the firm towards a breakeven analysis and identify break even quantity of production, as well as determine the Firm's production function, cost function and revenue function, including the firm's average cost curve. The analysis will also shed light on the factory's production options and optimum choices with respect to cost minimization, profit maximization and output levels.

The factors of production for Watany Marble are mainly labor, capital and raw materials. Inputs and outputs are measured in flow units. A certain number of machine hours of work per week and a certain amount of labor per week produce a certain amount of $m^2$ of marble per week. We assumed that Watany has no power over pricing as the factory is operating in a competitive market.

## Fixed Interest Payments

To derive the factory's cost function we need to readdress fixed costs to account for the fixed interest payments, which constitute the interest paid on the loan. As stated earlier, total amount of the loan was US$ 1.75 mill, the equivalent of which was LE 5,950,000 at an exchange rate of $/LE 3.4 at that time.

Table (24): Loan repayment schedule

**Loan Repayment**

| Year | Date | Narration | DR | CR | Balance |
|---|---|---|---|---|---|
| 1 | Jan-00 | Loan Disbursement | (5,950,000.00) | | (5,950,000.00) |
| | Dec-00 | Interest | (595,000.00) | | (6,545,000.00) |
| | Dec-00 | Interest Payment | | 595,000.00 | (5,950,000.00) |
| 2 | Dec-01 | Interest | (595,000.00) | | (6,545,000.00) |
| | Dec-01 | Interest Payment | | 595,000.00 | (5,950,000.00) |
| 3 | Jan-02 | | | | (5,950,000.00) |
| | Dec-02 | Interest & interest payment | (595,000.00) | 595,000.00 | (5,950,000.00) |
| 4 | Jan-03 | | | | (5,950,000.00) |
| | Dec-03 | Interest & 1st installment | (595,000.00) | 1,222,163.00 | (5,322,837.00) |
| 5 | Jan-04 | | | | (5,322,837.00) |
| | Dec-04 | Interest & 2nd installment | (532,283.70) | 1,222,163.00 | (4,632,957.70) |
| 6 | Jan-05 | | | | (4,632,957.70) |
| | Dec-05 | Interest & 3rd installment | (463,295.77) | 1,222,163.00 | (3,874,090.47) |
| 7 | Jan-06 | | | | (3,874,090.47) |
| | Dec-06 | Interest & 4th installment | (387,409.05) | 1,222,163.00 | (3,039,336.52) |
| 8 | Jan-07 | | | | (3,039,336.52) |
| | Dec-07 | Interest & 5th installment | (303,933.65) | 1,222,163.00 | (2,121,107.17) |
| 9 | Jan-08 | | | | (2,121,107.17) |
| | Dec-08 | Interest & 6th installment | (212,110.72) | 1,222,163.00 | (1,111,054.89) |
| 10 | Jan-09 | | | | (1,111,054.89) |
| | Dec-09 | Interest & 7th installment | (111,105.49) | 1,222,160.37 | 0.00 |
| | | | | | |
| | **TOTAL** | | **(10,340,138.37)** | **10,340,138.37** | |
| | | Total Interest Paid | (4,390,138.37) | | |

Table (24) above shows the loan repayment schedule which reflects loan amount, interest payable yearly as well as total yearly installments over the ten years. It should be noted that the factory had a grace period of 3 years. During the 3 years grace period, Watany was not required to repay any installment of the principal loan amount and only yearly interest due on the outstanding debit balance was paid. Repayment of installments started with the beginning of the fourth year. Total interest paid on the loan reached LE 4,629,100 which constitutes about 77.8% of the principal amount totaling LE 5,950,000. Accordingly the loan will be repaid as LE 10,579,100 covering loan and interest payable to the Bank.

**Relationship between Total Revenues, Total Costs and Quantity Produced**

Total Production Cost constitutes Total Fixed Cost (TFC) and Total Variable Cost (TVC). TFC, after accounting for the fixed interest payments, and TVC are reflected in Table (2). Total Variable Cost is dependent on the Quantity of output produced as illustrated:

$$VC(Q) = \alpha Q, \qquad \text{assuming linearity of the relationship} \tag{5.1}$$

where $\alpha$ constitutes average cost per unit of output.

After obtaining TFC and TVC, the cost function of Watany Factory is derivable and is be stated as follows:

$$C(Q) = TFC + \alpha Q \tag{5.2}$$

After establishing the cost side, the same is to be done with the revenue side, where revenues are a function of price, P and quantity sold, Q. Watany is a price taker in the marble output industry, hence, P is taken as given and might change from one year to the other depending on market conditions.

$$R(Q) = PQ \tag{5.3}$$

Table (25): Total Production Cost after accounting for Fixed Interest Payments

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item / Time | t1 | t2 | t3 | t4 | t5 | t6 | t7 | t8 | t9 | t10 | |
| Indirect Labor | 133 | 139 | 146 | 154 | 161 | 169 | 178 | 187 | 196 | 206 | 1,668 |
| Factory o/h | 245 | 257 | 270 | 283 | 298 | 312 | 328 | 344 | 362 | 380 | 3,079 |
| Rent | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 340 |
| Marketing o/h | 119 | 125 | 131 | 138 | 145 | 152 | 159 | 167 | 176 | 185 | 1,497 |
| Interest Payment | **595** | **595** | **595** | **595** | **532** | **463** | **387** | **304** | **212** | **111** | **4,389** |
| **Total Quasi Fixed Cost** | **1,129** | **1,150** | **1,176** | **1,204** | **1,169** | **1,131** | **1,086** | **1,036** | **979** | **915** | **10,973** |
| Raw Materials | 10,678 | 11,546 | 12,521 | 14,042 | 15,001 | 15,934 | 16,940 | 18,006 | 19,136 | 20,335 | 154,139 |
| Raw Marble Blocs | | | | | | | | | | | |
| Raw Granite Blocs | | | | | | | | | | | |
| Steel Shots | | | | | | | | | | | |
| Limestone | | | | | | | | | | | |
| Direct Labor | 265 | 278 | 292 | 307 | 322 | 338 | 355 | 373 | 392 | 411 | 3,336 |
| Utilities | 92 | 92 | 92 | 92 | 92 | 102 | 102 | 102 | 102 | 102 | 969 |
| Water | Underground water is used and no cost of water charged | | | | | | | | | | |
| Electricity | | | | | | | | | | | |
| Spare parts | 35 | 43 | 51 | 70 | 80 | 89 | 102 | 117 | 133 | 151 | 871 |
| Maintenance | 217 | 239 | 277 | 351 | 393 | 433 | 478 | 527 | 597 | 675 | 4,185 |
| Grandly Stones | | | | | | | | | | | |
| Diamond Steel | | | | | | | | | | | |
| Diamond Disk | | | | | | | | | | | |
| Steel Grit | | | | | | | | | | | |
| **Total Variable Cost** | **11,287** | **12,198** | **13,234** | **14,861** | **15,888** | **16,897** | **17,977** | **19,124** | **20,360** | **21,675** | **163,500** |
| **Total Cost** | **12,416** | **13,348** | **14,410** | **16,065** | **17,057** | **18,027** | **19,063** | **20,161** | **21,339** | **22,590** | **174,473** |
| **Total Production Cost** | **12,416** | **13,348** | **14,410** | **16,065** | **17,057** | **18,027** | **19,063** | **20,161** | **21,339** | **22,590** | **174,473** |
| **Total production in $m^2$** | **230,400** | **288,000** | **345,600** | **345,600** | **326,400** | **326,400** | **307,200** | **307,200** | **307,200** | **307,200** | |
| **Production Capacity** | **60%** | **75%** | **90%** | **90%** | **85%** | **85%** | **80%** | **80%** | **80%** | **80%** | |

Table (25) highlights the different values for the cost variables over the period of 10 years. All cost variables exhibited an increasing trend over time. This is attributable in the first years starting 2000/2001 to the increase in the production capacity, where the factory reaches its highest attainable operating capacity of 90% in the years 2002 and 2003. Starting the year 2004, the efficiency of the old production line starts to decrease due to wear and tear and depreciation which accordingly affects the production and cause a drop of 10%. Nevertheless, the 10% decrease in production capacity and accordingly in raw materials needed, is more than offset by the expected increase in the cost of the factors of production including raw materials causing the total variable cost to rise. Another factor pushing the fixed cost upwards is the progressive increase in cost of maintenance and spare parts from one year to the other. It should be noted here that spare parts are mainly imported and accordingly are paid for in foreign currency, yet a mitigating factor is the export orientation of the firm which generates up to 75% of its revenues in foreign currency.

