CHARACTERISTICS OF THE MARBLE INDUSTRY IN EGYPT

By

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ABSTRACT

This paper presents a microeconomic assessment of the marble industry in Egypt. The marble industry is considered 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 relatively high due to the high profit margins achieved. In addition, there was, and still is, lack of effective government regulation especially related to the marble extraction process from the quarries. Currently, the marble industry in Egypt could be described as that of monopolistic competition, where products are highly differentiated, nature of competition is capacity-constrained, and there are tangible barriers to entry. Moreover, 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, firm-specific analysis was conducted. Results show net ROI (return on invested capital) to be 12.24% using weighted-average opportunity cost of capital considerations, and pre-tax internal rate of return (IRR) as a direct measure of profitability estimated to be as high as 49.16%, while guaranteed yield using external rate of return (ERR) calculations estimated at a minimum yield of 26.19%. On the other hand, the cost structure in the industry shows declining long run average cost with increasing returns to scale in production of 2.2 given by an estimated Cobb Douglas production function \( Q(K, L) = K^{0.89} L^{1.33} \). The marginal rate of technical substitution between labor and capital resources was found to be the equivalent of $1000 of capital substitutable by 7.5 units of unskilled labor. In general, market segmentation is expected to arise more deeply in the future according to level of technology use by suppliers. In addition, high profitability is expected to level off when the supply of marble quarries becomes relatively scarce.
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I. INTRODUCTION

Marble is a precious ornamental stone used by man very early in history. 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 such as Alabaster. Some historians assert that the Greek and the Romans acquired the skills of quarrying and processing 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 differentiated product that is internationally traded. The price and value of marble depends on one hand on its natural characteristics (like quality, type and color) and on the other hand on technological processing (giving it a special shape, polish, size and thickness). Hence, the production of marble can be considered as (1) highly differentiated, and (2) strongly dependent on level of technology use. 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 technological base that could allow it to properly extract and process marble for local and international trading.

The objective of this paper is to study the characteristics of the marble industry in Egypt using a microeconomic approach with industry analysis and firm-level application. Specifically, the research is directed to study the Egyptian Marble industry with respect to market structure, product quality and characteristics, economic performance, as well as prospects, impediments and needed regulations. In general, there is very little published information on the Egyptian Marble Industry, therefore lots of field research was conducted and extensive 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, representative firm analysis was conducted based on the following criteria: (1) medium-size enterprise with accessibility to both
local and export markets (most of the firms in the industry are medium size), and (2) established after the 1980s in order to represent the generation of marble producers that evolved during that time and shaped this industrial sector over the past twenty years, in terms of technology used.

This research is viewed as an eye opener to this very important industry in Egypt, an industry that deserves to receive much more attention than it currently does.

II. Types and Characteristics of Marble Products

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

Marble is either antique or modern. 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). 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 industry 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.2

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1 Panos Tomaras, Ancient Greek Marbles some still used today, p.1
2 Marble varieties, www.findstone.com
There are few marble products which are of a single color. Some are fine black and others are of white specimens, and even the most pure of these are often tinged with grey or brown. All other types are of various colors. There is red Marble with its various shades, orange yellow and yellowish, green and greenish, blues, 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.

Table (1): Marble as a Natural Stone - Main uses

<table>
<thead>
<tr>
<th>Main uses of Natural Stone</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooring</td>
<td>37.0%</td>
</tr>
<tr>
<td>Exterior cladding</td>
<td>10.0%</td>
</tr>
<tr>
<td>Interior cladding</td>
<td>10.0%</td>
</tr>
<tr>
<td>Stairs</td>
<td>3.5%</td>
</tr>
<tr>
<td>Special works</td>
<td>12.0%</td>
</tr>
<tr>
<td>Structural works</td>
<td>10.0%</td>
</tr>
<tr>
<td>Funeral art</td>
<td>15.0%</td>
</tr>
<tr>
<td>Others uses</td>
<td>2.5%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Source: Stone 2000

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 which is an important determinant of its price and value. It often happens that portions differently colored, and differently marked with spots and veins, are found in the same quarries, and sometimes within the same block.

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

Over the past decade, natural stone (mainly marble and granite) have become the standard material used for many 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 (see Table 1 for main uses of marble).

**III. EVOLUTION OF THE MARBLE INDUSTRY IN EGYPT**

Nature has gifted Egypt with large deposits and high quality marble and granite. Since 2700 B.C., the 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 coupled with the acquired technical know how, the marble industry flourished and the Italians became world leaders in the production of marble.

