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FIXED EFFECT COBB-DOUGLAS PRODUCTION FUNCTIONS FOR FLOOR TILE FIRMS, FAYOUM AND KALYUBIYA, EGYPT, 1981-1983

By

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ABSTRACT

FIXED EFFECT COBB-DOUGLAS PRODUCTION FUNCTIONS
FOR FLOOR TILE FIRMS, FAYOUM AND KALYUBIYA,
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James Lawrence Seale, Jr.

The purpose of this thesis is to develop and estimate individual, firm-specific measures of differences in production among Egyptian small-scale tileries in Fayoum and Kalyubiya governorates using a fixed-effect Cobb-Douglas system and panel data collected in Egypt under the supervision of the author. Other measures to determine if tileries are failing to maximize profit and to combine variable inputs in a least cost manner are developed and estimated. After obtaining the above measures, it is determined if certain firm or entrepreneurial characteristics are associated with these estimates.

The analytical procedure used in this thesis combines techniques developed in the econometric literature on frontier production (cost) functions and panel data estimation. Physical, stochastic production functions are fitted to the panel data allowing for differences in production among firms using a fixed-effect Cobb-Douglas model. The data sets from the two areas are pooled, and tests are constructed that indicate that effects from the production function, taken as a whole, add to the explanatory power of our production function equation and that ordinary least squares or the "within" estimator is more appropriate for estimating the model with the Egyptian tilery data.

Major findings are that the tileries produce under constant returns to scale; that there are differences in production among tileries, both within and between the two areas, but these differences are generally not great from an economic point of view; that tileries on average are failing to maximize profit by employing too little capital and too little labor; and that tileries on average are not combining labor and capital efficiently as they employ too much capital relative to the amount of labor they use, though the cost of this inefficiency is small.

The model performed quite well in estimating actual differences in production among the tileries. Rankings in terms of the fixed effects in the production function are quite similar to a priori rankings made by the author based on his firsthand knowledge of the tileries over a two year period. The estimates measuring failure to maximize profit and to combine variable inputs efficiently also seem reasonable.

Dedicated to my wife, Colleen Seale.

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CHAPTER I

INTRODUCTION

The purpose of this thesis is to develop and estimate individual, firm-specific measures of differences in production among Egyptian small-scale tileries in Fayoum and Kalyubiya governorates using a fixed-effect Cobb-Douglas system and panel data collected in Egypt under the supervision of the author. Other measures to determine if tileries are failing to maximize profit and to combine variable inputs in a least cost manner are developed and estimated. After obtaining the above measures, it is determined if certain firm or entrepreneurial characteristics (e.g., size of firm, age of firm, education and age of entrepreneur) are associated with these estimates. Finally, a statement is made based on the analyses and the author's firsthand knowledge of the tileries and their production processes as to how well the model performs and what the model's fixed effects are measuring.

The major goals of the study are:

a) The presentation and summarizing of new information pertaining to small-scale manufacturing firms in Egypt, particularly in Fayoum and Kalyubiya governorates, using panel data collected in Egypt under the supervision of the author.

b) The collection and processing of weekly panel data for twenty-five Egyptian small-scale tileries in Fayoum and Kalyubiya governorates over a period of sixty-six weeks.

c) The review and synthesis of the econometric literature on frontier production (cost) functions and panel data.

d) The generalization of a model developed by Hoch (1962) to include individual firm measures of the failure to maximize profit and to combine variable inputs in a least cost manner.

e) The estimation of a model developed by Schmidt (1984) using the Egyptian panel data.

f) The systematic study of whether certain firm characteristics are associated with the fixed effects on the production function or the efficiency measures on the factor share equation.

The analytical procedure used in this thesis combines techniques developed in the econometric literature on frontier production (cost) functions and panel data estimation. Stochastic production functions using physical units of output and inputs are fitted to the panel data collected in Egypt for small-scale floor tileries allowing for differences in production among firms. A fixed-effect Cobb-Douglas model is chosen for the analysis. An F-test is used to determine if the structural form of the tileries' subproduction functions are the same in both governorates. When no significant differences are found in the estimated elasticities of variable inputs, the data sets from the two areas are pooled. Tests are also constructed to determine if the fixed effects from the production function, taken as a whole, add to the explanatory power of our production function equation, whether the fixed effects for different firms are the same, and whether ordinary least squares or the "within" estimator is more appropriate for estimating the model with the Egyptian tilery data.

Differences in output-input relationships among firms are captured in a neutral shift in the individual firm subproduction functions. The reasoning behind this assumption is that all firms are using the same technology (i.e., all tileries have the same elasticities for variable inputs in their subproduction functions), but that the subproduction function of one tilery may be above or below that of other firms. This is similar to an argument made by George Stigler (1976, p. 215) that "in neoclassical economics, the producer is always at a production frontier, but his frontier may be above or below that of other producers."

The fixed effects from the production function will be estimated for each tilery and tested to see if individual firm measures are significantly different from each other. Tileries will be ranked in terms of the fixed effects from the production function and factor share equation in the model. Based on the authors firsthand knowledge of each tilery, the analyses of this study, and other relevant information collected in Egypt, the question as to whether these rankings seem sensible will be explored.

In the past, stochastic frontier production functions have been fitted for industries, but little progress has been made in fitting intra-industry stochastic production functions. By pooling cross-sectional data, a stochastic function can be estimated for each firm. Differences in industry functions have often been attributed to "technical" ineffficencies although the issue has never been studied systematically. Thus, this research hopes to make two contributions: to measure intra-industry (firm specific) stochastic production functions, and to explore what the estimation procedure is actually measuring.

The research will also look at how well the tileries are allocating inputs in the production process; whether the firms are using variable inputs such that the value of marginal product of each input is equal to its marginal factor cost. Measures to determine if tileries are combining variable inputs in a least cost manner are developed and estimated for the model. From these estimates, one can learn whether the tileries are using too much or too little of each variable input and whether these variable inputs are being combined efficiently.

In Chapter 2, the areas of study for the thesis are discussed as well as the Non-Farm Employment Project-Egypt, its goals and the findings from its research. In Chapter 3, the econometric literature pertinent to this study is reviewed, and the theoretical underpinnings of this thesis are developed. In Chapter 4, a fixed-effect Cobb-Douglas system is presented and generalized to include individual, firm-specific measures of differences in production and inefficiencies in allocating variable inputs. Alternative estimation procedures are described and discussed, and the panel data used in the analyses are discribed. Results from estimating the model are presented in Chapter 4, and, finally, a fixed effect Cobb-Douglas model developed by Schmidt (1984) is estimated using the Egyptian panel data. In Chapter 5, a description of all tileries in our sample is presented, and, following this, firm characteristics that are associated with the measures obtained in Chapter 4 are identified. Conclusions are given in Chapter 6.

CHAPTER II

FIELD RESEARCH AND DATA COLLECTION IN EGYPT

2.1 Description of Study Areas

The two governorates selected for study are different in a number of important ways. Kalyubiya is immediately adjacent to the greater Cairo urban area; in the new regionalization of the country, for planning purposes, the governorate as a whole is treated as a part of that metropolitan area. The biggest city in the governorate--Shubra El Khayma, with a population of about four hundred thousand--is just north of Cairo and is essentially an extension of that city. The governorate lies astride the main highway from Cairo to Alexandria; transportion and communication links to the outside are good.

The situation with regard to Fayoum is quite different. It is essentially a large oasis located 60 kilometers southeast of Cairo and is separated from the Nile river valley by 10-30 kilometers of desert. There are two main roads entering the Fayoum, one from Cairo and one from Beni Suef, and a railway system that connects the three largest towns in Fayoum to the Nile river valley. The oasis is irrigated by a canal, the **Bahr Yousef**, which brings water into the depression from the Nile. Although the transportation network within the Fayoum is poor, there is a good network between Fayoum City and Cairo; buses, taxis and trucks make that run frequently over a reasonably good road.

Table 1 provides comparative statistics on the two governorates. The population figures for Kalyubiya include the city of Shubra El Khayma, which is not covered in this study; excluding that city, the population is virtually the same (1.1-1.3 million) in each of the two governorate under study. Line 4 makes clear that Kalyubiya is far more developed than Fayoum in terms of private, larger scale manufacturing employment; on a per capita basis, the figure for Kalyubiya is some 4.5 times the level for Fayoum. On the other hand, population density is over 2.5 times as high in Kalyubiya (line 2). Line 3 shows that Kalyubiya is considerably more urbanized than Fayoum, reflecting in part the inclusion of Shubra El Khayma in these statistics for Kalyubiya. Lines 5 and 6 give some measures of welfare of the population of each governorate; they show that Kalyubiya has a higher literacy rate and a more extensive piped water supply. These figures suggest that, while the size of the total population under study is approximately the same in the two governorates, the level of urbanization, industrialization, and population density are all higher in Kalyubiya.

2.2 Phase I Survey[1]

The Phase I Survey had two major goals. The first was to provide comprehensive data concerning the extent and basic characteristics of small enterprises in the areas under study. The second was to provide the sample frame for the selection of particular industries and enterprises for the more detailed analysis in Phase II of the study.

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[1]Much of this section is taken from Badr, Seale, Mostafa, Sheikh, Davies, and Saidi (1982).

TABLE 1

Selected Characteristics of Governorates Under Study

		Fayoum	Kalyubiya
1.	Estimated Total Population, 1979 (000)	1,140	1,674
2.	Population Density: Population per Square Kilometer	557	1,439
3.	Rural Population as % of Total	76	59
4.	Private Manufacturing Employment, Firms With Ten or More Employees (1970/71)	1,727	11,511
5.	Literacy Rate	26	46
6.	Availability of Piped Water	12	20

Sources and Definitions:

1. CAPMAS estimates
2. 1976 Population Census
3. 1976 Population Census
4. CAPMAS estimates
5. Percentage of the total population of the governorate recorded as literarte, in 1976 populaton census.
6. Percentage of the total population of the governorate with piped water in the building where they reside, as recorded in 1976 housing census.

2.2.1 Questionnaire Content

The survey instrument comprised the two sides of one mark-sense computer card. After identifying the respondent (name, location, primary and secondary products produced), nine questions were asked: the form of ownership of the firm; the sex of the owner; the location of the workshop and the type of building in which it is housed; the work force; the number of machines in use, value of the most sophisticated machine, the total value of all machines and tools, and the use of power; and the seasonality of production. A more detailed paraphrasing of the questionnaire is provided in Appendix A.

2.2.2 Industry Coverage

The central focus of the survey was on small manufacturing firms. Small was defined as any firm with 50 or less employees; larger establishments were not enumerated. Mobile or itinerant producers--those without any fixed place of work--were also excluded from the survey. Manufacturing was defined to include all industry groups covered in the International Standard Industrial Classification of All Economic Activities (ISIC) codes 31-39, a somewhat restricted definition of manufacturing; in addition, the coverage was extended to cover ISIC code 951, relating to the repair of manufactured goods. It was felt that, in the Egyptian context, such repair shops are often engaged in manufacturing activities as well. This classification scheme is also consistent with the system that has been used in most published Egyptian censuses. The enumeration also covered laundries, barber and beauty shops, photographic studios, painters, and construction enterprises, although information from these five industries are not included in any of the tables except in the addendum to Table 2. Similarly, it was decided after some discussion to include producers of **fool** and **taamiya** in the survey; these enterprises could be considered as either producers of food products (manufacturers) or as restaurants (producers of services). Again, these producers are shown separately in the addendum to Table 2 below, but are excluded from all other tables.

2.2.3 Sampling Approach

The basic sampling approach was one of stratified random sampling within clusters. The clustering was done by villages and towns, and the strata were defined in terms of the population of the various villages or towns. This basic approach was applied somewhat differently in the two governorates.

In the Fayoum governorate, a distinction was made in sampling among towns (defined as any place which is a seat of government at a district, governorate, or national level) and villages (all other locations). Fayoum has five towns, ranging in population from 19,671 to 166,910. All five of these towns were enumerated. With regard to villages, it became evident during the familiarization phase of the study that certain villages were specialized in producing one main nonagricultural commodity. In these villages, a significantly larger percentage of the working population is involved in small-scale manufacturing than in those villages which are not specialized. Drawing upon the local knowledge of team members and others, all Fayoum villages were classified as either specialized or nonspecialized. The villages were then further stratified by population size.

From the 156 total villages in the Fayoum Governorate, 143 villages were classified as nonspecialized and thirteen were classified as specialized. All of the specialized villages were enumerated. The nonspecialized villages were further stratified by population size. Within each stratum, villages were selected randomly, and the stratum sampling fractions were increased as population size increased, reflecting the general finding that small villages are rather homogeneous while differences among villages within stratum increase as population size increases.

In Kalyubiya, the sampling approach was somewhat different. Executives of village councils were asked to fill out a brief questionnaire providing information about the extent of nonfarm activities in their jurisdictions. The results of this questionnaire showed no clear need for the treatment of certain villages as specialized. Also, while it was clear that commercial activities and services increased in the towns, it was not clear that manufacturing would differ between towns and large villages. The Kalyubiya survey, then, stratified all localities--villages as well as towns--by population.

The last locality drawn in the random sample in each of two strata in Kalyubiya (3,000-5,999 and 12,000-19,999) was replaced by a locality of similar size known to have had substantial government efforts directed at small enterprises through cooperatives. The survey results suggest that these efforts were neither particularly large nor particularly effective. On the other hand, Shubra El Khayma, a large and highly industrialized area on the northern border of Cairo containing both large and small firms, was excluded from the sample frame and from the survey.

Table 2 shows the resulting pattern of localities selected for sampling. Within any locality selected--village or town--100% of the

TABLE 2

Total Number of Villages and Towns in Fayoum and Kalubiya and in the Sample

	Size of Locality (Population)						
	0-2999	3000-5999	6000-11999	12000-19999	20000-29999	40000+	Total
FAYOUM							
Specialized Villages:							
Total No. of Villages	0	5	4	4	0	0	13
Villages Selected	0	5	4	4	0	0	13
Sampling Percentage	-	100%	100%	100%	-	-	100%
Non-Specialized Villages:							
Total No. of Villages	51	48	34	9	1	0	143
Villages Selected	5	5	5	3	1	0	19
Sampling Percentage	10%	10%	15%	33%	100%	-	13%
Towns:							
Total No. of Towns	0	0	0	1	2	2	5
Towns Selected	-	-	-	1	2	2	100%
Sampling Percentage	-	-	-	100%	100%	100%	100%
Total, Villages & Towns:							
Total No.	51	53	38	14	3	2	161
No. Selected	5	10	9	8	3	2	37
Sampling Percentage	10%	19%	24%	57%	100%	100%	23%
KALYUBIYA							
Total, Villages and Towns:							
Total No.	60	60	47	16	8	2	193
No. Selected	12	12	10	6	4	2	46
Sampling Percentage	20%	20%	21%	40%	50%	100%	24%

Source: Survey Data, Phase I.

small-scale enterprises were enumerated. In Fayoum City and most of the towns of Kalyubiya, this involved having the enumerator walk down each street or lane, asking about small enterprises if he had reason to suspect their existence. In the villages of both governorates and in all the towns of Fayoum except Fayoum City, the enumerators approached each household asking whether any manufacturing activities were taking place there.

Phase I survey results have been "blown up" using the inverse of these sampling proportions, so they reflect the whole governorate (or in the case of Kalyubiya, the whole governorate excluding Shubra El Khayma). The actual number of enterprises sampled by stratum and the sampling proportion inverses are presented in Table 3 below. The names of the villages selected in the Phase I Survey and their populations are reported in Appendix B.

2.2.4 Enumeration Procedure

The enumeration began in early April, 1981, and was completed in late July of that year. The enumerators for the Phase I survey included both high school and college graduates, both male and female. They were carefully trained and took part in both pre-testing of the questionnaire and in field trials of the final survey instrument which was administered to people not in the Phase I sample. In general, the enumerators were a well motivated and well trained group.

In both governorates, before enumerating a village or town, the **omda** (mayor) or the local council members were contacted and informed of the purpose of the survey and introduced to the professional staff and the enumerators. Their support, which was offered freely in almost every case, gave credibility to our project and facilitated our work.

TABLE 3

Sampled and Estimated Total Number of Enterprises and Employees in Fayoum and Kalyubiya - 1981

	Sampled Enterprises			Estimated Enterprises			
	No. of Enter-prises	Employ-ment	Sampling Proportion Inverse	No. of Enter-prises	Employ-ment	Employ-ment per Enter	Emp./100 Pop.
Province and Location Size							
FAYOUM:							
0- 2,999	772	891	10.13	7,891	8,472	1.1	10
3,000- 5,999	3,452	3,869	4.76	16,429	17,586	1.1	8
6,000- 11,999	5,385	6,396	2.58	13,916	16,955	1.2	6
12,000- 19,999	9,054	11,229	1.39	12,544	15,671	1.2	10
20,000- 39,000	3,686	4,948	1.00	3,686	4,948	1.3	6
40,000+	2,818	7,487	1.00	2,818	7,487	2.7	4
TOTAL	25,167	34,820	2.27	57,212	71,119	1.2	7
KALYUBIYA:							
0- 2,999	1,624	2,752	4.76	7,730	13,152	1.7	11
3,000- 5,999	1,981	3,076	5.10	10,108	15,356	1.5	6
6,000- 11,999	1,738	3,111	4.76	8,273	14,809	1.8	3
12,000- 19,999	2,880	4,798	2.50	7,220	12,078	1.7	5
20,000- 39,999	1,364	3,429	2.00	2,728	6,858	2.5	3
40,000+	1,064	3,900	1.00	1,064	3,900	3.7	2
TOTAL	10,651	21,066	3.49	37,123	66,153	1.8	5
GRAND TOTAL	35,818	55,886	2.63	94,335	137,272	1.5	6

Source: Survey Data, Phase I.

2.2.5 Card Printing and Processing Procedure

After the questionnaires had been tested in the field and then revised, they were sent to East Lansing, Michigan for printing. When the original number proved inadequate, a second printing was done in Cairo, with sufficiently satisfactory results to be able to read the information recorded on the cards into the microcomputer.

The original processing of the survey results was done largely by hand, as the delayed arrival of the card reader, microcomputer and printer all precluded processing rapidly enough to keep the following stages of project work on schedule. Subsequently, however, all Phase I survey results were processed through the project's microcomputer in Egypt; all the compilation, cross-tabulations and adjustments to move from sample to population universe figures were estimated making use of that equipment.

2.2.6 Phase I Results

The first phase of our study, undertaken between April and July of 1981, was designed to provide an overview of small enterprises in the two governorates under examination. Tables 3-5 summarize the major findings in terms of numbers of enterprises and employment by locality size, by industry group, and by employment categories. Among the major findings of this first phase of the study are the following:

a) The numbers involved are large: 94,000 establishments, employing nearly 140,000 people, in the two governorates combined. Approximately one person in fifteen in the total population of the governorates--men, women, and children--is involved at least on a part-time basis in small manufacturing activities.

As indicated in Table 3, these activities are widely dispersed in different-sized localities. On a per capita basis, they are most heavily concentrated in smaller communities. The industry composition differs widely by locality size: in smaller villages, the main activities are household-based (e.g., dairy products, knitting of hats, embroidery, making baskets), while in larger locations they are more sophisticated, often with hired workers and more capital invested. Even within one industry, product lines change as one goes from smaller to larger localities: in smaller villages, tailors and dressmakers make the same traditional outfits year after year, while urban firms make more modern clothes, with annual style changes.

b) The average firm size is small: 1.5 workers per establishment, including owners and family members. Nearly sixty percent of all establishments had only one worker; less than one percent had ten or more workers. Again, this differed somewhat by location and even more clearly by industry type, but the overwhelming characteristic is one of many small, privately owned firms. Over ninety-nine percent of all firms with less than forty-nine workers are privately owned.

c) The composition of small-scale industries is detailed in Table 4. Perhaps the most striking feature is the dominant role of makers of dairy production; in each of the two governorates, over 50% of all reported employment is in this activity, generally involving the making of butter and cheese in villages, partly for own consumption, partly for sale. Aside from dairy products, over 40% of all small enterprise employment is in textiles, broadly defined: tailors and dressmakers, needlework and knitting, spinning, the making of mats, rugs, fish nets, and a variety of related activities. The third largest group, with 20 percent of total employment excluding dairy products, is wood products: crates, baskets made from henna branches, furniture, doors and windows. This is followed by other food products (primarily butchers and bakers). Other activities are smaller in the aggregate, although they may be quite important either in particular locations (e.g., bricks), in terms of their backward and forward linkages (e.g., blacksmiths and welders, essential oils), or in terms of their growth potential (e.g., cement floor tiles, machine shops, repairs).

d) Women constitute a significant part of the small-scale industry labor force in the two governorates. The labor force data in Table 5 again show the preponderance of workers in dairy enterprises, where most of the work connected with the production and sale of dairy products is done by females. Women are important in other industry groups as well, making up over 30% of the work force in all industries other than dairy products. Women comprise nearly 50% of the work force in the textile subsectors and are important in Fayoum in the production of a variety of palm products included in the wood products category.

From a different perspective, family members dominate the labor profile. Virtually all workers in the dairy products industry, for example, are family members. Aside from that subsector, family members comprise nearly sixty-five percent of the total work force; just over a quarter are hired workers, with the remaining nine percent being apprentices. Both hired workers and apprentices are more heavily concentrated in particular industries: textiles, wood products, tiles, and other food products. These highlighted findings as well as other aspects of the Phase I survey results are discussed in more detail in Badr, Seale, Mostafa, Sheikh, Davies, and Saidi (1982).

TABLE 4

Distribution of Estimated Total of Enterprises and Employment in Fayoum and Kalyubiya by Industry - 1981

Subsectors	Fayoum		Kalyubiya	
	Number of Enterprises	Employment	Number of Enterprises	Employment
Food:				
Dairy Products	36,555	37,622	23,415	34,519
Bakeries	133	1,042	165	1,213
Butchers	986	1,477	806	1,466
Flour and Rice Mills	84	313	90	345
Other Food Products	160	311	623	1,575
TOTAL	37,918	40,765	25,099	39,118
Textiles, Leather, and Wearing Apparel:				
Tailors, Dressmakers	4,095	5,568	4,594	7,831
Clothmaking	196	280	176	776
Knitting by Machines	22	22	109	272
Needlework, Hand Knitting	2,131	2,320	552	716
Spinning, including Ropes	2,560	2,832	305	711
Rugs	34	192	259	1,193
Mats	832	1,705	341	1,020
Shoemaking, Repair	293	459	506	799
Fish Nets	673	1,417	0	0
Other Textiles	84	152	113	248
TOTAL	10,920	14,938	6,955	13,566
Wood Products:				
Furniture	642	1,659	422	1,084
Doors and Windows	403	701	671	1,254
Agricultural Tools	174	290	62	25
Baskets, Crates and Rafia Hats	4,314	5,079	364	1,539
Other Wood Products	54	150	224	990
TOTAL	5,589	7,879	1,743	4,962
Paper and Printing:				
TOTAL	30	146	32	92
Chemicals:				
Essential Oils	62	693	4	116
Other	96	179	11	53
TOTAL	158	872	15	169
Non-metallic Minerals:				
Tiles	22	154	130	742
Mud Bricks	740	1,025	112	155
Red Bricks	29	663	51	774
Other	535	1,720	155	352
TOTAL	1,326	3,562	448	2,023
Metal Products:				
Blacksmiths and Welders	192	579	544	1,376
Machine Shops	38	131	84	247
Other	141	250	360	602
TOTAL	371	960	988	2,225
Other Manufactures:				
TOTAL	62	126	9	17
Repairs:				
Electric Appliances	254	463	252	324
Automobiles	250	714	667	2,065
Bicycles	146	281	263	517
Other	188	413	652	1,075
TOTAL	838	1,871	1,834	3,981
GRAND TOTAL	57,212	71,119	37,123	66,153
Addendum:				
Other Services	1,308	1,711	2,814	5,246
Fool and Ta'miya	658	926	672	1,469

Source: Survey Data, Phase I

TABLE 5

Estimated Total Employment in Fayoum and Kalyubiya by Sex and Employment Category - 1981

	Males	Females	Total	Family	Hired	Apprentice
FAYOUM						
Food: Dairy Products	276	37,346	37,622	37,556	50	16
Other Food	2,978	165	3,143	1,695	1,182	266
Total Food	3,254	37,511	40,765	39,251	1,232	282
Textiles	6,982	7,955	14,938	12,971	1,339	628
Wood Products	4,071	3,808	7,879	6,234	1,040	605
Paper and Printing	105	41	146	51	46	49
Chemicals	828	44	872	213	610	49
Non-metallic Minerals	3,026	536	3,562	1,742	1,549	271
Metal Products	953	7	960	471	320	169
Other Manufactures	108	18	126	104	18	4
Repairs	1,857	14	1,871	1,033	477	361
Subtotal, excluding Dairy	20,909	12,588	33,497	24,514	6,581	2,402
Province Total	21,185	49,934	71,119	62,070	6,631	2,418
KALYUBIYA						
Food: Dairy Products	472	34,047	34,519	34,168	235	116
Other Food	3,669	930	4,599	2,805	1,658	136
Total Food	4,141	34,977	39,118	36,973	1,893	252
Textiles	7,794	5,772	13,566	8,275	3,439	1,852
Wood Products	4,829	133	4,962	2,399	2,227	336
Paper and Printing	83	9	92	38	50	4
Chemicals	167	2	169	24	137	8
Non-metallic Minerals	1,911	112	2,023	560	1,317	146
Metal Products	2,201	24	2,225	1,152	861	212
Other Manufactures	17	0	17	10	4	3
Repairs	3,960	21	3,981	2,196	1,230	555
Subtotal, excluding Dairy	24,631	7,003	31,634	17,459	10,923	3,252
Province Total	25,103	41,050	66,153	51,627	11,158	3,368
GRAND TOTAL, BOTH PROVINCES						
Excluding Dairy Products	45,540	19,591	65,131	41,973	17,504	5,654
Including Dairy Products	46,288	90,984	137,272	113,697	17,789	5,786

Source: Survey Data, Phase I

2.3 <u>Phase II Survey</u>

The goals of the Phase II survey are four:

1) to determine the "big picture" of small enterprises in selected locations in Egypt: the number of firms, the levels of employment, and some basic enterprise characteristics by industry group;

2) to examine in more detail a sample of firms in selected industries in order to determine their production and distribution patterns, their economic viability, their constraints, and their potential for future growth;

3) to suggest to the Government of the Arab Republic of Egypt and to the United States Agency for International Development the types of policies, programs, and projects that might effectively support the development of small enterprises in these areas;

4) to collect longitudinal data in order to estimate production functions and to perform other empirical analyses.

2.3.1 Industry and Firm Selection

The Phase I survey provided an overview of small enterprises in the two governorates under study. In order to understand the production and marketing patterns, the economic viability, as well as the problems and growth potential of these producters, a sample of firms and industries was selected for more detailed analysis. To make this selection on an informed basis, the researchers on the project undertook preliminary interviews with assorted producers and merchants in a number of different industries to determine which industries to include in the more detailed Phase II study. Following discussion among the researchers and with informed outsiders, thirteen industries were selected for

TABLE 6

Industries Covered in Phase II Survey - 1982

Project Code Number	Industry	Abbreviation in Subsequent Tables	Main Products or Activities	Fayoum: Total Number of Enterprises: in Phase II Sample	Fayoum: Total Number of Enterprises: in Governorate (from Phase I Survey)	Fayoum: Total Employment in Governorate (from Phase I Survey)	Kalyubiya: Total Number of Enterprises: in Phase II Sample	Kalyubiya: Total Number of Enterprises: in Governorate (from Phase I Survey)	Kalyubiya: Total Employment in Governorate (from Phase I Survey)
1	Rugs	Ru	Tied (not woven) rugs	5	34	192	13	259	1,193
2	Tiles	Ti	Cement floor tiles	8	22	154	13	130	742
3	Dairy Products	Da	Butter and cheese	32	36,555	37,622	19	23,415	34,519
5	Embroidery	Em	Embroidered garments	10	939	1,078	6	107	267
6	Mats	Ma	Reed mats	16	832	1,705	16	341	1,020
7	Tailors	Ta	Gallabiyas, Suits, Shirts	15	1,420	2,551	31	1,739	3,509
8	Dress-makers	Dr	Dresses	13	2,675	3,017	34	2,855	4,322
9	Shoes	Sh	Assembly of shoe parts; making, repair	16	293	459	33	506	799
10	Furniture	Fu	Living room, dining room, bedroom furniture	21	642	1,659	19	422	1,084
12	Hats	Ha	Knitted farmers' hats (taiyas)	22	1,191	1,243	0	0	0
13	Baskets	Ba	Reed (Fayoum) or henna (Kalyubiya) baskets	24	3,681[a]	3,874[a]	15	293	1,218
14	Machine Shops	MS	Repair, making of metal parts and products	11	38	131	19	84	247
15	Agricultural Implements	AI	Metal and wooden parts of hoes, plows, waterwheels, etc.	9	174	290	6	62	95
			Total, 13 industries	202	48,496	53,975	224	30,213	49,015
			Total, all industries		57,212	71,119		37,123	66,153

Notes: [a]The figures reflect all basket producers in Fayoum. The Phase II sample, however, only included the Fayoumi baskets, which represented 11 percent of the total.

Source: Survey data, Phase I and Phase II further analysis. As indicated in Table 6, these industries account for approximately seventy-five percent of all employment in small enterprises in the two governorates, as reported in the Phase I survey. The selection of particular firms to be included in the Phase II study was done by a process of random sampling, using the Phase I sample as universe.

There were some minor departures from purely random sampling. In Fayoum, a few isolated villages were eliminated from the sample frame, to reduce logistical problems. In Kalyubiya, since household dairy producers are widespread and are thought to be relatively homogeneous, they were selected last, from the universe of producers in villages where other producers had already been selected in the sample (thus avoiding the need for enumerators to go to any village solely to interview dairy producers). In both governorates, a few larger dairy products producers were nonrandomly selected and added to the sample to ensure a more complete picture of this industry.

2.3.2 Data Collection

Three types of information were collected from the thirteen industries chosen for detailed study in Phase II. They were as follows:

a) A regular longitudinal questionnaire was administered to each of 430 sample firms, either once or twice a week over one full year, from December 1981 to December 1982. The questionnaire used for this purpose included information on production and sales, current inputs purchased, and labor use. Information was collected and processed making use of mark-sense cards, a Chatsworth card reader, and a Radio Shack TRS-80 Model II microcomputer. Data collection involved approximately twenty s

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enumerators and two supervisors in each governorate, working full-time over the full period of the survey.

This extensive longitudinal collection of flow data was necessitated by the lack of reliable information concerning the seasonality of production over the course of the year, the virtual nonexistence of records among small producers, and the limited accuracy of their memory recall. These three factors together meant that one-shot surveys could provide only limited information of uncertain validity concerning production, employment and income flows over the course of a full year.

b) A second set of two questionnaires--approximately ten pages each-- was administered to these firms, during the period September-December 1982. These two special questionnairescovered information concerning the organization, management, and history of the enterprise; the owner/manager; the capital stock; market links and marketing patterns; the labor force and labor contracts; the producers' contacts with government and financial institutions; and problems and future prospects of the firm, as perceived by the owner.

c) With minor exceptions, each of the thirteen industries being studied in Phase II was the responsibility of one of the researchers associated with the project. This meant that in principle he was responsible for the supervision of the enumerators working in that industry, as well as for participating in both the regular interviewing process and in supplementary discussions with producers (both in and outside the sample) and with other knowledgeable people, to gain an understanding of the dynamics of that particular industry. While the depth of this understanding has varied from case to case, the result has been to provide a firmer grasp of the nature of the sector than could be gained simply by an analysis of statistics emerging from processed survey data.

2.4 Phase II Industries: An Overview[1]

This section will synthesize the findings on individual industries from the Phase II survey by classifying the studied industries into two main categories, household enterprises and micro enterprises, which will be defined below. Readers interested in a more detailed presentation of the Phase II results should see Davies, Seale, Mead, Badr, El Sheikh, and Saidi, "Small Enterprises in Egypt: A Study of Two Governorates", (1984).

Household enterprises have two defining characteristics: minimal uses of machinery and equipment, and skill levels of workers which are low or widely available. For working purposes, L.E. 50 per firm[2] (current replacement cost of machinery, equipment, and tools) has been used as a cut-off point for the first aspect: the specification in terms of skill levels must be less precise.

With regard to micro enterprises, these are set apart from household enterprises by their more complex production patterns, making use of more machinery and equipment (i.e., more than L.E 50) or (usually, and) a higher level of skills among the work force. The aspect which differentiates them from larger, more advanced and more complex organizational forms is their simple marketing system. In general, this

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[1]Much of the following material is from Mead, Davies, and Seale (1984).

[2]The currency units throughout this thesis are Egyptian pounds (L.E.). Since the exchange rate during this period was approximately L.E. 1 = US $1, they can also be thought of as US dollars.

is based on an arrangement whereby final consumers contact producers directly to place orders; production then takes place in response to these orders.