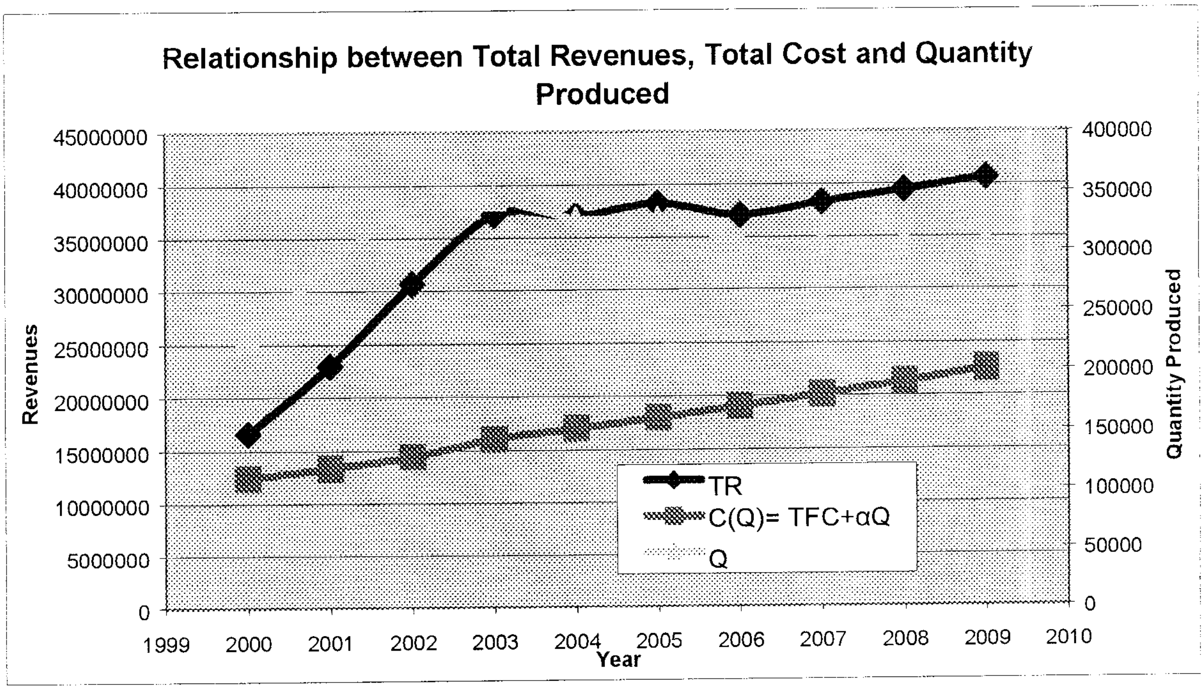
On the other hand, the loan and interest repayment schedule had their effect on the shape of the total cost curve as well. In the first three years only interest costs were paid. Starting the fourth year, the settlement of the principal loan amount decreased the outstanding debit balance of Watany, accordingly fixed interest payable on the loan decreased from one year to the other. This is illustrated in Table (24) under fixed interest payments.

Table (26): Cost Function and Revenue Function

| Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| TVC | 11,287,000 | 12,198,000 | 13,234,000 | 14,861,000 | 15,888,000 | 16,897,000 | 17,977,000 | 19,124,000 | 20,360,000 | 21,675,000 |
| AVC | 49 | 42 | 38 | 43 | 49 | 52 | 59 | 62 | 66 | 71 |
| TFC | 1,125,400 | 1,150,220 | 1,176,281 | 1,203,645 | 1,169,377 | 1,130,546 | 1,086,223 | 1,036,485 | 979,409 | 915,079 |
| AFC | 5 | 4 | 3 | 3 | 4 | 3 | 4 | 3 | 3 | 3 |
| $C(Q)= TFC+\alpha Q$ | 12,412,400 | 13,348,220 | 14,410,281 | 16,064,645 | 17,057,377 | 18,027,546 | 19,063,223 | 20,160,485 | 21,339,409 | 22,590,079 |
| $AC= C(Q)/Q$ | 54 | 46 | 42 | 46 | 52 | 55 | 62 | 66 | 69 | 74 |
| Q | 230,400 | 288,000 | 345,600 | 345,600 | 326,400 | 326,400 | 307,200 | 307,200 | 307,200 | 307,200 |
| $\alpha$ | 49 | 42 | 38 | 43 | 49 | 52 | 59 | 62 | 66 | 71 |
| Price P | 72 | 80 | 89 | 108 | 114 | 117 | 121 | 125 | 129 | 132 |
| Profit Margin/unit | 23 | 38 | 50 | 65 | 65 | 65 | 62 | 63 | 62 | 62 |
| $R(Q)=PQ=TR$ | 16,628,000 | 23,010,000 | 30,638,000 | 37,230,000 | 37,085,000 | 38,239,000 | 37,150,000 | 38,330,000 | 39,511,000 | 40,691,000 |

The cost curve illustrated in Figure (12) below reflects the behavior and the trend of total production cost over the ten years. It also depicts the revenue curve and relates both, revenues and costs to quantity produced.

Figure (12): The relationship between total revenues, total costs and quantity produced




The revenue curve shows a sharp increase over the first years, firstly due to the increase in the production capacity offering by that more production into the market, secondly due to the devaluation of the Egyptian Pound which started to evolve in year 2000 and intensified until 2004, where the Egyptian Pound lost about 50% of its value vis-à-vis the US$, as well as vis-à-vis most of the other foreign currencies. Nevertheless, the presence of the factory in the export markets, where it sells about 75% of its production was a very favorable point driving its revenue proceeds translated into LE upwards as revenues in $ translate into more Egyptian Pounds as shown clearly in Table (26), where revenues increase progressively.