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 from the days of the Ancient Egyptians. 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. 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 late 1940s and early 1950s.
Marble extraction witnessed a relative boom starting the late fifties in Egypt. This boom was mainly related to the construction of the High Dam in Aswan, the construction of which required a 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. This sector suddenly gained importance and the 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 marble activity in Egypt.

For the first time, Egypt's Five Year Plan (1960/1965) included projects related to the exploitation of ornamental stones. 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.

In 1979, the Aswan 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 10,000 m$^2$ of granite plates. The total project cost was LE 3 million. 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$^2$. Since capacity utilization was in the vicinity of 80%, this means that 60,000 m$^2$ were being extracted in Egypt during this time. (Afia, 1998)
With the privatization trend in the early 1990s, investors started to be interested in the marble and granite industry that was flourishing with high profit margins and which seemed to have good potential for growth. Moreover, cost of quarrying was not high, due to the use of relatively cheap technology (via the overvalued currency) and relatively cheap labor (mostly unskilled). However, still, there was a high demand for marble relative to a limited supply resulting in high potential profits. This high profit margin invited more and more businessmen to enter the industry. Entry permits became even easier with the decentralization of the permits for the quarrying activity. Granting permits became just a procedure and informal connection to higher authorities in the governorates facilitated the issuance of these permits.

In general, during the late 1980s to mid 1990s, entry level into the industry accelerated, encouraged by the high profit margins achieved coupled with the low economic barriers to entry. This motivated investors to spend on expensive and modern imported technologies. Over time, massive market entry forced prices down and average cost of production upward. One of the most important factors which contributed to the increase in average cost was the constant devaluation of the Egyptian pound which drove the fixed cost of imported modern machinery up. Also, there was increasing demand for skilled labor hence the cost of labor increased. This resulted in turning the marble industry into an "increasing cost industry" as demand flourished.

If the marble industry in Egypt 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 improves the shape of the extracted block of marble and makes stone cutting and transportation easier. It can 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 can save this precious resource from being wasted through the traditional extraction methods which are environmentally wasteful. With respect to marble processing, this sector of the industry is almost already saturated, as the number of factories operating in this sector are operating at full capacity and at approximately marginal cost.
Currently, 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.

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, also 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 required less administrative procedures unlike dynamite where permits and approvals are needed.

IV. LOCATION OF MARBLE QUARRIES IN EGYPT

The Map of Egypt, Figure (1), 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, Aswan and the Eastern Desert. Experts confirm that Egypt has big reserves of undiscovered marble. Table (2) specifies the type of marble available in different marble quarries as a natural resource in Egypt and gives a description of each type. It also states the commercial name of the marble extracted which is not necessarily its scientific name. The name "Black Carrara" is an example for such a discrepancy. 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 but with a black color. It is noteworthy to mention that Carrara is by default white. Table (2) reflects that Egyptian marble has a wide variety of colors which is an important determinant to its price, quality, and ultimately, economic value.
Figure (1): Location of Marble Quarries and Marble factories in Egypt

Source: Current Mining Development, Samih Afia
Table (2): Location of the different types of Marble Quarries in Egypt

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

Source: Mohamed Samih Afia, Current Mining Development

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 distributing them to workshops that handle further cutting and polishing, (2) factories that cut and polish the plates, and (3) factories that do the whole process until the final product is produced.

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 time, interested investors in this area were granted about 10,000 m² for the price of LE 70/m² 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 landscape area that is surrounded by a wall and has a main entrance gate. It is divided into a main stream of two streets where 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 marble factories in the whole country.³

V. MARBLE PRODUCTION AND REGULATION

The production of marble passes through several stages. The main stages are demonstrated in Figure (2). The first stage of production is (1) exploration and identification of a quarry location, followed by (2) extraction of marble from the quarries, then (3) lifting and transportation, (4) inventory management, (5) cutting the stone into slabs and tiles, (6) polishing, and finally, (7) distribution to end users. Below is a detailed description of each of the production processes for the marble industry in Egypt.

(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 (Egyptian General Survey and Measurement Authority) to areas where a potential for Marble quarries exist.

b. 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 EGSMA. 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 quarrying proves a viable operation, the extraction process starts after obtaining necessary approvals.

³ Interview, Mr. Ibrahim Ghaly, Supplier of Marble processing equipment.
**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 (2): Marble Production Process
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.

When operation in a certain quarry proves technically and economically 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 location (governorate), 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 then allowed to use the dynamite for the extraction of the marble.