From these basic defining charactistics of the two producer types, several features follow. First, a summary of the result is given, but will subsequently be supported by data. With regard to household enterprises, the most important characteristics are the following:

a) Production in household enterprises relies primarily on family workers, most of whom are women, although in some industries men predominate. The work may be either on a part-time or a full-time basis, but is generally low-skilled, and uses virtually no capital. The work generally takes place within the home. Firms are small (in most cases, only one worker), with little or no specialization by task.

b) With these simple production technologies, the products made are generally correspondingly simple and of low quality.

c) With low and easily learned skills and only limited capital, there is easy entry into these product lines; partly as a result, returns to labor are quite low.

d) With low returns to labor, simple raw materials available from local sources, and virtually no capital, production costs are low; competition among producers means that product prices are correspondingly low.

e) Low-quality, low-price products are suitable for mass markets among low-income consumers. The result is that large quantities of these products are made and sold, supplying a significant portion of the consumption needs of low-income consumers. Markets may be segmented by location, but are extensive in the aggregate.

f) Large markets and labor-intensive production technologies mean that many people are involved in these production processes. While incomes per person or per hour are low, many people participate.

g) The markets in which household enterprises sell are threatened by increasing penetration of modern, factory-made goods. Improved transportation, the development of lower-cost, mass-produced products, and the increasing availability of such products throughout the country mean that the simpler products made by household enterprises have a hard time maintaining their market position.

h) Low levels of production skills, limited use of capital, and limited experience in marketing or production management mean that household enterprises have little capacity to adapt, modify or upgrade their product lines. Easy access to these production lines among large numbers of people with few employment options and limited job flexibility means stiff competition for problematic markets, which in turn means a threat of stagnant or falling returns per hour worked.

The prognosis for micro enterprises is substantially different. The primary characteristics of this group of producers include the following.

a) With few exceptions (particularly for dressmakers), the entrepreneurs in these enterprises are men. In the aggregate, nearly a third of the labor hours are supplied by hired workers; these as well as the family members involved work an average of about forty-two hours per week. Most firms have more than one worker for at least part of the year; the average is two or more workers in six of the ten micro enterprise industries studied.

b) There is a substantial investment in machinery, equipment, and tools. Beyond this, firms in some micro industries hold substantial amounts of inventories, particularly of raw materials and semi-finished products. Production generally takes place in a workshop separate from the home.

c) Returns to the producer per hour or per year are substantially higher than for household enterprises.

d) The products made are more diverse than those produced by household enterprises. Some items, such as the products of village tailors, dressmakers, and shoemakers, continue to be consumed primarily by lower-income groups; others, such as furniture, cement floor tiles and machine shops, are designed primarily for higher-income consumers. The income elasticity of demand for these products varies from case to case, but on the whole it is generallly well above the level for products of household enterprises.

e) If the demand characteristics of these industries are more favorable that those of household enterprises, so also are the production conditions, particularly in terms of their capacity to respond to shifts in tastes and to new marketing opportunities. With somewhat higher levels of education and skills both in production and in management, many producers from this group have a substantially greater chance of taking advantage of and benefiting from any growth dynamic which exists in the country, being carried along by it rather than being swept aside.

f) For most micro enterprises, on the other hand, the marketing system remains quite simple. Most sell directly to a limited range of final consumers, often restricted to those in the immediate neighborhood of the producer. Often this marketing system is further simplified--but further restricted as well--by the fact that production takes place only on the basis of orders previously placed by final consumers.

These characteristics should be thought of as referring to individual firms or producers. Subsequent discussion--in particular, the data in the tables--focuses not on individual enterprises, but on industry averages. In most cases, the range within each industry is narrow enough so industry averages are a good reflection of the characteristics of individual firms within that industry; not only industry averages, then, but the great majority of the individual producers within each industry fit quite cleanly into one of the two categories. There are three partial exceptions.

a) In two industries studied--dairy products and embroidery--the sample included producers of two distinctly different types. One of these clearly fits the definition of household producers, while the other group uses substantially more capital and skills, and so should be considered as micro enterprises. In subsequent discussion and tables, we have divided these two industries into two components, to reflect this dichotomy.

b) There are two industries where the individual producers are reasonably homogenous within the industry, but where the industry averages might make them candidates for an intermediate or borderline category. Instead of creating an intermediate category, one should recognize that one of these (mats) is in many respects at the upper end of the household enterprise category, while another (dressmaking) is at the lower end of the micro enterprise category.

c) The small-scale floor tileries, which is the focus of this dissertation, represents a borderline case of a different type, being at the top end of the micro enterprise category. Particularly in terms of specialization of management, tile producers might be considered to be in a class by themselves among the Phase II sample of producers;[1] yet their other production and marketing characteristics are similar enough to other micro enterprises so that it is felt to be reasonable to include them with that group.

With this background, we will now examine in more detail the characteristic of these enterprises. In particular, we will look at questions of labor use (Section 2.4.1); capital (Section 2.4.2); marketing (Section 2.4.3); and income earned (Section 2.4.4).

2.4.1 Labor

Of the considerable information collected in the original study concerning labor use, we report here on six aspects: the sex of the owner/entrepreneur in the enterprise; the average number of workers per firm; the breakdown of labor time between family and hired workers; the extent to which the work is a part-time or full-time activity for the work force; the level of education of the owner/entrepreneur; and the total employment in these industries in the two governorates. Information is presented in Table 7.

The first column of the table makes clear that there is considerable concentration by sex of owner/operators in the two industry groups. Except for mats, household enterprises are largely in the hands of women; except for dressmakers, micro enterprises are virtually all

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[1]Family members in the floor tileries spent only 18% of their reported working time in production activities (as opposed to marketing, input procurement, supervision, repair, and other). For all other micro enterprises taken together, by contrast, an average of 80% of all working time is spent in production activities.

TABLE 7

Labor

	Sex of owner/entre-preneur (% males)	Average number of workers per enterprise	% breakdown of total hours worked			Average number of hours worked per person per week			Average number of years of education of entrepreneur	Total number of people involved, two gover-norates
			Family	Hired	Apprentice	Family	Hired	Apprentice		
Household enterprises										
Mats	95.8	2.1	77.6	17.9	4.6	46.4	45.8	42.9	0.5	2,463
Hats	0	1.0	100.0	---	---	40.3	---	---	1.4	1,191
Baskets	7.8	0.9	99.9	0.1	---	38.4	---	---	0.3	628
Dairy products	14.3	0.8	99.3	0.7	---	23.7	---	---	0.2	47,970
Embroidery	0	0.8	99.8	0.2	---	15.5	45.0	---	0.3	722
Average	15.2	0.8	98.9	1.0	0.1	26.8	45.8	42.9	0.2	52,974[a]
Micro enterprises										
Modern dairy	100.0	2.3	28.8	71.2	---	28.9	43.7	---	12.5	16
Modern embroidery	100.0	1.8	87.2	12.8	---	32.9	42.7	---	5.0	185
Tailors	100.0	2.0	59.9	37.5	2.6	47.1	41.7	43.9	4.1	6,318
Dressmakers	8.6	1.1	82.5	11.6	5.8	36.7	30.3	28.9	1.9	6.083
Shoemakers	97.7	1.4	83.9	16.1	---	46.8	47.0	---	3.0	1,119
Furniture	100.0	2.3	49.5	38.3	12.3	51.6	48.5	37.2	4.4	2,447
Rugs	97.7	na	19.7	69.0	11.3	na	na	na	3.6	na
Tiles	98.2	4.5	25.0	73.9	1.2	45.7	48.0	33.6	7.5	684
Machine shops	100.0	2.4	51.3	39.7	9.1	42.2	44.5	18.8	5.2	293
Agricultural implements	94.7	1.8	74.2	23.5	2.4	35.2	40.0	17.9	1.3	425
Average	63.8	1.6	70.5	24.5	5.1	42.3	42.7	33.5	3.0	17,570[a]

Source: Survey data, Phase II.

Note: [a]/Total

run by men. This division clearly reflects the low levels of skills, mobility, and access to investible funds among women in provincial towns and villages of Egypt.

Turning to questions of firm size and breakdown of labor supply between family and hired workers, mats again are something of an exception among household enterprises; except for that industry, the average firm size is one or less persons,[1] with virtually exclusive reliance on family labor. Mat production requires two people to work larger looms, so the average firm size is somewhat larger; while more than three quarters of the labor time in this industry is still supplied by family members, there is also some hiring of workers and apprentices from outside the family.

In the case of micro enterprises, the average firm employs 1.6 workers.[2] There is considerable variation around that average, ranging from 1.1 workers for dressmakers to 4.5 for cement floor tiles. In the smaller micro enterprise industries (those averaging less that two workers per firm), family workers supplied 70-90 percent of the labor time; among those averaging two or more workers, family members supplied 25-60 percent of the labor force. The survey information indicates that among enterprises with more than one worker, the second (or third) worker is frequently also a family member rather than simply someone hired from

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[1]The average is calculated as the number of workers reported each week, summed and divided by the number of weeks of the survey. Thus an average of one worker could mean either two workers for half the year and zero for the rest, or one person working each week for fifty-two weeks.

[2]In this and other cases in these tables, the averages by industry type (e.g., for all household enterprises taken together) are weighted averages, where the weights are estimated total numbers of producers (enterprises, or firms) in a particular industry in the two governorates.

the outside[1]. This is confirmed by responses to a separate question (not reported on here) which indicate that a substantial share of the workers in micro enterprises are family members of the owner/entrepreneur.

The next set of columns of Table 7 makes clear that there is considerable diversity concerning the extent to which these are full-time, as opposed to part-time activities. Among the household enterprises, mats, hats, and basket making might be considered as full-time occupations, while dairy products and embroidery are done on a part-time basis, in between other household chores. Hired workers in mat production seem to match the full-time work of the family members along side whom they work. There is considerable diversity in length of work among family members in micro enterprises. For some (e.g., agricultural implements), the shorter work week may reflect a limited demand for the product. In other cases, the primary explanation may be the involvement of the entrepreneur in other activities, either of a household nature (for dressmakers) or in other business activities (e.g., for modern dairy producers, many of whom operate urban grocery stores, so making dairy products is only a part of their total economic activity). In the case of hired workers, in every case but dressmakers these people work an average of at least forty-eight hours per week; in six of the ten micro industries listed, they work longer hours than the family members, often substantially so. Assuming a six-day work week, which is common among all small producers in Egypt, one finds that family members in furniture making have the longest average work day, at 8 1/2 hours per day; for

[1]For modern embroidery, for example, the information in the table concerning total employment, share of total working time supplied by family members, and average hours worked per week by each implies an average of 1.6 family members and 0.2 hired workers per enterprise.

micro enterprises as a whole, seven hours per day for family members and hired workers alike does not reflect sunup-to-sundown hours. Of course these are averages, but as such they do not suggest excessively long hours of work.

We have no satisfactory direct measure of skill levels in these industries. Imperfect and indirect measures include estimates of earnings (discussed below) and our own direct observations of the production processes and the skills which they require. A further indicator is the level of education of the entrepreneur. The next-to-last column of Table 8 shows that, among household enterprises, the entrepreneurs have an average of only 0.2 years of schooling. Among micro enterprises, there is considerable diversity, but the average is more than ten times this high. Education is only a partial indicator of skill levels, but it is consistent with other indicators which suggest a significantly higher skill level among micro enterprises than among household producers.

The last column of Table 7 gives an indication of the numbers of people engaged in small enterprise production among all establishments in these industries in the two governorates under study. The total population of the two governorates amounts to about 2.4 million persons (excluding Shubra El Khayma, which is not covered in the study), which suggests that nearly three percent of the total population of the two governorates--men, women, and children--are engaged at least part-time in small enterprise production in these thirteen industries. Over two-thirds of these people are women, reflecting the overwhelming dominance of dairy products producers, followed by micro enterprise dressmakers and producers in other household enterprises.

2.4.2 Capital

There are three dimensions of capital use which are of interest here: the location of the work place itself; the level of investment in machinery, equipment, and tools; and the level of inventories. Summary data are presented in Table 8.

With regard to the location of the work place, it is not surprising that with few exceptions the household enterprises are located in the home.[1] In the case of micro enterprises, only for dressmaking and rugs are the majority of producers located in the home. For the rest, the greatest number are in rented quarters. Only among producers of tiles, rugs, and dairy products are there significant numbers of micro enterprises in owned premises which are separate from the home. Rent control regulations are widespread in Egypt but are unevenly enforced, especially in rural areas. Where they are enforced, they have the effect of providing a subsidy to currently existing enterprises operating out of rent-controlled premises, but of making it more difficult for firms to move to larger or more suitable locations. It is hard to know what would happen to rental rates in an unregualted market. Our impression is that on balance the control regulations are hurting the small enterprises as a group, since the decreased mobility resulting from a reduced supply of rental space is more significant than the price subsidies enjoyed by by those who currently have access to such space.[2]

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[1]Note that this is not a part of the **definition** of household enterprises--despite the name!--but is something which emerges from the data.

[2]For further discussion of this issue, see Davies, Liedholm, Mead, Seale, and Strassman, "Choice of Location Among Small Enterprises in Egypt: Tailors and Shoemakers in Fayoum and Kalyubiya," April 1984 (mimeo).

TABLE 8

Capital

	Location of work place			Current replacement cost of machinery, equipment and tools	Inventories
	In the home	Separate Rented	Separate Owned		
	(% of all producers)			(Avg. per producer, in L.E.)	
Household enterprises					
Mats	94.2	5.8	0	48	35
Hats	100.0	0	0	5	0
Baskets	99.5	0.5	0	6	1
Dairy products	100.0	0	0	13	2
Embroidery	100.0	0	0	6	9
Average	99.9	0.1	0	13	2.5
Micro enterprises					
Modern dairy	14.3	57.1	28.6	671	649
Modern embroidery	0	100.0	0	1050	0
Tailors	20.2	75.4	4.9	339	17
Dressmakers	94.7	5.3	0	222	16
Shoemakers	10.1	82.9	7.0	221	225
Furniture	2.0	90.6	7.4	625	891
Rugs	65.5	13.3	20.2	1164	588
Tiles	7.9	60.2	32.0	2845	963
Machine shops	0	93.1	6.9	2555	6
Agricultural implements	45.4	46.5	8.1	464	105
Average	54.8	41.6	3.7	389	141

Source: Survey, Phase II.

Turning to the use of machinery, equipment, and tools among small producers, the gap between household and micro enterprises is striking and clear. Part of the definition of household enterprises is that they have, on average, less than L.E. 50 of machinery, equipment and tools; as the table makes clear, all but mats are well below this cut-off point. Among the micro enterprises, by contrast, the level of investment is many times this level. From the sample of 267 micro enterprise firms covered in the survey, eleven had machinery and equipment of over L.E. 4,000 (current replacement cost), while an additional twenty-five firms had investments of L.E. 2,000 or more. Cement floor tileries and machine shops were at the top of this list in terms of industry averages, while some individual furniture producers had comparably substantial investments in machinery and equipment.

The patern of inventory holding is significant as an indicator of the extent to which small enterprises need working capital for their operations. Table 8 reflects considerable diversity in this regard. Some enterprises such as floor tileries, furniture, modern dairy, and rugs reportedly hold quite substantial inventories, particularly of raw materials and semi-finished products, reflecting among other things the uncertainties and lack of assured availability of input supplies in these industries. The small inventories of tailors and dressmakers reflect the fact that these producers generally do not keep either raw materials or finished products in stock; the customer brings the cloth when he or she places an order and picks up the garment when it is completed. Diverse inventory levels in other industries are primarily a reflection of the varying extent to which this pattern is followed in other sectors.

2.4.3 Marketing

Table 9 indicates that marketing patterns for household enterprises are rather diverse. Some households produce primarily or exclusively on order, while others operate this way only rarely. Orders are received either from merchants or from final consumers. In some cases the customer supplies raw materials, but this practice is limited to certain industries among the household enterprise category.

Among firms in the micro enterprise group, there is considerably more homogeneity. The first column of Table 9 indicates that most industries in this category produce mostly in response to orders. The second section of the table makes clear that while some of these orders are placed by merchants (particularly for rugs and embroidery), by far the largest source of orders is the final consumer of the product. On the average, this source of demand accounts for fully ninety percent of the orders received by this group of producers.

The striking change in marketing patterns, from diversity in the household industries too much greater homogeneity in the micro enterprises, may be explained in terms of differences in the types of products made. If firms are not producing for a known customer who has placed an order, they must be producing for inventory for later sale to currently unknown customers. The reason why one method of marketing is chosen over the other lies primarily in the characteristics of the goods and the resulting effect on the inventories that must be maintained by the merchant in order to be able to sell to unknown customers.

Products from household industries are generally more homogeneous (and simple) in terms of units of quantity, informal grading, the number of characteristics embodied in the good, and the range of styles.

TABLE 9

Marketing Patterns

	% of all sales where production was under-taken in response to orders	Primary source of orders				Arrangements with buyers					
		one merchant	several merchants	final consumer	others, no orders	usually bring raw materials	sometimes bring raw materials	usually make cash down payment	sometimes make cash down payment	never do either	others, no orders
			(% of all firms)			(% of all firms)					
Household enterprises											
Mats	58.7	42.9	0	36.1	20.8	8.3	13.2	1.8	5.9	38.8	31.8
Hats	100.0	59.0	0	40.9	0	100.0	0	0	0	0	0
Baskets	14.1	14.6	5.9	2.6	76.8	1.6	0	15.3	0	4.7	78.4
Dairy products	14.0	2.0	0	46.8	51.2	2.0	0	0	2.4	24.9	70.7
Embroidery	75.2	0	0	75.7	24.3	36.4	36.4	3.0	0	0	24.3
Average	17.3	3.9	0.1	46.4	49.6	4.4	0.7	0.2	2.3	24.1	68.1
Micro enterprises											
Modern dairy	0	0	0	0	100.0	0	0	0	0	0	100.0
Modern embroidery	97.4	19.4	61.2	0	19.4	0	61.2	0	0	38.8	0
Tailors	92.4	0	0	98.3	1.6	78.8	0	3.3	11.2	4.9	1.6
Dressmakers	78.9	0	0	89.1	10.8	68.0	12.5	1.7	3.4	3.4	10.6
Shoemakers	78.8	0	2.0	91.0	6.9	2.0	9.2	30.1	24.7	27.0	6.9
Furniture	87.8	5.4	0	94.5	0	6.0	2.0	72.2	17.9	2.0	0
Rugs	30.1	68.1	0	31.8	0	50.0	0	0	20.3	29.5	0
Tiles	58.9	0	12.1	87.8	0	0	6.1	14.1	40.2	27.4	12.1
Machine shops	82.7	0	7.6	89.5	2.8	3.8	5.6	2.8	22.9	57.1	7.6
Agricultural implements	82.5	0	5.3	94.7	0	46.2	8.2	0	18.7	26.9	0
Average	82.3	2.4	1.0	90.2	6.5	57.5	7.7	10.8	9.8	7.7	6.4

Source: Survey data, Phase II.

Because of this homogeneity, any amount of product may be sold in the central market by anyone who can find a place to sit down. The amount of working capital required for producing in this way is modest, and can be expanded incrementally. In contrast, trying to sell from inventory the more heterogeneous and complicated goods that are produced by micro enterprises requires a substantially larger investment in inventories in order to make one sale. The entire array of possible products must be available to the customer so that he can make a choice. The fact that most micro enterprises sell on order is consistent with the idea that there is a systematic difference in the complexity of the goods between these two groups of producers, and that micro enterprise producers respond to this increasing complexity by utilizing an efficient, risk-adverse business strategy.

The final section of Table 9 indicates that for several of the micro enterprises, customers either supply raw materials (tailors, dressmakers, rugs, agricultural implements) or make a down payment when the order is placed (furniture; to a lesser extent, shoemakers and floor tileries). This pattern of input procurement can be quite helpful in meeting the working capital needs of small producers.

2.4.4 Income

Table 10 presents information concerning the value of production, value added, and income earned among small producers. The returns to the family are derived by deducting from the value of production all purchases of raw materials and intermediate inputs (including purchased services), wages paid to nonfamily workers, and an imputed cost of

TABLE 10

Value Added and Income

	Wage Rate per Hour Value of Production	Value Added	Net Returns to Family	(L.E. Per Person Per Hour)	Paid Family Members	Hired Workers	Apprentices	Total Value Added, Two Governorates
	(L.E. Per Firm Per Year)				(L.E.)	(L.E. 000)		
Household Enterprises								
Mats	1494	522	413	0.11	.05	.10	.04	612
Hats	58	56	55	0.02	.01	--	--	67
Baskets	426	176	173	0.08	--	--	--	123
Dairy products	298	54	49	0.08	--	--	--	3238
Embroidery	52	25	23	0.04	--	--	--	23
Average	313	63	57	0.08	0.03	0.10	0.04	4063
Micro enterprises								
Modern dairy	9964	2250	1761	1.38	--	0.12	--	16
Modern embroidery	1088	846	662	0.26	0.14	0.10	--	87
Tailors	2161	1923	1518	0.61	0.04	0.17	0.09	6075
Dressmakers	457	381	317	0.20	--	0.15	0.03	2107
Shoemakers	3137	1824	1592	0.56	0.09	0.26	--	1457
Furniture	8714	3926	2767	0.96	0.22	0.35	0.12	4177
Rugs	na	na	na	na	0.16	--	0.07	na
Tiles	28,464	14,497	11,235	4.99	--	0.39	0.11	2204
Machine shops	5236	3088	1890	0.70	0.04	0.34	0.10	376
Agricultural implements	3067	1863	1469	0.57	0.21	0.27	0.05	440
Average	2506	1557	1205	0.50	0.09	0.23	0.07	16.939

Source: Survey data, Phase II.

capital for machinery, equipment, and tools.[1] Data limitations make it impossible to make a similar deduction for inputed costs of land and buildings, so these are included along with estimated labor income under the heading, returns to family.

Looking first at household enterprises, it is clear that mat production supplies a fairly substantial income to mat-producing families. The L.E. 413 average may be put in perspective by indicating that a university graduate starting out in government service would earn a beginning salary of about L.E 420 (L.E. 35 per month). The low returns per hour in the next column for mat production, on the other hand, remind us that this substantial annual family income requires work by an average of 1.6 members, each working an average of forty-six hours per week throughout the year.

In fact, average returns to the family per hour of work are strikingly low for all household enterprises, ranging from L.E. 0.03 to 0.11 per hour. Because these activities require little capital and minimal skills, there is considerable ease of entry into these industries; competition among producers keeps returns exceedingly low. For comparative purposes, the wage rate of an unskilled agricultural laborer was L.E. 0.20-0.25 during this period (Hansen and Radwan, 1982); among household enterprises, only mat production approached even half that level. It is interesting to find that the hourly pay of hired workers in mat production is approximately equal to the net return to family members in the industry. In the case of dairy products, while net

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[1]Costs of capital are calculated using a capital recovery factor, $R = rv/(1-(1+r)^{-n})$ where v is the value of the asset, r is the discount rate, and n is the useful life of the asset in years. For the calculations reported here, r is taken to be 10%, n is assumed to be 15 years for machinery and equipment, and 7 years for tools.

returns per family per year and per hour are both quite low, the fact that so many households are engaged in this type of work means that over L.E. three million was earned by dairy producers in these two governorates, quite an important supplement to the income of rural households, particularly to rural women.

It is clear that micro enterprises generate substantially higher returns than household producers. Overall average returns per family (or per producer) per year for micro enterprises are some twenty times as high as for household enterprises. Even dressmakers, who make the least returns per family hour of work among the micro enterprises, have average net returns of L.E. 0.20 per family hour of work, almost twice as high as for mats which has the highest hourly return per family hour worked among the household enterprises. One reason for the higher returns among micro enterprises may be the skill or capital requirements, which impose barriers to entry into these enterprises. Competition is still there, in varying degrees, but the barriers do prevent an influx of people sufficient to drive incomes down to the levels earned in household industries. Even in the borderline case of dressmaking, in spite of the widespread availability of required production skills and limited requirements in terms of marketing abilities, the need for L.E. 100 or more for a sewing machine has kept returns well above what could be earned in making hats or household embroidery, for example, where skill levels are comparable, but capital requirements are much lower.

With regard to wage rates for hired workers, it is interesting to find that in almost every case paid family members earn returns well below those earned by hired workers. This could reflect "self-exploitation"; it could reflect the fact that family members also share in the family's net returns (they get room and board at the family table); or it could indicate that family members who are paid a wage are young people, who are less skilled than hired outsiders.

Wages for nonfamily hired workers in micro enterprises fall into two groups. For "modern" dairy, embroidery, tailors, and dressmakers, wages are low: L.E. 0.10-0.17 per hour, on the average. While these wages are above the range of returns for household enterprises, they are still well below the wage rates for unskilled agricultural workers. Low wages in these industries reflect the low skill levels of the workers, as well as (particularly for dressmaking and embroidery) the fact that the industry itself yields only low returns, even to the entrepreneurs.

The rest of the micro enterprises pay substantially higher wages, averaging L.E. 0.26-0.39 per hour. For all in this group except cement floor tile, hourly returns of hired workers are just under half the level earned by family members working in the industry. Among this group of micro enterprises, wage rates are about four times the average earning of family members in household enterprises.

The last column of Table 10 gives an estimate of total value added in these industries, among all producers in the two governorates under study. The figures make clear that although there are fewer people involved, micro enterprises contribute substantially more to the aggregate income of people in these governorates than household enterprises. Tailors, furniture, tiles, and dressmakers are each particularly important; the total for all firms in the ten micro enterprise industries in the two governorates is nearly L.E. 17 million.

CHAPTER III

THEORETICAL FRAMEWORK

There has been much interest in the measurement of frontier production functions since the pioneering work by Farrell (1957). Instead of measuring an "average" production function, many have felt that the frontier production function is closer to the theoretical concept of production in neoclassical economics, that is, each firm operates on the production function which allows the maximum amount of output from given quantities of productive inputs. As Stigler (1976,p. 214) points out, the above assertion is "a simple corollary of profit or utility maximization."

When a researcher estimates an "average" production function (e.g., estimation by ordinary least squares (OLS)), the implicit assumption is that all firms in the sample are producing on one function, the average function, and any deviation from this average function is due only to "noise" or random events not controllable by the firm. There are several reasons why the above may not be the case. If, for example, firms are using the same technology (i.e., the elasticities of the variable inputs are the same for every firm when the production function is a Cobb-Douglas function) but for some reason one firm's subproduction function is above or below another firm's, then measurement of an "average" production function by OLS may give biased results (Mundlak, 1961). Although not known as a proponent of frontier production function analysis, Stigler (1976, p. 215) has asserted that "in neoclassical economics, the producer is always at a production frontier, but his frontier may be above or below that of other producers."

Whether firms are producing on subproduction functions identical except for a neutral disembodied productivity differential is, in principle, a testable hypothesis. One problem in the past with testing this hypothesis has been due to the use of mathematical programming techniques that do not allow statistical tests; another has been due to the use of stochastic models that do not allow estimation of individual firm measures.

This study generalizes earlier models used in estimating frontier production functions and enables one to estimate "individual" firm subproduction functions that are the same for each firm (the elasticities of variable inputs are the same) except that subproduction functions of firms may be above or below that of other firms (a firm's intercept term from the production function can be different from that of other firms). If firm differences in production are found, then the obvious question to ask is what the causes or sources of these differences are. Many explanations can be given as to why one firm seems to produce more output than another firm from an apparently similar set of variable inputs. Advocates of frontier production analysis generally attribute differences among firms to differences in "technical" inefficiencies due to such factors as information deficiencies, adjustment cost, lags, and differences in management skill, effort, and will. Shapiro and Mueller (1977) have asserted that measured "technical" inefficiencies are due to misspecification of the model by leaving out relevant productive inputs such as information. Stigler (1976, p. 215) makes a similar argument stating that "the effects of these variation [technical inefficiencies] in output are all attributed to specific inputs... [sometimes] chiefly due to the differences in entrepreneurial capacity...Neoclasical economics...allocates the foregone product to some factor, so in turn the owner of that factor will be incited to allocate it correctly."

Recently, Johnson (1985a) has stated that frontier function advocates view the production frontier as the surface of a solid. According to Johnson, there are three views of the production function, none of which are comparable to a frontier function. These three views are as follows:

> 1. A production function is deterministic and stable and is viewed as a surface; the stability of nature insures that there can be no variation in output from identical sets of rigorously controlled inputs.
>
> 2. A production function can be stochastic with all differences in output from a rigorously specified set of inputs being the consequences of uncontrolled inputs varying at random; thus, all variation in output from its expected value is devoid of any efficiency meaning, whether technical or allocative.
>
> 3. A production function allows for observed "wild card" inliers and outliers because of gross nonrandom
>
>   (i) input or output aggregation errors or
>   (ii) failure of observed instances to conform to the specifications as to which inputs are fixed at what levels.

View one is what is used in economic theory; however, it is not generally appropriate for empirical analysis since the production process, in fact, is stochastic. View two is what an empiricist is striving for as an ideal when he is specifying a production function for empirical estimation. A rigorously specified subproduction function under the second view would indicate which factors of production are variable, which are fixed and at what level, and which are varying randomly with an expected value of zero. This rigorously specified subfunction will have both outliers and inliers that are due to randomness only; thus, it does not allow for systematic differences among firms. The third view allows for systematic differences among firms, but only because of mistakes made by the researcher in specifying the subfunction or in aggregating output or inputs.

Johnson holds that, except for stochastic variations, all firms in a panel should be rigorously specified as a part of a larger function. This larger function, view one, can be expressed as $Y = f(X_1, X_2, \ldots\ldots, X_t)$ where Y is output and the X's are all possible inputs, both fixed and unfixed, known and unknown, discovered and undiscovered. As Johnson points out, this function is probably unknown and unknowable. One possible subfunction of the above production function which corresponds to view two would be $Y = f(X_1, \ldots, X_n) + u$ where $X_1, \ldots, X_n$ are variable factors of production and $u = g(X_{n+1}, \ldots, X_t)$ with $X_{n+1}, \ldots, X_t$ being randomly distrubuted about $\underline{X}_i$, $i = n+1, \ldots, t$, such that $E(u) = 0$. Another specified subfunction of the overall production function is $Y = f(X_1, \ldots, X_g / X_{g+1} = C_{g+1}, \ldots, X_n = C_n) + u$ where Y is output, $X_1, \ldots, X_g$ are the known variable inputs, $X_{g+1}, \ldots, X_n$ are unknown inputs fixed at C_i where C_i is the same for each firm, $u = g(X_{n+1}, \ldots, X_t)$, and $X_{n+1}, \ldots, X_t$ are variables randomly distrubuted about their means, $\underline{X}_i$, for $i = n+1, \ldots, t$, such that $E(u) = 0$ and allowing for the possibility that for some $i = n+1, \ldots, t$, X_i may be equal to $X_j - E(X_j)$ for $j = g+1, \ldots, n$.

One can also envision the case where the subfunction is identical to the second subfunction above, except that C_i for $i = g+1, \ldots, n$ can be fixed at different levels for different firms. Johnson (1985b) allows for the C_i's to differ among firms, but says the differences are due to t

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the fact that the firms "do not conform stochastically to the specification of what factors are fixed at what levels, i.e., inputs which are specified to be fixed may actually vary nonstochastically from [firm to firm]." Firms with more than the specified amounts of the so-called fixed variables are outliers and those with less than the specified amounts will be inliers. To correct for this, Johnson says we should (1) only use those firms that adhere to our specifications in estimating a subproduction function and eliminate those that do not or (2) identify the offending inputs and treat them as variable inputs.

For the Cobb-Douglas function, view one is $y = aX_1^{b_1}\ldots X_t^{b_t}$. The first subproduction function as presented above that conforms to the second view of the production function is $Y = aX_1^{b_1}\ldots X_n^{b_n}$ as now $E(u) = 1$; the second subfunction which conforms to view two as presented above is $Y = AX_1^{b_1}\ldots X_g^{b_g}$ where $A = aC_{g+1}^{b_{g+1}}\ldots C_n^{b_n}$ as $E(u) = 1$ and C_i for $i = g+1,\ldots,n$ is the same for all firms. The first production function is not estimable, but the other two are estimable with ordinary least squares (OLS). When one makes allowances for the fact that the C_i's may differ among firms, we have potentially more than one subproduction function, up to as many as the number of firms in our panel data.

This author would suggest that, in empirical estimation, the possibility of not being able to specify the subproduction exactly, so that no systematic differences remain among firms, is quite common. For example, if differences in fact do remain among firms, then to specify the subproduction function as if those differences do not exist may (but not always) cause our estimates to be biased. If we are unwilling to throw out those firms that do not adhere to our specifications of the fixed variables being fixed at the same levels for all firms or are unable to identify the "offending" inputs to the point that we can consider them variable inputs, then an estimator such as the "within" estimator, which will be used in this dissertation for estimation purposed, may improve our estimates over those of OLS.

As misspecification is always a possibility, when one has panel data it will often be reasonable to specify and estimate one's subproduction function according to both views: there are no systematic differences among firms (the C_i's are the same for all firms), and there are systematic differences among firms (the C_i's may be different among firms). The first view is actually a restricted form of the second function, and one can construct an F-test to determine if allowing for differences among firms as to the explanatory power of our production function. Also, by using a Hausman (1978) test, one can determine whether the assumptions necessary to make OLS efficient are met (no specification errors) or whether the assumptions for the unrestricted view are more appropriate for the data being used in estimation.

The unrestricted specification, that systematic differences among firms may exists, is used in this dissertation when estimating subproduction functions for Egyptian small-scale tileries. If one interprets $X_{g+1},\ldots,X_n$ to be factors that affect "technical" inefficiency, then the specification is a composed error model similar to Aigner, Lovell, and Schmidt (1977) for cross-section data. For panel data, when one believes these variables to be fixed at nonzero levels (or correlated with the other regressors, $X_1,\ldots,X_g$), a fixed-effects model should be used in estimation;[1] if one believes these variables to be

[1]It is recognized that, if correlation exists between the fixed variables and those that are included in the model, the elasticity estimates will be imprecise (the larger the correlation, the more imprecise), but this problem also exists for the specification that does

random with nonzero means and to be uncorrelated with the other regressors in the model, a random effects model should be used. Our assumptions about what $X_{k+1},...,X_n$ are does not change the correct estimation procedure, but only the interpretation of the model and the results.