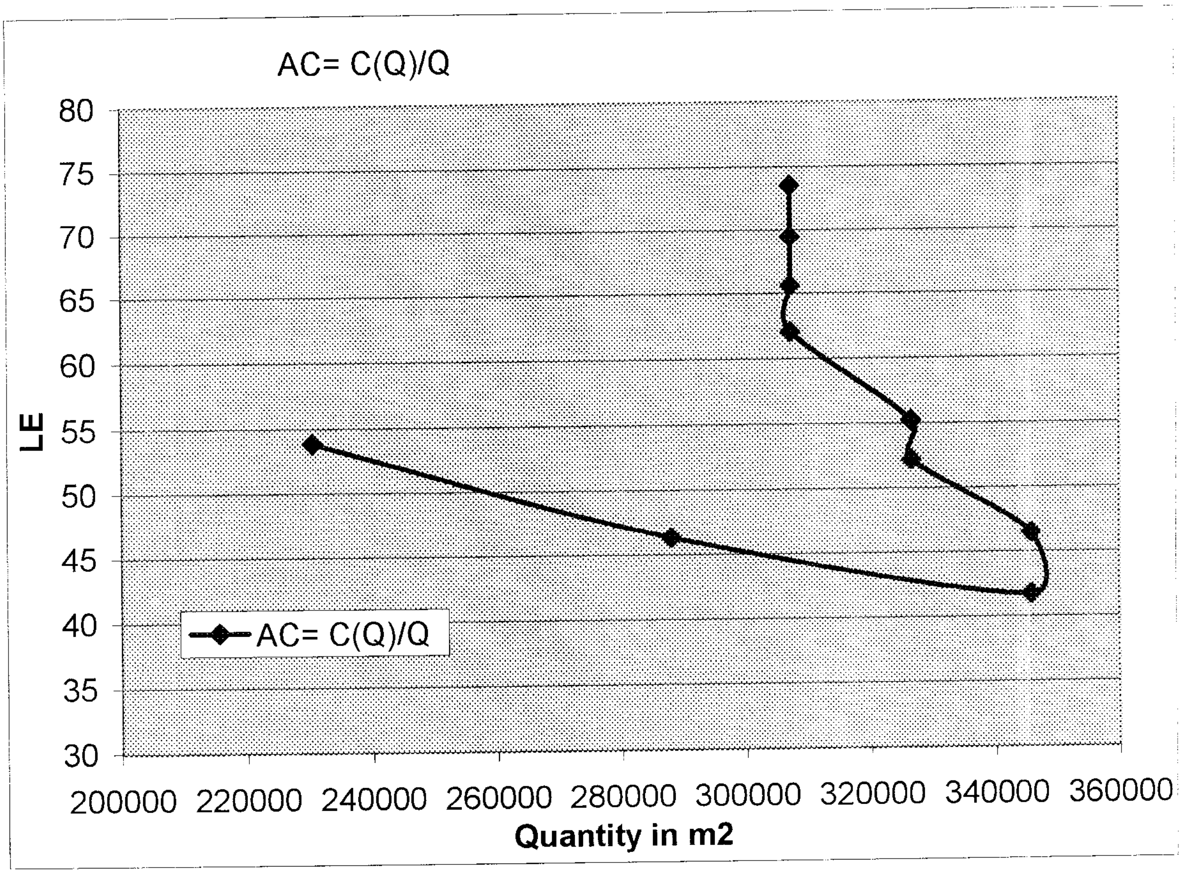
Beginning in the year 2003, the production capacity started to decrease from a peak of 345,600m$^2$ until it reached 307,000 m$^2$/per year starting 2006 and stabilized at this level until the end of the 10$^{th}$ year. Inspite of the decrease in production capacity, the revenues maintained a slightly increasing trend. This is again attributable to the increase in the exchange rate which was predicted to show a slight increase, but sufficed to raise up the revenue level to continue the subtle increasing trend. exchange rates quoted from 2005 onwards are predictions. Due to the overall constantly changing economic conditions of Egypt, predictions of exchange rates over the years proved to be difficult and often inaccurate. The tendency also proved to be in favor of the dollar against the Egyptian Pound. Therefore predicting a slight increase in exchange rate over the years is being at the cautious side in predicting revenues and incomes. Yet inspite of adopting this cautious approach, the revenue curve rose.

Table (26) reflects that the increase in revenues was possible through a progressive increase in the price of the product which is the in m$^2$ of marble. With the constant increase in prices mainly caused by the deflation of the Egyptian pound, the profit margin continued to increase, until it leveled off towards the end of 2006.

**The Average Cost Curve**

Average Cost function for Watany Marble measures the total cost per unit of output produced in m$^2$. The Average Cost function reflects both; the average variable cost function which measures the variable costs per unit of output and the average fixed cost function measuring fixed costs per unit. The average variable costs eventually increase as output increases, while the average fixed cost decreases as output increases. This usually results in a U-shaped average cost curve. For Watany Marble the Average Cost Curve reflects a "Backward-Bending" shape as depicted in Figure (13).

Figure (13): Watany's Backward Bending Average Cost Curve




In an attempt to explain the shape of the curve, we can argue that as production capacity expands in the first three years, we find that AFC reflects a decreasing trend, as production capacity increases, though it includes the fixed interest payments for the Bank loan. The AVC also reflects a decreasing trend in the first three years, probably by reaping the advantages of the economies of scale.

As production efficiency and accordingly capacity starts to decrease with the beginning of the 5th year of operation, AFC falls subject to 2 influences: decrease of its major component which is the fixed interest payment after the repayment of the principal loan amount starts, thus decreasing the outstanding debt balances of the Firm and accordingly fixed interest payments. On the other hand, the decrease in Quantity produced makes the fixed costs divided over fewer units produced. Both effects offset each other and the AFC remains almost the same. The AVC on the other hand increases due to the increase in the cost of raw material, especially the imported component of the raw material as well as due to the increase in the cost of the maintenance and spare parts. An increase in AVC drives the AC curve to bend backwards. As the quantity produced stabilizes around the production capacity of 307,000 $m^2$, while AVC maintains its increasing trend, the curve line goes upward reflecting a continuously increasing AC with the same quantity of output being produced.

**Break-Even Analysis**

The break-even quantity $Q^{BE}$ is the minimum capacity needed for production in order to "break-even", i.e. revenues cover total costs. Total costs constitute of fixed and variable costs, which we assumed to be a linear function for Watany Marble. An inverse relationship exists between $Q^{BE}$ and the profit margin realized for every unit of output.

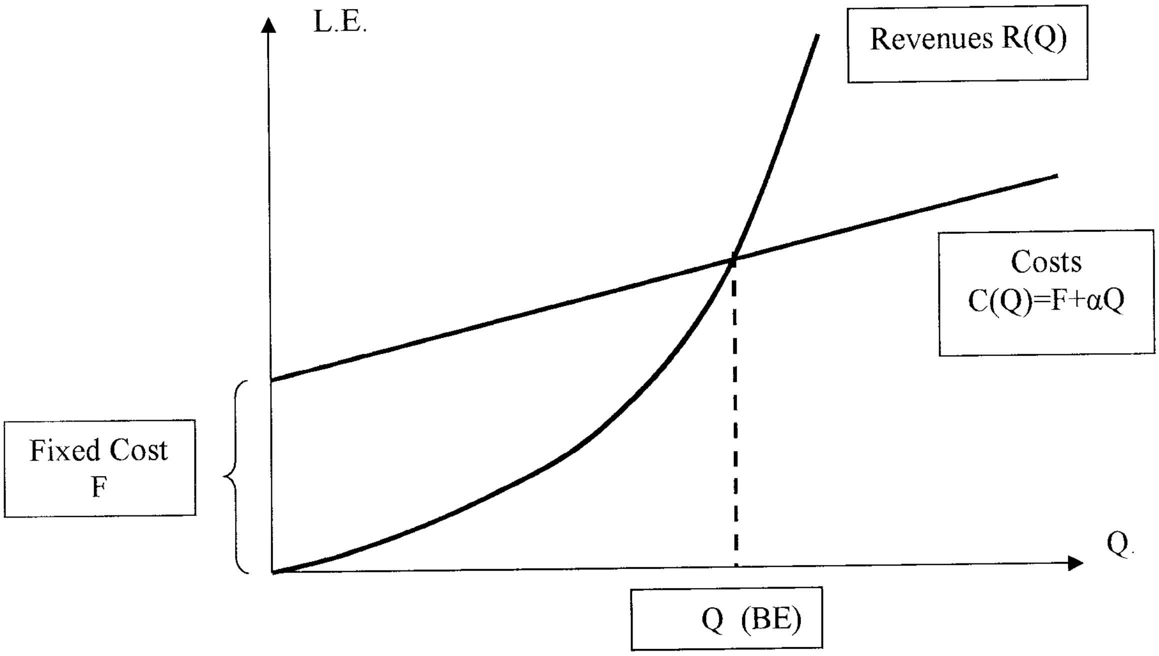



Figure (14): Breakeven Analysis for Watany Marble

As illustrated in Figure (14) above, break even is when total revenues just cover total cost, in that case Watany Factory would not be achieving any profits or incurring any losses.