Amendments to quarrying regulations have been lately presented for approval to the Egyptian Parliament which suggest the following: (i) first-time permits to operate the quarries should be given only after technical and financial assessment to the qualifications of the candidate registered company, and (ii) permits should be granted for a minimum period of at least one year and for 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 critical operations are drilling vertical holes, using a twin-headed rig, and the use of a wire-saw cable for cutting the marble blocks. A flame cutter is used to blast a deep fissure into the quarry face. The use of explosives is intense. 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 economic and environmental waste.

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

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.

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 management operations of the quarrying industry (such as economies of scale and estimated profit margins).
Other factors that determine the technology used in quarrying marble 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 in this case the quarry starts to be considered a valuable resource.

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. 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.

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 fees paid.

(3) Lifting and Transportation

After cutting the rocks of marble, marble blocs need to be lifted to a truck for transportation to the factories. Lifting happens 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, or 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 towards a third destination. The cost of transportation constitutes a high percentage of the cost of marble production and can reach as high as 60% of total delivered 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 roads. 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 direct sea transportation of marble to the different countries of the world.

(4) Inventory Management

The Inventory of raw stone blocks is very bulky and requires a very spacious area. An "inventory room" usually occupies the backyard of a typical marble factory. One of the characteristics of the marble 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 into 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 a wooden "chair", with a maximum of three blocks feasibly placed on top of each other.

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

Deciding on the inventory to be stored depends on contracted client demand. 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. The order is then processed in due time. Marble types that enjoy a high demand in the market are kept in special inventory stakes.
(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, depending on the model of the cutting machine as well as the status of its diamond wire or diamond blades. 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:

a. The quality of finished Marble and granite processed in that way is not competitive internationally which makes it cheaper - in both price and quality - and thus adversely affects the reputation of the Egyptian Marble.

b. It continues to drive demand for Egyptian Marble towards 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 high 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 and (b) Tumbling. The polishing operation is fully automated with 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 shinier and smoother is the surface of the marble. Here, 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. 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. Then, sometimes, a thermal / flame 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. 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. Hence, polishing operations use more capital resources than labor, provide a value-added and overhead operation to the stone, and uses water extensively as an input. Polishing is very sensitive to the price of water usage.

(7) Distribution

The distribution channels depend 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 customer delivery (rather than distribution) takes place. The final product is delivered to the customer according to an agreed upon time and place. As 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 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. They also 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. Factories that are involved in cutting the plates of marble into tiles and slabs usually deal with bigger orders where the marble is required for a whole building and a contract is signed between the marble supplier and the building contractor for the quantity supplied.

Hence, distribution is directly related to the scale of client demand. As noted earlier, there are an estimated 500 marble factories and 3000 marble workshops in Egypt.
VI. CHARACTERISTICS OF THE MARBLE INDUSTRY: COMPETITIVE ANALYSIS

The Marble Industry has unique competitive characteristics that differentiate it from any other industry in terms of technology use and operational characteristics, in addition to its differentiated market characteristics. 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 marble industry in Egypt is growing from one day to the other and it is very valuable studying and analyzing the market 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 or from substantially smaller workshops which 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 in 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 (capacity) competition exists where the suppliers that can provide big quantities and can operate their own quarries have a clear edge over others. However, there is also a tough price competition. Small suppliers sometimes dump the market by lowering their prices severely, just for the sake of selling their product and generating cash. Therefore, bigger marble producers on scale do not always enjoy a
price advantage even though their average operating cost may be lower. Also, market competition is highly differentiated by quality (vertical differentiation). This depends on target demand and whether the end user is local or production is done for export purposes. In addition, horizontal differentiation also exists (according to type and color of marble produced). Usually, horizontally differentiated competition is for suppliers who target the elite market.

There is hardly any seasonality of demand. Marble is required all year long, although is follows very much the business cycle of 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 (3): Gaining a Competitive Edge in the Industry