All the above arguments have more to do with the interpretation of the model and the results from estimating the model than with the construction of the model. Improved methods of measuring firm differences in output may bring us closer to understanding what these measured differences are and what causes the differences, especially if, as firm-specific measures are refined, research is directed toward explaining these differences. For example, according to the view that all firm differences in production must be due to aggregation errors, specification errors, or fixed factors being fixed at differenct levels for different firms, it should be possible in practice to estimate a subproduction function under view three and then to return to the firms and continue studying their production processes until one discovers the omitted variables or sources of error. Once this is done, one can enter these new variables into the subproduction function as specified in view two or make the necessary corrections for aggregation or measurement error and, if the specification is correct, all firm differences except those due to stochastic variations should disappear.

Before leaving this section, another point should be discussed. Some (though not all) advocates of frontier analysis assert that a firm can move from the interior of the production surface to the frontier

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not allow for systematic differences among firms as well as the problem of the estimates being biased.

without any cost to the firm. For example, Bagi and Huang (1983) in a study of farms in Tennessee found that, on average, the farms were approximately twenty-three percent "technically" inefficient in the cases of both crop and mixed farms. From these results, they wrongly assert that "through the efficient use of existing inputs the farm output can be increased by almost 23 percent without any additional cost to the farmers."

Johnson suggests that if a firm's subproduction function is different from that of another firm's, it must invest in more fixed inputs to shift upward or disinvest to shift its subproduction function downward. Whether a firm should shift upward or downward depends on the costs and benefits of making such shifts. If the firm is investing, acquisition prices are the appropriate prices to use in making the decision; if it is disinvesting, salvage prices are the appropriate prices to use. In some cases, it will pay the firm to shift its subproduction function while in others it does not.[1]

This author feels that the views of "technical" efficiency advocates and nonadvocates are reconcilable. Both these views allow the output levels of the production process to differ by firms using the same measured bundle of variable inputs, though they attribute the variation to different causes. One view is that differences are due to "technical" efficiency; another is that it is due to fixed factors being fixed at different levels for different firms. If the management skills of the entrepreneur affect the production process and two firms have different skill levels of management, the differences in output given the same

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[1]See Edwards (1958) for a more complete exposition of this theory.

bundle of variable inputs are attributed to "technical" efficiency by the "technical" efficiency advocates and to fixed factors (management skill) being fixed at different levels by the fixed variables advocates. One almost feels that the differences are more semantic than substantive. What is more crucial is whether these differences can be "corrected" freely as some "technical" efficiency advocates suggest, or whether there is a cost involved on the part of the firm in removing these differences. Johnson points out that free correction is usually unrealistic. Shifts among subproduction functions are not ordinarily "free". He states that, since prices and costs must be considered when deciding whether a shift among subproduction functions pays (benefits outweigh costs), the "distinction between technical and price or allocative efficiency evaporates as price allocation is clearly involved in the case of so-called technical efficiency."

This author would differ slightly and claim there may be two sources of "inefficiency": one where a firm is allocating its **variable** inputs wrongly given its prices for these inputs; the other due to fixed factors being fixed at different levels for different firms, factors such as management skill, technological "know-how" (learned from experience), and information. For example, for a complex production process, the entrepreneur with more education than other entrepreneurs may have an advantage in assimilating and using the necessary technology and, from the same bundle of measured variable inputs, can produce more measured output than other firms. The more educated entrepreneur may also have an advantage in searching for, learning, and using information which can make the firm more productive.

Also, an entrepreneur with more experience than another entrepreneur may have learned ways to speed up the production process. In the production of tiles, the experienced entrepreneur may have learned that by relocating tiles stacking racks two steps closer to the tile presses, one can increase the hourly production of tiles in his firm by a square meter, or, by monitoring the weather closely, he can make decisions to shorten the soaking or drying step in producing tiles by several hours to a full day. As an entrepreneur gains more experience, he may be able to more often mix raw materials such as sand, water, and cement in the optimal manner to minimize waste and production of the wrong tile type. Adjustment lags in allocating factors (both fixed and variable) in response to changes in relative prices, changes in the demand for the product or product types, or changes necessary to correct past mistakes may also be of differing lengths among firms and cause some firms to produce more measured output from the same set of measured variable inputs. Once the above inefficiencies have been identified, the decision to "correct" for them is an allocative decision; however, the distinction among sources of inefficiencies should remain.

The remaining sections of this chapter will survey the development of deterministic non-parametric frontiers, deterministic parametric frontiers, stochastic frontiers, and frontier systems which attempt to estimate "technical" as contrasted to "allocative" efficiency. In reviewing this literature, the author is not expousing the view of "technical" efficiency, but presents this literature more for its contribution to econometric estimation, since the two models to be estimated in this thesis are an outgrowth of this literature as well as the econometric literature on panel data.

3.1 Deterministic Non-parametric Frontiers

Although earlier authors have developed models to measure "technical" inefficiency (Marschak and Andrews, 1944; Hoch, 1955), Farrell (1957) is considered to be the first researcher to measure "technical" inefficiency relative to a frontier production function (or a frontier unit isoquant). In Farrell's well-known procedure, he hypothesizes that efficiency can be divided into two components, "technical" efficiency and "price" efficiency, and that these components can be summed into overall "productive" efficiency.

Farrell uses linear programing to construct a frontier unit isoquant by constraining all observations to lie on or above the unit isoquant. The distance that an observation is from the unit isoquant is attributed to "technical" inefficiency and can be measured by drawing a straight line from the axis to the observation and then by dividing the distance from the axis to the unit isoquant by the distance from the axis to the observation. "Price" efficiency is assumed to be independent of "technical" efficiency and is the ability to allocate productive inputs according to their opportunity costs. Given relative factor prices, an isocost line can be constructed that is tangent to the unit isoquant line and intersects a line from the axis to an observation. Price efficiency for a particular observation can be measured by dividing the distance from the axis to the intersection of the isocost line with the line from the axis to the observation by the distance from the axis to the unit isoquant line along the same straight ray. Overall productive efficiency is measured by dividing the distance from the axis to the intersection of the isocost line with the straight line from the axis to the observation by the distance along the ray from the axis to the observation.

Although Farrell's technique has the advantage of not imposing a functional form on the data and the ability to calculate "technical" efficiency measures for individual observations (firms), it is still considered by many production frontier advocates to be overly restrictive. Assumptions that must be maintained are constant returns to scale, free disposability of inputs, and all variations in output being attributed to "technical" inefficiency. There is no relationship among observations except that they must lie within a frontier isoquant and, as the method does not use the entire sample to compute the frontier, it is highly sensitive to extreme observations and measurement error. Another major weakness is that the efficiency measures are not statistical in the sense that no standard errors or t-ratios can be computed; thus, hypotheses about the measures can not be tested statistically.

The "data envelopment analysis" (DEA) technique developed by Charnes, Cooper, Rhodes and their colleagues as well as by Fare and his colleagues is a further refinement of Farrell's pure programming technique. This approach essentially uses a sequence of linear programs to construct a transformation frontier and to compute "technical" (primal) and "allocative" (dual) efficiency àla Farrell relative to the frontier.[1] The first of the three steps in the procedure is to construct an input set which satisfies necessary conditions to ensure a "well-behaved" technology. Often further restrictions, strong input and output disposibility, are imposed on the input set. The second step is to solve the Farrell "technical" efficiency measure for each production unit in the sample by solving a minimizing programming problem. The

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[1]See Lovell and Schmidt (1983) for an excellent and more detailed summary of DEA.

third step is to compute the minimum cost for each production unit in the sample by solving another minimizing programming problem. This third step computes measures of what Farrell called "price" efficiency and "economic" efficiency, the latter a composite measure of "technical" and "price" efficiency.

The input set constructed above will be nonparametric, and the data set is enveloped or bounded by a convex weak-disposal hull made up of a series of facets. It contains the smallest input set that includes all the observations from the sample and satisfy the conditions for a "well-behaved" technology. This "smallest" input set provides an upper bound of the "actual" efficiencies, but does not provide a corresponding lower bound.

Varian (1983) has shown necessary and sufficient conditions for an input set that "rationalizes" the data in that the data could have been generated by cost-minimizing behavior for that given input set. Further, he derives the tightest possible inner and outer bounds for any input set that "rationalizes" the data and finds that his inner bound is identical to the input set constructed by DEA. Banker and Maindiratta (1983) extend Varian's analysis to the case where the all the data in the sample could not have been generated from cost-minimizing behavior and then show how to identify the subset of data that does obey the conditions for rationalizability. As they show, the input set constructed by DEA "rationalizes" this subset of data, though this input set is not unique in the sense that it is not the only input set that can rationalize the subset of data; however, what has yet to be shown is the outer bounds for all input sets that rationalize the rationalizable data subset.

One of the most appealing aspects of DEA is that it constructs the input set that is the smallest well-behaved set containing all the data and is piecewise linear. Aside from certain technical problems with DEA that have to do with the radial nature of the Farrell measure of "technical" efficiency (as opposed to some type of nonradial measure), the technique does have major deficiencies. The entire deviation of an observation from the frontier is attributed to "technical" efficiency, taking no account of the possibility that the deviations, at least in part, may be the result of random shocks, measurement error, omitted variables (specification error), or fixed factors being fixed at different levels for different firms. In addition, since the technique is nonstatistical, it is not possible to make probabilistic statements about the shape or position of the frontier, nor can one construct statistical tests concerning the individual efficiency measures.

3.2 Deterministic Parametric Frontier Functions

Farrell proposed a method of computing a parametric convex hull of the observed input-output ratios, but it is Aigner and Chu (1968) who first use this method. Aigner and Chu specify a Cobb-Douglas functional form and require all observations to lie on or beneath the frontier production function by constraining each residual to be less than or equal to zero. Two estimation techniques are proposed: linear programming, which minimizes the sum of the absolute values of the residuals subject to the constraint that all residuals be nonpositive; and quadratic programming, which minimizes the sum of squared residuals subject to the constraint that all residuals be nonpositive.

Although this method imposes a functional form on the data, it has the ability to handle non-constant returns to scale, and it is still able to estimate individual efficiency measures for each observation (firm). Disadvantages to the approach are that it limits the number of observations that can be efficient to the number of parameters being estimated, that it only uses a subset of the data to measure the frontier which causes the estimated frontier to be highly sensitive to extreme observations and measurement error, that it attributes all variations among observations in output given a set of inputs to "technical" efficiency (including any measurement errors or random errors to output), and that the approach is nonstatistical in the sense that no standard errors or t-ratios are computed.

Recognizing the sensitivity of the estimated frontier function to extreme observations and measurement error, Aigner and Chu (1968) suggest and Timmer (1971) inplements an approach to "desensitize" the estimation. Timmer uses linear programming to estimate the frontier which is specified as a Cobb-Douglas function with the constraint that all residuals be nonpositive. Timmer proposes first estimating the frontier with one hundred per cent of the sample and then to reestimate the frontier with (100-P) per cent of the sample, with P prespecified.

Alternatively, Timmer suggests dropping the most efficient observations, one at a time, until the resulting estimated coefficients of the function stabilize. Criticisms to these methods are that the selection of P is arbitrary, that observations must be thrown out of the sample, that only as many efficient firms as there are parameters in the production function are allowed by this method, that the parameter estimates are still nonstatistical, and that the method is sensitive to outliers.

Recently, Kopp (1981) has shown that Farrell's input-based measures of "technical" efficiency can be generalized to deterministic parametric functions. He calculates, in addition to multiple-factor efficiencies, single-factor efficiency. Although recognizing that the same weaknesses of the method remain as discussed above, Kopp proposes this method whenever the researcher is interested in estimating individual efficiency measures as he believes that estimation of individual efficiency measures from stochastic frontier models are generally impossible.

3.3 Deterministic Statistical Frontier Functions

Afriat (1972) extends the model proposed by Aigner and Chu (1968) by assuming a distribution for the nonpositive residuals (which he calls efficiencies). This allows the model to be statistical in the sense that by explicitly assuming a distribution for the residuals the possibility of calculating standard errors and t-ratios exits. As a result, the estimated parameters of the model can at least be potentially tested by the usual statistical tests for significance. Afriat proposes a two parameter (mean and variance) beta distribution for the efficiencies (residuals) and suggests estimation by a maximum likelihood method.

In addition to assuming a beta distribution for the residuals, Afriat also suggests assuming a gamma or an exponential distribution. Richmond (1974) considers the model assuming a gamma distribution and shows that, by transforming the model slightly (subtracting the expected value of the error term from the intercept term and adding the expected value of the error term to the error term), OLS will give unbiased and consistent estimates of the slope coefficients as well as the mean of the residuals. Consider the model where

$$(1) \qquad Y_t = A \prod_{i=1}^{K} X_{it}^{b_i} u_t \qquad t=1,\ldots,T$$

and $u_t = \exp(-z_t)$ and the z_t's are assumed to be a random sample from a Gamma distribution. Then it can be shown that

$$(2) \qquad E(u) = \int_0^{\infty} \exp(-z) G(z;n) dx = 2^{-n}$$

where $E(z_t)=n$, $Var(z_t)=n$, and $Cov(z_t,z_s)=0$, $s \neq t$. Writing the model in logs, we have

$$(3) \qquad y_t = a + \sum_{i=1}^{K} b_i x_{it} - z_t$$

where $y_t=\ln Y_t$, $x_t=\ln X_t$, $a=\ln A$, and z_t is defined as above. Now letting $b_0=a-n$ and $v_t=n-z_t$, we have a model that can be estimated by OLS; that is,

$$(4) \qquad y_t = b_0 + \sum_{i=1}^{K} b_i x_{it} + v_{it}$$

where $E(v_t)=0$, $E(v_t^2)=n$, and $E(v_t,v_s)=0$, $s \neq t$. By also assuming $E(v/X)=0$, where $v'=(v_1,\ldots,v_T)$ and $X=(X_{it})$, it can be shown that an unbiased estimate of n is

$$(5) \qquad \hat{n} = \frac{1}{T - K - 1} \sum_{t=1}^{T} (y_t - \hat{b}_0 - \sum_{i=n}^{K} \hat{b}_i x_{it})^2.$$

From the above, it follows that $E(\hat{b}_0)=a-n$, $E(\hat{b}_i)=b_i$, and $E(\hat{n})=n$ for $(i=1,\ldots,K)$. It also follows that $\hat{b}_0 + \hat{n}$ is an unbiased estimate of a, that $\exp(\hat{b}_0+\hat{n})$ is an upward biased but consistent estimator of of A, and that $E(\hat{u})=E(2^{-\hat{n}})$ is an upward biased but consistent estimator of $E(u)=2^{-n}$. The estimate of the last term, E(u), gives us an estimate of the average level of efficiency for the population being estimated.

Schmidt (1976) shows that, by assuming the residuals are distributed exponentially, Aigner and Chu's linear programming technique is maximum likelihood, and that, by assuming the residuals are distributed half-normally, their quadratic programming technique is maximum likelihood. In addition, Schmidt shows that OLS gives unbiased and consistent estimates of the slope coefficients, but that the OLS estimate of the constant term is biased and inconsistent in a statistical sense; however, it should be noted that using corrected OLS (COLS) as suggested by Richmond will give consistent estimates of the intercept term.

Problems have been encountered when trying to estimate the statistical properties of the estimated parameters with maximum likelihood methods. Schmidt (1976) points out that the range of the dependent variable depends on the parameters being estimated, thus violating the usual conditions used in proving the consistency and efficiency of maximum likelihood estimates. Greene (1980a) shows that by assuming a gamma distribution for the residuals the usual asymptotic properties of the maximum likelihood estimators can be derived; however, distributions such as the truncated normal or the exponential distributions do not allow such calculations. The reason, as is shown by Greene, is that in order for the usual desirable asymptotic properties of maximum likelihood to hold, the density of u, the error term, must equal zero at zero and the derivative of the density of u with respect to its parameters must approach zero as u approaches zero. Since different distributional assumptions for the residuals lead to different estimates for the maximum likelihood estimators, the restriction on choice of distributional assumptions for the residuals is not a trivial matter. Also, these estimates are highly sensitive to outliers as are the previously discussed deterministic models.

Of course, COLS as proposed by Richmond (1974) can be used as an alternative to maximum likelihood estimators. However, even after correction for the OLS estimates, residuals may have the wrong sign (positive for a production frontier and negative for a cost frontier). Also, the correction for the OLS intercept is not independent of the distribution of the residuals, and different distributional assumptions lead to different estimates of average "technical" efficiency. Greene (1980a) suggests a remedy to the above problems by shifting the OLS constant term upward until all observations lie on or below the production frontier. This ensures that all residuals have the "correct" sign and does not allow distributional assumptions for the residuals to change the estimate of average "technical" efficiency. The problem of sensitivity to outliers, however, is not removed by using COLS ala Richmond or Greene.

3.4 Stochastic Frontiers

Much criticism has been leveled against deterministic frontier functions. Most economists have difficulty in believing that all variations in a firm's output given its input set are attributable to "technical" efficiency. After all, we live in a world full of uncertainty, and the luxury of knowing production processes exactly is not possible. Weather, unpredictable machinery breakdowns, and luck are just a few of the many factors that are not controllable by the firm. In addition, whenever empirical work is done, there is always the possibility of measurement error as well as specification error. Also, since these models constrain all observations to lie on or below the production frontier, they are highly sensitive to outliers. To lump all random and uncontrollable exogenous shocks to the firm's production process (as well as measurement error and specification error) under the heading of "technical" efficiency is not desirable.

Aigner, Amemiya, and Poirer (1976) address the above issues by proposing a weighting scheme to weight positive residuals less than negative residuals, specifically

$$(6) \qquad e_i = \begin{cases} \dfrac{e^*_i}{1-\Theta} & \text{if } e^*_i > 0 \\ & \qquad\qquad . \qquad i = 1,\ldots,n \\ \dfrac{e^*_i}{\Theta} & \text{if } e^*_i \leq 0 \end{cases}$$

where e^*_i is independently normally distributed with mean zero and variance σ^2 for $0 < \Theta < 1$, but is either negative or positive truncated normal for $\Theta = 1$ or $\Theta = 0$, repectively. Their justification for the above specification is that differences among firms in their production of output given productive inputs may be due to the inability of all firms to use the "best practice" technology which would call for a one-sided error distribution or may be due to either symmetric measurement error in output or the influence of an additive random and symmetric input which could cause the error term to be above or below zero. The term Θ is interpreted to be a measure of the relative variability of observations above or below zero. When $\Theta = 1$, the model becomes the deterministic parametric statistical frontier or "full frontier", and when $\Theta = 1/2$, it becomes the average function case.

A more direct and seemingly more reasonable approach to the above issues is taken by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). Both groups of authors explicitly acknowledge the possibility of shocks and other random factors outside the firm's control as well as the inability of some firms to produce on the frontier function because of factors that are controllable by the firm. Consider the following production model,

(7) $$Y_i = f(X_i;B)+e_i \qquad (i = 1,\ldots.,n)$$

where Y_i is the maximum amount of output obtainable from X_i, a vector of nonstochastic productive inputs for the i^{th} firm, and B is a vector of unknown parameters to be estimated. In addition we note that

(8) $$e_i = v_i + u_i \qquad i = 1,\ldots.,n$$

where v_i is the error component representing symmetric disturbances distributed normally with zero mean and variance σ_v^2. The error component u_i representing "technical" inefficiency is assumed to be independently distributed from v_i and less than or equal to zero. If $\sigma_v^2 = 0$, then the model collapses to the deterministic frontier model. If $\sigma_u^2 = 0$, then we have the stochastic production function proposed by Zellner, Kmenta, and Dreze (1966).

The composed error model can be estimated by assuming distributions for both u_i and v_i and applying a maximum likelihood method. Both Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977) estimate the model by assuming that v_i is normal with mean zero and variance σ_v^2 and that u_i is distributed exponentially. In addition, Aigner, Lovell, and Schmidt estimate the model assuming that u_i is distributed as a negative half-normal with mean zero and variance σ_u^2. Stevenson (1980) estimates the model assuming a negative half-normal distribution for u_i, but allows the mean of u_i to differ from zero.

This model has the desirable feature that statistical properties of the estimated parameters can be calculated and that all variation in output given a set of inputs is not attributed to "technical" efficiency. The major weakness of the model is its difficulty in estimating individual efficiency measures for each observation (firm) although average efficiency for the population is readily available from estimation by Maximum likelihood methods or COLS. Until recently it was felt that to decompose the individual residuals into their two components was impossible (Forsund, Lovell, and Schmidt (1980); Kopp (1981)). However, Jondrow, Lovell, Materov, and Schmidt (1982) show that by assuming v_i is normal, u_i is negative half-normal, v_i and u_i are independent, and that inefficiency is independent of the regressors, then an estimate of the individual inefficiencies for each observation (firm) can be obtained, though not consistently. The estimate for u_i is based on the conditional mean of u_i given e_i, that is

$$(9) \qquad E(U_i/e_i) = \sigma_\bullet \frac{f^* e_i \lambda / \sigma}{1-F^*(e_i \lambda / \sigma)} - \frac{e_i}{\sigma}$$

where f^* and F^* represent the standard normal density and distribution function, respectively, and $\sigma_\bullet = \sigma^2_u \sigma^2_v / \sigma^2$, $\sigma^2 = \sigma^2_u + \sigma^2_v$, and $\lambda = \sigma^2_u / \sigma^2_v$. By replacing e_i with its estimate, e_i, and $\sigma_\bullet$, σ, λ by their estimates, U_i can be estimated. Bagi and Huang (1983) estimate individual efficiency measures for 193 farms in Tennessee using this method, and, more recently, Huang (1984) developes an EM (expected-maximization) algorithm as an alternative to the two-step procedure proposed by Jondow, Lovell, Materov, and Schmidt to estimate individual efficiency measures for 151 farms in India.

3.5 Frontier Systems

In addition to measuring "technical" efficiency, a researcher may also be interested in measuring "allocative" efficiency, that is, whether or not a firm is producing off its least cost expansion path, and, if so, by how much. The duality between a production function and its associated cost function has been recognized by economist for quite some time, either function uniquely defining the firm's technology. If the necessary conditions for duality are met, then knowledge of the production (cost) function will allow derivation of the cost (production) function, provided that the functional form of the production (cost) function is tractible. Thus, if we are able to measure technical (allocative) efficiency from the production (cost) function, we can then, in principle, derive measures for allocative (technical) efficiency from the parameters in the production (cost) function.

The stochastic frontier model has been extended by Schmidt and Lovell (1979) to allow measurement of average "technical" efficiency for the population and allocative efficiency for each observation (firm). The system of equations to be estimated are the production function as specified in Aigner, Lovell, and Schmidt (1977) plus K-1 factor share equations derived from the first-order conditions for cost minimization, K being equal to the number of productive inputs into the production process. The behavioral assumption is made that firms choose to minimize cost given their desired level of output (i.e., that output is exogenous and inputs are endogenous). A firm is defined to be technically inefficient if it is producing output below that of the most technically efficient firm for a given set of productive inputs; a firm is allocatively inefficient if it is operating off its least cost expansion path. In addition to being able to derive K-1 stochastic factor demand equations, the cost function can be derived, and, from it, allocative efficiency measures for each observation (firm) can be estimated.

The model is estimated using cross-sectional data for a sample of US steam-electric plants under three different assumptions: firstly, firms are allocatively efficient, but may be technically inefficient; secondly, firms may be both allocatively and technically inefficient but without any systmatic tendency to over (under) utilize any input relative to any other input; and thirdly, firms may be both allocatively and technically inefficient and may tend to over (under) utilize any input relative to any other input. In all three cases, "technical" and "allocative" inefficiencies are assumed to be uncorrelated. This assumption is relaxed in Schmidt and Lovell (1980), and a test is constructed to test for the presence of such correlation.

Greene (1980) develops a similar model, but assumes that the error term for the production function is one-sided and has a gamma distribution. Unlike Schmidt and Lovell who specify a Cobb-Douglas functional form, Greene specifies a translog cost function and derives its corresponding factor share equations using Shephard's (1953) Lemma. Alternatively, as an example, Greene specifies a translog production function with its associated share equations and measures average "technical" efficiency. From the residuals on the share equations, he is able to obtain allocative efficiency measures for each firm. The translog functional form is more flexible than a Cobb-Douglas function, but does not allow explicit solution for the production function (cost function) corresponding to the translog cost function (production function); thus, it is difficult to know how an error in one function relates exactly to the corresponding quantity in the other function.

3.6 Stochastic Frontiers and Panel Data

The problem of estimating individual "technical" efficiency measures from stochastic frontier functions with cross-sectional data is due to a lack in degrees of freedom. If we have n firms, we have n equations from which to estimate k+n parameters, k slope parameters and n "technical" efficiency parameters (one for each firm); thus, we use up all of our degrees of freedom plus some. Jondrow, Lovell, Materov, and Schmidt (1982) show that one can obtain individual measures of "technical" efficiency (u_i) conditional on the estimated residuals from the stochastic frontier ($e_i = v_i - u_i$); however, this measure is inconsistent.

An obvious extension of cross-sectional estimation of stochastic frontiers is to estimate the frontiers using panel data. The use of panel data to estimate individual and statistically validated measures of "technical" efficiency for each observation (firm) seems to have been first applied by Hoch (1955; 1962), although he normalizes his measures relative to the "average" and not the "frontier" firm.[1] Hoch assumes that entrepreneurs maximize "anticipated" profits and, making this assumption, makes output endogenous and inputs exogenous, enabling him to obtain unbiased estimates for the model from OLS.[2]

Hoch's assumption implies that entrepreneurs are able to sell any amount of output that they produce without influencing the market. Output prices are known as are input prices; thus, the maximization problem for the entrepreneur is to produce the amount of output that maximizes expected profits. Production is assumed to be captured by a Cobb-Douglas function. Let N equal the number of firms, K equal the number of inputs, and t equal the time period. Following Hoch (1962) but using our notation, his model can be written as follows:

(10) $$Y_{it} = D_i D_t \prod_{j=1}^{K} X_{itj}^{a_j} e^{v_{it}}$$ Production Function

(11) $$\pi_{it} = PY_{it} - \sum_{j=1}^{K} W_j X_{itj}$$ Profit Function

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[1]Mundlak (1961) uses the same technique, but specifies his model to measure slope coefficients free of "management bias".

[2]Zellner, Kmenta, and Dreze (1966) make a similar assumption that entrepreneurs maximize "expected" profit, or the mathematical expectation of profit. Although using different terminology than Zellner, Kmenta, and Dreze (1966), Hoch, when he operationalizes his model, makes it clear that he is also speaking of maximizing the mathematical expectation of profit.

$$(12)\quad \frac{\partial E(\pi_{it})}{\partial X_{itj}} = 0 \qquad \text{Maximizing conditions}$$

where Y_{it} is the amount of output for firm i at time t, X_{itj} is the amount of input j for firm i at time t, P is the price per unit of output, W_j is the price per unit for input j, π_{it} is the profit for firm i at time t, E(˚) is the expectations operator, and v_{it} is a random error term. The a_j's are the parameters of the Cobb-Douglas production function, and D_i and D_t are the fixed effects for the firm and the time period, respectively, where i=1,...,N is the firm and t=1,...,T is the time period.

From the system above, we can solve for the expected profit maximization conditions of the form

$$(13)\quad \frac{P(\partial E(Y_{it}))}{(\partial X_{itj})} = R_j W_j e^{z_{itj}} \quad (i=1,\ldots,n;\ j=1,\ldots,K;\ t=1,\ldots,T)$$

where R_j=1 for exact profit maximization, R_j is less than or greater than one when profit maximization is not exact, and z_{itj} is a random error term; thus, R_j is a measure of the average deviation from optimality, and firm variations around this average in Hoch's model are treated as part of z_{itj}. These equations can be rewritten as K factor demand equations and, when combined with the production function, give us an estimable system of K+1 equations. The logarithmic form of the system is

$$(14.A) \quad y_{it} = d_i + d_t + \sum_{j=1}^{K} a_j x_{itj} + v_{it}$$

$$(14.B) \quad x_{itj} = \ln(a_j P/R_j W_j) + \ln(E(Y_{it})) + z_{itj}$$

$$(i=1,\ldots,n;\ j=1,\ldots,K;\ t=1,\ldots,T)$$

where $y_{it}=\ln Y_{it}$, $x_{itj}=\ln X_{itj}$, $d_i=\ln D_i$, and the other variables are as defined above.

The equations above are estimated by Hoch (1962) for a sample of sixty-three Minnesota farms over a six-year period, from 1946 through 1951. Individual firm "technical" efficiency measures, the d_i's, are obtained, but R_J, the deviation from optimality for input j, is measured as an average for the population and is not made firm specific. The fixed effects, elasticities, marginal returns, and returns to scale are estimated, and several tests concerning the statistical significance of these estimates are made. Results from this unrestricted model are compared with the results from a restricted version of the model which assumes that $d_i=0$ and $d_t=0$ for all i and t. The d_i's and the d_t's when taken jointly are found to be significantly different from zero, and the d_i's when converted to antilogs range from 1.4 to 0.7. It should be noted that two-thirds of the firms had firm effects less than seventy percent as large as the largest firm effect and approximately ten percent of the firms had firm effects less than half the size of the largest. The restricted model (estimated by ordinary least squares (OLS)) indicates constant returns to scale; however, the unrestricted model which allows the d_i's and the d_t's to differ from zero indicates diminishing returns to scale. The estimated measure of the R_j's from the unrestricted model indicate that too much labor is being allocated to the production process and too little nonhuman inputs. Hoch ends his paper by showing that the d_i's (which he calls firm measures of "technical" efficiency) are related to firm size.

More recently, Pitt and Lee (1981) use panel data (three years only) to estimate individual "technical" efficiency measures from a sample of fifty Indonesian weaving establishment. Pitt and Lee generalize the composed error model developed by Aigner, Lovell, and Schmidt (1977) to allow for estimation with panel data. Pitt and Lee's model is essentially a variance components model of the following form:

$$(15) \qquad y_{it} = x_{it}B + u_{it} + v_{it} \qquad i=1,\ldots,N;\ t=1,\ldots,T$$

where $y_{it}=\ln Y_{it}$ and represents output, $x_{it}=\ln X_{it}$ and represent inputs, the u_{it}'s are less than or equal to zero and represent "technical" efficiency, the v_{it}'s are a stochastic variable representing uncontrollable random shocks in the production process, i represents the i^{th} production unit, and t represents the t^{th} time period.

By making different assumptions concerning u_{it} and v_{it}, Pitt and Lee have three models which they estimate and compare with each other. The first model assumes u_{it} is time invariant, thus becoming u_i, and is estimated by maximum likelihood and analysis of covariance (the "within" estimator). The second model assumes that for all $t \neq t'$, $E(u_{it}u_{it'})=0$ for all i and $E(u_{it}u_{it'})=0$ for all $i \neq j$; that is, none of the firms' inefficiencies stays with them over time. This second model is essentially the same model set forth by Aigner, Lovell, and Schmidt (1977) when t=1 and is estimated with maximum likelihood. The third model assumes that for t=t', $e(u_{it}u_{it'})=\sigma^2_{it'}$ for all i and $E(u_{it}u_{it'})=0$ for all $i \neq j$. This model allows some firm inefficiencies to remain with the firm over time and some which do not and is estimated by generalized least squares (GLS) much as a random effects model is estimated.

The model specifications are tested with a procedure developed by Joreskog and Goldberger (1972). Support for the third model over the other two models is found, though the maximum likelihood estimates for the first model and the GLS estimates for the third model are quite close. Another, perhaps questionable, procedure carried out by Pitt and Lee is that they estimate the first model with analysis of covariance ("within" estimator) and then regress the individual firm effects on type of ownership (foreign or domesticly owned), the age of the firm, and the size of the firm. Finding a correlation between these variables and the firm effects, they introduce these variables directly into the production function and estimate the third model and reestimate the first.

Schmidt and Sickles (1984) use panel data (35 quarters) to measure individual "technical" efficiency measures for twelve airline companies. Their model is essentially the same Pitt and Lee's (1981) general model (Equation 15 above) with the additional assumption that firms are maximizing expected profit as discussed by Zellner, Kmenta, and Dreze (1966). Schmidt and Sickles give an excellent review of panel data estimation procedures and discuss under what assumptions one should use the different estimation techniques to estimate their model.[1]

Ruling out estimation of the model by OLS, Schmidt and Sickles choose the "within" estimator, the GLS estimator, and the maximum likelihood estimator (MLE); the results are quite similar for all three

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[1]A detailed discussion of estimation procedures for panel data under different assumptions concerning the fixed effects and the error term is presented in Chapter 4.

estimation procedures. Increasing returns to scale are found in all three cases with 1.12 from the "within" estimator, 1.13 from GLS, and 1.18 from MLE. Using a Hausman-type test, they find no correlation between the effects and the regressors. (This is as expected since the results from estimating with the "within" and GLS estimators are so similar.) In addition, a joint hypothesis, effects and regressors being uncorrelated and correct distributional assumption (i.e.,normal v, half-normal u), is tested by comparing the "within" estimates with the maximum likelihood estimates and support for this hypothesis is found.