$$R(Q) = PQ = TFC + VC(Q) \tag{5.4}$$

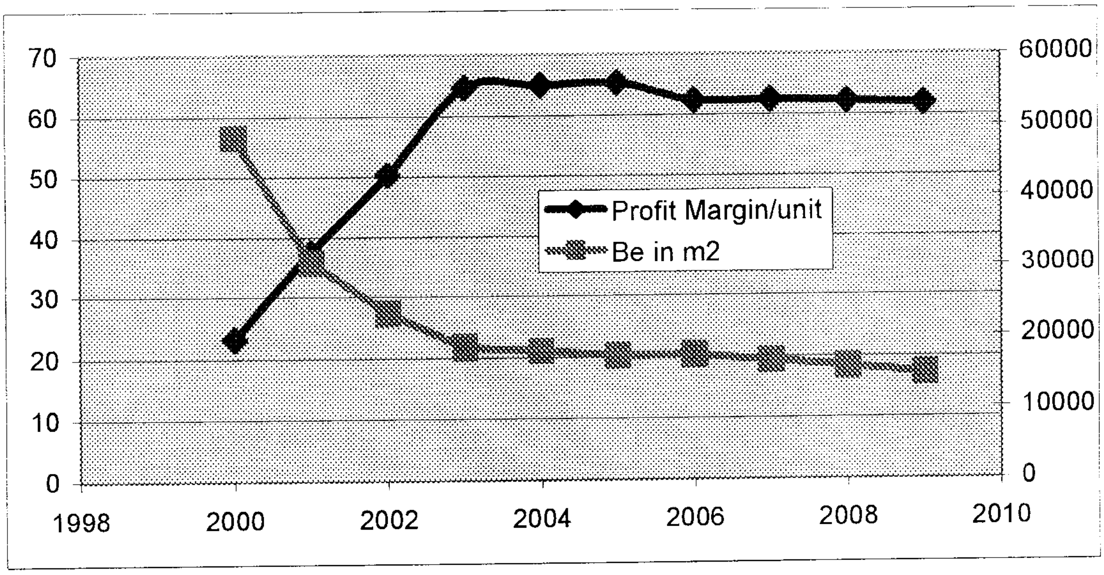
$$PQ = F + \alpha Q \tag{5.5}$$

$$Q^{Be} = \frac{F}{P - \alpha} = \frac{F}{\text{profit margin / unit}} \tag{5.6}$$

Table (23) shows that Break-Even "$B^{QE}$" point varies from one year to another. In the first year, the breakeven point was at an output level of 48,530 $m^2$, which constitutes

21% of planned production level. The Break-even production level took a continuing decreasing trend over the years, where at the 10th year it reached a production level as low as 14,798 $m^2$ constituting about 5% of production capacity only, meaning that the factory was able to break even at very low production levels. This could be attributed mainly to the exportation of 75% of the factory's output. As the value of the dollar vis-a vis the Egyptian pound appreciated by more than 100%, this led to more than doubling the proceeds received in Egyptian Pounds, leading to high profit margins achieved per each unit of output, placing by that the break-even point at a very low level of production. Figure (15) plots the break even point against time.

**Figure: (15) Break-even Analysis**




On the other hand, the factory succeeded to maintain low production cost, one of the reasons behind that is the loan agreement it concluded with its Bank very early which stipulated a fixed interest rate of 10% over the period of the ten years. This is relatively low, if compared to current on-going lending rates which are not lower than 14%. Moreover all increases in cost items, apart from the cost of raw material which is taken as given, witnessed very moderate and reasonable increases over the years reflecting the careful management of the cost side at the factory and accordingly the moderate expenses encountered. The low break-even production level reflects that the factory's profitability increases over time.

Table (27): Break-even Analysis

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Q** | 230,400 | 288,000 | 345,600 | 345,600 | 326,400 | 326,400 | 307,200 | 307,200 | 307,200 | 307,200 |
| **TFC** | 1,125,400 | 1,150,220 | 1,176,281 | 1,203,645 | 1,169,377 | 1,130,546 | 1,086,223 | 1,036,485 | 979,409 | 915,079 |
| **α** | 49 | 42 | 38 | 43 | 49 | 52 | 59 | 62 | 66 | 71 |
| **Profit Margin/unit** | 23 | 38 | 50 | 65 | 65 | 65 | 62 | 63 | 62 | 62 |
| **Price P** | 72 | 80 | 89 | 108 | 114 | 117 | 121 | 125 | 129 | 132 |
| **$B^e$ in $m^2$** | 48,547 | 30,638 | 23,358 | 18,596 | 18,007 | 17,290 | 17,404 | 16,579 | 15,711 | 14,783 |

As illustrated earlier, the relationship between the level of profitability and the breakeven point as depicted in Figure (15), shows that it is an inverse relationship. The lower the breakeven point, the higher the profits achieved on each unit produced. This is simply explained by the fact that costs are covered with very little production; after that, every item produced adds revenues to the company which constitute pure profits. Therefore in that case, the more the company produces, the higher profits are generated.

**Profit Maximization**

Profit maximization is the goal of enterprises working in the commercial business. However many enterprises, especially in Egypt operate in the market, without really knowing exactly at which capacity they would be maximizing their profits. Nevertheless as experience is gained in the field and after some years of operation, they develop a sense of an optimum operation level, where they would feel that their profits are maximized at. As Watany Marble is a case study, the next section is devoted to find out the profit maximization production level as stipulated by economic rules. It would be interesting to see how efficient the owner has been operating with respect to selecting his optimum production capacity.

Profit is obtained by subtracting Total Revenues (TR) from Total Costs (TC), hence profits are given by:

$$\Pi = TR - TC \quad (5.7)$$

$$\Pi = R(Q) - C(Q) = R(Q) - F - VC(Q) \quad (5.8)$$

To maximize profits, we differentiate the above expression with respect to quantity ie capacity selection. For Profit Maximization, the first order condition has to be satisfied by equating the differentiated expression to 0. Accordingly;

$$\frac{\partial \Pi}{\partial Q} = \frac{\partial R(Q)}{\partial Q} - \frac{\partial C(Q)}{\partial Q} = 0 \quad (5.9)$$

Therefore,

$$MR - MC = 0 \quad (5.10)$$

$$MR = MC \quad (5.11)$$

In economic terms, profit maximization is reached, when the marginal revenue obtained from producing one extra unit of output equals its marginal cost, as highlighted above. To apply this rule to Watany Marble, quantities produced were sorted in ascending order to correlate quantities produced to total revenues as well as total costs, irrespective to the year, where this production has taken place. It was found that different levels of revenues and costs are related to the same production level. As the profit maximizing production condition would be when MR = MC, best estimates had to be obtained for the Revenue function and the production function. Equation fitting was done on both functions to get the best fit. Accordingly the equations for the Revenue function and cost function for Watany Marble is obtained as follows:

$$R(Q) = -0.0025Q^2 + 1613.9Q - 200mill \quad (5.12)$$

$$C(Q) = 30.672Q + 8mill \quad \text{(assuming a linear cost function)} \quad (5.13)$$

It is then easy to verify that:

$$MR = -0.005Q + 1613.9 \quad (5.14)$$

$$MC = 30.672 \quad (5.15)$$

For profit maximization; $MR = MC$, which results in:

$$-0.005Q + 1613.9 = 30.672 \quad (5.16)$$

Hence,

$$Q^* = \frac{1613.9 - 30.672}{0.005} = 316{,}645m^2 \quad (5.17)$$

To ensure that 316,645 $m^2$ is the profit maximization quantity, the second order condition has to hold, where the second derivative is negative.

$$\frac{\partial^2 R(Q)}{\partial Q^2} - \frac{\partial^2 C(Q)}{\partial Q^2} = \frac{\partial(MR)}{\partial Q} - \frac{\partial(MC)}{\partial Q} \quad (5.18)$$

$$-0.005 - 30.672 < 0 \quad (5.19)$$

The profit maximizing point is illustrated graphically in Figure (16). As we are assuming a linear cost function, MC = LE 30.672 and is illustrated by a straight line. MR intersects with the MC at a production level of 316,645 $m^2$, which is the profit maximizing production quantity. For Watany to achieve maximum profits, it has to strive to maintain this production level.