<table>
<thead>
<tr>
<th></th>
<th>Means to Gain It</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ready availability of the product demanded and the ability to respond quickly to higher quantities.</td>
<td>Own the right to operate a number of quarries.</td>
</tr>
<tr>
<td>Ability to produce high quality standardized product according to specifications.</td>
<td>Ownership of high technology, if not in extraction, then at least in the factories.</td>
</tr>
<tr>
<td>Ability to maintain a constant price level, despite variations in quantities demanded.</td>
<td>Operating cost is either constant or decreasing with higher quantities produced.</td>
</tr>
<tr>
<td>Ability to minimize the waste during the production process to increase the returns on the whole operation.</td>
<td>The ownership of re-cycled technology and skilled labor specialized in environmental waste.</td>
</tr>
<tr>
<td>Ability to offer rare types of Marble with unusual colors to cater to the tastes of a highly selective niche of clients.</td>
<td>Active in exploring and acquiring rare types in local and international Markets.</td>
</tr>
<tr>
<td>Access to the international markets and the ability to export and open new markets internationally.</td>
<td>• Source of income in foreign currency, facilitating the acquisition of updated imported technologies.</td>
</tr>
<tr>
<td></td>
<td>• Awareness of international standards.</td>
</tr>
</tbody>
</table>
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 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 marble 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.4

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 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

4 Interview with entrepreneurs in the Marble Industry
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 months. To establish a factory in Egypt for marble processing, an investment of LE 8 to LE 10 million is needed as initial fixed cost of investment.

There are other “indirect or hidden” economic barriers to entering this industry in Egypt, such as:

(1) Lack of skilled labor: there are no colleges or schools that qualify skilled workers to work in this industry. Engineering majors in Egyptian Universities include mining studies, but this only qualify students to work in marble quarrying as mining/quarrying engineers. In Aswan, there was a college that taught the skills of cutting and craving marble and granite, but this college no longer offers this specialization. Therefore, in order to get skilled labor, marble suppliers have to hire a worker with previous experience in another factory i.e. suppliers have to attract other competitors’ staff which could be quite risky and expensive. The other option would be to provide on-the-job training to new labor, which is time consuming and not cost effective if the labor switching constraint is binding.

(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 m². Moreover, the industry is characterized by regional concentration of the factories within 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 5000m² with an average land price of LE 100 per m².
- 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 equipment and machinery for a marble production line:
  - 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 (varies)
  - 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: cost between LE 120,000 – LE 150,000.

Equipment prices quoted above are usually paid in foreign currency. 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 being a family business, where the business got inherited from one generation to the other. A significant number of the current 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 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 company's brand name acts 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 estimated 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 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. However, none of them acts as a monopoly and there are no signs of collusion.

5. Use of Technology
The technology used 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, several factories still import second handed (sometimes 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, 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 months 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 60 m$^3$ per hour of operation.

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 pricing upwards. The technology used in quarrying also affects price. 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 offering relatively lower prices. At the extreme lower end of pricing comes suppliers who intentionally use the cheapest and most wasteful way of extraction (like dynamite and explosives). 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, and the difference in pricing is pushed on to society by wasting its limited resources. This produces a low product price coupled with a high social cost.
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 the economics of natural resources. There are no regulations in force that control the stone cutting process or the percentage of waste acceptable to the authorities from the quarrying or extraction operation.

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

- Type, quality and rareness of the marble: the higher the quality of marble and/or more rare the type is, the more expensive it becomes. Rare types are priced according to demand based on maximum consumer willingness to pay. According to marble traders, selling a shipment of imported marble that had rare colors relative to the types available in Egypt is done at a price five times higher than the bottom price initially set for the shipment.

- 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. 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. As mentioned earlier, marble is differentiated vertically (by quality) and horizontally (by type and color). Also, there are different 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 exists marble types that are very common and affordable and are considered normal goods. The color, cut, shape, and polish of the marble stone create varying degrees of product differentiation. 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 4 m² 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 as has been discussed in the previous section.

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 registered companies are working in this field in Egypt. Table (4) 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 one 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 is a major distributor of marble processing machinery, half of all marble producers are concentrated in Cairo. 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. This produces high social opportunity costs in terms of transportation overhead and due to lack of adequate regional industry planning.

According to several marble factory owners interviewed, factories cannot 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 is insufficient as well as the needed infrastructure to ensure a minimal level of living standard for the workers. On the other hand, transportation of the finished product is much more complicated and risky, as the processed marble is very fragile while solid raw marble stone can be transported without concerns of fragility.
Table: (4) Number and Regional Distribution of Marble Enterprises in Egypt

<table>
<thead>
<tr>
<th>Governorate</th>
<th>Big Enterprises</th>
<th>Medium size enterprises</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cairo</td>
<td>6</td>
<td>59</td>
<td>65</td>
</tr>
<tr>
<td>Giza</td>
<td>2</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Kaliobia</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sharkia</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Alexandria</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Monofeya</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Ismailia</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Aswan</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Damietta</td>
<td></td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Gharbia</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Dakahlia</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Port Said</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Beni Sewef</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>103</td>
<td>119</td>
</tr>
</tbody>
</table>

Source: General Arab Organization For Industrialization

Another important feature of the industry in Egypt is not only the concentration in cities, but it is also noticeable that marble producers within 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 factories as 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.
9. Current Local Regulations

The following are regulations that organize the marble quarrying industry in Egypt:

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 15 days. 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 20,000, 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. Fees paid vary from one governorate to the other.
6. There are no environmental waste regulations for marble extraction.