More recently Schmidt (1984) develops a model which generalizes the model presented in Schmidt and Lovell (1979) by allowing estimation of that model with panel data. It is also similar to the model above except that the model is no longer a single equation model, but a system of factor share equations combined with the production function; it is also similar to and is a generalization of the model presented by Hoch (1962). One essential difference between Hoch's model and Schmidt's model is their assumptions concerning output and inputs. Hoch assumes that entrepreneurs maximize "anticipated" profits. By making this assumption, Hoch makes output endogenous and inputs exogenous and can obtain unbiased estimates for the model using the "within" estimator. Schmidt assumes, as in Schmidt and Lovell (1979), that entrepreneurs are minimizing the cost of producing for a given amount of output; that is, output is exogenous and inputs are endogenous. Schmidt, as does Hoch, also assumes that output and input prices are exogenous and known.

Under the assumption of cost minimization for a given amount of output, output is not a decision variable for the entrepreneur but is decided by demand factors outside the control of the firm. Examples of industries producing under this assumption have generally been natural gas and power plants. The problem for the entrepreneur under this assumption is to minimize the cost of producing a given amount of output.

Schmidt's model is as follows:

$$(16.A) \quad y_{it} = \sum_{j=1}^{K} a_j x_{itj} + d_i + v_{it} \qquad (i=1,\dots,N;\ t=1,\dots,T;\ j=2,\dots,K)$$

$$(16.b) \quad x_{it1} - x_{itj} = B_{itj} + g_{ij} + u_{itj}$$

where d_i is the individual fixed effect measuring "technical" efficiency, g_{ij} is the individual fixed effect measuring allocative efficiency, and v_{it} and u_{itj} are random error terms. B_{itj} is made up of a_j's and prices and is not an additional parameter:

$$(17) \qquad B_{itj} = \ln W_{itj} - \ln W_{it1} + \ln a_1 - \ln a_j$$

where W_{itj} is the price of the j^{th} input at time t for the i^{th} firm and $j=2,\dots,K$.

Schmidt assumes independence across firms and time; that is, temporal dependence at the firm level is picked up by the fixed effects. Also, v and the u_j's are assumed to be independent, v is iid $N(0, \sigma_v^2)$, and the vectors $(u_2,\dots,u_K)'$ are iid $N(0, \Omega)$. It should be noted that the form of the conditional MLE's as derived by Schmidt depends on normality, but the consistency of the resulting estimator does not since its consistency only depends on the first two moments.

The fact that y_{it}, output, is now considered to be exogenous complicates the estimation procedure considerably. If OLS is applied to the model, biased and inconsistent regression coefficients will result. This is because OLS requires the variables to the right of the equal sign to be exogenous, and this condition is violated in the production function. The "within" estimator could be applied to the model, but again the estimated coefficients will be biased for the same reason they are when estimated by OLS. This condition will also generally apply to the restricted GLSE.

The problem of obtaining consistent and unbiased estimates of the coefficients is not irreconcilable. Following Chamberlain (1980), Schmidt derives the conditional MLE's for the model by conditioning on sufficient statistics for the individual effects which are assumed to be fixed and can be correlated with the regressors.

In order to derive the conditional MLE's, the following assumptions are made:

i. $v = (v_{i1},\ldots,v_{i22})'$ is independent of $u_2 = (u_{i1\,2},\ldots,u_{i22\,2})'$,

ii. d_i and g_{i2} are fixed individual effects,

iii. individuals are independent of each other and over time,

iv. v is iid $N(0,\sigma_v^2)$ and u_j is iid $N(0,\sigma_u^2)$.

Under the above assumptions, Schmidt (1984) shows that the logarithmic likelihood function is of the form:

$$(18)\qquad L = \text{constant} + NT \ln r - NT/2(\ln \sigma_v^2 - NT/2(\ln|\Omega|)$$

$$- 1/2\, \sigma_v^2 [\sum_i \sum_t (y_{it} - \sum_j a_j x_{itj} - d_i)^2]$$

$$- 1/2(\sum_i \sum_t z_{it}'\, \Omega^{-1} z_{it})$$

where, in our case, i=1,...,N, t=1,...,T, j=1,...,K, and

$$(19)\qquad r = \sum_j a_j$$

$$(20)\qquad z_{it} = \begin{bmatrix} x_{it1}-x_{it2}-B_{it2}-g_{i2} \\ \vdots \\ x_{it1}-x_{it2}-B_{it2}-g_{i2} \end{bmatrix}$$

The likelihood function can then be decomposed into two parts, the "within" and the "between" variation of the data; from this, it can be shown that only the "between" variation depends on the individual effects, d_i and g_{ij}, and that the MLE's for the effects are

$$(21)\qquad d_i = \underline{y}_i - \sum_{j=1}^{K} a_j \underline{x}_{ij}$$

$$(22)\qquad g_{ij} = \sum_{t=1}^{T} g_{itj}/T$$

where i=1,..,N; j=1,...,K; t=1,...,T; and

$$(23)\qquad g_{itj} = x_{it1} - x_{itj} + w_{it1} - w_{itj} + \ln(a_j) - \ln(a_1)$$

and

$$(24) \qquad \underline{y}_i = \sum_{t=1}^{T} y_{it}$$

$$(25) \qquad \underline{x}_{ij} = \sum_{t=1}^{T} x_{itj}/T$$

It can also be shown that, at the point of maximization for the likelihood function, the "between" variation equals zero when we insert Equations 21 and 22 into Equation 18; thus, the MLE's of a, σ^2_v, and Ω come from maximization of the "within" variation only.

The joint MLE's of all the parameters will have desired characteristics (consistency and asymptotic efficiency) when $T \rightarrow \infty$ for fixed N, but not when $N \rightarrow \infty$ for fixed T; in this latter case, the estimates of the individual effects will not be consistent and, due to their pressence, the MLE's of the other parameters of the model may not be consistent. The problem is caused by the fact that the number of parameters to be estimated increases as N increases and is discussed by Chamberlain (1980); however, by deriving conditional MLE's for the parameters based on sufficient statistics for the individual effects, consistent and unbiased estimates of all the parameters of the model can be obtained as either N or $T \rightarrow \infty$.

Schmidt shows that the sufficient statistic for $(d_i, g_{i2}, \ldots, g_{iK})'$ is $(\underline{x}_{i1}, \underline{x}_{i2}, \ldots, \underline{x}_{iK})'$ and that the conditional likelihood function is

$$(26)\qquad L_c = \text{constant} + N(T-1)\ \ln r - \frac{N(T-1)}{2}\ \ln|\Omega|$$

$$- 1/2\ \sigma_v^{2}\,[\sum_i \sum_t (y^*_{it} - \sum_j a_j x^*_{itj} - d_i)^2]$$

$$- 1/2(\sum_i \sum_t z^*_{it}{}'\ \Omega^{-1} z^*_{it})$$

where $y^*_{it} = y_{it} - \underline{y}_{it}$, $x^*_{itj} = x_{itj} - \underline{x}_{itj}$, and z^*_{it} is a vector of the following form:

$$(27)\qquad z^*_{it} = \begin{bmatrix} x_{it1} - x_{it2} - \underline{x}_{i1} + \underline{x}_{i2} - B^*_{it2} \\ \vdots \\ x_{it1} - x_{itK} - \underline{x}_{i1} + \underline{x}_{iK} - B^*_{itK} \end{bmatrix}$$

and

$$(28)\qquad B^*_{itj} = w_{itj} - w_{ij1} - \underline{w}_{ij} + \underline{w}_{i1}$$

By concentrating the likelihood function over σ_v^2 and Ω, where

$$(29)\qquad \sigma_v^2 = \frac{1}{N(T-1)} \sum_i \sum_t (y^*_{it} - \sum_j a_j x^*_{itj})^2$$

$$(30)\qquad \Omega = \frac{1}{N(T-1)} \sum_i \sum_t z^*_{it}\, z^*_{it}{}'$$

the concentrated conditional likelihood function can be obtained which depends only on $a = (a_1, a_2, \ldots, a_K)'$ and is maximized by the conditional MLE of a as shown below.

(31) $$L^*_c = \text{constant} + N(T-1)\ \ln r|\Omega|$$

$$- \frac{N(T-1)}{2} \ln \frac{1}{N(T-1)} \sum_i \sum_t (y^*_{it} - \sum_j a_j x^*_{itj})^2$$

$$- \frac{N(t-1)}{2} \ln \left| \frac{1}{N(T-1)} \sum_i \sum_t z^*_{it} z^{*\prime}_{it} \right|$$

As can easily be seen from above, z^*_{it} does not depend on a, so that the last term does not enter into the calculation of the conditional MLE of a; thus, none of the parameters in the production function (a, d_i, and σ^2_v) depend on the input prices, though the estimates of Ω and g_{ij} do.

From differentiating the concentrated conditional likelihood function with respect to $a = (a_1 \ \ a_2)'$ and setting the result equal to zero gives the following:

(32) $$\hat{a} = \underline{a} + \frac{SSE}{\hat{r}}(x_*'x_*)^{-1}e$$

where

(33) $$\underline{a} = (x_*'x_*)^{-1}x_*y_*$$

(34) $$SSE = (y_* - x_*\hat{a})'(y_* - x_*\hat{a})$$

(35) $$\hat{r} = e'\hat{a} = \sum_j \hat{a}_j$$

and

$$(36)\qquad y_* = \begin{bmatrix} y^*_{11} \\ \vdots \\ y^*_{iT} \\ \vdots \\ y^*_{N1} \\ \vdots \\ y^*_{NT} \end{bmatrix} \qquad x_* = \begin{bmatrix} x^*_{111},\ldots,x^*_{11K} \\ \vdots \quad \vdots \\ x^*_{1T1},\ldots,x^*_{1TK} \\ \vdots \quad \vdots \\ x^*_{N11},\ldots,x^*_{N1K} \\ \vdots \quad \vdots \\ x^*_{NT1},\ldots,x^*_{NTK} \end{bmatrix}$$

Notice that $\underline{a}$ is the "within" estimator which is obtained from regressing y* on x* by OLS. Further, Schmidt shows that the conditional MLE's of the model can be obtained from a "within" transformation on the data plus correction factors that account for the fact that output is assumed to be exogenous and inputs endogenous; that is,

$$(37)\qquad \hat{a} = \underline{a} + (\underline{SSE}/\underline{r})(x_*'x_*)^{-1}e$$

$$(38)\qquad \hat{r} = e'\hat{a} = \underline{r} + D\ \underline{SSE}/\underline{r}$$

$$(39)\qquad SSE = (y_* - x_*\hat{a})'(y_* - x_*\hat{a}) = \underline{SSE} + D\ \underline{SSE}^2/\underline{r}^2$$

$$(40)\qquad \hat{d}_i = \underline{y}_i - \sum_j \hat{a}_j \underline{x}_{ij}$$

$$(41)\qquad \hat{g}_{ij} = \underline{x}_{i1} - \underline{x}_{ij} - \hat{\underline{B}}_{ij}$$

$$(42)\qquad \hat{\underline{B}}_{ij} = \underline{P}_{ij} - \underline{P}_{i1} + \ln\hat{a}_1 - \ln\hat{a}_j$$

where $\underline{a}$, $\underline{r}$, $\underline{SSE}$, and D are all derived from OLS of y* on x* so that

(43) $\underline{r} = e'\underline{a}$

(44) $\underline{SSE} = (y_* - x_*\underline{a})'(y_* - x_*\underline{a})$

(45) $D = e'(x_*'x_*)^{-1}e$

and $\underline{a}$ is given above in Equation 33, and e is a Kx1 vector of ones. In addition, the asymptotic variances of the estimators are derived from the information matrix and have the following form:

(46) $$-\frac{\partial^2 L_c^*}{\partial \hat{a}\ \partial \hat{a}} = \frac{1}{\hat{\sigma}^2} x_*'x_*$$

In summary, we have the interesting conclusion that in this fixed-effects model, the conditional MLE's are obtained by making a simple correction to the "within" estimator. Although distributional assumptions must be made concerning the residual terms in order to calculate the conditional MLE's, the consistency of the derived estimates does not depend on the distributional assumptions; their consistency depends only on the first two moments of the residuals. It should also be noted that the above discussion skirts the difficult distributional issues that evolve if one normalizes the individual effects for the production function as done in Schmidt and Sickle (1984). One still obtains consistent estimates of the individual effects and can make comparisions across firms as $T \rightarrow \infty$. In addition, as $N \rightarrow \infty$, the overall intercept can be separated from the one-sided individual effects, and it is possible to measure the individual effects relative to an absolute standard; however, the asymptotic variances have not yet been derived.

CHAPTER IV

ANALYSES AND RESULTS

The purpose of this chapter is to present the model, the estimation procedure, and the results from the analyses. The hypothesis to be tested is that individual firms produce using the same technology (i.e., have the same elasticities of variables inputs), but that each is producing on its own sub-production function that can differ from that of other firms by a neutral shift in the sub-production function; thus, a firm's sub-production function can be above or below that of another firm. In addition, a measure to determine whether the individual firms are maximizing profit will be developed as well as a measure to determine if firms are combining variable inputs in a least cost manner.

Because the author views the analytical techniques developed in this thesis to be appropriate for diagnostic purposes, the next chapter, Chapter 5, will be concerned with presenting characteristics of the different firms and their respective entrepreneurs in order to see if certain firm and entrepreneurial characteristics are associated with the measures developed to differentiate differences in production among individual firms. Ideally, it is hypothesized that a researcher with the appropriate panel data for a sample of firms from the same industry can obtain reliable measures of firm differences in the production process as well as any firm differences in the allocation of variable inputs. Once these measures are obtained, the analysis can be carried further if the appropriate information is available or, more ideally, if the opportunity exists to revisit the firms to systematically study the causes of the differences in the production process among the individual firms. For example, using this method of analysis one can obtain rankings of the firms based on their measured production functions as to which firms are producing a greater amount of output given an apparently similar set of variable inputs and then return to the same firms to ascertain the reasons why these measured differences in production among the firms exist.

Unfortunately, this author is unable to return to Egypt to further explore why some firms are more productive than others; however, prior to the termination of the data collection, a two-part entrepreneurial questionaire was administered to the firms in this study. This information, combined with information from the longitudinal survey and the firsthand knowledge of the firms by the author, will be used to address the issue of what the econometric techniques used for analyses in this thesis are actually measuring; that is, what are the characteristics of the firms that are associated with the measured differences in their individual sub-production functions.

In Section 4.1, the model presented by Hoch (1964) will be generalized to allow for differences in the production process of individual firms as well as firm-specific measures relating to cost minimization and profit maximization. In Section 4.2, the data--how it was collected and processed--and how variables in the model are aggregated and measured will be carefully documented. In Section 4.3, techniques for estimating the model econometrically are discussed as to their strengths and weaknesses, and it is argued that the appropriate estimator for this data set, Egyptian small-scale tileries, is the "within" estimator.

Section 4.4 presents the empirical results from estimating the model. In Section 4.4.1, the production function is estimated using panel data collected for the Kalyubiya tileries. In Section 4.4.2, the production function is estimated using the panel data for the Fayoum tileries. In Section 4.4.3, statistical tests are performed to determine if the data sets for small-scale tileries from Fayoum and Kalyubiya governorates can be pooled. When tests indicate that the two data sets are drawn from the same population of small-scale tileries and can be pooled, the model is estimated with the pooled data and results are reported in Section 4.4.4. Finally, in Section 4.5, a model developed by Schmidt (1984) is estimated using the pooled data.

4.1 Statement of the Model

In this section, the model which is a generalization of the one presented by Hoch (1962) is stated using the assumption that entrepreneurs are maximizing expected profit.[1] This assumption is justifiable based on the way entrepreneurs make decisions on how much output to produce. Since there is always an element of uncertainty in any production process, an entrepreneur will not know what the actual quantity of output will be from a given set of inputs and will base his decision on the expected quantity of output; thus, the firm is not maximizing profit but expected profit. As a result, the causality between inputs and output runs in one direction only, from inputs to output so that the production function can be estimated as a single

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[1]See Section 3.6 for a discussion of Hoch's model.

equation without causing simultaneity bias.[1] This is because when entrepreneurs are maximizing expected profit, output is an endogenous variable and inputs are exogenous variables in the production equation. Also following from this behavioral assumption is that entrepreneurs are able to sell all the product that they choose to produce without affecting the product's price in the market. Output prices are known by the entrepreneurs as are input prices; thus, the maximization problem for the entrepreneur is to choose to produce the amount of expected output that maximizes expected profit.

In addition, the model is generalized to allow estimation of firm-specific measures which indicate whether or not an individual firm is deviating from exact profit maximization. The model also allows estimation of measures that indicate whether the individual firms are combining variable inputs in a least cost manner.

Production is assumed to be captured by a Cobb-Douglas function. Generalizing Hoch's model to obtain individual firm measures of the deviation from exact profit maximization and making the model specific to the estimation of Egyptian small-scale floor tileries in Fayoum and Kalyubiya governorates, the model can be written as follows:

(1) $Y_{it} = D_i L_{it}^{a_1} K_{it}^{a_2} e^{v_{it}}$ Production Function

(2) $\pi_{it} = PY_{it} - W_{it1} L_{it} - W_{it2} K_{it}$ Profit Function

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[1]Zellner, Kmenta, and Dreze (1966) make a similar assumption that entrepreneurs maximize "expected" profit, or the mathematical expectation of profit. Although using different terminology, Hoch, when he operationalizes his model, makes it clear that he is also speaking of maximizing the mathematical expectation of profit.

(3.A) $$\frac{\partial E(\pi_{it})}{\partial L_{it}} = 0$$ Maximizing conditions

(3.B) $$\frac{\partial E(\pi_{it})}{\partial K_{it}} = 0$$

where Y_{it} is the amount of output for firm i at time t, L_{it} is the amount of labor hours used in producing output by firm i at time t, K_{it} is the amount of machine hours used in producing output by firm i at time t, P is the price per unit of output, W_{it1} and W_{it2} are the wage rates per hour for labor and machine hours, respectively, for firm i at time t, respectively, π_{it} is the profit for firm i at time t, E(˚) is the expectations operator, and v_{it} is a random error term. The coefficients, a_1 and a_2, are the elasticities of labor and machine hours, respectively, and D_i is the fixed effect for firm i at time t.

From the system above, we can solve for the maximization conditions by maximizing expected profit to obtain

(4.A) $$\frac{P(\partial E(Y_{it}))}{(\partial L_{it})} = R_{i1}W_{it1}e^{z_{it1}}$$

(4.B) $$\frac{P(\partial E(Y_{it}))}{(\partial L_{it})} = R_{i2}W_{it2}e^{z_{it2}} \quad (i=1,\ldots,25;\ t=1,\ldots,22)$$

where $R_{ij}=1$ for exact profit maximization (j=1,2) , R_{ij} is less than or greater than one when a firm fails to maximize profit exactly, and z_{itj} is a random error term. These equations when combined with the production function, give us an estimable system of equations. The logarithmic form of the system is

$$(5) \qquad y_{it} = a_1 l_{it} + a_2 k_{it} + d_i + v_{it}$$

$$(6) \qquad l_{it} = \ln(a_1 P/R_{i1} W_{it1}) + \ln(E(y_{it})) + z_{it1}$$

$$(7) \qquad k_{it} = \ln(a_2 P/R_{i2} W_{it2}) + \ln(E(y_{it})) + z_{it2}$$

$$i = 1,\ldots,25; \; t=1,\ldots,22$$

where y is the natural log of cement floor tiles (output) measured in square meters and aggregated by tile type, l is the natural log of labor hours used in production aggregated by labor type, k is the natural log of machine hours used in production aggregated by machine type, d_i is the firm-specific individual effect, $E(\cdot)$ is the expectations operator, W_{it1} is the wage rate per hour for labor at time t for firm i, W_{it2} is the wage rate per hour for machine usage for firm i at time t, R_{i1} is a measure of the marginal return for one Egyptian Pound (approximately one U.S. dollar) of labor used in production for firm i, R_{i2} is a measure of the marginal return for one Egyptian Pound of machine services used in production for firm i, and v_{it} and u_{it2} are random variables with mean zero and variance σ_v^2 and σ_u^2, respectively. Each production period, t, covers three weeks for a total of twenty-two periods spanning from December 1980 through March 1983. Twenty-five floor tileries, nine in Fayoum governorate and sixteen in Kalyubiya governorate, make up the sample and are represented by i.

In addition, estimates of the marginal value product of labor (MVP_l) and the marginal value product of machine services (MVP_k) are obtained. The question of whether firms are combining variable inputs in a least cost manner is of importance and a measure to determine this is developed in the model. (It should be noted that these measures correspond to the g_{ij}'s (j=2,...,K) in the model developed by Schmidt (1984) and presented in Section 3.6.)

In order to derive these measures, we first subtract all factor demand equations from one factor demand equation, say the factor demand equation for x_{it1}. This will give the following set of K-1 factor share equations where K is the number of variable factors in the production function.

$$x_{it1} - x_{itj} = \ln(a_1P/R_{i1}W_{it1}) - \ln(a_jP/R_{ij}W_{itj}) + \ln(E(Y_{it})) - \ln(E(Y_{it})) + z_{it1} - z_{itj} \quad (i=1,\dots,N;\ j=2,\dots,K;\ t=1,\dots,T) \tag{8}$$

which is equal to

$$x_{it1} - x_{itj} = \ln(a_1P/R_{i1}W_{it1}) - \ln(a_jP/R_{ij}W_{itj}) + z_{it1} - z_{itj} \ . \tag{9}$$

Next we write $\ln(a_1P/R_{i1}W_{it1}) - \ln(a_jP/R_{ij}W_{itj})$ in its logarithmic form:

$$\ln(a_1P/R_{i1}W_{it1}) - \ln(a_jP/R_{ij}W_{itj}) = \ln P - \ln P + \ln a_1 - \ln a_j + \ln W_{itj} - \ln W_{it1} + \ln R_{ij} - \ln R_{i1} \tag{10}$$

which becomes

$$\ln(a_1P/R_{i1}W_{it1}) - \ln(a_jP/R_{ij}W_{itj}) = \ln W_{itj} - \ln W_{it1} + \ln a_1 - \ln a_j + \ln R_{ij} - \ln R_{i1} \ . \tag{11}$$

Noticing that

$$(12) \qquad B_{itj} = lnW_{itj} - lnW_{it1} + lna_1 - lna_j \ ,$$

Equation 12 becomes

$$(13) \qquad ln(a_1P/R_{i1}W_{it1}) - ln(a_jP/R_{ij}W_{itj}) = Bitj + lnR_{ij} - lnR_{i1} \ .$$

Substituting Equation 13 into Equation 9, we have the following:

$$(14) \qquad x_{it1} - x_{itj} = B_{itj} + lnR_{i1} - lnR_{ij} + u_{itj} \quad j=2,...,K$$

where

$$(15) \qquad u_{itj} = z_{it1} - z_{itj} \ .$$

Finally, letting

$$(16) \qquad g_{ij} = lnR_{ij} - lnR_{i1} \qquad j=2,....,K \ ,$$

we arrive at the following equation

$$(17) \qquad x_{it1} - x_{itj} = B_{itj} + g_{itj} + u_{itj} \quad (j=2,...,K)$$

where g_{itj} is a measure of least cost combination of x_{it1} with x_{itj}. Remembering that g_{itj} is measured in natural logs and G_{itj} is in antilogs, when G_{itj} is equal to one, the firm is combining x_{it1} and x_{itj} in a least cost manner; if G_{itj} is not equal to one, then the firm is not combining x_{it1} and x_{itj} efficiently. In the case of the Egyptian small-scale floor tileries where the variable inputs are labor and machine hours, the measure obtained is

$$(18) \qquad g_{i2} = \ln R_{i2} - \ln R_{i1} .$$

4.2 Data

The data used by this thesis were collected under the supervision of the author in conjunction with the Non-Farm Employment Project-Egypt.[1] In addition to the fifty-two weeks of data collected in that project, an additional fourteen weeks of data for the Egyptian small-scale floor tileries were collected in both Fayoum and Kalyubiya governorates. Once a week, enumerators visited the same firms and administered the same longitudinal questionaire to each firm. In addition to the longitudinal survey, a two-part entrepreneurial questionaire was administered to the tileries. All data were recorded on mark sense computer cards which were developed and printed in Egypt. Also in Egypt, the cards were read by an electronic cardreader, and the data were tranferred to a microcomputer and stored on floppy disks.

Much of the preliminary data processing was done in Egypt, and printouts of the weekly data were obtained prior to the end of the data collection enabling the author to review the data in consultation with the enumerators from both areas. As the author visited each tilery

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[1]See Chapter 2 for a detailed discussion of the Non-Farm Employment Project-Egypt: its goals, survey instruments, data collection, and findings.

several times during the survey taking notes on their production process and interviewing their entrepreneurs, he has firsthand knowledge of each tilery and, particularly for the Fayoum firms, an in depth understanding of the production system of each tilery in the sample.

The length of the production period is determined by the production process. Ideally, one wants to choose the beginning of the production period when the production of a unit of output is initiated and the end of the production period when that unit of output is finished. For Egyptian small-scale floor tileries, it generally takes four to five days, depending on the time of year, to produce a unit of cement floor tile from beginning to end. On the first day, the cement, sand, and other materials are mixed, placed into a form, and pressed into the desired shape and size. The next day, the tiles are soaked in water, and then dried for two days in the sun. Colored tiles are finished at this point; mosaic and ordinary tiles are polished after the drying process is complete. During the winter, it generally takes an extra day to dry the tiles.

The production process can be considered as continuous in that, while tiles pressed the previous day are soaking, new ones are being pressed and others are being dried or polished. As a result, no matter how one chooses the production period, there will be overlap; tiles that are initiated prior to the beginning of the production period will be finished during the period, and tiles begun near the end of the production period will not be completely finished until after the end of the period. The production period could have been chosen to cover one week of production; however, to reduce the problem of overlap, a three week period is chosen to represent the length of the production process.

The output of the cement floor tiles is measured in square meters; however, there are eight different types of floor tiles produced by the sampled tileries. These eight types can be placed into two main categories; colored tiles and non-colored tiles. The colored tiles generally take longer to form and require more skill to produce than do non-colored tiles, but they do not have to be polished as do most types of non-colored tiles. White cement, which is more expensive than ordinary cement, is used in the production of colored tiles, while non-colored types can be produced with either white or ordinary cement; however, many, but not all, types of non-colored tiles call for additional raw material inputs such as small stones for mosaic tiles and sometimes even marble or alabaster.

As one can see, even in the case of a product as seemingly homogenous as cement floor tile, aggregation into one product type to be used as "output" can be difficult; some tile types take more labor to be produced while the production of others uses more capital. For this study, the average unit value of each tile type is used as its weight in aggregation. This assumes that the additional use of labor or capital is captured in the average unit value of the product type. Problems may arise when differences in value per unit of output for different tile types are due to diffences in the use and value of raw materials (white cement versus ordinary cement; use or non-use of stones, marble, or alabaster) and not due to differences in the input of labor or capital.

There are five types of laborers found in the sampled tileries: owners, family workers, permanent hired workers, temporary but often full-time hired workers, and hired apprentices. The number of hours spent each week in the categories of production, supervision, marketing, repair, and input procurement was collected for each worker in each tilery. Only hours spent in production are used to aggregate into labor hour equivalents. As the author is familiar with all the tileries in the sample, their capital stock, and how each worker participated in the production process, he uses this knowledge to reclassify each worker by the work activity that he performed into new categories which are assigned weights used in aggregating the variable, labor hours. The four new categories include family workers and are: owners, "form" workers who work at the hydraulic presses and form the cement tiles, "press" workers who pump the manual hydraulic presses, "polishers" who polish the tiles with the geliah (tile polishing machine), and apprentices or "mixers" (almost always young boys) who mix the sand, cement, water, and other raw material inputs and perform other "odd" jobs.

Three weighting schemes were considered:

1) A weight of one is assigned to owners, form workers, press workers, and polishers and a weight of 0.4 is assigned to apprentices and mixers;

2) A weight of one is assigned to owners and form workers, a weight of 0.8 is assigned to press workers and polishers, and a weight of 0.4 is assigned to apprentices and mixers;

3) A weight of one is assigned to owners, family workers, nontemporary hired workers, and temporary but often full-time hired workers, and a weight of 0.4 is assigned to hired apprentices.

The first and second schemes are superior to the third because they categorize the laborers by work activity. Regressions were run with both of the first two weighting schemes, but because there were no significant differences in the results, only the results from the first weighting scheme are reported in this dissertation. Apprentices and mixers are given a smaller weight than other workers because their contribution to given a smaller weight than other workers because their contribution to production for each hour they work is less than an hour of production of other workers. Also, the average hourly wage received by apprentices and mixers was slightly less than 40% that of other workers.[1]

The production hours of all workers were not recorded in the longitidinal survey by the enumerators for certain tileries, particularly in Kalyubiya. As a result, there are four measures of the number and type of workers for certain tileries: the number of workers and the hours they worked as recorded on the weekly, longitudinal labor questionaire; the number of workers as stated by the enumerators when asked by the author; the number of workers as stated by the entrepreneurs during formal interviews with the author; and the number of workers actually counted by the author when visiting the tileries. In order to have a starting point for aggregating labor hours for each tilery, the initial aggregation of labor hours uses the "best" estimate of the number of workers and is not necessarily from the same information source. The initial regression uses this aggregation procedure and adjustments are made in an iterative fashion; the procedure is presented in detail in Section 4.4 that follows.

Machine hours aggregated by machine types and aggregated over three week periods are used to measure the capital used in the production process. As data on machine hours by machine types for each tilery were not collected until week forty-two of the longitudinal survey, it is necessary to construct from other available data a variable which represents machine hours and spans the entire survey period. Obvious candidates for these variables are the number of machines by type, the

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[1]See Davies, Seale, Mead, Saidi, Sheikh, Bodr (1984).

quantity of raw materials (other than capital and labor) actually used in the production process, and perhaps the price of certain raw materials.

Data on the number of machines by type and the price of raw materials were collected over the entire period, but the quantities of raw materials actually **used** in production were not collected until the forty-second week; however, the quantities of raw materials **bought** by the tileries were collected and recorded for the full survey period. The quantities of raw materials bought, though not perfectly correlated with the quantities of raw materials actually used in production, serve as a close proxy for this variable (except in cases where raw materials are purchased for resale or are bought infrequently and in bulk). Sand is the best example of a raw material that is rarely resold and is not bought in large bulk; white cement is the raw material most often resold or bought in bulk.

The procedure used to construct a variable highly correlated with the data for machine hours collected in the latter part of the survey and which spans the entire survey period is first to regress machine hours, for the weeks it was collected, on the number of machines by type, the quantities of raw materials bought by each tilery, and the price of selected raw materials, all for the same time period. Though not having the "ideal" variables to complete the series for machine hours, the variables available are able to give a fit of 80 percent; that is, over the period beginning with week forty-two and ending with week sixty-six, by regressing aggregated machine hours on the set of chosen variables, eighty percent of the variance in machine hours is "explained" by these variables.[1]

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[1]This does not mean that there is any causality between the chosen variables and aggregated machine hours, nor that these variables

The next step in the procedure is to calculate the expected value of aggregated machine hours from the chosen set of variables for weeks one through forty-one. This can be done by multiplying each variable entered into the regression for each time period by its corresponding coefficient estimated above, summing over these products, and adding to these sums the firm's intercept term obtained in the regression.[1] For weeks forty-two through sixty-six, the variable, machine hours, consists of the data actually collected during the latter part of the longitudinal study.

Labor hours and machine hours as measured above are the only inputs that enter into the production function for Egyptian small-scale floor tileries.[2] The production of cement floor tiles is almost more of a service rendered to the final consumer than a production process. Although cement floor tiles consist of materials such as cement, sand, and small stones, the production process can be thought of, in terms of raw materials, as a flow through system.

As seen from the discussion above, the variables in this study are much more disaggregated than in most studies, are measured in physical quantities, and are not aggregated over firms; thus, the problems of aggregating production functions over firms is avoided as well as many of the inherent problems of measuring production functions in monetary value terms instead of physical quantities. Although aggregation problems still remain, the problems of aggregating over

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"explain" aggregated machine hours.

[1]The interested reader will find in Appendix C a more detailed account of how the variable, machine hours, was constructed.

[2]"Wastage" of raw materials can occur, but will not be captured in the production function since raw materials are not variables in the model.

relatively homogenous cement floor tile types, labor types, and machine types are miniscule relative to the task many economists have had in aggregating output and inputs on farms where several crops as well as livestock are raised, in industry studies carried out at a highly aggregate level, or in the study of all manufacturing industries for a region or a country.

Measurement error, of course, is also a potential problem with this study as with all quantitative studies. This research has had the advantage that the author supervised the fieldwork and collection of the data over a two and a half year period, visited all tileries in the sample and, in the case of the Fayoum tileries, visited some firms over twenty times each. By the end of the survey, the author had learned Arabic well enough to converse in Arabic with entrepreneurs and laborers in Arabic and to personally administer short interviews. Also, because the longitudinal data were entered into a microcomputer in Egypt, the author was able to obtain printouts of the data by week forty of the longitudinal survey and began processing the data in Egypt. This gave him the opportunity to go directly to the enumerator who had collected the data whenever any discrepencies appeared. Indeed, when analysing data at the firm level, a researcher does not have the luxury of hoping problems in the data will average out. Intimate knowledge of how the data were collected, what the potential problems with the data are, and what reasonable corrections can be made to obvious problems in the data are essential ingredients in obtaining meaningful results and being able to interpret the results, especially when the analysis is at the firm level.