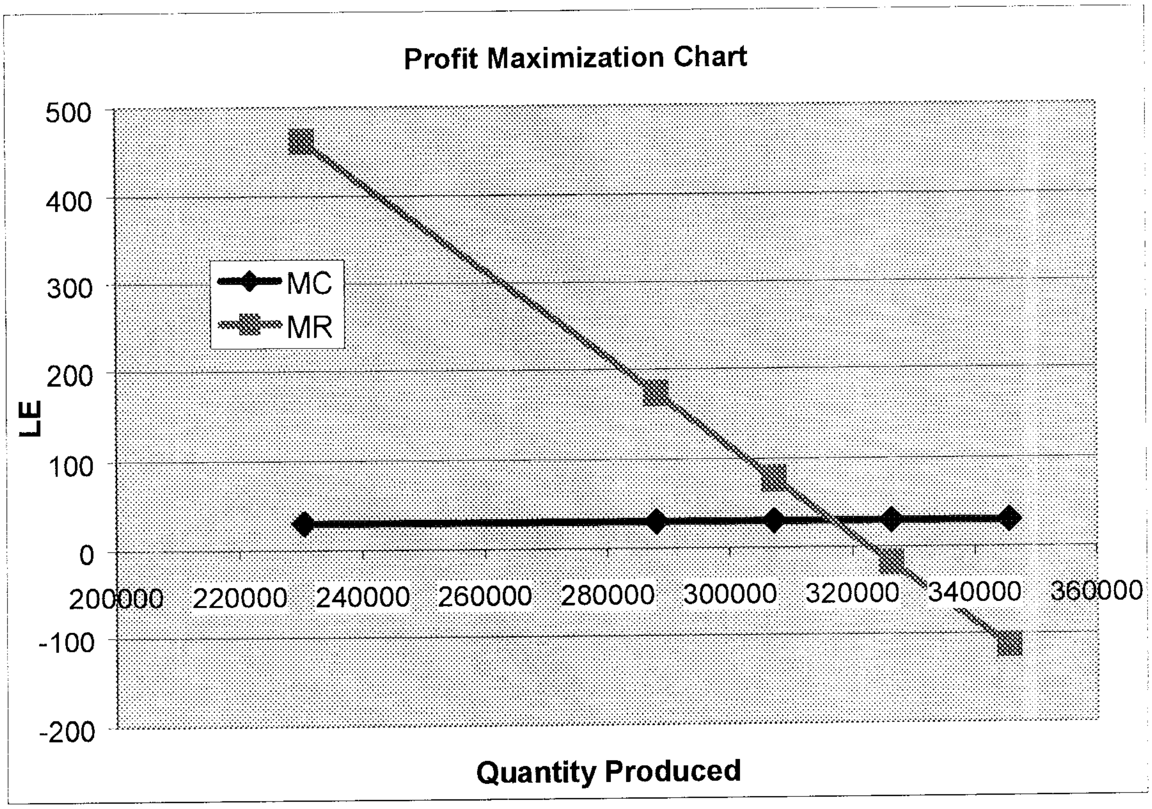



Figure ( 16 ): Profit Maximization Chart

To verify numerically the profit maximization production level, Table (25) was constructed. It reflects Q, MC, MR as well as marginal profit achieved when the different quantities of output are produced. We can see that at a production level of 230,400 $m^2$, MR achieved were LE 461.9, while Marginal Profits for the same production level reached LE 431. As quantity produced increased to reach levels as high as 288,000 $m^2$ and 307,200 $m^2$, MR dropped to reach levels closer to MC, while marginal profits dropped as well but remained positive. A further increase in production capacity to 326,400 $m^2$ turned MR negative, which in turn influenced marginal profits achieved to be negative as well.

Table (28): MC, MR and Marginal Profit

| Q | TVC-adj | MC | MR | Marginal Profit |
|---|---|---|---|---|
| 230,400 | 10,990,263 | 30.672 | 461.9 | 431.228 |
| 288,000 | 11,365,849 | 30.672 | 173.9 | 143.228 |
| 307,200 | 13,301,647 | 30.672 | 77.9 | 47.228 |
| 307,200 | 13,540,997 | 30.672 | 77.9 | 47.228 |
| 307,200 | 13,795,371 | 30.672 | 77.9 | 47.228 |
| 307,200 | 14,053,951 | 30.672 | 77.9 | 47.228 |
| 326,400 | 12,960,632 | 30.672 | -18.1 | -48.772 |
| 326,400 | 13,065,141 | 30.672 | -18.1 | -48.772 |
| 345,600 | 11,845,507 | 30.672 | -114.1 | -144.772 |
| 345,600 | 12,729,000 | 30.672 | -114.1 | -144.772 |

It is very interesting to note that Watany Marble reverted over the longer run to stabilize the production level at 307,000 m2, which is very close to the profit maximization production quantity. The choice of the production capacity was done without performing any objective economic analysis but was decided on after gaining experience in the market. Nevertheless the Factory owner is advised to increase production levels up to 316,645 $m^2$ to achieve maximum profits.

**Cobb Douglas Production Function**

For Watany Marble, we assume that the factory has a Cobb Douglas Production Function, with the form $Q = K^{\alpha}L^{\beta}$, where K represents Capital in thousands of US$ and L number of workers (labor). The coefficients $\alpha+\beta$ represent the Returns to Scale (RTS) between capital and labor. If $\alpha+\beta > 1$, then this represents Increasing Returns to Scale (IRS), if $\alpha+\beta < 1$, this would represent Decreasing Returns to Scale (DRS), and if $\alpha+\beta = 1$ then this implies Constant Returns to Scale (CRS).

Table (29) illustrates number of workers employed at Watany Marble. A total number of 40 workers are employed ranging from unskilled labor to Management.

Table (29): Workers employed at Watany Factory

| Labor Type | Total No. employed | Unit Year Cost in $ | Total Yearly Costs in $ |
|---|---|---|---|
| Unskilled | 5 | 1,300 | 6,500 |
| Skilled and Technical | 24 | 3,000 | 72,000 |
| Clerical/Administration | 8 | 3,000 | 24,000 |
| Management | 3 | 5,000 | 15,000 |
| Total | 40 | | 117,500 |

From the table above, yearly cost of labor could be identified as follows:

$$w = \frac{\text{cost of labor}}{\text{\# of employees}} = \frac{117{,}500}{40} = \$2{,}937 \text{ per person/year} \tag{5.20}$$

From previous chapters, initial Capital Investment $K = \$6{,}009$ in thousands.

From the Cobb-Douglas production function:

$$Q = K^{\alpha} L^{\beta} \tag{5.21}$$

Taking the natural logarithm "ln" of both sides we get:

$$\ln Q = \alpha \ln K + \beta \ln L \tag{5.22}$$

Using standard regression analysis; the Cobb-Douglas coefficients are:

$\alpha = 0.89$

$\beta = 1.33$

Accordingly, $Q = (6009)^{0.89} (40)^{1.33} = 311{,}798\, m^2$ (5.23)

From the calculation above, the average production capacity is 311,798 $m^2$, which is very similar to the optimum production capacity due to profit maximization in the previous section which was calculated to be 316,645 $m^2$.

It should be noted that the combination of labor and capital in Watany Marble is resulting in increasing returns to scale (IRS). Labor and capital coefficients $\alpha+\beta$ resulted in 2.2, hence doubling all inputs in marble production should make output more than doubled. This behavior of Increasing Returns to Scale (IRS) implies the economic use of efficient technology such that any increase in factor inputs will be reflected in a more than proportionate increase in output.

As the owner is not willing to invest further in technology or capital, we assume that technology and capital will remain fixed during the ten years under study. Bearing this in mind:

$$Q = (\bar{K})^{0.89}(L)^{1.33} = (2307)L^{1.33} \tag{5.24}$$

As the Company has currently 40 workers;

$$MP_L = 3068\,L^{0.33} = 10{,}365\,\text{units} \tag{5.25}$$

Since the $MP_L > 0$, then this implies that hiring additional labor should increase production due to the high labor productivity involved. Also, increasing one additional unit of labor would increase production output by $\frac{10{,}365}{311{,}798}$ or approximately 3.3% of total output.

Notice also that;

$$AP_L = \frac{Q}{L} = \frac{311{,}798}{40} = 7{,}795\,m^2 \tag{5.26}$$

Hence; $AP_L < MP_L$ (5.27)

Therefore, using standard microeconomic theory, employment of extra units of labor should add to total productivity in the sense that marginal productivity (10,365 units per labor) is larger than average productivity (7,795 units per labor).