10. Needed Regulations and Prospects for the Industry in Egypt

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, such as:

- Misuse of the quarries, which results in lots of environmental waste especially in the extraction phase of production.
- 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 minimum basic infrastructure, such as the supply of water. Accordingly, tanks of water are sold to the factories to be able to run their operation which creates large
overhead cost.

- 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 in the international market.

- 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 concentrates the labor movement and expertise in limited places.

- 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 research and development that serves the industry.

If we look at the contribution of the industry to the Egyptian Economy, we find that this sector has grown tremendously over the past decades and especially post 1990s. According to Eng. Medhat Mostafa⁵, President of Sinai International Marble Company and Vice President of the Association of Marble and Granite producers, capital 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 as labor force. Egyptian Exports of Marble reached LE 275 million in 2002 and achieved in the first quarter of 2003 more than LE 125 million. It is expected that exports will increase during the coming three years to reach one billion Egyptian Pounds. However, 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 especially with the case of extracted marble⁶.

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⁵ El Ahram Newspaper, Friday June 27th, 2003
VII. CHARACTERISTICS OF THE MARBLE INDUSTRY: SUMMARY OF TECHNICAL ANALYSIS

Based on industry structure and representative firm analysis, we assume a general Cobb-Douglas production function of the form:

\[ Q(K, L) = AK^\alpha L^\beta \]

where \( K \) represents Capital in thousands of US$ and \( L \) number of workers (labor). The coefficients \( \alpha + \beta \) represent the Returns to Scale (RTS) in production\(^7\).

Standard optimization yield factor input demands, which are dependent on the annual wage \( w \) per person per year and annual opportunity cost of capital \( r \), given by:

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

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

Hence:

\[ K^* = \left( \frac{\alpha w}{\beta r} \right) L^* \]

Then, the total cost function for production \( TC^* = wL^* + rK^* \) can be estimated by:

\[ \log TC = -\frac{1}{\alpha + \beta} \log A [ (\alpha - \beta) (\log \beta - \log \alpha) ] + \frac{\beta}{\alpha + \beta} \log w + \frac{\alpha}{\alpha + \beta} \log r + \frac{1}{\alpha + \beta} \log Q \]

\(^7\) 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).
This gives us the sensitivity of total cost to the wage rate \( w \), interest rate \( r \), and production capacity \( Q \). From this, average cost and average productivity can be easily calculated.

In addition to production calculations, we also estimate financial profitability indicators for a medium-size representative firm to include Return on Investment (ROI), Internal Rate of Return (IRR), and External Rate of Return (ERR).

The Internal Rate of Return (IRR) gives a pre-tax profitability index and is considered equivalent to the discount rate \( \rho \) at which internal cash flows are re-invested:

\[
-I + \sum_{t=1}^{n} \frac{B_t - C_t}{(1 + \rho)^t} = 0
\]

(6)

On the other hand, the External Rate of Return (ERR) gives minimum guaranteed yield \( r_e \) estimated by:

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

(7)

Return on Investment (ROI) gives undiscounted average yearly profit margins \( R_I \):

\[
R_I = \frac{n + 1}{n} \sum_{t=1}^{n} \frac{B_t - C_t}{n \left[ I - \frac{t}{n} (I - S_y) \right]}
\]

(8)

Tables (5) and (6) below summarize results for the technical analysis based on medium-size firm representation in the marble industry in Egypt.
Table (5): Economics of Production for a Medium-Size Representative Firm in the Marble Industry in Egypt