Before presenting the results from estimating the model, several potential estimation procedures will be discussed along with their underlying assumptions. The data from the Egyptian small-scale floor tileries, as discussed above and in Appendix C, will be used for estimation purposes. Next, a detailed discussion of the estimation process is presented as to how the "final" results are obtained. Summary tables of the results are presented along with a discussion on the plausibility and interpretation of the results.

4.3 Estimation Procedures

One potential estimation procedure is ordinary least squares (OLS) which treats $v_{it} + d_i$ as the OLS residual in the production function and $u_{it2} + g_{i2}$ as the OLS residual in the factor share equation. When firms are maximizing expected profit, output is endogenous and inputs are exogenous in the production function. Because of this, as $N \to \infty$, consistent estimates of the a_j's (but not the individual fixed effects) can be obtained if the individual effects are not correlated with the regressors, l_{it} and k_{it}; however, as $T \to \infty$ with fixed N, the a_j's will not be consistent.

To assume that the individual effects are independent of the regressors may not be an attractive or a realistic assumption. Many researchers have argued that "technical" efficiency in a firm will be correlated with input usage in the firm. If one is not willing to acknowledge the possibililty of "technical" inefficiency, but is willing to acknowledge the possibility of firm-specific "subfunctions" of the stochastic production function that differ among firms and are the result of omitted variables or fixed factors being fixed at different levels for different firms, then OLS will still give biased estimates of the a_j's except in the case where the omitted variables or the fixed factors are not correlated with the variable inputs of the model.

As one can see, using OLS when there is the possibility of individual firm effects being correlated with the regressors of the model leads to biased and inconsistent estimators. As it is always possible to test whether the fixed effects as a whole are significantly different from zero when using longitudinal or panel data, the standard OLS analysis is not recommended. It can, however, be done for comparitive purposes with other estimation procedures.

Another potentially attractive estimation procedure for the model which requires relatively weak assumptions is the "within" estimator. This estimation procedure treats the individual firm effects, d_i and g_{i2}, as fixed, implying the same slope coefficients for each firm, but different intercepts. No distributional assumptions concerning the random variables v_{it} and u_{it2} are necessary as the consistency of the "within" estimator depends only on the first two moments.

When firms are maximizing expected profit, two estimation procedures can be used that give identical results. The model can be estimated by adding a dummy variable (representing d_i) for each firm (if the common intercept is estimated, by adding n-1 dummy variables where n is the number of firms in the sample and d_i is now equal to the estimated d_i + the overall intercept term) and estimating the production function with OLS. Alternatively, the data can be transformed for each variable by subtracting from each observation, the corresponding firm mean for that variable. As an example, the transformed dependent variable, y_{it*}, is equal to $y_{it} - \underline{y}_i$ where $\underline{y}_i = \sum_t Y_{it}/T_i$ with T_i being used to express the possibility of unequal time periods for each firm. The same transformation is made to all variables in the production function, and, once the transformations are made, OLS is applied to the transformed production function.

These two methods give identical estimates for the a_j's. For the dummy variable case, the estimated coefficients of the dummy variables are equal to the d_i's; for the deviations from the firm means case, it is easy to show that

$$(19) \qquad d_i = \underline{y}_{it} - a_1\underline{l}_i - a_2\underline{k}_i$$

$$(i=1,...,25;\ j=1,2;\ t=1,...,T_i;\ T_i \quad 22).$$

Once the estimates of the a_j's are obtained, then it is also easy to show that

$$(20) \qquad g_{it2} = l_{it} - k_{it} + w_{it1} - w_{it2} + \ln(a_2) - \ln(a_1)$$

and that

$$(21) \qquad g_{i2} = \sum_{t=1}^{T_i} g_{it2}/T_i \qquad (i=1,...,25;\ t=1,...,T_i).$$

Advantages of using the "within" estimator are that consistent estimates of the a_j's can be obtained as either T or N goes to infinity, that correlation between the fixed effects and the regressors does not cause the estimates for the a_j's to be biased, and distributional assumptions are not necessary to obtain consistent estimates of the a_j's.

For the estimates of the individual fixed effects to be consistent, T must go to infinity.

A disadvantage of the "within" estimator is that regressors which are invariant over time can not be included into the model, even if they vary over firms. Unless one is willing to assume that the individual fixed effects are not correlated with the regressors, this problem will persist. For example, if the regressors and the fixed effects are correlated, then the "within" estimator is the generalized least squares estimator (GLSE) whether the effects are fixed or random (Mundlak, 1978). Only when the effects are random and uncorrelated with the regressors can we improve the efficiency of the "within" estimator by performing what Mundlak calls restricted GLSE (RGLSE). In this case, when the covariance matrix is known with certainty, consistent estimates for the a_j's can be obtained as either N or T goes to infinity. These estimates will be more efficient than the "within" estimates except in the case where T goes to infinity; in this case, the estimates converge.

Taylor (1980) has shown that feasible RGLSE when the fixed effects and the regressors are uncorrelated is more efficient than the "within" estimator except in cases of relatively small sample sizes (i.e., n - k equals ten or less); however, in order to obtain consistent estimates of the a_j's from RGLSE, N must go to infinity. When both N and T go to infinity, RGLSE converges to the "within" estimates. Even worse, if the individual effects are correlated with the regressors, then the estimates of the a_j's are biased and inconsistent even if the covariance matrix is known unless <u>both</u> N and T go to infinity.

The main advantage of using feasible RGLSE[1] over the "within" estimator is that it allows regressors that are invariant over time at the firm level to be entered into the model. An obvious choice as a capital variable might be the number of machines in each firm; however, unless the number of machines used in production by each firm changes over the survey period, this variable cannot be entered into the model when estimated by the "within" estimator. This can be a major liability, particularly when the researcher does not have the luxury of possessing capital measures such a machine hours by machine type or electricity consumed by machinery (assuming that the machines are electrical and not manual, animal powered, water powered, or fuel powered).

Further, if we are willing to make distributional assumptions about the random variables, v_{it} and u_{itj}, maximum likelihood estimates (MLE) or conditional MLE's can be obtained. When assuming that the residual terms are i.i.d. $N(0,\sigma_v^2)$ and i.i.d. $N(0,\sigma_u^2)$, respectively, and that the individual effects are random and correlated with the regressors, then MLE is the "within" estimator as N goes to infinity even for fixed T (Chamberlain, 1980). This can be shown by maximizing the joint likelihood function with respect to a_1, a_2, σ_v^2, and σ_u^2.

The conditional MLE's can be obtained for the fixed-effects model by basing the likelihood function on the distribution of the data, and conditioning on a set of sufficient statistics for the incidental parameters. In this case, the sufficient statistic for d_i and g_{i2} is y_{it}. Neither the conditional density, $f(y_{i1}, y_{i2},\ldots,y_{i22}/ \sum_t y_{it})$, or the conditional log-likelihood function depends on d_i or g_{i2}, but

[1]The case where the covariance matrix is known with certainty is too unrealistic to consider in actual empirical estimation.

only on a_1, a_2, σ^2_v, and σ^2_u (i.e., there is no incidental parameter problem). By maximizing the conditional likelihood function over these parameters, it can be seen that the conditional MLE for the a_j's is the "within" estimator. The advantage of the conditional MLE over the joint MLE is due to the difference in its derived estimate for the covariance matrix; the conditional MLE of the covariance matrix is corrected for degrees of freedom and ensures consistency, while the joint MLE does not.

An alternative to assuming fixed effects for each firm is to assume that the effects are random and follow a distribution. Again we assume that the residuals, v_{it} and u_{it2}, are normal i.i.d variables with zero mean and variance. In addition, if we are willing to specify the distributional function for the random effects, we can construct a density function for y given x, a, and the distribution function of the random effects where $y=(y_{i1},\ldots,y_{i22})'$, $x=(1\ \ k)$, $a=(a_1, a_2)'$, $l=(l_{i1},\ldots,l_{i22})'$, and $k=(k_{i1},\ldots,k_{i22})'$. The likelihood function to be maximized becomes one that is not conditional on the random effects, but marginal on them. From this, if $N \to \infty$ and certain weak regularity conditions are met, we can obtain consistent estimates for the a_j's and the parameter vector for the distribution of the random effects. The conventional random effects model assumes that the random effects are independent of x. If this is not true, then it is important to specify a conditional distribution for the random effects given x that allows for dependence; otherwise, our estimates will not be consistent and will be biased.[1]

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[1]See Chamberlain (1980) for an example of the importance of allowing for dependence between the random effects and the regressors when they are correlated.

In summary, the author is not willing to assume the fixed effects on the production function and the factor share equation are uncorrelated with labor hours and machine hours for Egyptian small-scale floor tileries. He also hypothesizes that the fixed effects are significant as a whole for both equations and should be included in the specification of the model. This hypothesis is later tested in Section 4.4.4. As a result of the above, the appropriate estimation procedure to use in estimating the model as applied to Egyptian small-scale tileries and using panel data is the "within" estimator. It should be noted, however, that the model will also be estimated using OLS for comparative purposes.

4.4 Empirical Results

In this section, the iterative process by which the "final" results are obtained will be discussed in detail. The discussion begins by using the data as processed and aggregated in Section 4.2. Each step used in obtaining the "final" data set will be presented, with final results being discussed and reported in tabular form.

Prior to pooling the data from Kalyubiya and Fayoum into one data set, regressions using the "within" estimator under the assumption that firms are maximizing expected profit are run for both areas separately until the "final" results for each area are obtained. As the analysis for each area is essentially carried out separately until the "final" data set is obtained, a discussion of the iterations involved in reaching the final results for the Kalyubiya tileries will be followed by a discussion of the Fayoum tileries.

In order to test whether the variances of the residuals from the separate regressions of the two areas are statistically different, a likelihood test is performed. The data from the two areas are then pooled, and F-tests are made to test whether the slope coefficents from the separate regressions of the two areas are statistically different and whether the individual fixed effects as a whole should be included in the production function. The marginal value products of the variable inputs are calculated, a test to determine if firms are exactly maximizing profit is performed, and efficiency measures from the factor share equation are calculated from the estimated parameters of the production function.

4.4.1 "Within" Analysis for Kalyubiya Firms

The first major problem to resolve is finding the best available measure of labor hours used in production. As stated in Section 4.2, there are four main sources of information on the number of workers in each firm and the number of hours they spent in production activities. The data on labor hours from Fayoum is initially aggregated according to the recorded number of production hours for each worker as collected in the longitudinal survey because it was felt that the data on labor hours and number of workers from the longitudinal survey in Fayoum were relatively accurate.

In Kalyubiya, the case was radically different because of instuctions given to enumerator for that area for collecting data on firms with more than six workers. For this area, the information source that was felt by the author to give the most accurate estimate of the reported number of workers in each firm is used for the initial aggregation of the labor hours and in the initial regression of the production function in the model.

For four out of the sixteen Kalyubiya tileries, in the initial regression analysis, the labor data are based on the number of workers as reported from the longitudinal survey for weeks one through fifty-four. Five tileries have labor data based on the number of workers reported in the longitudinal survey for weeks fifty-five through sixty-six, two have labor data based on the number of workers reported by the enumerators during discussions with the author, two have labor data based on the number of workers as reported by the entrepreneurs during formal interviews with the author, and three have labor data based on the number of workers as recorded in the author's notes taken during visits to the firms throughout the survey period. The total production hours for each firm in each production period[1] is the weighted sum of all production hours for each worker by weighting owners, form workers, press workers, and polishers by one and by weighting apprentices or mixers by 0.4; hours in other activities such as marketing, input procurement, or supervision are not included in this measure of labor hours.

Output is measured in square meters aggregated by type of floor tile. The weights used in aggregation are the average value of each floor tile type averaged over both areas. No changes were made to the output data after the initial regression analysis.

The measure for capital is the number of machine hours used in production. For weeks one through forty-one, the variable is constructed as described in Section 4.2 and Appendix C. Machine hours for weeks forty-two through sixty-six are based on data collected by the enumators for each machine used in the production in each tilery.

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[1]There are a total of twenty-two production periods with each period representing three weeks of production.

The slope coefficients of the production function from the initial regression of the Kalyubiya tileries using the "within" estimator are 0.9830 (0.0645) and 0.0387 (0.0482) for labor hours and machine hours, respectively.[1] The sum of the elasticities, 1.022, indicates constant returns to scale as it is not significantly different from one. The goodness of fit is respectable with an R^2 of 0.62. The tilery with the largest individual fixed effect is Firm 411, located in Tukh on the agricultural highway between Cairo and Benha. The one with the second largest individual fixed effect is Firm 116, also from Tukh, with a fixed effect ninety-four percent the size of the largest. One other tilery, Firm 552 from Kofr Shukr, has a fixed effect at least ninety percent as large as that from Firm 411. Three tileries have fixed effects that are between 89% and 80% as large as the largest, six have effects that are between 79% and 70% as large as the largest, three have effects that are between 69% and 60% as large as the largest, and one tilery, Firm 355 from El Hanka, has a fixed effect only thirty-one percent as large as the fixed effect of Firm 411.

OLS run on the same data set gives estimates of the elasticities of labor hours and machine hours as 0.9515 (0.0640) and 0.0223 (0.0299), respectively; both estimates are below those estimated by the "within" estimator. The sum of the elasticities, 0.974, is slightly less than that using the "within" estimator; however, the sum is not significantly different than one, indicating constant returns to scale. The R^2 for the regression is 0.47, indicating that less than half the variance of the

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[1] Standard errors are reported in parentheses throughout this section.

independent variable, square meters of cement floor tiles, is explained by labor hours and machine hours as measured in the initial data set.

As the measure of labor hours is complicated by the nonreporting of workers by the enumerators in Kalyubiya for certain tileries, it is not surprising that the individual effects are relatively widely dispersed. Theory would tell us that when firms are in equilibrium, we might expect firms to be found producing on different subfunctions, but not ones that differ as much as forty percent or, as in the case of Firm 355, by almost seventy percent. If this were the case, we would expect firms to either make the necessary adjustments to move to a new subfunction or to go out of production altogether. Some differences, however, can be expected to remain because of transportation and transactions costs (which can be quite substantial for a heavy product such as cement floor tiles). The relatively wide dispersion among the individual fixed effects may be due to measurement error in machine hours and in the way that output is aggregated; however, it is felt that the main problem at this point in the analysis is due to measurement error in labor hours.

There are several candidates as sources of error for the labor data which could justifiably be corrected from information known by the author.[1] Among these are the possibility that, in certain tileries, the number of laborers reported is incorrect, that the prior updating of

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[1]Changes made to the data are justifiable because of the author's intimate knowledge of the data collection process, the enumerators, and each of the sampled tileries from both areas as a result of having spent two and a half years in Egypt working on the survey. It would have been exceedingly difficult, if not impossible, for a reseacher not as familiar with the data to have made knowledgeable corrections to the data at this point.

certain laborers is incorrect, that certain tileries still contain incorrectly reported labor hours for some workers, and that the hours reported as production hours for some owners are, in reality, hours spent in supervision. Instead of trying to make all possible corrections at once, it was decided to choose one criteria at a time and apply this rule to all tileries that are affected. Once these changes are made, the parameters of the production function are remeasured and, afterwards, a new criteria is applied to the data until the final results are obtained.

The labor data for the second iterative regression are changed for six tileries only: Firms 116, 312, 314, 355, 411, and 582. For Firm 116, the number of workers is changed from five as based on the reported number of workers on the longitudinal survey for weeks fifty-five through sixty-six to six workers as recorded in the author's notes from visiting the firm, the sixth worker being added as a mixer. Also, the type of worker for two workers in Firm 116 are changed, one from a press worker to a form worker and the other from a mixer to a press worker. For Firm 312, in editing the data prior to the initial regression analysis, production hours for one of the workers is added into several of the weeks that were thought to be missing (not reported by the enumerator when the worker was actually working). The change made for this firm is to use the data as collected by the enumerator in the longitudinal survey prior to the update. One worker in Firm 314 is deleted, with the total number of workers for that tilery being five workers as recorded in the author's notes taken during visits to that tilery. For Firm 355, the number of workers is changed from seven as reported in the longitudinal survey for weeks fifty-five through sixty-six to five workers as reported in the longitudinal survey for weeks one through fifty-four. In Firm

411, the number of workers, seven, as recorded in the questionaire administered to the entrepreneurs by the author is replaced by the number of workers, six, as reported in the longitudinal survey by the enumerator. For Firm 582, one worker is changed from a polisher to a mixer which changes his weight to 0.4 from one.

Regressions are run on the production function using the above corrections for the labor data. The "within" estimates for the elasticities of labor hours and machine hours are 0.9723 (0.0529) and 0.0331 (0.0457), respectively, a slight decrease for both from the previous estimates. The sum of elasticities decreases for the "within" estimator from 1.022 to 1.011 but still indicates constant returns to scale. The goodness of fit increases slightly from an R^2 of 0.62 to 0.66. The individual fixed effects increase on average 16% with Firm 411 decreasing the most (-6%) and Firms 312 and 582 increasing the most (+31%). Firm 535, from Benha, which had the third largest individual effect in the initial regression now replaces Firm 411 from Tukh as the tilery with the largest individual fixed effect; Firm 411 is now ranked sixth among the sixteen tileries with a fixed effect measured at 94% that from Firm 535. Firm 72 from Benha, initially ranked fourth, has the second largest individual fixed effect at 99.7% that of Firm 535. Nine tileries have fixed effects estimated to be at least ninety percent as large as that of Firm 535, and four are between 89% and 84% as large. The only tilery to have a fixed effect less than 84% that of the largest is Firm 355 from El Hanka, with a measure of only forty-seven percent.

The revised data set is also estimated by OLS. The elasticity estimate for labor hours increases from 0.9515 (0.0640) to 0.9877 (0.0529) and the elasticity for machine hours decreases from 0.0223

(0.0299) to -0.0156 (0.0271); the elasticity for machine hours is not significantly different from zero for any conventional value of alpha. The sum of the elasticities remains essentially unchanged at 0.98, again indicately constant returns to scale since it is not significantly different from one (alpha = 0.05). The goodness of fit increases as measured by R^2 from 0.47 to 0.58. In the initial regression, the elastiticity estimates for labor hours and machine hours from the "within" estimator are in both cases greater than those estimated by OLS. In this iteration, the "within" estimate for the elasticity of labor hours is less than that estimated by OLS, but the estimate for the elasticity of machine hours is greater than that estimated by OLS.

One might ask if the revisions made in the data change the estimates of the individual fixed effects from the production function in a predictable manner. Essentially, Firms 411 and 116 have the two largest individual effects in the initial regression, with these being relatively large when compared with the average size of the fixed effects, 74% that of the largest effect. What the revisions for these two tileries essentially did is to make their fixed effects smaller absolutely and also smaller relative to other tileries. For example, in the initial regression, the absolute size of the fixed effects for Firm 411 and Firm 535 are, in antilogs, 3.8236 and 3.1368, respectively. In the second iteration, their absolute values are 3.1513 and 3.3552, respectively. In relative terms, the tileries that are near the average for the initial regression are still near the average, but the average size of the individual effects relative to the largest is now 90%. The changes in relative rankings are not extreme. Eleven of the sixteen tileries moved up or down in rank no more than three places. One tilery, Firm 312, moved up the scale four positions, two tileries, Firms 116 and 411, moved down the scale five positions, and one tilery, Firm 582 from Benha, moved up the scale ten places from position thirteen to third; all tileries that moved more than plus or minus three positions in the rankings are tileries that had their labor data revised.

The fixed effect of Firm 355 from El Hanka still remains extremely small relative to the fixed effects from the other Kalyubiya tileries. Discussions with the resident researcher in Kalyubiya brought to light certain characteristics of this tilery that help explain its relative position to the other tileries. Through the majority of the survey period, this tilery produced relatively little output using only temporary workers. It had originally been established by two owners, a lawyer who was using the business as a capital investment and another person who was to be the manager. This relationship did not work as planned, and the lawyer finally became the sole owner; however, he did not have the time to organize the tilery to make it competitive. Towards the end of the survey, the lawyer hired a full-time manager, full-time workers, and a new electric hydraulic press. It was during this latter period that the author visited the tilery and collected data on capital, number of workers, and other firm related information. By basing the aggregation over the entire survey period for both labor hours and machine hours for this tilery on its newly purchased machinery and newly hired workers, the original measures for labor hours and machine hours for this tilery are inflated causing its estimated fixed effect to be much smaller than it should be. Not until after the second iteration of estimating the production function with the "within" estimator did the author learn of this error.

Prior to the third iteration, only labor data had been revised. Upon learning the new information about Firm 355's capital and labor, it became necessary to revise the data for machine hours for this firm by reestimate the coefficients used in constructing the variable. The new coefficients are those presented in Equation 2 of Appendix C and can be compared with those in Equation 1 of the same appendix. All other variables used in the third iteration for estimating the parameters of the production function are the same as used in the previous iteration.

Not surprisingly, the parameter estimates obtained from the "within" estimator applied to the production function are similar to those obtained in the second iteration, with the largest adjustments being for the elasticity estimate for machine hours. The "within" estimate for the elasticity of labor hours decreases only slightly from 0.9775 (0.0529) to 0.9725 (0.0531) while the estimate for machine hours more than doubles from 0.0331 to 0.0682 (0.0557). The sum of the elasticities again indicates constant returns to scale. The goodness of fit as measured by R^2 increases one percent to 66%.

There is little movement in relative measures for the fixed effects or the relative rankings of tileries. Firm 582 from Benha has the largest fixed effect while Firm 535 from Benha, ranked first in the second iteration, drops to third with a fixed effect that is ninety-eight percent as large as the largest. Firm 552 from Kofr Shukr, ranked second, has a fixed effect that is barely differentiable from the largest and is 99.8% its size. Firm 72 from Benha, ranked second in the second iteration, drops to fourth position but still has a fixed effect 98% as large as the largest.

The relative firm measures, on average, move a mere negative one-half percent. Only Firm 318 from Kalub moves as much as four percentages, moving from 84% to 80%. Eight tileries have individual fixed effects at least ninety percent as large as that of Firm 582, and all other fixed effects except that of Firm 355 are at least eighty percent as large as that for Firm 582. Only two tileries move in the rankings as much as three positions: Firm 59 from El Rhamla drops from ninth to the twelfth position, and Firm 318 from Kalub goes from fifteenth to eleventh. What is surprising is that the relative size of the fixed effect of Firm 355 from El Hanka, the tilery for which machine hours is revised, remains unchanged at forty-seven percent the size of the largest fixed effect.

OLS is also applied to the data after making the corrections to Firm 355's data for machine hours. The estimate for the elasticity for labor hours drops from 0.9877 (0.0529) to 0.9599 (0.0531) and the estimate for the elasticity of machine hours becomes positive, increasing from -0.0156 (0.0271) to 0.0198 (0.0197). The sum of the elasticities increases slightly to 0.980 from 0.972, again suggesting constant returns to scale since it is not significantly different from one for alpha = 0.05. The goodness of fit as measured by R^2 remains unchanged at 58%. The OLS estimates for the slope coefficients (elasticities) is once again lower than those estimated by the "within" estimator, particularly for captital.

The last corrections applied to the labor data set for the Kalyubiya tileries are made to tileries that had supervisory hours spent by the entrepreneur reported incorrectly as hours spent in production. Three tileries had obvious errors in the reporting of entrepreneurial hours, Firms 306 and 318 from Kalub and Firm 355 from El Hanka. For the last iteration, for these tileries, hours reported for the entrepreneur spent in production activities are changed to hours spent in supervisory activities.

The results from estimating the production function with the "within" estimator are reported in Tables 11 and 12. The estimated elasticity of labor hours is 0.9556 (0.0574) which is highly significantly different from zero. The estimate for the coefficient on machine hours is positive at 0.0585 (0.0575) but is not significantly different from zero. The sum of the elasticities is 1.014 indicating constant returns to scale since it is not significantly different from one (alpha = 0.05).

The average fixed effect of the sampled tileries located in Kalyubiya is ninety-two percent that of the largest fixed effect which belongs to Firm 306 from Kalub. Eleven of the sixteen tileries have fixed effects at least ninety percent as large as that of Firm 306; all tileries except Firm 355 from El Hanka have fixed effects at least eighty-four percent as large as the largest fixed effect. The tilery with the smallest fixed effect is again Firm 355, with its fixed effect being fifty-seven percent the size of the largest.

OLS is also applied to this last revision, and results are reported in Table 11. The elasticity of labor hours is 0.9898 (0.0506) which is slightly higher than that estimated by the "within" estimator. The elasticity of machine hours is 0.0471 (0.0271), slightly less than that estimated by the "within" estimator. The sum of the elasticities is 1.017, which is extremely close to the sum of the elasticities estimated from the "within" estimator; it also indicates constant returns to scale since it is not significantly different from one (alpha = 0.05).

TABLE 11[a]

Regression Results From Production
Function - Kalyubiya Governorate

	"Within" Estimates	Ordinary Least Squares
Estimates of Elasticities		
Constant[b]	---	1.0959 (.2920)
a_1, Labor Hours	.9556 (.0574)	.9698 (.0506)
a_2, Machine Hours	.0585 (.0564)	.0471 (.0281)
Returns to Scale	1.01	1.02
R^2	.65	.60
Sum of Squared Errors	32.496	37.306
Total Sum of Squares	93.711	93.711

[a] Standard errors are reported in parentheses.

[b] Individual fixed effects from "within" estimates reported in Table 13.

TABLE 12

Fixed Effects From Production Function - Kalyubiya Governorate

Firm Code	Rank	Fixed Effects/ Largest Effect	Fixed Effects (logs)	Standard Errors
306	1	1.00	1.212	.445
582	2	.99	1.204	.410
535	3	.99	1.201	.446
72	4	.98	1.196	.443
552	5	.98	1.194	.392
315	6	.97	1.180	.395
318	7	.96	1.176	.464
116	8	.94	1.153	.412
411	9	.93	1.136	.450
101	10	.92	1.124	.426
312	11	.90	1.112	.357
536	12	.90	1.109	.462
59	12	.89	1.093	.436
314	14	.88	1.083	.394
311	15	.84	1.038	.453
355	16	.57	.646	.429

4.4.2 "Within" Analysis for Fayoum Firms

The initial estimation of the production function for the Fayoum tileries using the "within" estimator utitlizes output (square meters of aggregated cement floor tile), labor (aggregated labor hours), and capital (aggregated machine hours) as constructed in Section 4.2 and Appendix C. The weights used in aggregating output and labor hours are identical to those used for aggregating the data for the Kalyubiya firms. Initially, workers are classified as follows: owner, family workers, hired workers, temporary workers, and apprentices. As is the case with the Kalyubiya firms, only the parameters of the production function and not of the factor demand equations are estimated. Again, the behavioral assumption is that entrepreneurs are maximizing expected profit, thus making output endogenous and inputs exogenous in the production function. Once the final data set for Fayoum has been obtained, the data from Fayoum governorate are pooled with that of the Kalyubiya governorate and the "pooled" results are reported and discussed in Section 4.4.4.

In the first regression run for Fayoum, square meters of cement floor tiles aggregated by type and weighted by average value per square meter is used as the output variable; machine hours prior to the correction for the machine hours in Firm 355 from Kalyubiya is used as the capital variable.[1] The labor variable, labor hours, is a weighted aggregate by labor type as originally collected in the longitudinal survey. Owners, family workers, hired workers, and temporary workers are weighted by one and apprentices are given the weight of 0.4.

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[1]See Appendix C for a description of how this variable is constructed.

Using the same output and labor variables but using machine hours corrected for Firm 355 from Kalyubiya as the capital variable, a second regression is executed for the production function. The results obtained from the two regressions are essentially identical as none of the relative measures for the individual fixed effects differs by more than one percentage point whether one uses machine hours aggregated prior to the correction for Firm 355 or after the correction is made. Because of this, only the results from the regression using machine hours corrected for Firm 355 will be discussed below.

The production function is estimated by the "within" estimator under the assumption of expected profit maximization. The estimated elasticity of labor hours is 0.9410 (0.0582) and the estimate for the elasticity of machine hours is 0.1483 (0.0808).[1] The labor coefficient is significantly different from zero for an alpha value even less than 0.05, while the capital coefficient is significantly different from zero for alpha = 0.10. The sum of the elasticities is 1.09 and is not significantly different from one (alpha = 0.05), indicating constant returns to scale. The goodness of fit as measured by R^2 is equal to 0.77 and is significantly higher than for any of the regressions using the Kalyubiya data.

All the tileries from Fayoum City have larger fixed effects than tileries from the smaller **markaz** (district) towns. This is not surprising and is as predicted. The tileries outside Fayoum City are in some ways protected from competition with the Fayoum City tileries by transportion costs that are quite substantial, while tileries in Fayoum

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[1]Again, the standard errors of the estimates are reported in parentheses.

City must compete directly with all other tileries in the city since the cost of moving tiles from one section to another in the city is relatively small when compared with moving tiles from Fayoum City to one of the **markaz** towns.

Firm 216 from Fayoum City has the largest fixed effect from the production function among the Fayoum tileries with its fixed effect being substantially larger than the second largest, which is associated with Firm 215; Firm 215 has a fixed effect seventy-three percent as large as the largest. There are three tileries, all from Fayoum City, that have fixed effects between 69% and 60% as large as the largest. Firm 2 from Itsa, the **markaz** town closest to Fayoum city, has the largest fixed effect among the **markaz** towns, its fixed effect being fifty-nine percent as large as the largest. The other three tileries from **markaz** towns, Firms 117, 138, and 208, have individual fixed effects that are almost identical at 50%, 50%, and 49%, respectively.

The relative rankings seem reasonable, but the wide dispersion between the fixed effect of Firm 216 and the other tileries is probably due more to measurement error in the labor variable than to differences in fixed factors among the firms. In other words, the fact that Firm 216 is ranked as the most productive tilery in Fayoum governorate seems quite reasonable, especially in light of a priori rankings by the author based on his knowledge of the tileries prior to any formal analyses that are quite close to the rankings obtained from this regression; however, the estimate of the fixed effect of Firm 216 seems to be larger absolutely than can justifiably be attributed to differences in production based on what the author knows about the sampled tileries.

The parameters of the "average" production function are also estimated by OLS and are expected to give biased estimates of the parameters if the individual fixed effects, as a whole, are significantly different from zero and are correlated with either the labor or capital variables. The elasticity of labor hours is 0.9104 (0.0495), slightly less than that estimated by the "within" estimator, while the elasticity of machine hours is 0.1696 (0.0725), slightly larger than that estimated by the "within" estimator. Both coefficients are significantly different from zero for alpha = 0.05. The sum of the elasticities, 1.08, is slightly less than the sum of the elasticities as estimated by the "within" estimator and indicates constant returns to scale since it is not significantly different from one (alpha = 0.05). The goodness of fit as measured by R^2 is sixty-nine percent, nine percent larger than the R^2 for the final OLS regression for the Kalyubiya firms.

For the second iteration, all workers except for the owners are reclassified according to their job task. Owners, form workers, press workers, and polishers are given the weight of one, and mixers are given the weight of 0.4. In addition, corrections for labor hours are made for certain tileries. In Firms 2 and 117, labor hours of some workers tended to be overstated on the longitudinal survey and corrections are made to bring the weekly estimates of production hours for these workers more in line with that of other workers in the same tilery and the known operating hours of the tilery. Firms 215 and 216 had labor hours that were not reported on the longitudinal survey for some workers when, most probably, the workers were actually working; as a result, estimates of production hours are made by the author for these workers and inserted into the data set. The basic changes made to the other firms are in recatagorizing the workers by job activities. It is noted that during this revision it was felt that the longitudinal data overstated the number of workers in Firms 138 and 217; however, corrections for this are not made until the next iteration.

The production function is reestimated by the "within" estimator using the newly revised labor variable. The estimates of the parameters change quite noticeably. The new estimate for the elasticity of labor hours increases to 1.0438 (0.0550) from 0.9475 (0.0584), and the estimate for the elasticity of machine hours decreases to 0.0063 (0.0745) from 0.1483 (0.0808) and is no longer significantly different from zero at alpha = 0.05. The sum of the elasticities is 1.05 which has slightly decreased from the prior sum of elasticities estimated by the "within" estimator for the initial data set. Again, it indicates constant returns to scale as it is not significantly different from one. The goodness of fit as measured by R^2 has increased to 0.82.

The relative measures of the fixed effects from the production function also increase substantially for most tileries, with an average increase of twenty-five percent. Firm 216 from Fayoum City continues to be the tilery with the largest fixed effect while Firm 218, the largest tilery from Fayoum City, moves in ranking from third to second and has a fixed effect ninety-nine percent as large as the largest. Firm 215, the tilery from Fayoum that shut down its operation during week forty-three of the survey, moves from second place to fifth place with a fixed effect that is now ninety percent as large as the largest fixed effect. The tilery that moves upward the most is Firm 117 from Ta'miya, a **markaz** (district) town. The relative measure for its fixed effect increases forty-two percentage points, and the tilery moves from seventh to fourth position in the rankings.

There are now four tileries that have fixed effects at least ninety percent as large as the largest, and two tileries have fixed effects between 89% and 86% as large as the largest. The two tileries with the smallest fixed effects are again Firm 138 from Sinnouris and Firm 208 from Ibshaway, with fixed effects 75% and 69% as large as the largest, respectively. Both of these tileries were ranked at the bottom in the previous "within" regression; however, the relative measures for their fixed effects rose 25% and 20%, respectively.