On the other hand, using the estimated Cobb-Douglas production function, we can also calculate the marginal product of capital as follows:

$$MP_K = 0.89K^{-0.11}L^{1.33} = 0.89(6009)^{-0.11}(40)^{1.33} = 46\text{units} \qquad (5.28)$$

If we compare the $MP_L$ to $MP_K$, we will find that the marginal productivity of Capital compared to Labor is very small. A possible explanation is that Watany Marble has actually exhausted its capital resources which implies no need for extra units of capital to be employed. This is one of the rational reasons behind Watany marble's reluctance to expand on its capital base.

The result reached above is in harmony with the nature of this relatively heavy industry. Though in ancient times, labor was used intensively to deal with this type of industry, modern inventions have replaced needed manpower with machinery, cranes, cutting and polishing machines. Nowadays work done by a crane does not require much labor work to operate the crane and at the same time, labor is not considered a substitute for the crane, especially if we talk in terms of marginal units. This applies also for the different machines in a Marble factory, like cutting machine and polishing machine. Accordingly capital and labor are not directly substitutable. Therefore the results reached above are quite reasonable, where the addition of one extra unit of labor would increase yearly production capacity by 3.3%, via probably operating the machines more efficiently. On the other hand, no room for extra units of capital was there, because in a modern marble factory the production process is almost fully automated, with little room left for operational manpower.

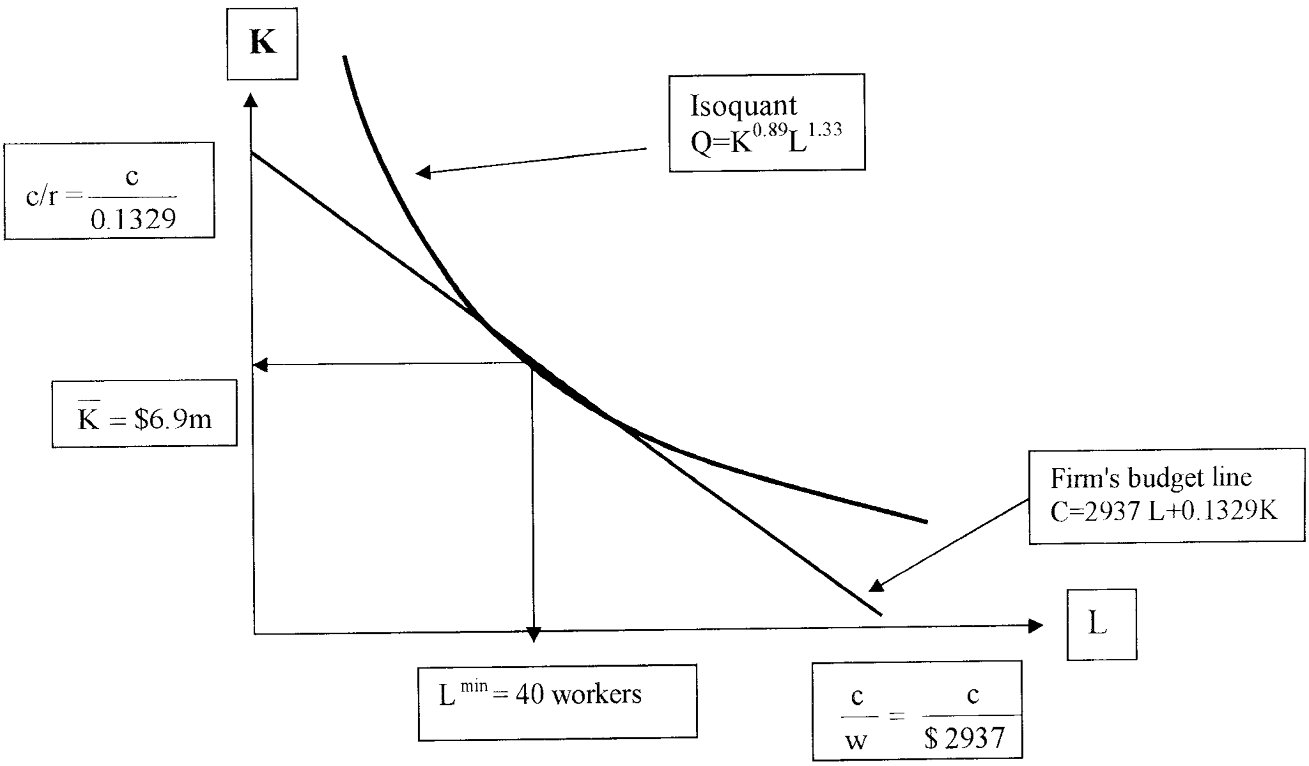



Figure (17) Cobb Douglas Production Function for Watany Marble

From Figure (17), we can see that the budget line is defined by the wage rate, w, and the opportunity cost of capital, r, where w = \$2937 per worker per year and the opportunity cost of capital r = 13.29% per year. Accordingly, the firm's yearly budget would be given by C = 2937 L + 0.1329 K. This implies that the maximum labor employed with zero capital would be $\frac{c}{w} = \frac{c}{2937}$, similarly, maximum amount of capital used with zero labor would be $\frac{c}{r} = \frac{c}{0.1389}$. Based on the Cobb Douglas Production Function we have the factory's isoquant estimated as $Q = K^{0.89}L^{1.33}$. The choice of capital and labor by the firm is K=$6.9 mill and a minimum of L=40 workers. This inference is in line with economic principles as illustrated in Figure (17), such that the slope of the budget line $\left(\frac{w}{r}\right)$ is equal to the slope of the isoquant. This point of tangency reflects that the firm is operating efficiently.

In addition, since the ratio of factor cost (w/r) equals the MRTS (marginal rate of technical substitution between factor inputs), then it is easy to verify that $\underset{L,K}{MRTS} = \frac{w}{r} = \frac{\$2937}{0.1329} = 22{,}099$ which is equivalent to 7.5 workers. Hence, the rate of substitution between factor inputs for Watany marble implies that every $1000 units of capital is substitutable by 7.5 units of labor in order to achieve the same output level.

Consequently, we can derive the optimum number of labor required given the fixed amount of capital. Recall that $MP_L$ was positive and greater than $AP_L$ from previous analysis, implying that additional labor should be employed to reach optimum production capacity of 316,645 units. Knowing that the chosen capacity level is 311,798 (a 1.53% deviation from the optimum), thus the extra units of labor required to reach this optimum production level would be approximately five additional workers, calculated as follows:

As the firm's budget for factor inputs is given by the cost of those factors employed, $C = wL + r\overline{K} = 2937 * 40 + 0.1329 * 6{,}009{,}000 = \$916{,}076$; then an additional budget amount of $14,016 would be required to employ additional labor needed to reach optimum production level. This additional budget (if divided by the wage rate of $2937) would yield 5 additional units of labor if capital is to be held constant. Therefore, it can be concluded that Watany Marble's optimum level of labor inputs is 45 workers, given a rate of substitution between labor and capital described by $1000 units of capital equivalent to 7.5 units of labor.

**Cost Minimization and L-R input demand**

To find the conditional input demands and the long run cost function for the general Cobb-Douglas production function, we set up and solve the firm's cost minimization problem subject to the general Cobb-Douglas production function as a constraint.