<table>
<thead>
<tr>
<th>Valuation</th>
<th>Equation</th>
<th>Description</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTS</td>
<td>$Q(K, L) = K^{0.89}L^{1.33}$</td>
<td>Returns to Scale</td>
<td>$\alpha + \beta = 2.2$</td>
<td>This implies Increasing Returns to Scale in production</td>
</tr>
<tr>
<td>AP_L</td>
<td>$AP_L = \frac{Q(K, L)}{L} = f(L^{0.33})$</td>
<td>Average Labor Productivity</td>
<td>7,795 m² per person per year</td>
<td></td>
</tr>
<tr>
<td>w</td>
<td>$w = $2,937 per person, per year</td>
<td>Wage rate per year</td>
<td>$2,937$</td>
<td>Accounts for the purchasing power of money</td>
</tr>
<tr>
<td>r</td>
<td>Opportunity cost of capital</td>
<td></td>
<td>13.29%</td>
<td></td>
</tr>
<tr>
<td>MRTS</td>
<td>$MRTS = \frac{\partial Q}{\partial L} \bigg</td>
<td>_{K} = \frac{\partial Q}{\partial K} \bigg</td>
<td>_{L}$</td>
<td>Marginal Rate of Technical Substitution</td>
</tr>
<tr>
<td>L*,K*</td>
<td>$L^* = \left( \frac{\beta}{\alpha w} \right) \alpha + \beta \left( \frac{Q}{A} \right) \frac{1}{\alpha + \beta}$</td>
<td>Conditional Factor Input Demands based on Cost Minimization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$K^* = \left( \frac{\alpha w}{\beta r} \right) \frac{\beta}{\alpha + \beta} \left( \frac{Q}{A} \right) \frac{1}{\alpha + \beta}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LRAC</td>
<td>$LRAC = \frac{TC^<em>}{Q} = \frac{wL^</em> + rK^*}{Q}$</td>
<td>Long Run Average Cost</td>
<td>$LRAC = \gamma Q^{-0.55}$</td>
<td>Declining LRAC (also implying Increasing Returns to Scale)</td>
</tr>
<tr>
<td>Valuation</td>
<td>Equation</td>
<td>Description</td>
<td>Value</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------</td>
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</tr>
<tr>
<td><strong>IRR</strong></td>
<td>[-I + \sum_{t=1}^{n} \frac{B_t - C_t}{(1 + \rho)^t} = 0]</td>
<td>Is the discount rate at which the present worth of investment benefits equals that of its costs. At this discount rate, the present worth of investment is zero.</td>
<td>49.16 %</td>
<td>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.</td>
</tr>
<tr>
<td><strong>ERR</strong></td>
<td>[(-I)(1 + r_e)^n = \left(\sum_{t=1}^{n} \frac{B_t - C_t}{(1 + r)^t}\right)(1 + r)^n]</td>
<td>A measure of the minimum guaranteed return on the capital investment.</td>
<td>26.19 %</td>
<td>ERR &lt; IRR As ERR is a more conservative approach in investment valuation.</td>
</tr>
<tr>
<td><strong>ROI</strong></td>
<td>[R_I = \frac{n + 1}{n} \sum_{t=1}^{n} (B_t - C_t) - \frac{\sum_{t=0}^{n} \left[I - \frac{I - S_v}{n} (I - S_v)\right]}{n}]</td>
<td>Is the ratio between average yearly profit and average-year investment.</td>
<td>12.24 %</td>
<td>A relatively subtle ROI.</td>
</tr>
</tbody>
</table>

*S_v* is the salvage value of investment.
VIII. 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, but 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 development stage, in spite of its long history. Extraction of raw marble blocs from the quarries is an area that needs to be especially overviewed and regulated from an environmental standpoint. 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 a change in extraction techniques towards using different tools such as diamond wires and automated bloc cutters to achieve standard sizes. 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 (in terms of quality) which is a requirement to meet international standards of the industry.

The marble industry in Egypt has the characteristics of a monopolistic competition market structure, where there are tangible barriers to entry, a high degree of product differentiation, and competition is driven by economies of scale and relative prices. There are few big producers that own a substantial market share, and on the other hand, many smaller size companies also 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, also due to shift from labor-intensive to capital-intensive production.

Technical analysis for medium-size representative firm showed increasing returns to scale in production (a scale of 2.2) using an estimated Cobb Douglas production function given by $Q(K, L) = K^{0.89} L^{1.33}$. From this, the Marginal Rate of Technical Substitution (MRTS) between labor and capital resources was estimated with the implication that every $1000 units of capital
are generally substitutable by 7.5 units of unskilled labor.

Moreover, the pre-tax profitability index was estimated using Internal Rate of Return (IRR) calculations to reach as high as 49.16%, whereas minimum guaranteed yield measured by the External Rate of Return (ERR) shows a minimum yield of 26.19%. Average yearly profit margins estimated using Return on Investment (ROI) was found to be 12.24% which is relatively subtle but still exceeds the ongoing interest rate on deposits in banks.

In general, 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 well-being especially as natural resources abound. 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. 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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