In absolute terms, Firm 216's estimated fixed effect, measured in natural logs, decreases from 0.697 in the initial "within" regression to 0.594 in this iteration. The estimate for Firm 218 from Fayoum City, now ranked second, increases from 0.276 to 0.561. Firms 138 and 208, the two tileries ranked last in the initial regression and in this regression, have fixed effects that increase from 0.004 to 0.315 and from 0.020 to 0.223, respectively. Essentially, all the fixed effects measured absolutely in logs increase in size except that of Firm 216 which decreases slightly; as a result, the divergence between the largest fixed effect, Firm 216's, and the smallest, Firm 208's, shrinks. In the previous regression, the average fixed effect was sixty-four percent as large as the largest, but now the average fixed effect is eighty-nine percent the size of the largest fixed effect.

The revised data set is also used to estimate the "average" production function by OLS. Interestingly, the elasticities of labor hours and machine hours move in the same direction as they did when estimating this data set using the "within" estimator and are quite close to the elasticities estimated by the "within" estimator. The elasticity of labor hours increases to 1.0802 (0.0550) from a signficantly lower estimate of 0.9171 (0.0495); the estimated elasticity of machine hours decreases substantially to 0.0100 (0.0614) from 0.1696 (0.0725) and is no longer significantly different from zero for any standard alpha value. The sum of the elasticities is now 1.09, a slight increase from the prior OLS regression sum of 1.08 but still indicates constant returns to scale as it is not significantly different from one (alpha = 0.05) The R^2 value has increased in size ten percent, to seventy-nine percent, and is almost twenty percent higher than from the final OLS R^2 using the Kalyubiya data set.

In the final revision of the data for the Fayoum governorate tileries, one apprentice (mixer) is deleted from Firm 217 and labor hours for two apprentices in Firm 138 for the period when its electric press was inoperative are deleted. The labor hours of two workers in Firm 208 are also updated since the hours for these workers are higher than would be expected given the hours worked by other workers in this tilery and the hours it was in operation. In Firm 2, one worker's classification is changed from a polisher to a mixer. No other changes are made to the labor data; no changes are made to the output or capital data for any tileries. As noted above, the changes made in this iteration had been felt to be necessary when reviewing the data during the second revision, but the author was unwilling to make all changes to the labor data at once as too many revisions at one time would make the task of keeping track of the effects of the corrections extremely difficult.

The results from the "within" regression on the production function are quite similar to the results from the second iteration and are reported in Tables 13 and 14. The estimates of the elasticities of labor hours and machine hours have hardly changed from those of the

TABLE 13[a]

Regression Results From Production Function - Fayoum Governorate

	"Within" Estimates	Ordinary Least Squares
Estimates of Elasticities		
Constant[b]	---	.0511 (.3325)
a_1, Labor Hours	1.0550 (.0554)	1.1075 (.0445)
a_2, Machine Hours	.0118 (.0743)	.0187 (.0597)
Returns to Scale	1.07	1.13
R^2	.82	.80
Sum of Squared Errors	19.604	21.100
Total Sum of Squares	106.155	106.155

[a] Standard errors are reported in parentheses.

[b] Individual fixed effects from "within" estimator are reported in Table 14.

TABLE 14

Fixed Effects From Production Function - Fayoum Governorate

Firm Code	Rank	Fixed Effects/ Largest Effect	Fixed Effects (logs)	Standard Errors
216	1	1.00	.504	.425
218	2	.98	.488	.469
217	3	.94	.442	.421
117	4	.93	.431	.425
215	5	.90	.396	.443
214	6	.89	.384	.413
2	7	.84	.329	.402
138	8	.80	.283	.443
208	9	.73	.190	.406

second iteration and are 1.0550 (0.0554) and 0.0118 (0.0743), respectively. The sum of elasticities is 1.07, a slight increase from the previous "within" estimate, indicates constant returns to scale as it is not significantly different from one (alpha = 0.05).

The relative measures for the fixed effects have changed only slightly from the previous "within" regression. Firm 216 from Fayoum City still has the largest fixed effect among the Fayoum tileries. Firm 218, the largest tilery in Fayoum City, is again ranked second with a fixed effect that is ninety-eight percent the size of the largest. The two tileries with the smallest fixed effects are again Firms 138 and 208, with fixed effects that are 80% and 73% as large as the largest fixed effect, respectively. Four tileries have fixed effects at least ninety percent as large as the largest, two have fixed effects between 89% and 80% as large as the largest, and one tilery has a fixed effect less than eighty percent that of the largest, at seventy-three percent its size.

The rankings are similar to those from the second iteration, and only two tileries have changes in their relative rankings. Firm 2 from Itsa drops from third place to seventh, and Firm 217 from Fayoum City goes to third place from seventh place. The only tilery from a **markaz** (district) town that has a larger fixed effect than those of any tileries in Fayoum City is Firm 117 from Ta'miya, and it has a fixed effect larger than those of Firms 214 and 215 from Fayoum City. From visits made to the tileries and from interviews with both entrepreneurs and laborers, the author feels that the tilery in Ta'miya was better organized, more productive, and more consistent in its production than any of the other tileries from **markaz** towns.

The OLS estimates of the elasticities of labor hours and machine hours both increase relative to the OLS estimates from the second iteration. The elasticity of labor variable is now 1.1075 (0.0445), slightly higher than that from the second estimation and over twenty percent as large as the estimated elasticity of labor hours from the initial OLS analysis. The estimate of the elasticity of machine hours is 0.0187 (0.0597) and has increased slightly from that of the second iteration but is much lower than the estimate from the initial OLS regression. The sum of the elasticities is greater than from the two previous OLS regressions or from any of the "within" regressions; its value is 1.13 and indicates increasing returns to scale. The goodness of fit as measured by R^2 has increased to 0.80 from 0.79 in the second iteration and from 0.69 in the initial OLS regression using the Fayoum data set.

One may also be interested in comparing the estimates from the initial estimation of the production function and those of the final iteration. In terms of relative rankings of tileries by the size of their fixed effects, the tilery with the largest fixed effect--Firm 216 from Fayoum City--still has the largest fixed effect; the two tileries with the smallest fixed effects in the initial regression--Firm 138 from Sinouris and Firm 208 from Ibshaway--also have the smallest in the final iteration. No tilery moves in the rankings more than three positions. Firm 117 from Ta'miya moves upward three places from seventh to fourth; Firm 215 drops from second to fifth. In the initial rankings, no tilery from a **markaz** (district) town is ranked higher than any of the Fayoum City tileries; in the final regression, one tilery from a **markaz** town, Firm 117, moves in the rankings above two tileries from Fayoum City.

What is more noticeable than the changes in relative rankings of tileries is the relative measures for the fixed effects normalized by the largest. In the initial analysis, the three tileries with the smallest fixed effects have effects that are at least one percentage point within being equal to only fifty percent the size of the largest. Also, the tilery with the largest fixed effect had an effect twenty-seven percent larger than the second largest fixed effect. In the final analysis, the tilery with the smallest fixed effect has one that is seventy-three percent the size of the largest, and the tilery with the largest fixed effect has one only two percentage points larger than the second largest.

4.4.3 Pooling the Fayoum and Kalyubiya Data Sets

In this section, test statistics are constructed to determine whether the data sets from the two governorates can be legitimately pooled into one data set. All the analyses in this section are done under the assumption that the entrepreneurs are maximizing expected profit; that is, output is endogenous and inputs are exogenous. Because of this, the production function can be estimated consistently as a single equation, and the estimates of its coefficients can be used to calculate the parameters of the factor share equation, specifically g_{i2}.

Although the tileries in the sample are not identical, the technology that they use to produce cement floor tiles is quite similar, and one can hypothesize that all the tileries are producing on subfunctions of the same general production function. The assumption that all tileries in the same area are using basically the same technology is implicit in the analyses above as no test is made firm by firm to see whether the elasticities of variable inputs are the same for all tileries. However, it is easy to test whether tileries on average from the two governorates are using the same technology; that is, whether the elasticities of variable inputs estimated separately using the two area data sets are statistically the same. The purpose of the test is to see if the two data sets can be legitimately pooled, which should increase the accuracy of our estimates for the parameters of the model.

The appropriate test to construct is an F-test. Implicitly, this test assumes that the variances of the two data sets are the same; otherwise, the conclusions drawn from the F-test may be incorrect. We should first test whether the variances of the residuals on the production function from the two data sets are the same; if so, we can then apply an F-test or equivalent test to discover whether the elasticities obtained from the two separate regressions are the same. If the variances and elasticities are the same, then we can pool the data from the two different governorates.

The correct test statistic for determining whether the variances of the two area samples are the same is a likelihood ratio test which, in practice, becomes an F-test of the form

$$(22) \qquad F_{d_f, d_k} = \frac{\hat{s}_f^2}{\hat{s}_k^2}$$

where

$$(23) \qquad \hat{s}_f^2 = \frac{SSE_f}{N_f - K_f}$$

and

$$(24) \qquad \hat{s}_k^2 = \frac{SSE_k}{N_k - K_k}$$

SSE_f is the sum of squared errors from the final "within" regression on the Fayoum data, SSE_k is the sum of squared errors from the final "within" regression on the Kalyubiya data, N_f and N_k are the number of observation in the Fayoum and Kalyubiya data sets (177 and 306, respectively), K_f and K_k are the number of parameters being estimated by the "within" estimator for the two areas[1], $d_f = N_f - K_f$, and $d_k = N_k - K_k$.

Formally, the hypothesis we are testing is H_o: $\sigma_f^2 = \sigma_k^2$ against H_a: not H_o. If our calculated F-statistic is greater than $F_{0.05}(200,1000)=1.22$, the null hypothesis, H_o, is rejected. Substituting into Equation 24 the numeric values obtained from the two separate area regressions on the production function, we find that our calculated F-statistic is 1.05 and is less than $F_{0.05}(200,1000) = 1.22$; thus, the null hypothesis, H_o, is not rejected, and we conclude that the variances of the two area samples, from Fayoum and Kalyubiya governorates, are the same; thus, the two data sets can be pooled.

Having pooled the data from the two governorates, it is now possible to test whether the tileries in the two areas are producing on subfunctions of the same general production function; that is, whether the elasticities of labor and machine hours are statistically the same for the two areas when allowing for different fixed effects for each

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[1] K_f and K_k are equal to the number of dummy variables plus the number of regressor coefficients plus one to take account of the overall intercept.

tilery. Again, the correct statistic is an F-statistic which is given below.

$$(25) \qquad F_{d_1,d_2} = \frac{(SSE_r - SSE_u)/d_1}{SSE_u/T-K_u}$$

where d_1 equals the number of restriction, d_2 equals the number of observation, $T = \sum_i T_i$, T_i is the total number of production periods for firm i in the sample, K equals the number of parameters of the unrestricted regression, SSE_r is the sum of squared errors from the restricted regression, and SSE_u is the sum of squared errors from the unrestricted regression.

The null hypothesis being tested is H_o: $a_{1f} = a_{1k}$; $a_{2f} = a_{2k}$ without the restriction of a common intercept for all tileries. We can obtain SSE_r by regressing y (natural log of output) on l (natural log of labor hours), k (natural log of machine hours), and d_i (natural log of the individual fixed effects for all tileries).[1] This regression is the "within" estimator executed on the production function, equation 20, using the pooled data.

The SSE_u is obtained by pooling the data and estimating the production function using the "within" estimator as above but with two additional variables added to allow for elasticity differences on variable inputs to differ between the two regions. The variables

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[1]If the program used for analysis constrains the regression to include an overall intercept term, instead of twenty-five dummy variables--one for each firm--only twenty-four dummy variables are added to the production function and the d_i's of the production function in the model (under the assumption of maximization of expected profit) are calculated by adding the overall intercept to the estimated coefficients of the dummy variables. The d_i for the firm without a dummy variable is estimated by the overall intercept term.

added are $x_l = l * b_l$ and $x_k = k * b_k$ where b_l and $b_k = 1$ if the firm is from Fayoum and b_l and $b_k = 0$ if the firm is from Kalyubiya. The estimates of the elasticities of l and k from this regression are equal to those from the separate "within" regression on the Kalyubiya data set. If we add $a_1 + b_l$ and $a_2 + b_k$, their sums are equal to the estimates of the elasticities of l and k, respectively, when the "within" estimator is applied to the Fayoum data set. The individual fixed effects from the pooled regression when added to the "overall" intercept term are identical to the estimates of the fixed effects when the the "within" estimator is applied separately to the two area data sets.

From the above regressions, an F-statistic can be calculated to test H_o: $a_{1f} = a_{1k}$; $a_{2f} = a_{2k}$ where a_{jf} and a_{jk} (j=1,2) are the coefficients from the Fayoum and Kalyubiya regressions, respectively. If the F-statistic is greater than $F_{0.05}(2,1000)=3.0$, then H_o is rejected. In our case, substituting the estimated values from the above two regressions into Equation 25, we find that our calculated F-statistic is 0.797 and is less than $F_{0.05}(200,1000)=1.22$; thus, the null hypothesis, H_o, is not rejected for alpha = 0.05 and we conclude that, as had been hypothesized earlier, the technology used by the Egyptian small-scale floor tileries is the same for both survey areas.

4.4.4 Estimating the Model with Pooled Data

It is shown in the previous section that the data from the two areas are from the same population of small-scale tileries and that the data sets from Fayoum and Kalyubiya can be pooled. It is also shown that the elasticities of labor hours and machine hours are statistically the same for tileries in both areas, and that--under the behavioral assumption of expected profit maximization--consistent estimates of all the parameters of the model can be obtained from applying the "within" estimator to the pooled data.

The results from this regression are presented in Tables 15 and 16. The elasticity of labor hours is 1.0074 (0.0395) and is significant for any standard alpha value.[1] The elasticity of machine hours is 0.0417 (0.0449), positive as expected but not significantly different from zero (alpha = 0.05). The R^2 value from the "within" (least-squares-with dummy-variables) estimator is 0.82; that is, eighty-two percent of the variation in output from the sampled tileries is explained by the independent variables, labor hours, machine hours, and the fixed effects.

The sum of the elasticities is 1.049, and, when tested as to whether or not it is significantly different from one, it is established that it is not different; thus, we conclude that Egyptian small-scale tileries are producing under constant returns to scale.

We might ask if the behavior of the tileries as observed during the survey period supports the above conclusions. During the survey period, several tileries were experimenting with the production process and felt that their profit could be increased by purchasing more capital and hiring more labor. In fact, three tileries from Fayoum (thirty-three percent of the Fayoum sample) and two from Kalyubiya (thirteen percent of the Kalybubiya sample) purchased additional machinery during the survey period. In the year prior to the survey period, six tileries from Kalyubiya (thirty-eight percent of the Kalyubiya sample) and one from Fayoum (eleven percent of the Fayoum sample) increased their capital stock. In total, forty-eight percent, almost half of the sampled

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[1]The standard errors of the estimates are reported in parentheses.

TABLE 15[a]

Regression Results From Production Function for Pooled Data -- Fayoum and Kalyubiya Governorates

	"Within" Estimates	Ordinary Least Squares
Estimates of Elasticities		
Constant[b]	---	-.2337
		(.2063)
a_1, Labor Hours	1.0074	1.1779
	(.0395)	(.0342)
a_2, Machine Hours	.0417	.0347
	(.0449)	(.0278)
Returns to Scale	1.05	1.21
R^2	.82	.75
Sum of Squared Errors	52.283	72.300
Total Sum of Squares	283.546	283.546

[a] Standard errors are reported in parentheses.

[b] Individual fixed effects from "within" estimator are reported in Table 16.

TABLE 16

Fixed Effects From the Production Function for
Pooled Data -- Fayoum and Kalyubiya Governorates

Firm Code	Area	Rank	Fixed Effect/ Largest Effect	Effect (logs)	Standard Errors
216	Fay	1	1.00	0.624	0.292
218	Fay	2	0.98	0.607	0.319
217	Fay	3	0.96	0.580	0.292
117	Fay	4	0.93	0.579	0.292
215	Fay	5	0.90	0.519	0.307
214	Fay	6	0.85	0.460	0.280
2	Fay	7	0.84	0.447	0.280
138	Fay	8	0.80	0.398	0.303
208	Fay	9	0.71	0.281	0.277
306	Kal	1	1.00	0.988	0.324
552	Kal	2	0.99	0.982	0.284
582	Kal	3	0.99	0.977	0.297
72	Kal	4	0.98	0.969	0.322
318	Kal	5	0.98	0.968	0.341
535	Kal	6	0.98	0.968	0.324
315	Kal	7	0.95	0.940	0.283
116	Kal	8	0.92	0.905	0.297
411	Kal	9	0.92	0.904	0.327
312	Kal	10	0.92	0.903	0.261
59	Kal	11	0.90	0.883	0.320
536	Kal	12	0.90	0.881	0.337
101	Kal	13	0.89	0.876	0.306
314	Kal	14	0.87	0.850	0.283
311	Kal	15	0.84	0.812	0.330
355	Kal	16	0.57	0.425	0.313

tileries, increased their capital stock either during or just prior to the survey period. If firms are indeed producing under constant returns to scale, this type of behavior might be expected--expansion by buying more capital and labor--during a period of increased market demand and rising prices for cement floor tiles as was the case in Egypt during the survey period.

There are, however, reasons other than constant returns to scale that can explain the above behavior. If the price of labor relative to the price of capital is rising, then we would also expect to see an increase in the capital stock, but at the expense of the number of laborers per unit of capital stock. In fact, the trend in real labor wages for almost all sectors of the Egyptian economy during the early eighties has been upward, and many of the entrepreneurs in the sample complained about the relatively high cost of workers.

One of the major trends in capital investment for the firms is the purchase of electical hydraulic presses to replace manual presses. One reason is that three workers using a manual press can generally produce daily thirty-five to forty square meters of floor tile (two men working the forms and one man manually pumping the press) while three men on an electric press can produce daily about sixty square meters of tile. When a fourth worker is employed in combination with an electric press, the tilery, by replacing a manual press with an electric, can increase daily production of the firm to about eighty square meters of tiles daily.

In Table 16, tileries are sorted by area and, within each area, are ranked in descending order by the size of their estimated fixed effect, d_i. The average fixed effect for the tileries in Fayoum measured in natural logs is 0.502 while the average fixed effect for those in Kalyubiya is 0.892. As discussed above, transportation costs prohibit transporting cement floor tiles between the two governorates at the prevailing output prices. This, in essence, separates the two areas into two distinct market areas. Kalyubiya governorate is much more accessible to Cairo than is Fayoum and has a better developed infrastructure. Income, education, and other measures of urbanization are higher in Kalyubiya. Kalyubiya firms also have more highly developed raw material markets and better access to raw materials than do Fayoum firms. Because of these differences, tileries are only ranked within an area and not between areas.

The fixed effects on the production function for the Fayoum tileries estimated from the "within" estimator using the pooled data are quite similar to those estimated for the same tileries when using the Fayoum data set; the resulting rankings for the Fayoum tileries are the same. The average size of the fixed effects, however, increases slightly when estimating the model with the pooled data, increasing from 0.387 to 0.502 (natural logs). Again, five tileries--all but one from Fayoum City--have fixed effects at least ninety percent as large as the largest fixed effect. All but one of the nine Fayoum tileries have fixed effects at least eighty percent as large as the largest effect from Firm 216. Firm 208 from Ibshaway still has the smallest fixed effect, seventy-one percent the size of the largest fixed effect, but its fixed effect has decreased slightly relative to the prior measure obtained when using the Fayoum data set to estimate the model. In fact, only three tileries have fixed effects that change relative to the largest fixed effect; none have relative measures that change by more than four percent.

The rankings for the Kalyubiya tileries obtained from pooling the two data sets are slightly different from that obtained by using the Kalyubiya data set. Although the rankings change for eight tileries, none change more than three places: 535 goes up from sixth place to third, Firm 552 goes from second place to fifth, and Firm 101 goes from thirteenth place to tenth. Actually, the changes in rankings are somewhat misleading since the actual changes in the fixed effects are quite small. Only one tilery, Firm 101, has its estimated fixed effect change by three percentages (from 89% to 92%) when compared to that obtained by using the Kalyubiya data set. All other changes in this measure are less than three percent.

The reason why such small changes in the estimated relative sizes of the fixed effects cause half of the Kalyubiya tileries to have ranking changes is because the estimated fixed effects in absolute values for the majority of the tileries are so similar. Five tileries have relative measures of ninety-eight percent or above, seven have measures ninety-five percent or above, and twelve out of the sixteen have measures ninety percent or above. It is also interesting to note that the three tileries that had the smallest fixed effects when using the Kalyubiya data also have the smallest when using the pooled data. In fact, there is no change in rankings or relative size to the largest fixed effect for the bottom two firms; the change for Firm 314, with the third smallest fixed effect, is only one percent, from 87% to 88%. The average size of the fixed effects measured in natural logs for the Kalyubiya tileries decreases from 1.128 to 0.892

The production function is also estimated using OLS, and the results are reported in Table 15. The labor coefficient, a_1, is 1.1779

(0.0342) and is significantly different from zero for any reasonable alpha. The coefficient on machine hours is 0.0347 (0.0247); though it is positive as expected, it is not significantly different from zero for alpha=.05. The returns to scale from this regression is 1.21 and is significantly different from one, indicating that the firms are producing under increasing returns to scale; this finding is due to the large coefficient on the labor variable.

In order to test whether the individual fixed effects, the d_1's, as a group increase the explanatory power of our production function for the dependent variable, square meters of aggregated cement floor tiles, we can test the null hypothesis, H_o: $d_i = 0$ for all i where i = 1,...,25, against the alternative hypothesis, H_a: not H_o, by constructing an F-statistic as developed in Equation 25 above. Substituting the correct values into Equation 25, we find that H_o is rejected (alpha = 0.05) and conclude that the addition of the fixed effects in the production function does increase its explanatory power.

By using a Hausman (1978) test, we can construct an even more power statisitic to test the hypothesis of misspecification when estimating the model with OLS as opposed to the "within" estimator. If there is no misspecification, an asymptotically efficient estimator must have zero covariance with its difference from a consistent, but asymptotically inefficient estimator. If the OLS model is the correct specification, then it is BLUE, and the "within" estimator will be consistent, but asymptotically inefficient. The null hypothesis is H_o: no misspecification using OLS, and the alternative hypothesis is H_a: misspecification. The test statistic is

$$(26) \qquad (\hat{B}_w - \hat{B}_o)'[\mathrm{cov}(w) - \mathrm{cov}(o)]^{-1}(\hat{B}_w - \hat{B}_o)$$

where $\hat{B}_w$ and $\hat{B}_o$ are vectors of parameters obtained from the "within" estimator and OLS, respectively, and cov(w) and cov(o) are the covariance matices from "within" and OLS, respectively. This statistic has an asymptotic distribution as central χ^2_k where k is, in our case, the number of fixed effects, one for each of the twenty-five tileries, and has a critical value at 37.7 for alpha = 0.05. When calculated, the value of our statistic is 88.0; thus, we reject H_o and conclude that using OLS leads to misspecification, and our estimates will be biased and inconsistent. Alternatively, we conclude that the "within" estimator in lieu of OLS is the appropriate estimator for estimating the model for Egyptian small-scale floor tileries.

An F-test is also constructed to test whether the average fixed effects of the two areas are significantly different from each other, and it is found that the average fixed effects from the production function are indeed significantly different for alpha = 0.01. We also test whether individual fixed effects are significantly different from zero for each tilery. The hypothesis that the individual fixed effects are equal to zero (H_o: d_i=0 for all i=1,...,25) can be tested by regressing output on labor hours, machine hours, and a dummy variable for each firm (no overall constant term) and constructing a t-test using the standard errors of the fixed effect estimates.

Looking at the standard errors for the individual fixed effects reported in Table 16, one can see that some but not all the fixed effects are significantly different from zero for alpha = 0.05. All the tileries from Kalyubiya except Firm 355, which has the smallest fixed effect in that area, have fixed effects significantly different from zero. In Fayoum, although all the fixed effects are estimated to be positive, only the two tileries with the largest estimated fixed effects in that area, Firms 216 and 217, have fixed effects significantly different from zero.

One can also test the hypothesis that the largest fixed effect in Fayoum (Kalyubiya) is equal to the other fixed effects of firms from Fayoum (Kalyubiya). The simplest way to do this is to regress output on labor hours, machine hours, and a dummy variable for each firm except the tilery with the largest fixed effect in Fayoum (Kalyubiya). (Its fixed effect will be represented by the overall constant term.) The coefficients on a dummy variables are estimates of the difference between a firm's fixed effect and that of the largest fixed effect in Fayoum (Kalyubiya).

The results of this regression when the largest fixed effect in Fayoum is represented by the overall constant term are reported in Table 17. When the largest fixed effect in Kalyubiya is represented by the overall constant term, the results are reported in Table 18. When one looks at the standard errors of the fixed effects, we see that the fixed effects for all tileries producing in Fayoum City (Firms 214, 215, 216, 217, and 218) as well as Firm 117 (Ta'amiya) and Firm 2 (Itsa) are not significantly different from that of the largest effect. Only Firm 138 from Sinouris has a fixed effect significantly different from the largest fixed effect, that of Firm 216 in Fayoum City. For Kalyubiya, the only tilery with a fixed effect significantly different from that of the largest, Firm 306's, is Firm 355 which has the smallest estimated fixed effect in that area.

TABLE 17

"Within" Regression From Production Function for Pooled Data - Firm 216 (Fayoum) as Constant

Firm Code	Area	Rank	Fixed Effects	Standard Errors
CONSTANT (216)	Fay	1	.624	.292
218	Fay	2	-.017	.106
217	Fay	3	-.044	.103
117	Fay	4	-.075	.102
215	Fay	5	-.105	.119
214	Fay	6	-.164	.112
2	Fay	7	-.176	.115
138	Fay	8	-.225	.103
208	Fay	9	-.342	.108
306	Kal	1	.364	.109
552	Kal	2	.358	.104
582	Kal	3	.353	.105
72	Kal	4	.345	.110
318	Kal	5	.345	.121
535	Kal	6	.344	.111
315	Kal	7	.316	.109
116	Kal	8	.289	.118
411	Kal	9	.280	.111
312	Kal	10	.280	.131
59	Kal	11	.260	.111
536	Kal	12	.257	.114
101	Kal	13	.253	.109
314	Kal	14	.226	.107
311	Kal	15	.188	.111
355	Kal	16	-.199	.111

TABLE 18

"Within" Regression From Production Function for Pooled Data - Firm 306 (Kalyubiya) as Constant

Firm Code	Area	Rank	Fixed Effects	Standard Errors
216	Fay	1	-.364	.109
218	Fay	2	-.381	.103
217	Fay	3	-.408	.112
117	Fay	4	-.439	.109
215	Fay	5	-.469	.122
214	Fay	6	-.528	.119
2	Fay	7	-.540	.126
138	Fay	8	-.589	.106
208	Fay	9	-.706	.117
CONSTANT (306)	Kal	1	.988	.324
552	Kal	2	-.006	.114
582	Kal	3	-.011	.112
72	Kal	4	-.019	.107
318	Kal	5	-.019	.110
535	Kal	6	-.020	.108
315	Kal	7	-.048	.122
116	Kal	8	-.082	.128
411	Kal	9	-.084	.106
312	Kal	10	-.084	.148
59	Kal	11	-.105	.108
536	Kal	12	-.107	.105
101	Kal	13	-.111	.115
314	Kal	14	-.138	.120
311	Kal	15	-.176	.105
355	Kal	16	-.563	.111

In a well integrated market one would not expect to find a great divergence among the differences in production among firms within the same market area; those firms that were significantly less productive would not be able to compete and would be driven out of business unless they improved their productivity. We would expect only those firms which are protected, so to speak, from the competition of more productive firms to survive while continuing to be significantly less productive. In Fayoum, those tileries that compete directly with other tileries in the market of Fayoum City are producing on sub-production functions that are quite similar; those tileries which are separated from the Fayoum City market by significant transportation and transactions costs are producing on lower subfunctions. The only exception is Firm 117 in Ta'amiya which is experiencing a stronger than average demand for its product because of the construction of a new governmental center in that town.

Kalyubiya has a much better transportation infrastructure than Fayoum and is much closer to Cairo; thus, its market is much larger in terms of area and population and is better integrated than the Fayoum market. As a result, the tileries located in the larger population areas or along the Agricultural Highway, the main transportation artery in Egypt, all have fixed effects that are similar in size. This is to be expected since transportation costs between these localities are relatively small; however, it is interesting to note that the most isolated tilery in the Kalyubiya sample, Firm 355 from El Hanka, has the smallest fixed effect (as did the most isolated tilery in the Fayoum sample, Firm 206 from Ibshaway).

4.4.5 Efficiency Measures--Variable Inputs

Having obtained consistent estimates for the parameters of the production function by using the "within" estimator, one can now calculate consistent estimates of the R_{ij}'s (j=1,2) from the factor demand equations, Equations 6 and 7, that indicate whether individual firms are maximizing profit; that is, whether or not firms are equating marginal value product to marginal factor cost for all variable inputs. Table 19 presents for each tilery the estimates for the marginal value products of labor hours (MVP_l) and machine hours (MVP_k), and the marginal factor cost (wage rate) for an hour of labor (MFC_l) and an hour of machinery (MFC_k). Tileries are reported in the order of the rankings obtained from the size of the fixed effects from the production function.

The (MFC_l) is the average value of wages per hour for aggregated labor hours for each tilery. The MFC_k is calculated from the formula

$$(27) \qquad MFC_k = \frac{rv}{1-(1+r)^{-n}}$$

where r is the interest rate , v is the value of the aggregated machines, and n is the expected life of the machines. For our calculation, acquisition cost of machinery is used to compute v, n is twenty years, and the interest rate, r, is ten percent. The salvage price of machinery can also be used to calculate MFC_k if one observes that firms are disinvesting in capital; however, when firms are adding to their capital stock by purchasing new machinery, the appropriate measure is acquisition cost.

Whenever one derives estimates from first order conditions, the estimates should be viewed with caution. Our estimates which tell us if firms are maximizing profit or whether firms are combining variable

TABLE 19

Marginal Value Products and Marginal Factor Costs - Variable Inputs

Firm Code	Area	MVP_L	MVP_K	MFC_L	MFC_K
216	Fay	2.44	0.19	0.44	0.06
218	Fay	2.47	0.14	0.39	0.10
217	Fay	2.31	0.28	0.47	0.11
117	Fay	2.26	0.16	0.45	0.07
215	Fay	2.21	0.17	0.48	0.05
214	Fay	2.07	0.06	0.30	0.06
2	Fay	2.01	0.17	0.33	0.09
138	Fay	1.97	0.12	0.34	0.09
208	Fay	1.72	0.07	0.38	0.06
306	Kal	3.63	0.21	0.28	0.05
552	Kal	3.45	0.31	0.37	0.12
582	Kal	3.46	0.37	0.27	0.16
72	Kal	3.54	0.23	0.30	0.09
318	Kal	3.65	0.10	0.35	0.03
535	Kal	3.54	0.26	0.21	0.04
315	Kal	3.25	0.68	0.38	0.05
116	Kal	3.18	0.66	0.21	0.04
411	Kal	3.34	0.23	0.26	0.04
312	Kal	3.06	0.47	0.35	0.08
59	Kal	3.26	0.14	0.18	0.06
536	Kal	3.31	0.17	0.45	0.04
101	Kal	3.14	0.51	0.47	0.11
314	Kal	2.98	0.51	0.30	0.04
311	Kal	3.06	0.17	0.55	0.05
355	Kal	2.04	0.14	0.44	0.05

Interest Rate = 10%; Machine Life = 20 Years.

inputs in a least cost manner are first derivatives of the production function. Even when the functional form specified for the production function fits the data well, it does not always follow that the first derivatives will be accurately indicate whether firms are allocating variable inputs efficiently. The problem stems from the fact that firms may be smoothing inputs usage over time. If this is the case, to say that the firm should be at the tangent point each period is not realistic. Also, in our case, coefficient on machine hours used in calculating the individual marginal value products of machine hours has a large standard error which in turn means that our measures of MVP_k also have large standard errors.

The average MVP_l and MVP_k for Fayoum tileries are L.E. 2.16 (L.E. 1 = US $1) and L.E. 0.15, respectively. For Kalyubiya tileries, they are L.E. 3.24 and L.E. 0.32, respectively. Remembering that, in antilogs, R_{ij}=1 indicates profit maximization, we find that the average value of R_{i1} is 6.60, with a range of 4.57 (Firm 2, Itsa) to 8.27 (Firm 217, Fayoum City) for the Fayoum tileries, and 9.42 for Kalyubiya tileries, with a range of 6.27 (Firm 552, Kofr Shukr) to 12.51 (Firm 315, (Kalub). The average value of R_{i2} for the Fayoum is 2.07, with a range of 1.06 (Firm 214, Fayoum City) to 3.25 (Firm 216, Fayoum City); for Kalyubiya, it is 5.87, with a range of 2.35 (Firm 582, Benha) to 16.76 (Firm 116, Tukh). These results are reported in Table 20.