To minimize Total Cost:

$$\min TC = wL + rK \tag{5.29}$$

subject to: $Q = AK^{\alpha}L^{\beta}$

The Lagrangian is:

$$\ell = wL + rK + \lambda(Q - AK^{\alpha}L^{\beta}) \tag{5.30}$$

The first-order conditions are:

$$\frac{\partial \ell}{\partial L} = w - \lambda * \left[\beta A(K^*)^{\alpha}(L^*)^{\beta-1}\right] = 0 \qquad \Rightarrow \lambda^* = \frac{w}{\beta A(K^*)^{\alpha}(L^*)^{\beta-1}} \tag{5.31}$$

$$\frac{\partial \ell}{\partial K} = r - \lambda * \left[\alpha A(K^*)^{\alpha-1}(L^*)^{\beta}\right] = 0 \qquad \Rightarrow \qquad \lambda^* = \frac{r}{\alpha A(K^*)^{\alpha-1}(L^*)^{\beta}} \tag{5.32}$$

$$\frac{\partial \ell}{\partial \lambda} = Q - A(K^*)^{\alpha}(L^*)^{\beta} = 0 \tag{5.33}$$

Equating the values of $\lambda^*$ from (4.31) and (4.32)

$$\lambda^* = \frac{w}{\beta A(K^*)^{\alpha}(L^*)^{\beta-1}} = \frac{r}{\alpha A(K^*)^{\alpha-1}(L^*)^{\beta}} \tag{5.34}$$

Solving for K*,

$$K^* = \frac{\alpha w}{\beta r}L^* \tag{5.35}$$

Substituting (5.35) in (5.34)

$$Q - A\left(\frac{\alpha w}{\beta r}L*\right)^{\alpha}(L*)^{\beta} = 0 \qquad \Rightarrow \qquad (L*)^{\alpha+\beta} = \frac{Q}{A}\left(\frac{\beta r}{\alpha w}\right)^{\alpha} \tag{5.36}$$

Solving (5.36) for L*,

$$L* = \left(\frac{\beta r}{\alpha w}\right)^{\frac{\alpha}{\alpha+\beta}}\left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} \quad , \text{ the conditional input demand for L} \tag{5.37}$$

Substituting (5.38) in (5.36),

$$K* = \frac{\alpha w}{\beta r}\left(\frac{\beta r}{\alpha w}\right)^{\frac{\alpha}{\alpha+\beta}}\left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} \tag{5.38}$$

$$= \left(\frac{\beta r}{\alpha w}\right)^{-1}\left(\frac{\beta r}{\alpha w}\right)^{\frac{\alpha}{\alpha+\beta}}\left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} = \left(\frac{\beta r}{\alpha w}\right)^{\frac{-\beta}{\alpha+\beta}}\left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}}$$

$$= \left(\frac{\alpha w}{\beta r}\right)^{\frac{\beta}{\alpha+\beta}}\left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} \text{, the conditional input demand for K}$$

Substituting (5.38) and (5.39) in the objective function (5.28).

$$TC^* = wL^* + rK^* = w\left(\frac{\beta r}{\alpha w}\right)^{\frac{\alpha}{\alpha+\beta}}\left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} + r\left(\frac{\alpha w}{\beta r}\right)^{\frac{\beta}{\alpha+\beta}}\left(\frac{Q}{A}\right)^{\frac{1}{\alpha+\beta}} \quad (5.39)$$

$$= \left\{\frac{1}{A}\left[\left(\frac{\beta}{\alpha}\right)^{\alpha} + \left(\frac{\alpha}{\beta}\right)^{\beta}\right]\right\}^{\frac{1}{\alpha+\beta}} (r)^{\frac{\alpha}{\alpha+\beta}} (w)^{\frac{\beta}{\alpha+\beta}} (Q)^{\frac{1}{\alpha+\beta}}$$

Now notice that (5.39) can be expressed in logs:

$$\log TC = -\frac{1}{\alpha+\beta}\log A[(\alpha-\beta)(\log\beta - \log\alpha)] \quad (5.40)$$

$$+\frac{\beta}{\alpha+\beta}\log w + \frac{\alpha}{\alpha+\beta}\log r + \frac{1}{\alpha+\beta}\log Q$$

This gives us the sensitivity of total cost to the wage rate, interest rate, and production capacity.

To minimize the cost of producing one unit of Marble at Watany Factory, the above cost minimization technique will be applied.

Our Cobb-Douglas Production Function as stated earlier is:

$$Q = K^{0.89}L^{1.33} \quad (5.41)$$

Hence, the cost minimization problem for Watany marble is:

$$\min TC = \overline{w}L + \overline{r}K \tag{5.42}$$

subject to $\overline{Q} = AK^{0.89}L^{1.33}$, where A is normalized (A=1).

Accordingly the conditional input demand for labor L* in terms of factor costs and output (r, w and Q) would be:

$$L^* = 1.174\left(\frac{r}{w}\right)^{0.4} Q^{0.45} \tag{5.43}$$

By substituting optimum Q= 316,645 $m^2$ in (4.43), we get the conditional input demand function for labor:

$$L^* = 350.69\left(\frac{r}{w}\right)^{0.4} \tag{5.44}$$

On the other hand, the conditional input demand for Capital K* would be:

$$K^* = 0.786\left(\frac{w}{r}\right)^{0.6} Q^{0.45} \tag{5.45}$$

Also by substituting optimum Q= 316,645 $m^2$ in (4.45), we get:

$$K^* = 234.79\left(\frac{w}{r}\right)^{0.6} \qquad (5.46)$$

Therefore, the overall capital-labor ratio as a function of factor costs is given by:

$$\frac{K^*}{L^*} = \frac{234.79\left(\frac{w}{r}\right)^{0.6}}{350.69\left(\frac{r}{w}\right)^{0.4}} = \frac{234.79\left(\frac{w}{r}\right)^{0.6}}{350.69\left(\frac{w}{r}\right)^{-0.4}} = 0.67\left(\frac{w}{r}\right) \qquad (5.47)$$

Since the capital-labor ratio is 0.67 of the ratio of factor costs, this implies that relative factor inputs are less than proportionately sensitive to relative factor costs. This confirms the notion that the industry is characterized by a limited choice of capital/labor combinations even when compared to their respective costs.

To get the long-run cost function, we substitute the conditional demands for labor and capital into the objective function for cost minimization, leading towards the following:

$$TC^* = \left[\left(\frac{1.33}{0.89}\right)^{0.89} + \left(\frac{0.89}{1.33}\right)^{1.33}\right]^{\frac{1}{2.22}} (r)^{\frac{0.89}{2.22}} (w)^{\frac{1.33}{2.22}} (Q)^{\frac{1}{2.22}} \qquad (5.48)$$

$$= \left\{0.91(r)^{0.4}(w)^{0.6}\right\}Q^{0.45}$$

Taking logs:

$$\log(TC) = \log(0.91) + 0.4\log(r) + 0.6\log(w) + 0.45\log(Q) \qquad (5.49)$$

Accordingly, changes in long-run production cost are explained by changes in the interest rate, wage rate, and capacity. Regarding changes in input prices, 40% is attributed to interest rate fluctuations while 60% is attributed to changes in the wage rate. Compared to the combined effect of changes in factor prices (both labor and capital), capacity alterations reflect 45% of those combined changes.

Long-run Average Cost (LRAC) is an important element in long-term production planning decisions. For the case of Watany marble, it can be easily verified that LRAC exhibits increasing returns to scale since:

$$LRAC = \frac{TC^*}{Q^*} = \frac{0.91r^{0.4}w^{0.6}Q^{0.45}}{Q} = \left[0.91r^{0.4}w^{0.6}\right]Q^{-0.55} \qquad (5.50)$$

The exponent of production capacity is negative (-0.55), which suggests a declining LRAC with quantity hence also implying increasing returns to scale in production, a result reached earlier in the analysis and reaffirmed with the result reached above .

**A Final Comment**

Due to the loan amortization and fixed interest payments payable to the Bank, the AC curve had a backward bending shape. Watany's breakeven point proved to be at very low levels of production compared to average production capacity. This gives the firm a very comfortable range of output that would result in a profitable operation. It is noteworthy to mention that the breakeven quantity is inversely proportional to profit-margin per unit of output. Profit Maximization production level is when MR=MC and this was found to be at a production level of 316,645 $m^2$. The Cobb Douglas Production Function showed that the Company enjoys Increasing Returns To Scale. It also produced the result that the Rate of Technical Substitution between the factors of production K and L implies that for every $ 1000 in K, 7.5 units of labor are needed to produce the same level of output. For the LR cost minimization, the LRAC is decreasing with quantity. This implied that the employment of extra units of labor would increase production efficiency and the optimum labor choice was found to be 45 workers. Results of analysis showed that $MP_L > MP_K$ though it is a capital intensive industry. For this case in particular, it signifies that capital resources have been exhausted.