These results indicate that, on average, Egyptian small-scale floor tileries in the two governorates are underutilizing **both** capital and labor. The fact that tileries in general were hiring both additional labor and capital during or just prior to the survey period has correspondence with these findings. In Egypt, where credit is rationed

TABLE 20

Efficiency Measures - Variable Inputs

Firm Code	Area	R_{il}	R_{ik}	G_{i2}
216	Fay	6.45	3.25	0.50
218	Fay	8.16	1.46	0.18
217	Fay	8.27	2.45	0.30
117	Fay	7.57	2.29	0.30
215	Fay	7.97	3.66	0.46
214	Fay	5.49	1.06	0.19
2	Fay	4.57	1.83	0.40
138	Fay	5.97	1.34	0.22
208	Fay	4.98	1.27	0.25
306	Kal	10.43	4.23	0.41
552	Kal	6.27	2.50	0.40
582	Kal	7.85	2.35	0.30
72	Kal	7.54	2.61	0.35
318	Kal	10.47	2.87	0.27
535	Kal	7.5	6.71	0.89
315	Kal	12.5	13.96	1.12
116	Kal	6.62	16.76	2.53
411	Kal	7.36	5.45	0.74
312	Kal	7.97	6.24	0.78
59	Kal	8.36	2.49	0.30
536	Kal	10.96	4.66	0.42
101	Kal	6.91	4.70	0.68
314	Kal	14.21	11.73	0.83
311	Kal	14.69	3.21	0.22
355	Kal	11.03	2.58	0.23

Interest Rate = 10%; Machine Life = 20 Years and imported machinery used in manufactoring cement floor tiles is heavily taxed, it is not surprising that there appears to be a lag in the tileries' adjustments to the dynamic market for their products, with the increased demand being largely driven by increased incomes from remittance payments to their families by Egyptian workers in other Arab countries. Also, because the emigration of workers is not strictly controlled and the pay for unskilled workers is relatively higher in neighboring oil-producing countries than are wage rates in Egypt, there seems to be a lag in the wage rate adjustments necessary to equate the MVP_1 with MFC_1.

In addition to the measures for determining profit maximization, one can also obtain measures to discover if firms are combining labor and capital in a least cost manner. The measure, g_{i2}, derived in Section 4.1 is reported in Table 20. Again, in antilogs, if G_{i2}=1, labor and capital are being combined in a least cost manner. The average value of G_{i2} for the Fayoum tileries is 0.31 with a range of 0.18 (Firm 218, Fayoum City) to 0.50 (Firm 216, Fayoum City); for the Kalyubiya tileries, it is 0.65, ranging from 0.22 (Firm 311, Kalub) to 2.53 (Firm 116, Tukh). This means that, on average, tileries in both areas are using too little labor relative to the amount of capital they are employing. Only two tileries, Firms 116 (Tukh) and 315 (Kalub), are using too much labor given the amount of capital they are employing. This finding also seems reasonable in light of the fact that tileries were indeed purchasing more capital and labor, with entrepreneurs emphasizing that the problem of finding and retaining workers (at the prevailing wage rate) is more of a problem than obtaining funds for purchasing additional capital.

Another interesting exercise is to determine the cost due to misallocating variable inputs in the production process for each firm in the sample. Following Schmidt and Lovell (1979), it can be shown that the cost of this inefficiency is

$$(28) \qquad C_i = E_{i2} - \ln r \qquad i=1,\ldots,25$$

where

$$(29) \qquad r = \sum_j a_j \qquad j=1,2$$

$$(30) \qquad E_{i2} = \frac{1}{T_i} \sum_t g_{it}$$

$$(31) \qquad E_{it2} = \frac{a_2}{r} g_{it2} + \ln\,(a_1 + a_2 e^{-g_{it2}})$$

with g_{it2} as defined in Equation 23 of Chapter 3. The estimates of C_i are reported in Table 21. The average cost due to the inefficient combination of variable inputs for Fayoum tileries is 0.05 or five percent, ranging from one percent (Firms 215 and 216, Fayoum City) to ten percent (Firm 218, Fayoum City). It is only two percent for Kalyubiya tileries with a range from zero percent (Firms 101, 312, 314, 315, 411, and 535) to six percent (Firm 355, El Hanka). The interesting result is that, although the measures for indicating ineffecient combination of variable inputs seem to be substantial, the actual cost of this inefficiency is quite low.

This relatively low cost to the firms for combining labor hours and machine hours in the wrong proportion helps explain why tileries, though they were adjusting, were adjusting with a time lag. The larger

TABLE 21

Cost of Inefficiency - Variable Inputs

Firm Code	Area	G_{i2} (logs)	Cost
216	Fay	0.50	0.01
218	Fay	0.18	0.10
217	Fay	0.30	0.04
117	Fay	0.30	0.04
215	Fay	0.46	0.01
214	Fay	0.19	0.09
2	Fay	0.40	0.02
138	Fay	0.22	0.07
208	Fay	0.25	0.06
306	Kal	0.41	0.02
552	Kal	0.40	0.02
582	Kal	0.30	0.04
72	Kal	0.35	0.03
318	Kal	0.27	0.05
535	Kal	0.89	0.00
315	Kal	1.12	0.00
116	Kal	2.53	0.01
411	Kal	0.74	0.00
312	Kal	0.78	0.00
59	Kal	0.30	0.04
536	Kal	0.42	0.02
101	Kal	0.68	0.00
314	Kal	0.83	0.00
311	Kal	0.22	0.07
355	Kal	0.23	0.06

Interest Rate = 10%; Machine Life = 20 Years.

the costs of inefficiencies, the faster one would expect firms to adjust to correct for these inefficiencies. Also, one could argue that, since the misallocation of variable inputs is due in part to using too much capital for the amount of labor employed, these cost are a necessary business expense (the building up of excess productive capacity) when the demand for the product is seasonal and often uncertain as is the case with many of the tileries in the sample.

4.5 Estimation of Model II--Exogenous Output

In all the above analyses, tileries are assumed to be maximizing expected profit; that is, they base their decision of how much output to produce on the expected quantity of output that would maximize expected profit. Under this assumption, output becomes a decision variable, and a firm chooses to produce the amount of output that will maximize expected profit and is able to sell all that it produces without influencing the market price for floor tiles.

In Egypt, particularly among small-scale floor tileries, much of the production is done on an order-by-order basis. The consumer goes to a producing tilery and orders the type and quantity of floor tiles that he desires given the output price for tiles. Once orders are placed, the entrepreneur produces the requested output and tries to minimize the cost of production. Inputs prices are assumed to be given. Output prices are also exogenous to the firm in that it can not gain monopoly control. Differentials in prices for output among firms are generally attributable to transportation costs and quality differences.

This type of marketing arrangement would fit the behavioral assumptions of the model developed by Schmidt (1984); however, tileries in major urban areas may be able to choose an output goal that would maximize expected profit, given input and output prices, and be able to sell all that they produce. Under these conditions, the marketing pattern fits the assumption of endogenous output. Realistically, what probably happens is that tileries producing for small market areas (those in small or outlying villages) produce almost totally on order with only enough finished product inventory on hand so that the consumer can start construction immediately while the entrepreneur fills the rest of the order.

In cities such as Fayoum City and Benha, it is more conceivable that tileries are able to choose output goals based on expected profit maximization and to sell all that they produce. Inventory amounts would probably be larger than under the first case and perhaps more variable than output produced. This is because we would expect to see more of a seasonal pattern of production from those producing exogenous output than from those that choose output production endogenously (unless demand is not seasonal, which, in the case of cement floor tiles for small firms in Egypt, it is).

If both cases of endogenous and exogenous output exist in the sampled tileries, then the appropriate model would perhaps be one that allows "switching"; that is, if expected demand for a tilery's output is less than the quantity of output necessary to maximize expected profit, then output could be considered exogenous. If the expected demand is equal to or greater than the quantity that would maximize expected profit, then output could be considered endogenous.

As discussed above, one might argue that tileries, at least some, are mainly responding to market orders only; that is, a tilery only produces when a customer enters the firm and places an order for a certain type and quantity of floor tiles. Under this type of market arrangement, tileries (particularly, those located in the more rural and limited market areas) can not expect to sell all that they are capable of producing at the given market price, but instead are reacting to **exogenous** output by minimizing the costs of producing the quantity of output being demanded by its customers. If this were a realistic assumption, one would want to use the model developed by Schmidt (1984) instead of the model developed in Section 4.1. since, under the assumptions of Schmidt's model, both the "within" estimator and OLS will give inconsistent estimates of the parameters of the model.

This second model as estimated for Egyptian small-scale floor tileries located in Kalyubiya and Fayoum governorates is:

(32) $$y_{it} = a_1 l_{it} + a_2 k_{it} + d_i + v_{it}$$

(33) $$l_{it} - k_{it} = B_{it2} + g_{i2} + u_{it2}$$

$$(i = 1,\ldots,25;\ t=1,\ldots,22)$$

where y is the natural log of cement floor tiles (output) measured in square meters and aggregated by tile type, l is the natural log of labor hours used in production aggregated by labor type, k is the natural log of machine hours used in production aggregated by machine type, d_i and g_{i2} are firm-specific fixed effects, and v_{it} and u_{it2} are random variables with mean zero and variance σ_v^2 and σ_u^2, respectively. Each production period, t, covers three weeks for a total of twenty-two time periods starting December 1980 and ending March 1983. Twenty-five firms, nine in Fayoum governorate and sixteen in Kalyubiya governorate, make up the sample and are represented by i.

As shown in Section 3.6 of Chapter 3, the estimates of the parameters for this model are easily obtained by making a correction to the estimates obtained from the "within" estimator, specifically

(34) $\hat{a} = \underline{a} + (\underline{SSE}/\underline{r})(x_*'x_*)^{-1}e$

(35) $\hat{r} = e'\hat{a} = \underline{r} + D\ \underline{SSE}/\underline{r}$

(36) $SSE = (y_* - x_*\hat{a})'(y_* - x_*\hat{a}) = \underline{SSE} + D\ \underline{SSE}^2/\underline{r}^2$

(37) $\hat{d}_i = \underline{y}_i - \sum_j \hat{a}_j \underline{x}_{ij}$

(38) $\hat{g}_{ij} = \underline{x}_{i1} - \underline{x}_{ij} - \hat{\underline{B}}_{ij}$

(39) $\hat{\underline{B}}_{ij} = \underline{W}_{ij} - \underline{W}_{i1} + \ln\hat{a}_1 - \ln\hat{a}_j$

where $\underline{a}$, $\underline{r}$, $\underline{SSE}$, and D are all derived from OLS of y* on x* ($y^*_{it} = (y_{it} - \underline{y}_i)$ and $\underline{y}_i = \sum_t y_{it}/T_i$) so that

(40) $\underline{r} = e'\underline{a}$

(41) $\underline{SSE} = (y_* - x_*\underline{a})'(y_* - x_*\underline{a})$

(42) $D = e'(x_*'x_*)^{-1}e$

where e is a Kx1 vector of ones. In addition, the asymptotic variances of the estimators are derived from the information matrix and has the form

(43) $$-\frac{\partial^2 L_c^*}{\partial \hat{a} \, \partial \hat{a}} = \frac{1}{\hat{\sigma}^2} x_*' x_*$$

The above estimates will be consistent if our assumptions are correct; that is, if output is exogenous and inputs are endogenous. (Their consistency does not depend on distributional assumptions about the residuals since the consistency of the derived estimates depends only on the first two moments of the residuals.) The direct relationship between the conditional MLE's under the two differing behavioral assumptions is not at all surprising given that the basic difference between estimating the two models is the designation of which variables are exogenous and which are endogenous. In fact, from Equation 34, it can be seen that the smaller is the SSE from the OLS regression of y_* on x_*, the closer will our estimates be from estimating this model versus estimating the first model. In addition to estimating the above parameters of Equations 32 and 33, the marginal value product of labor (MVP_l) and the marginal value product of machine services (MVP_k) are estimated as well as estimates of R_{i1} and R_{i2}.

The estimates of the parameters of this model turn out to be quite different from those obtained from estimating the prior model using the "within" estimator and assuming that tileries are maximizating expected profit. The estimate of the elasticity of labor hours is 1.4937 (0.0574), and the elasticity of machine hours is 0.7278 (0.0652); both elasticities are significantly different from zero for small values of alpha.[1] The R^2 value for the production function regression is lower than those obtained using either the "within" or the OLS estimators and is 0.61. The returns to scale, as estimated by this model, is extremely large with a value of 2.23, is significantly different from one, and indicates increasing returns to scale. It should also be noted that the SSE for this regression is over twice the size of the SSE from estimating the first model using the "within" estimator.

The estimates of the fixed effects from the production function are also quite different from those obtained from the first model. The average size of the d_i's measured in logs (antilogs) for the Fayoum and Kalyubiya tileries is -5.884 (0.004) and -5.836 (0.003), respectively. The rankings obtained from comparing the fixed effects of the tileries to the largest fixed effect in their area are noticeably different from those obtained from the "within" estimator. Firm 2 (previously ranked seventh) from Itsa now has the largest fixed effect among the Fayoum tileries, and Firm 9 (previously ranked second) from Fayoum City has the smallest. The average size of the fixed effects relative to largest in Fayoum is seventy-four percent.

The rankings of the Kalyubiya tileries are also different from those obtained with the first model. Firm 312 (previously ranked tenth) from Kalub is now the tilery with the largest fixed effect for the area and is a noticeable outlier when compared to the other tileries in the sample. Firm 536 (previously ranked twelfth) from Kalub now has the smallest measured fixed effect in the area. The average size of the fixed effects relative to the largest fixed effect is only thirty-one percent, a result of Firm 312 having a fixed effect so much larger than any of the others.

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[1]The asymptotic standard errors are in parentheses.

The average MVP_l and MVP_k when using acquisition cost in calculating these measures are 3.21 and 2.65, respectively, for the Fayoum tileries and 4.82 and 5.61 for those from Kalyubiya. These averages of the estimates for the MVP_l's are slightly greater than obtained from the first model, but the averages of the MVP_k's are much larger than the previous estimates of the MVP_k's from the first model. The average estimate for G_{i2} is 3.67 for the Fayoum tileries and 7.67 for those from Kalyubiya, indicating that tileries in both areas are using too little capital given the amount of labor they employ, the opposite conclusion obtained from the first model. The average costs incurred by the Fayoum and Kalyubiya firms for misallocating variable inputs are much larger than the costs estimated from the first model. For the Fayoum firms, the average cost is thirty-one percent and is sixty-five percent for the Kalyubiya firms.

The results obtained by estimating this model under the assumption that output is exogenous and that firms are minimizing the cost of producing a given the amount of exogenous output lead us to reject this model as being applicable to Egyptian small-scale floor tileries in Fayoum and Kalyubiya governorates. The high elasticity estimates for labor and machine hours and the extremely increasing returns to scale that result from this model seem quite implausible. Egypt would indeed be an extremely distorted economy if firms are producing with any degree of stability under the returns to scale indicated by this model. With such high returns to scale, we would expect firms to be growing larger at an extremely fast rate (assuming that the market is able to absorb the increased production). If not, we would expect to see a few large firms emerging and the other firms to go out of business.

From another perspective, one may ask under what conditions that correspond to the Egyptian case would small tileries such as found in our sample continue to be small when producing with such large returns to scale. The obvious things to search for are constraints that inhibit the growth of firms. In Egypt, there are many constraints which impede the expansion of firm size. Large firms are more conspicuous to tax assessors, and firms with over ten workers are taxed much more heavily than firms with less than ten workers. In order to expand production, a tilery must be able to increase its supply of raw materials such as cement. In Egypt, domestically produced cement is rationed and is in short supply; also, imported cement is heavily taxed and in short supply. Machinery is also difficult to obtain as imported machinery is heavily taxed and Egypt has yet to establish a large and thriving capital producing sector; there are only three or four firms in all of Egypt that produce electric hydraulic presses, and these firms employ less than fifty workers. Credit is also a constraint to growth in Egypt as formal credit is rationed and is extremely difficult to obtain by small manufacturing firms. Although we often think of Egypt as an overpopulated country, labor, both skilled and unskilled, is often felt to be in short supply (at the given wage rates) since so many workers are able to and do go to neighboring Arab countries for employment. Also, the business climate in Egypt is highly uncertain for small entrepreneurs as only recently has the government officially tolerated small, private businesses. So, one can see that, at least potentially, the possibility exists under the conditions found in Egypt for small tileries to continue to be small even when using technology that has increasing returns to scale; however, returns to scale as large as estimated by this model are not easily believed.

Econometrically speaking, there are also reasons why the returns to scale as estimated from this model are so large. Since the estimates of the elasticities on the variable inputs in this model are obtained from adding a correction term to the estimates obtained from the "within" estimator, and since this term is always positive, we would expect the returns to scale from this model to be larger than those estimated for the first model unless the SSE from the "within" estimation is zero or the returns to scale from this regression are infinite, both cases being highly unlikely. Given that we found constant returns to scale from the first model using the "within" estimator, it is no surprise to find increasing returns to scale from this model, although the size of the returns to scale is surprising. This large estimate of the returns to scale is directly related to the size of the SSE from the "within" regression, and in our case, though not unduly large, it is not small.

CHAPTER V

FIRM CHARACTERISTICS, PRODUCTION, AND EFFICIENCY

Having obtained estimates of the fixed effects from the stochastic production function for each individual tilery as well as individual measures of efficiency for allocating variable inputs, we proceed in this chapter to identify any firm or entrepreneurial characteristics that are associated with the size of the fixed effects (for both the production function and the factor share equations). As stated in the introduction of Chapter 4, this author hypothesizes that the rankings and efficiency measures obtained from estimating the model developed in Section 4.1 can be used as a diagnostic tool. Ideally, an extension or research person, having obtained the rankings of the firms in terms of the size of the fixed effects from the production function and the factor share equations, could now return to the each of the firms to study more carefully their production process, organization, and marketing strategy with the purpose of identifying characteristics that are associated with the rankings.

Because a major goal of this dissertation is to ascertain whether the model, at least for Egyptian small-scale floor tileries, estimates actual differences in production among firms, the rankings obtained from the size of the fixed effects on the production function are compared with rankings made by the author prior to the analyses and based on his firsthand knowledge of the firms after studying them in Egypt over a two-year period. Tileries were ranked according to the firms' organization, the quality of their workers and their entrepreneur, and, in general, how productive the tileries were in the opinion of the author. Spearman rank correlation coefficients are estimated by comparing the a priori rankings for both areas with those based on the size of the fixed effects on the production function. For Fayoum, the area where the author lived and supervised the field work, the rank correlation coefficient is 0.98 and is highly significant at any standard value of alpha and indicates that the two rankings for Fayoum are quite similar. For Kalyubiya, the rank correlation coefficient is 0.72 and is also signficantly different from zero for alpha = 0.05 (i.e., it is more than two standard deviations from zero, the mean of the rank correlation coefficient).

There are several reasons why firm differences in production can be found when estimating the model. Although the data used in this study are at the firm level, aggregation and measurement error of variables is still a potential problem which can affect our estimates of the fixed effects. In theory, each inputs that enters into the production function is assumed to be homogenous within and across all firms; this is just not the case in reality. For example, some workers doing the same identical production activity are more efficient at that task than other workers. Theoretically, unless workers are identical (which they never are), they are different inputs and should be entered into the production function as separate inputs. Even if one is aggregating workers, each worker should be given a different weight or we have aggregation error.

Although the above arguments are undeniable, in practice, it would be impractical to enter or treat as different in aggregation all potential inputs. In this study, labor is classified according to their production activities, and quality differences in workers performing the same task is not used in aggregation. If a tilery has laborers who are more efficient in forming tiles, that firm will have a larger fixed effect than other firms, ceteris paribus. Since the stated purpose of the analysis is to identify differences in production, the author does not feel this to be a major weakness of the model.[1]

The way a tilery is organized can also affect its production process. Although organization is not an input into the production function, it does affect how variable inputs are combined. For example, firms that organize the working area near the hydraulic press to minimize the amount of time and effort involved in removing the pressed tiles from the hydraulic press and stacking them in racks to later be carried and placed in water vats may also be those tileries with the largest estimated fixed effects from the production function. Again, one can argue that a tilery with a stacking rack three feet from the tile press is using a different input than a firm whose stacking rack is two feet from the press, and unless one enters or aggregates the two racks as different inputs, the model is misspecified. In practice, the accounting task of meticulously identifying and classifying all possible inputs as different inputs is impractical. However, as one would expect the fixed effects to pick up organizational differences that cause one tilery to produce more or less than others, ceteris parabus, this author does not

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[1]This does not mean that differences in production due to measurement or specification errors should be called technical inefficiency.

consider this problem to be a major weakness of the model. Similarly, entrepreneurs with the most education and experience in managing the firm may be able to adjust to changing market demands more quickly than entrepreneurs with less education and experience; thus, education and experience of the entrepreneurs could be positively associated with the size of the fixed effects from the production function or the factor share equation for that firm because entrepreneurs with these characteristics may be more able to organize the firm in the most productive and efficient manner.

In this chapter, a short description of each tilery in both areas is presented. Next, the results obtained in Chapter 4 are used to determine if tileries with the largest fixed effects from the production function or which are more efficient at combining variable inputs are also the tileries that are larger, located in or near major urban areas, and owned by entrepreneurs who are older, better educated, more experienced, and put more effort into the management of their tileries. All tables comparing firm and entrepreneurial characteristics with the fixed effects from the production function (factor share equation) will present the tileries from Fayoum first, followed by those from Kalyubiya. Within an area, tileries are presented according to their rankings derived from the fixed effects. Also, whether marketing strategy, production changes, and market size are associated with the size of the fixed effects is examined.

5.1 Description of Fayoum Firms

In this section, characteristics of each tilery from Fayoum will be briefly discussed so that the reader will have a more complete picture of the firms and what is unique about certain tileries. Tileries are presented in the order of their rankings derived from the fixed effects on the production function.

Firm 216--This tilery has the largest fixed effect from the production function among the Fayoum tileries and is located in Fayoum City on the road leading to Itsa.[1] The area is southwest of the town center and is one that has much new housing construction. The owner is forty-five years old, has fourteen years of formal education, and spends an average of thirteen hours per week managing his tilery.[2] He has two other work activities that are outside his tilery: farming and another private occupation, on which he spends an average of twenty-three hours a week. The firm was started five years ago, and the workshop is rented.

The capital in the firm consists of a manual hydraulic press and an electric tile polisher which have a replacement value of L.E. 1300 ($1300). Generally, the firm has two form workers, one press worker, one polisher, and one mixer; the oldest form worker, forty years of age, is the production supervisor. The turnover of employees in this tilery is quite low, and the majority of the tiles that it produces is noncolored mosaic tiles.

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[1]The fact that a firm has the largest fixed effect (is located on the highest subproduction function) does not automatically mean that this is the most efficient firm or one that all other firms should aspire to be like. Their are conceivable cases where a firm is on a higher subproduction function than other firms, but, economically speaking, the cost of producing more than the other firms is higher than the benefits it receives for being on the higher subfunction.

[2]Hours spent in management activities do not include hours spent directly in production which are treated as inputs into the production function. Management is not an input into production but controls and organizes the production process.

The firm site consists of a brick building and an open courtyard. The manual press is housed in the courtyard under a veranda. The polishing machine is located inside the building which is also used to store raw materials and finished tiles. Just inside the building to the right is the owner's office.

The organization of the firm is quite good. The area around the hydraulic press is laid out so as to minimize the effort of the form workers in pressing the tiles and in stacking the pressed tiles. The water vat for soaking tiles is inside the courtyard and the tiles are dried in the sun just outside the courtyard which has an exit that leads directly from the water vat to the drying area. Demand for this firm's tiles is enough to keep all the workers employed during the entire year.

Firm 218--This tilery is located in the center of town near the bus station and is the largest tilery in Fayoum City. The owner is forty-five years old, has no formal education, and spends on average twenty-two hours a week managing his firm. The tilery was started twelve years ago, and the building where it is located is rented. The capital in the tilery consists of one electric hydraulic press and one large new polishing machine, valued together at L.E. 3200 ($3200). In addition, near the end of the survey period, the owner purchased a second electric press which was not placed into service during the survey period and is valued at L.E. 1500. On average, the tilery employs four form workers, one polisher, and one mixer. The turnover of form workers is infrequent, and the majority of the tiles produced by this firm is noncolored mosaic tiles.

The tilery is located in a building with no courtyard. The building is essentially one large room with designated areas for different work task. Although not overcrowded, all space is being used and any expansion in that building would be difficult. Some inventory of finished tiles is being stacked and stored outside of the building in an adjacent alley. (The use of the area immediately outside a workshop is quite common among small businesses in Egypt.) There is no separate room designated as the owner's office, but an area with a desk is used as office space and is located just inside the building's entrance.

Everything in the shop is well organized, especially considering the limited amount of space relative to the size of the production activity. Each form worker has his own worktable attached to the electric hydraulic press, and his mixing barrel is in easy access to his work. The polishing machine is one of the more modern types and can polish almost four times as many tiles in a day as an older, "doughnut" stone polisher which is frequently used by other tileries. The demand for this firm's tiles is strong throughout the year, and the workers are always fully employed.

Firm 217--This tilery is also located in the center of Fayoum City. Its owner is sixty years old, has six years of formal education, has no other occupation outside his tilery, and spends an average of twenty-two hours a week managing his tilery. He established the tilery thirty years ago and rents the building. For one month during the survey period, the owner went on a pilgrimage, and his son, age twenty-five, managed the firm while the owner was away; upon the owner's return, the son continued in assisting with the management of the tilery.

The capital until the last six weeks of the survey period is comprised of two manual presses (one was not used except when the other press was broken) and one polishing machine, valued at L.E. 1200 ($1200). During the last six weeks, the owner put into service an electric hydraulic press valued at L.E. 1500. The workers usually consists of two form workers, both over fifty years old, one press worker, and a polish worker who also works as a mixer.

The firm site is a large building which includes several large, separate rooms used for storing raw materials. The office is to the right of the entrance and is quite large; space is not a problem with this firm. The work area although not visible from the office is well organized. The workers, though not as young as most tile workers, have years of experience working for this particular tilery. Demand for its tiles is enough to keep the workers employed all year, with the majority of tiles produced being noncolored mosaic tiles.

Firm 117--This tilery is located in Ta'amiya, a **markaz** (district) town about twenty-five kilometers northeast of Fayoum City, where a new governmental center is being built with all the floor tiles for its construction being contracted through this tilery. The owner is fifty years old, has twelve years of formal education, and spends an average of twenty-four hours a week managing his tilery. In addition, he is a full-time government employee.

The tilery was established two years prior to the survey, mainly in response to the construction of the governmental center, and the building is owned by the entrepreneur. The capital of the firm consists of one manual hydraulic press, one polishing machine, and one fine-polishing machine and is valued at L.E. 1450 ($1450). The workers in the firm are two form workers, one press worker, and one mixer; one of the form workers, age forty, is the production supervisor. The turnover of workers is low for this tilery.

The workshop consists of several storage rooms for raw material, an office, and a tin-covered courtyard where the production takes place. Its organization is adequate, and demand for its tiles is constant and steady all year because of the demand from the governmental construction.

Firm 215--Located just south of the center of Fayoum City, this tilery is located in a relatively isolated and newer section of town. The owner is about forty years old and works full-time for the government, spending only minimal time managing the tilery. Production was generally steady during the first part of the survey, but the tilery was shut down around the fortieth week of the survey; the owner was required to spend more time on his government job by a new, incoming governor. Because the firm was closed when the entrepreneurial questionaire was administered, some information for this tilery is missing.

The capital stock of this firm consists of a manual hydraulic press and a polishing machine and is valued at L.E. 1200 ($1200). The tilery, when it was in operation, generally employed two form workers, one press worker, one polish workers, and sometimes a mixer. The type of tiles produced most often by this tilery was noncolored mosaic tiles.

Firm 214--This tilery is located near the center of Fayoum City in a mostly residential area. The owner is female, is forty years old, has only one year of formal education, and spends on average eleven hours weekly managing her tilery. Her other activities consist of household responsibilities and the running of a warehouse operation which stores and sells imported cement. The tilery was started less than one year prior to the survey period. The warehouse business was started about fifteen years ago by her father. The capital in the firm until the last five weeks of the survey period was a manual hydraulic press and a polishing machine and was valued at L.E. 1350 ($1350). During the latter part of the survey, the entrepreneur sold her manual press and purchased an electric hydraulic press with a value of L.E. 1500. Until the purchase of the electric press, the tilery employed two form workers, one press worker, and one polish worker; sometimes there was an additional mixer. After the electric press was purchased, it employed three form workers, one polish worker, and one mixer. Non-colored mosaic tiles are the type of tile most often produced by this tilery.

The workshop is located on the ground floor of a multi-floored building which is also her family's residence. Next to this building is the warehouse, both buildings being owned by the entrepreneur. Raw materials used by the tilery are obtained from the warehouse. Also, cement used by this tilery is stored in the warehouse. During the first forty-two weeks of the survey period, information was collected on raw materials bought, not those actually used in production; thus, the figures on raw materials for this tilery are an inflated measure of raw materials actually used in production.

Its organization was somewhat lax, and the workshop was not laid out optimally during the majority of the survey period. The owner's attitude toward her tile business was that this initial period was for learning and experimenting to see whether she could make the business viable and profitable. At the latter part of the survey, she decided the business was profitable and decided to purchase an electric hydraulic press and reorganized the workplace.

After reorganization, the layout was much improved, lending itself to a more productive operation. For example, she moved the press from a small, cramped area into a more open and larger workspace. Next to this, she built a new concrete water vat for soaking the tiles. The vat was in easy reach of the press area, but not so close that it interferred with the pressing operation; the polishing machine was also moved to a more advantageous position. Also, during the earlier period, production was lower than the potential of the tilery, and sometimes the firm would not produce at all during certain weeks. Throughout the period, the main form workers were employed by the tilery, but because their salaries were relatively low during this period, they often opted to perform other short projects outside the tilery. After she purchased the electric press and reorganized her firm, the quantity of tiles produced increased as well as the workers' workload (and salaries).

Firm 2--This tilery is located in Itsa, a **markaz** (district) town about fifteen kilometers southeast of Fayoum City along a narrow and poorly maintained road. The owner is about fifty years old, has seventeen years of formal education, and only spends on average about four hours weekly managing his tilery. When the tilery was first established five years ago, its production had been quite high as the government was building a regional center in Itsa and buying all of its floor tiles from this tilery; however, during the survey period, the tilery's production was quite sporadic. In fact, it shut down during the middle of the survey for almost two months but was later reopened by the owner's son. The son is twenty-five years old, has seventeen years of formal education, and began managing the tilery on a part-time basis; he is also an officer in the Egyptian army and spends one and a half days weekly managing his father's tilery while on army leave.

The tilery's capital had been quite substantial during the period when the governmental center was being built. Then, the tilery had four manual hydraulic presses, a polishing machine, and a fine-polishing machine in operation; however, during the survey only one manual press, a polishing machine, and a fine-polishing machine were in service, with a value of L.E. 1500 ($1500). While the tilery was shut down, an older man, about fifty-five years old, acted as caretaker and, when it reopened, acted as the production supervisor. When in operation, the tilery generally employed two form workers, one press worker, a polish worker, and sometimes a mixer. Production was divided basically in half between producing noncolored normal and noncolored mosaic tiles.

The workshop is owned by the entrepreneur and consists mainly of a large enclosed, but open area (surrounded by a high brick wall). Inside the entrance and to the left is a small, brick building used as an office; at the far end of the yard is another small building used to store raw materials. The presses and the polishing machine are under a tin-covered veranda near the back of the courtyard. The fine-polishing machine is in the open; finished tiles are also stored in the open. Demand for the firm's tiles is highly seasonal and sporadic now that the governmental center is completed.

Firm 138--Located in Sinouris, a **markaz** (district) town fourteen kilometers north of Fayoum City on the road to Cairo, this tilery was started four years ago, and its owner is thirty years old with a college degree. He has a government job and spends on average five hours weekly managing his tilery. The tilery's capital consists of an electric hydraulic press which was broken several times throughout the survey, a manual hydraulic press used when the electric press is broken, and a polishing machine, all valued at L.E. 1636 ($1636). The tilery typically employs three form workers (two form workers and one press worker when the electric press is inoperable), a polish worker, and a mixer, and its turnover of workers is quite high relative to other tileries in Fayoum governorate; only Firm 208 has a higher turnover rate. About one-fourth of its production is colored tiles with the rest of production being almost evenly divided between noncolored normal and mosaic tiles; its tile production is somewhat sporadic because of the relatively frequent breakage of the electric press and seasonal demand.

The workshop is owned by the owner's family and is attached to the family's home. Much of the site is a brick building with an open but walled area accessed through the rear of the building. The firm's office is located in a separate room just to the right of the building's entrance. The organization of the firm could be improved; the working area around the electric press is organized for three workers only, while many tileries with an electric press are able to provide adequate space for four workers to form tiles. The total working area, though large, is clutered with broken tiles and empty sacks, giving a general impression of disarray.

Firm 208--This tilery is located in Ibshaway, the most isolated **markaz** town in Fayoum governorate; Ibshaway is twenty-four kilometers west of Fayoum City along a narrow, poorly maintained road. The owner is seventy-two years old, has no formal education, and spends seven hours a week, on average, managing his tilery. Most of his time is spent in working at his other private business which is located two blocks from the tilery. The tile business was started by the entrepreneur twelve years ago. The tilery's capital consists of a manual hydraulic press and a polishing machine. Its has a higher turnover rate than any other tilery in Fayoum governorate, and it is often closed because of the lack of workers.

The workshop is located in a large courtyard attached to the home of the entrepreneur and is owned by him. At one corner of the yard is a building used to store raw materials. The press and polishing machine are housed under a veranda inside the courtyard. Although its layout is organized adequately for producing tile, its relatively high turnover rate of workers has a negative effect on its production.

5.2 Description of Kalyubiya Firms

In this section, characteristics of each tilery from Kalyubiya will be briefly discussed so that the reader will have a more complete picture of these tileries and what is unique about certain of them. Tileries are discussed in the order of their rankings derived from the fixed effects on the production function.