# CHAPTER VI

# CONCLUSION

The Marble Industry is one of the oldest industries in the World. Ancient Civilizations in general and Ancient Egyptians in particular were very skillful in the utilization of the ornamental stones. In the old times this industry was labor intensive, due to its nature. With the development of modern technology, this industry became relatively capital intensive and almost fully computerized in many countries of the world. In Egypt this industry is still in a development stage, inspite of its long history. Extraction of raw marble blocs is an area that needs to be overviewed and regulated. Currently, extraction practices include the excessive use of explosives which results in an enormous waste to natural resources as well as to the deformation of the extracted blocs of marble. This needs regulations from the authorities and a collective act on the part of the marble extractors to start using more efficient extraction techniques and tools like diamond wire and efficient marble bloc cutters. The utilization of this modern technology in stone cutting will create a value added in terms of saving the resource as well as in terms of increasing the value of the raw stone itself. Standardization of the size of the raw stone bloc increases the operational efficiency of the machines that handle the carrying and the cutting of the bloc and leads to the standardization of the final product quality which is a requirement to meet international standards of the industry.

The Market for Marble products in Egypt has the characteristics of a monopolistic competition. There are few big producers that own a substantial market share as well as have access to the international market. On the other hand, there are many smaller size companies that compete in the market. During the past 20 years, barriers to market entry were low, while profit margins for the industry were high. This was an open invitation for investors to work in this sector, hence attracting market entry. Currently, with the devaluation of Egyptian Pound, barriers to entry are becoming more tangible as the required investment cost to establish a factory has increased sharply, i.e. due to shift from labor-intensive to capital-intensive production. Market leaders are characterized by producing high quality products, which open up the export market for them. Export orientation is a major advantage for factories operating in this industry, because the generation of revenues in foreign currencies is a good hedge against the devaluation of the Egyptian Pound. Moreover, the income source in foreign currency facilitates the acquisition of modern imported technology, which in turn boosts the factory's production

Marble products enjoy a high level of differentiation, which is a main characteristic of this product and thus influences its price within the market structure of monopolistic competition. Rare marble types are very expensive. Moreover the cut, thickness and polish of the stone constitute another way to differentiate this natural product and play a role as well in determining its final price. Marble products have different uses as floor tiles, walls, steps, working area as well as in different decorative consumer uses.

Watany Marble is a middle size marble factory managed by an expert in this industry who spent a long time of his work experience in Carara, the world's capital of marble. Encouraged by the good profit margins achieved during the past years, the owner of Watany Marble decided to invest in doubling the production capacity of his factory. Investment cost reached $ 6.009 mill. An appraisal of this investment decision using economic cost-benefit analysis was conducted in this thesis. The project's timespan was for the period of ten years. Results proved that the investment is viable and profitable. The changes that happened in the Egyptian economic environment were taken into consideration in the analysis. The most striking factor was the devaluation of the Egyptian Pound, where the exchange rate between the dollar and the Egyptian Pound jumped from a rate of $/LE=3.4 to a rate of 6.2 in the year 2004. Two factors saved Watany Marble from suffering under such a change in economic conditions. The first factor was that all imported machinery was obtained before the devaluation. The second factor was that Watany is export oriented and exports about 75% of its production. With the devaluation of the Egyptian Pound, both factors turned to be favorable for Watany Factory. Moreover, a weighted-average discount rate was calculated to be 13.29% to account for the opportunity cost of capital as well as for inflation. Based on traditional project appraisal methodology, Return on Investment, ROI, was found to be 12.24% which is relatively subtle and exceeds the ongoing interest rate on deposits in banks. The External Rate of Return was 26.19%, smaller than the Internal Rate of Return which was as high as 49.16%. This implies a dominant rate of cash-flow re-investment for Watany. The Payback period was 3.03 years which is a reasonable time frame for capital investment recovery.

Applied analysis of the Theory of the Firm was conducted to Watany Factory. Fixed interest payments of the loan were amortized using loan amortization calculations. A grace period was granted to the factory owner where only interest payments on the outstanding loan balance were due, while repayment of principal amount was delayed to the end of the grace period. Based on amortization and production cost calculations, the Average Cost curve of the factory was found to be "backward bending" and not having the usual U-shape and this was proven to be due to loan amortization which largely affected the cost structure of production. On the other hand, breakeven analysis was conducted and it was proved that the Factory reached its breakeven point at relatively low levels of production ranging around 21% of current production capacity. This reflects high profitability level for the factory's operation, because any extra unit produced beyond this minimal level of output would add extra revenues to the company that would constitute pure profits. It follows that there was an inverse relationship between break-even capacity and profit margin per unit, as given by $Q = \frac{F}{P - \alpha}$, where F = fixed cost, P = price per unit and $\alpha$ = marginal cost.

Profit Maximization analysis was applied to the case study and it was revealed that the factory would be maximizing its profits by operating at the yearly production capacity of 316,645 $m^2$. At this operational level, MR would equal MC. Further analysis proved that the Factory operates near optimum capacity, whereas average production capacity of the factory ranged around 311,798 $m^2$. This is minor deviation from optimum production capacity and proves that the decision makers in the factory own high expertise and good management abilities.

Using the Cobb Douglas production function of the form $Q=K^{\alpha}L^{\beta}$, where the coefficients $\alpha+\beta$ represent the returns to scale, it was proved that the production enjoys increasing returns to scale, where $\alpha$ equals 0.89 and $\beta$ equals 1.33. Hence $\alpha+\beta = 2.22$ implying increasing returns to scale in technology. Moreover, it implies that doubling all inputs for marble production would more than double production output. It should be noted that although marble production is capital-intensive, the returns to labor (1.33) outweigh the returns to capital (0.89). The implication for this finding is that capital reserves have been exhausted while labor resources are still at the increasing $MP_L$ stage.

For Watany Marble, amount of capital was taken as fixed, $\overline{K}$, at a level of \$6.009 mill, as the owner was not willing to invest further in capital. Optimum amount of labor to be employed with this level of capital proved to be 45 workers at an average wage rate of \$2937 per year. This was also confirmed by the analysis which proved that $MP_L > AP_L$ at the average production capacity level of 311,798 $m^2$. On the other hand, the $MP_K$ was very low compared to $MP_L$, though this is a capital intensive industry. This affirmed the notion that the capital resources were almost fully exhausted.

Hence, it could be said that the firm operated under a constrained budget line of C = 2937 L + 0.1329 K. The firm's budget was calculated to be $ 916,076 in terms of labor and capital as factors of production. Using Isoquant and Isocost production lines, the Marginal Rate of Technical Substitution between labor and capital, $MRTS_{L,K} = \frac{w}{r}$, implied that every $1000 units of capital would be substitutable by 7.5 units of labor in order to achieve the same level of output.

By studying cost minimization for Watany Marble, the conditional input demand for the factors of production was determined. The capital labor ratio proved to be 0.67 of the ratio of factor costs, implying that relative factor inputs are less than proportionately sensitive to relative factor costs. This indicates that the industry is characterized by a limited choice of labor/capital combinations, even when compared to their relative costs. Moreover, it was calculated that interest rate fluctuations influence changes in long run production cost by 40%, whereas the wage rate is responsible for 60% of the fluctuations in total cost and understandably so. With respect to the Long-Run Average Cost function $LRAC = \gamma\ Q^{-.55}$ exhibited a decreasing trend confirming that the factory is operating under increasing returns.

In conclusion, it is noteworthy to mention that the marble industry in Egypt has a good potential to prosper and to be one of the driving forces for the country's overall economic wellbeing especially as natural resources abound and comparative advantage in export markets exists. Regulating this important resource of the country is mandatory for sustainable development. Moreover, improving the quality of the final product is key to invading the international markets and establishing a reputation in this field. If Watany marble is taken as a representative firm in the monopolistic-competitive marble industry; the case study affirms that production is capital – intensive with increasing returns-to-scale in technology, with ROI reaching 12.24% using conservative opportunity cost of capital considerations. Hence, high profitability could lead to further market entry which may prove to attract more efficient production technology. This might lead to market segmentation, where value-driven and export-oriented firms will tend towards an oligopoly, whereas local-oriented cost-driven firms with relatively low technology will tend towards monopolistic competition. In all cases, to achieve a more competitive marble industry in Egypt in the long-run, effective government regulation is essential.

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