Firm 306--This tilery, which has the largest fixed effect from the production function of any tileries in Kalyubiya governorate, is located in the town of Kalub which stradles the Agricultural Highway and is twelve kilometers north of Cairo and thirty kilometers south of Benha. The owner is fifty years old, has three years of formal education, and manages the firm full-time for an average of fifty hours weekly. The tilery was started eleven years ago, and two of the main workers have been working for it for over five years. Part of the salary arrangement is the sharing of profit in addition to a piece rate for the form workers and a weekly rate for the other workers. Upon visiting the firm and meeting with the entrepreneur, the author recorded his impression that this was easily the best organized firm he had visited. (Note that this meeting was prior to any formal analyses.)

The tilery's capital consists of an electric hydraulic press, a modern polishing machine, and a manual press used only when the electric press is not working; the value of the machinery is L.E. 2000 ($2000). The tilery employs three form workers, one polish worker, and one mixer. As stated above, the turnover of workers is one of the lowest of any tilery in the survey. The type of tiles it produces most often is colored tiles followed by an even division between noncolored normal and noncolored mosaic tiles.

The workshop is a brick building owned by the entrepreneur and is located in a mostly residential section of Kalub that is expanding. Although the building is not exceedingly large, the space is adequate, and the tilery's layout is such that its available space is utilized efficiently.

Firm 552--This tiley is located in Kofr Shukr which is thirteen kilometers northeast of Benha. The owner established the tilery twenty years ago, is fifty-one years old, has sixteen years of formal education, and spends an average of thirty-two hours a week managing the tile firm; he also owns a flour mill and spends the other part of his working time managing that business. The tilery's capital consists of two manual hydraulic presses, one polishing machine, and one fine-polishing machine and is valued at L.E. 1400 ($1400); however, only one of the presses was used during the survey period. The tilery employs two form workers and one press worker who is also a mixer. The employees have been with the firm several years and share part of the profit from the business as is done in Firm 306. Demand for its output is strong throughout the year, with noncolored normal tiles being produced most often followed by noncolored mosaic tiles and colored tiles.

The workshop is located in a rather large compound made up of several connecting buildings, all owned by the entrepreneur. The polishing machine, the fine-polishing machine, and finished tiles are housed in one building, while the two manual presses are housed in another adjacent building. Further within the compound is another large room which houses the flour mill. Between the flour mill and the two buildings used for tile production is a small building (one room) used as an office. The entrepreneur expressed a strong desire to expand the production of his tilery but felt constrained by the lack of available and reliable laborers.

Firm 582--This tilery is located in Benha close to the train station. The owner is forty-seven years old, has nine years of formal education, and also has a construction company. He started the tilery twenty-five years ago as an offshoot of his construction company to supply it with floor tiles, and the workshop is rented. The owner's son, who also owns a small retail store, helps with some of the management responsibilites.

The tilery's capital consists of one manual hydraulic press, three screw-type presses, a polishing machine, and a fine-polishing machine; two of the screw-type presses are not being used in production. The capital actually being used in production is valued at L.E. 1700

($1700). The tilery employs six workers: three form worker, two press workers, and a mixer. One of the form workers, who is forty-seven years old, is the production supervisor and has supervised production in this tilery for seventeen years. The turnover of its form workers is not high; the turnover rate for the other workers is about average for tileries in Kalyubiya. The mix of tiles being produced is almost evenly distributed between colored and noncolored tiles, with the noncolored tiles being mainly composed of mosaic tiles.

The workshop is a large, enclosed area with two building on each side of the entrance; both buildings are used to store raw materials. The production area for pressing the tiles is at the back of the courtyard and is covered with a tin veranda. Finished floor tiles are stacked in the open area of the courtyard. The organization and size of the workspace seems adequate for the size of the operation. Demand for its tiles is good, being driven by the demand from the owner's construction company as well as from outside customer. During an interview with the author, the owner's son said they were planning to purchase two electric hydraulic presses and to increase their production capacity.

Firm 72--This tilery is located in the center of Benha in the downtown district. It is owned jointly by three persons, with one of the owners acting as the manager and was started twenty-two years ago. The owner-manager is forty years old, has sixteen years of formal education, and spends an average of thirty hours per week managing the firm. The tilery owns an electric hydraulic press, two manual presses, two polishing machines, and one fine-polishing machine; one of the manual presses and one of the polishing machines are rarely used. The machines used regularly in production are valued at L.E. 2400 ($2400). The tilery employs three form workers who work with the electric press, one form worker and a press worker who work with one of the manual presses, and a polish worker who is also a mixer. The majority of its production is noncolored mosaic tiles, with the rest being evenly divided between colored tiles and noncolored normal tiles.

The workshop is rented and is enclosed by a brick wall. Just inside the entrance to the left is the owner-manager's office and to the right is a building for storing raw materials. The presses and the polishing machines are at the back of the courtyard housed in a half-enclosed building. The working area is spacious and well organized with each form worker having his own small worktable connected to the press. Although the tilery has a steady demand for its product, the owner-manager told the author that he hopes to stop producing tiles and begin selling imported cement on a wholesale basis.

Firm 318--This tilery is located in the town of Kalub which stradles the Agricultural Highway and is twelve kilometers north of Cairo and thirty kilometers south of Benha. The owner is sixty years old, has five years of education, and has retired from the railroad. He started the tilery fourteen years ago, the workshop is rented, and the owner spends an average of forty-five hours weekly managing his tilery. Although the tilery is his main activity, he also raises poultry and water buffaloes.

The tilery's capital consists of two electric presses (only one is used in production), one polishing machine, and a fine-polishing machine; the capital actually being used in production is valued at L.E. 2400. Three form workers, one polish worker, and one mixer are employed by the firm. A little over a third of the tiles produced is noncolored mosaic tiles, another third is colored tiles, and a little less than a third is noncolored normal tiles.

The workshop comprises part of a large compound and is owned by the entrepreneur. The entrance into the compound from the street leads directly into his office. Passing through the office, one goes into an open courtyard. Toward the back of the couryard is a three story building, with the ground floor open and being used to house the firm's machinery. Above the production area is the owner's family residence. To the right of the entrance into the courtyard is a gate that opens into two smaller, divided courtyards having small, adjacent buildings used to store raw materials for the tilery as well as animal feed. To the left of the production area are the stables and poultry yards. Organization of the working area around the presses gives adequate working space.

Firm 535--This tilery is located in Benha. Its owner is fifty-six years old, has six years of formal education, and spends an average of twenty-six hours a week managing the firm. The workshop is rented, and the tilery was start twelve years ago. The capital of the firm consists of an electric hydraulic press, a polishing machine, and a fine-polishing machine which are valued at L.E. 1800 ($1800). The tilery employs four form workers, a polish worker, and one mixer. About half of the firm's production is noncolored normal tiles, with the rest being evenly divided between colored tiles and noncolored mosaic tiles. This tilery was visited by the primary field researcher in Kalyubiya several times, but was never visited by the author.

Firm 315--This tilery is located in Kalub which stradles the Agricultural Highway and is twelve kilometers north of Cairo and thirty kilometers south of Benha. Its owner is fifty years old, has five years of formal education, spends on average fifty hours a week working in his tilery, and often helps in the production of tiles. The tilery was started by the entrepreneur sixteen years ago, and the workshop is rented. Its capital throughout the survey consisted of one manual hydraulic press valued at L.E. 600 ($600). The tilery employs two form workers, one press worker, and a mixer. Production is about sixty percent noncolored normal or noncolored **molih** normal tiles; the rest are colored tiles. Demand for its tiles was quite strong during the survey period and had increased relative to the previous year.

The workshop is quite small for a tilery. Space is adequate for the manual press, but does not allow enough space to operate a polishing machine; also, there is not enough storage area for large quantities of raw materials or finished output. The entrepreneur had purchased an electric press and a polishing machine and was planning to move to a larger workshop when the machinery arrived. Turnover of workers for the firm is generally low, although one worker who had been with the tilery for five years had just left and started his own tilery business.

Firm 116--Located in Tukh, this tilery is just off the Agricultural Highway and is thirty kilometers north of Cairo and twelve kilometers south of Benha. For its size, Tukh has a relatively large amount of construction occurring in it. The tilery's owner is in his fifties and spends an average of forty-seven hours weekly managing his tilery. The tilery's capital consists of one manual press valued at L.E. 400 ($400). The tilery employs three form workers, one press worker, and one mixer. About sixty percent of its production is colored tiles, with the rest being noncolored normal or noncolored **molih** normal tiles.

The workshop consists of a rather large, long brick building next to a large unenclosed yard. Just to the right of the building's entrance is a small partitioned area designated as the office and another larger partitioned area used for storing cement. The manual press is toward the back of the building near a large exit leading into the yard where tiles are dried. There are worktables for three form workers attached to the manual press. (Usually, only two form workers produce tiles with one manual press.) Although longitudinal data were collected for this tilery throughout the survey period and the author visited it several times, an entrepreneurial questionaire was never administered to it.

Firm 411--Also located in Tukh, this tilery is located on the Agricultural Highway. Its owner is forty-five years old, has two years formal education, and spends an average of thirty-one hours a week managing his tilery. He started the tilery only two years prior to the survey period, but had twenty-seven years work experience in producing tiles. During the first eleven months of the survey, the capital of the firm consisted of a manual hydraulic press, a "doughnut" type polishing machine, and a fine-polishing machine, but in the latter five months, the tilery purchased and used an electric hydraulic press and a modern polishing machine; the average capital value of the firm for the entire survey period was L.E. 1775 ($1775). The workers in the tilery prior to the purchase of the electric press were three form workers, one polish worker, and two mixers; after the purchase, the press worker became a fourth form worker. About forty percent of its tile production is colored tiles; mosaic, noncolored normal, and noncolored **molih** tiles are also produced.

The workshop consists of a newly built, brick building and is rented. Although there is adequate space for the machinery, there is little space left for the storage of raw materials, and all finished tiles are stacked just outside the entrance to the shop.

Firm 312--This tilery is located in Kalub which stradles the Agricultural Highway and is twelve kilometers north of Cairo and thirty kilometers south of Benha. Its owner is in his late thirties and works full-time as a carpenter. He started the tilery in 1981 but shut it down during the fortieth week of the survey period because he felt he could make more money by working as a carpenter. The tilery's capital consists of a manual hydraulic press valued at L.E. 800 ($800). When in operation, it employed two form workers and a press worker who also was a mixer. About half of the production was in colored tiles, the other half in noncolored normal tiles.

The workshop is on the ground floor of the owner's home, and the building is owned by him. Because the tilery was not operating when the entrepreneurial questionaire was administered, this information is not available for this firm.

Firm 59--This tilery is located in El Rhamla which is just outside of Benha. The owner is forty-two years old, has sixteen years of formal education, and spends on average thirty-six hours managing his tilery. In addition to this activity, the entrepreneur owns and manages a rabbitry which is also located in El Rhamla. He started the tilery in 1977 from earnings saved while he was teaching in Saudia Arabia. The tilery's capital consists of an electric hydraulic press, a manual press (used only when the electricity is off), a polishing machine, and a fine-polishing machine; the machinery actually used in production, on average, is valued at L.E. 2400. The tilery employs three form workers, one polish worker, and one mixer. Over half of its production is colored tiles, while most of the other production is noncolored normal tiles with some production of mosaic tiles.

The workshop, owned by the entrepreneur, is a large compound consisting of several buildings, the biggest of which is used to store raw materials, a tractor, and other nontile equipment; it also serves as an office. Inside the compound is an open courtyard which is used to dry tiles and store finished output. Another building houses the tile machinery. It is interesting to note that the tractor is sometimes used to power the polishing machine when the electricity is off.

The demand for its output had been strong during the survey period, and one of the dreams of the entrepreneur is to buy a totally automated tile press, much like the one used in a large-scale factory located on the Agricultural Highway near Cairo. The reason given for this is that it is increasingly difficult to attract and keep workers in his tilery.

Firm 536--Located near the center of Benha, this tilery was started thirty years ago and is owned by three persons; the owner-manager is fifty-two years old with fifteen years of formal education. The workshop is rented, and the owner-manager spends an average of forty-four hours a week managing the tilery. Its capital consists of an electric hydraulic press, a manual press, and a polishing machine which are valued at L.E. 2600 ($2600). The tilery employs three form workers who work with the electric press, one form worker who works with the manual press, and a press workers who also mixes the cement for the form workers. A little over half of the production is colored tiles, with the majority of the rest being noncolored normal tiles.

Firm 101--The tilery is located in the center of Tukh which is thirty kilometers north of Cairo and twelve kilometers south of Benha. The owner started it in 1948 and moved it to its present location in 1957. He is fifty-five years old, has six years of formal education, and spends an average of twenty-five hours a week managing his tilery. In addition, he spends an average of eighteen hours weekly in work activities outside his tilery. The capital of the tilery consists of two manual hydraulic presses, a broken polishing machine, and a broken fine-polishing machine, with the two presses valued at L.E. 1100 ($1100). As both its presses are used in production, the firm employs two form workers and one press worker to work with one press, one form and one press worker to work on the second press, and one mixer. A little less than half of the production is colored tiles, with most of the other production being noncolored normal tiles. Demand for its output is strong during most of the year, with the peak in the summer; however, the fact that two of the workers have to pump the manual presses instead of forming tiles as they would on electric presses causes this firm's labor, in the aggregate, to be less productive than that of the other Kalyubiya tileries.

The workshop is in a completely enclosed, large brick building directly in the center of Tukh and is rented by the entrepreneur. As one enters the building, the office is to the right. The rest of the building is one large room, with the presses being near the center and to the left of the entrance; the broken polishing machine is near the back of the building. Space is no problem as the workshop can easily accomodate the owner's plan to buy an electric press and to expand his operation.

<u>**Firm 314**</u>--This is a small tilery located in the town of Kalub which stradles the Agricultural Highway and is twelve kilometers north of Cairo and thirty kilometers south of Benha. Its owner is thirty-eight, has four years of formal education, and spends an average of fifty hours weekly managing his tilery when it is in operation; however, when his press breaks, he often works as an interior house painter. The tilery was started seven years ago, and its capital consists of a manual hydraulic press valued at L.E. 600 ($600). It employs two form workers, one press worker, and two small boys who are mixers. Just under half of its production is in colored tiles, with the majority of the other being noncolored normal tiles with some being noncolored **molih** normal tiles.

The workshop is located on the ground floor of the entrepreneur's home and is owned by him. The space is barely adequate for the size of his present operation, and he plans to purchase an electric press and a polishing machine within a year and to move to a new location. Finished tiles are stored in the street in front of his home. As with most tileries, the peak season for its output is in the summer when Egytian workers return from Saudia Arabia and other Gulf Arab countries to visit their families. Also, the entrepreneur said the demand for his tiles has risen every year since he began his operation.

<u>**Firm 311**</u>--This tiley is located on the outskirts of Kalub which stradles the Agricultural Highway and is twelve kilometers north of Cairo

and thirty kilometers from Benha. It was started four years ago and is owned jointly by three owners; one owns the building and the other two pay rent. Two of the owners share the responsibilty of managing the tilery; the owner-manager with the main responsibility for management is forty-six years old, has six years of formal education, and manages the firm full time with an average of forty-four hours weekly. The capital of the firm consists of an electric hydraulic press, two manual presses, and a polishing machine; only the electric press and polishing machine are used regularly in production and are valued at L.E. 2600 ($2600). The tilery employs three form workers, one polish worker, and one mixer. The polish worker sometimes works as a form worker on the manual press with the mixer being the press worker, but this is only under unusually high demand. About forty percent of the tiles produced are colored tiles, with another forty-five percent being noncolored normal tiles and the rest being mostly noncolored mosaic tiles.

The workshop is a large building which is partitioned into two rooms. The first room is the office area for the owner-manager, with the production area and machinery in the second room toward the back of the building. Raw materials and finished tiles are also stacked in the second room.

Firm 355--This tilery is located in El Hanka which is located about twenty kilometers from the center of Cairo and about thirty-five kilometers southeast of Benha; El Hanka is not located on the Agricultural Highway. The tilery was started by two owners just prior to the start of the longitudinal survey. One owner is a lawyer and provided the capital; the other was to be the manager. The arrangement was unsatisfactory, and the lawyer eventually bought out the other man near the end of the survey. During the first twelve months of the survey, the tilery's capital consisted of a manual press, a modern polish machine, and a "doughnut" type polish machine. In the twelfth month, the lawyer placed into production an electric hydraulic press. Also, during the first twelve months, production was done mainly by part-time high school students. When the lawyer finally took over management, he employed three form workers, one polish worker, and two mixers. The tiles produced were about forty percent colored tiles, the rest being divided between noncolored normal and noncolored mosaic tiles.

The workshop is rented and enclosed by a brick wall. Near the front entrance and along the left side of the wall are roofed areas where the machinery is housed; most of the area is an open courtyard. Although there seems to be plenty of space for the size of the operation, the area is cluttered with broken tiles and other debris. From his visits to the tilery, it was obvious to the author that the firm was new and that both the workers and the entrepreneur were still learning how to become better organized and more efficient.

5.3 Characteristics of Entrepreneurs

In this section, we look at the age, years of formal education, and experience (measured by the age of the tilery) of the entrepreneurs in each tilery and see if there is any association between these characteristics and the rankings obtained from the fixed effects on the production function or the fixed effects on the factor share equation. In addition, we look at the amount of effort the owner puts into managing and organizing his tilery as measured by the average number of weekly hours spent in management activities. Table 22 lists the Fayoum tileries first, followed by those from Kalyubiya. Within each area, tileries are listed by the size of the fixed effects from the production function, from largest to smallest. Table 23 is arranged in the same format except tileries are listed within each area by increasing absolute distance from one (measured in antilogs) of the fixed effects in the factor share equation(i.e.,$|G_{i2} - 1|$).

It is sometimes hypothesized by researchers that management skill and human capital of the entrepreneur affect a firm's production. Although management is not an input into the production function, it affects the production process through the control and allocation of productive inputs. The ability to do this generally involves on the part of the manager a learning process which requires time to master. When an entrepreneur first opens a tile factory, he may not have had experience in supervising workers or in organizing production. At first, he may place the mixing trough further than necessary from the presses, thus requiring extra effort on the part of the form workers. Perhaps he does not allow the tiles to dry adequately in the sun or lets them soak in the water vat longer than necessary, or perhaps he places the stacking racks outside the easy reach of the form workers' production area. Other activities that must be learned are how to adequately motivate workers to produce as much as they are capable of producing and to avoid waste of raw materials and time.

The above reasons illustrate how management can affect production through the control and allocation of productive inputs, but it is the inputs that are actually entering into the production function and not management. One could argue that a stacking rack placed three steps from a tile press is a different input than a stacking rack two steps from a press. If they are not entered into the production function as separate inputs, then one has specification error; if they are aggregated into one input using identical weights for aggregating, then one has aggregation (measurement) error. This arguement is certainly valid, but to require such a demanding and meticulous accounting of all possible inputs for each firm over several months or, as in our case, sixty-six weeks would prove too costly to be practical.

There are still other reasons why a newer firm may not be as productive as a more established one whose entrepreneur has more experience. Part of the responsibility of the entrepreneur is to assure timely delivery of raw materials so that production is not held up. In Egypt, almost all of the raw materials are rationed in some way, and a newer firm is generally at a decided disadvantage in procuring inputs compared to an older firm which has had more time to cultivate relationships with wholesalers and retailers. As it usually takes a year to secure a license from the government to purchase subsidized cement and often another year before supplies are actually made available, a firm which has already established a regular buying pattern with the government has a better chance of obtaining these subsidized inputs in a timely fashion. Even purchases of imported cement through private channels require time to search out and cultivate a reliable source of materials.

Formal education is often used as a proxy for human capital or experience. Persons with more formal education are often hypothesized to have more ability to adapt to changing conditions (e.g., changing relative prices, changing demand for output, changing marketing strategies, new production methods for producing floor tiles) and to search out and assimilate information more cheaply than less educated persons. In many cases this may be true, but often formal education may not be as important to performing a function efficiently as just the hands-on experience of actually doing the function; thus, education as a proxy for ability or experience may become less important the longer a person is involved in the same activity.

It is also hypothesized that entrepreneurs who spend more time managing their tileries have more efficient firms than those whose entrepreneurs spend little time managing their tileries. The reason why this may be true is that those working longer hours managing their firms gain more experience over the same time period than those spending less time. They are more involved with the day to day operation of the firm; thus, they may be more able to quickly adapt to changes than entrepreneurs who spend less time managing. Also, these entrepreneurs are able to keep a closer watch over their workers and the production process to assure that they are working as efficiently as possible.

In neither Fayoum nor Kalyubiya does the age of the entrepreneur or his years of formal education seem to be strongly associated with the size of the fixed effects from the production function. It is true that in Fayoum, the two tileries with the youngest entrepreneurs are ranked second and third from last when ranked by size of fixed effects, but the tilery with the oldest entrepreneur has the smallest fixed effect in Fayoum. Also, in Kalyubiya, the two tileries with the youngest entrepreneurs are ranked last and third from last, but since the ages of most of the entrepreneurs are so similar, no strong pattern of association with the fixed effects stands out. At most, one might say that tileries with younger entrepreneurs tend to be in the bottom half when ranked by size of the fixed effects. An even less recognizable pattern is associated with the education of the entrepreneurs. This may be because most entrepreneurs are either highly educated (high school graduates or above) or have relatively little formal education (primary school or less).

The experience of the entrepreneur as proxied by the age of the tilery shows a slightly stronger pattern. In Fayoum, tileries that are less than six years old tend to rank below those that are older; the exceptions are Firm 216, five years old and ranked first, and Firm 208, twelve years old and ranked last. In Kalyubiya, five tileries are less than ten years old, and three of these have the three smallest fixed effects in their area; all five are ranked in the bottom half. Firm 411, ranked ninth out of sixteen, is only two years old, but the entrepreneur had been managing someone else's tilery for over twenty years; Firm 59, ranked eleventh out of sixteen, has been operating for six years, but the production supervisor has twenty-five years experience in producing tiles.

What is especially clear (Table 22) is that, in Fayoum, those tileries whose entrepreneur spends, on average, more time each week in management activities have the larger fixed effects from the production function. Entrepreneurs from tileries ranked in the top half for Fayoum spend, on average, over twenty hours weekly managing their tileries, while those in the bottom half spend, on average, only seven hours. In Kalyubiya, the pattern is not as distinct, but entrepreneurs of tileries ranked in the top half spend, on average, more time each week managing their tileries than those ranked in the bottom half. Also, the average fixed effect of Fayoum is smaller than that of Kalyubiya as well as the number of average weekly hours spent by Fayoum entrepreneurs in managing

TABLE 22

Entrepreneurial Characteristics
(Ranked by Size of Fixed Effects From Production Function)

Firm Code	Area	Rank	Age of Entre-preneur	Years of Formal Education, Entrepreneur	Age of Tilery	Total Management Hours by Entrepreneur	Total Work Hours Outside Tilery by Entrepreneur
216	Fay	1	45	14	5	13	23
218	Fay	2	45	0	12	22	3
217	Fay	3	60	6	30	22	4
117	Fay	4	50	12	2	24	20
215[a]	Fay	5	--	--	--	6	21
214	Fay	6	40	1	2	11	41
2	Fay	7	25	17	5	4	43
138	Fay	8	30	16	4	5	32
208	Fay	9	72	0	12	7	29
306	Kal	1	50	3	11	50	0
552	Kal	2	51	16	20	32	25
582	Kal	3	47	9	25	41	0
72	Kal	4	45	16	22	30	0
318	Kal	5	60	5	14	45	1
535	Kal	6	56	6	12	26	20
315	Kal	7	50	5	16	50	0
116[a]	Kal	8	--	--	--	47	0
411	Kal	9	45	2	2	31	15
312[a]	Kal	10	--	--	--	19	0
59	Kal	11	42	16	6	36	7
536	Kal	12	52	15	30	44	1
101	Kal	13	55	6	37	25	18
314	Kal	14	38	4	7	50	0
311	Kal	15	46	6	4	44	0
355	Kal	16	40	16	1	50	4

[a] Tilery has data missing from entrepreneurial questionnaire.

their tileries. In Fayoum, the entrepreneur spends on average only thirteen hours weekly in managing his tilery while entrepreneurs in Kalyubiya spend, on average, thirty-nine hours weekly managing their tileries.

Another measure of an entrepreneur's effort in managing his firm is whether or not the activity is full time and his major work activity, or whether he spends significant amounts of time on other work activities. In Fayoum, entrepreneurs that spend more time on average in work activities outside their tileries have tileries with smaller fixed effects as estimated from the production function than others that spend more time. Entrepreneurs of tileries ranked in the top half from Fayoum spend an average of thirteen hours weekly at outside work activities while those in the bottom half spend on average thirty-six hours weekly. In Kalyubiya, entrepreneurs of tileries ranked in the top half do not spend on average a different amount of time performing outside work activities than those whose tileries are ranked in the bottom half; however, the average for Kalyubiya (six hours weekly) is significantly less than the average for Fayoum (twenty hours weekly). This corresponds with the fact that the average fixed effect for Fayoum is smaller than the average for Kalyubiya.

Looking at Table 23, no significant pattern or association between the age of the entrepreneur and the absolute difference from one of the fixed effects on the factor share equation seems to emerge from either area. In Fayoum, the three tileries with the oldest entrepreneurs are ranked in the middle range; in Kalyubiya, only two tileries in the top half have entrepreneurs less than fifty, and, in the bottom half, only two have entrepreneurs older than fifty.

TABLE 23

Entrepreneurial Characteristics
(Ranked by Efficiency Measures From Factor Share Equation)

Code	Area	Rank	Age of Entre-preneur	Years of Formal Education, Entrepreneur	Age of Tilery	Total Management Hours by Entrepreneur	Total Work Hours Outside Tilery by Entrepreneur
216	Fay	1	45	14	5	13	23
215[a]	Fay	2	--	--	--	6	21
2	Fay	3	25	17	5	4	43
217	Fay	4	60	6	30	22	4
117	Fay	4	50	12	2	24	20
208	Fay	6	72	0	12	7	29
138	Fay	7	30	16	4	5	32
214	Fay	8	40	1	2	11	41
218	Fay	9	45	0	12	22	3
535	Kal	1	56	6	12	26	20
315	Kal	2	50	5	16	50	0
314	Kal	3	38	4	7	50	0
312[a]	Kal	4	--	--	--	19	0
411	Kal	5	45	2	2	31	15
101	Kal	6	55	6	37	25	18
536	Kal	7	52	15	30	44	1
306	Kal	8	50	3	11	50	0
552	Kal	9	51	16	20	32	25
72	Kal	10	45	16	22	30	0
59	Kal	11	42	16	6	36	7
582	Kal	11	47	9	25	41	0
318	Kal	13	60	5	14	45	1
355	Kal	14	40	16	1	50	4
311	Kal	15	46	6	4	44	0
116[a]	Kal	16	--	--	--	47	0

[a] Tilery has data missing from entrepreneurial questionnaire.

Entrepreneurs of tileries ranked in the top half for the Fayoum firms do have more formal education on average (12.3 years) than those whose tileries are ranked in the bottom half (4.3 years). In Kalyubiya, the opposite is true; those ranked in the top half have owners with an average of 5.4 years of formal education, while those in the bottom half have owners with an average of 12.4 years.

Fayoum tileries in the top half, on average, tend to have been established earlier than those in the bottom half. In Kalyubiya, the average age of the tileries is almost identical between those in the top half and those in the bottom half; however, those in the bottom half tend to be either the younger tileries or those that are at least twenty years old.

No clear association is forthcoming between the amount of effort spent by an entrepreneur as measured by the number of average weekly hours he spends in managing his tilery and the rankings obtained from the fixed effects on the factor share equation. In Fayoum, entrepreneurs of tileries ranked in the top and bottom halves spend on average essentially the same amount of weekly hours managing their firms; in Kalyubiya, entrepreneurs of tileries ranked in the bottom half spend slightly more hours weekly (forty-one weekly hours) managing their tileries than those in the top half (thirty-seven hours). When looking at the number of hours an entrepreneur spends on average each week performing outside work activities, we again get mixed and quite inconclusive results. In Fayoum, those with tileries ranked in the top half spend slightly less average weekly hours on work activities outside the firm than those in the bottom half, while in Kalyubiya the opposite is found.

5.4 Size of Operation

In Hoch's (1962) research, he found that "technical" efficiency as measured by the fixed effects on the production function was associated with the size of operation for Minnesota farms. Mundlak (1961) found that large firms were more productive than the smaller farms among a sample of Israeli farms. In this section, we will explore whether the rankings obtained from the fixed effects on the production function are associated with the size of the firm as measured by total quantity of output produced during the survey period, number of labor hours employed, number of machine hours employed, and average value of machinery used in production during the survey period. Rankings obtained from the absolute difference from one of the fixed effects on the factor share equation (measured in antilogs) will also be compared to the above variables. Table 24 reports the Fayoum firms before the Kalyubiya tileries, and, within each area, tileries are ranked by the size of the fixed effects on the production function. Similarly in Table 25, tileries are reported in order of the absolute difference from one of the fixed effects on the factor share equation.

Tileries in Kalyubiya had, on average, larger estimated fixed effects from the production function than those from Fayoum, and we find that the average total quantity of tiles (30438 square meters) produced by the Kalyubiya tileries during the survey period is greater than the average total amount (15906 square meters) produced by the Fayoum firms. The same relationship holds between quantity of output produced and rankings of tileries within Fayoum governorate; tileries ranked in the top half produced, on average, more than twice the quantity of floor tiles produced by those ranked in the bottom half. In Kalyubiya, there

TABLE 24

Variables Indicating Size of Tileries[a]
(Ranked by Size of Fixed Effects From Production Function)

Firm Code	Area	Rank	Total Floor Tile Production (Sq. Meters)	Total Labor Hours in Production	Total Machine Hours in Production	Total Value[b] of Machines Used in Production
216	Fay	1	22942	7995	4222	1300
218	Fay	2	28196	11107	7747	3200
217	Fay	3	21955	9389	3395	1309
117	Fay	4	17002	7204	4075	1450
215	Fay	5	12080	5421	2832	1200
214	Fay	6	6548	3083	3951	1347
2	Fay	7	8847	4415	1980	1500
138	Fay	8	16990	8090	5814	1636
208	Fay	9	8598	4408	3347	1400
306	Kal	1	44677	11387	8113	2000
552	Kal	2	25390	6723	3151	1400
582	Kal	3	33471	8799	3428	1700
72	Kal	4	39183	10669	6543	2400
318	Kal	5	39015	9796	14214	2400
535	Kal	6	41437	11702	6395	1800
315	Kal	7	31548	9506	2046	600
116	Kal	8	29266	8632	1907	400
411	Kal	9	41226	12321	7726	1775
312	Kal	10	9566	3073	803	600
59	Kal	11	27889	8259	7384	2400
536	Kal	12	44236	13547	10832	2600
101	Kal	13	39795	12353	3165	1100
314	Kal	14	26547	8606	2180	600
311	Kal	15	37131	12109	9148	2600
355	Kal	16	16845	7800	4940	2600

[a] Production period December 1982 through March 1983.

[b] Value reported in Egyptian pounds.

TABLE 25

Variables Indicating Size of Tileries[a]
(Ranked by Efficiency Measures From Factor Share Equation)

Firm Code	Area	Rank	Total Floor Tile Production (Sq. Meters)	Total Labor Hours in Production	Total Machine Hours in Production	Total Value[b] of Machines Used in Production
216	Fay	1	22942	7995	4222	1300
215	Fay	2	12080	5421	2832	1200
2	Fay	3	8847	4415	1980	1500
217	Fay	4	21955	9389	3395	1309
117	Fay	4	17002	7204	4075	1450
208	Fay	6	8598	4408	3347	1400
138	Fay	7	16990	8090	5814	1636
214	Fay	8	6548	3083	3951	1347
218	Fay	9	28196	11107	7747	3200
535	Kal	1	41437	11702	6395	1800
315	Kal	2	31548	9506	2046	600
314	Kal	3	26547	8606	2180	600
312	Kal	4	9566	3073	803	600
411	Kal	5	41226	12321	7726	1775
101	Kal	6	39795	12353	3165	1100
536	Kal	7	44236	13547	10832	2600
306	Kal	8	44677	11387	8113	2000
552	Kal	9	25390	6723	3151	1400
72	Kal	10	39183	10669	6543	2400
59	Kal	11	27889	8259	7384	2400
582	Kal	11	33471	8799	3428	1700
318	Kal	13	39015	9796	14214	2400
355	Kal	14	16845	7800	4940	2600
311	Kal	15	37131	12109	9148	2600
116	Kal	16	29266	8632	1907	400

a Production period December 1982 through March 1983.

b Value reported in Egyptian pounds.

is no clear division; firms ranked in the top half produced on average 30472 square meters of tile during the survey period, while those in the bottom half produced on average only slightly less (30404 square meters). Since the size of the fixed effects of the firms in Kalyubiya was generally quite similar, this is not too surprising. It is interesting to note that Firm 355 which had the smallest fixed effect among the Kalyubiya tileries produced less tiles during the survey period than any other tilery from that area except for Firm 312.

When looking at the number of aggregated labor hours used in production by each tilery, we see that the average total number of aggregated labor hours employed by the Fayoum tileries (6790 hours) is smaller than the average total for those in Kalyubiya (9705 hours). Within Fayoum, tileries ranked in the top half employed an average of 8924 total aggregated labor hours as compared with 4999 hours for those ranked in the bottom half. Again, the relationship is not as clear for the tileries within Kalyubiya. In fact, those ranked in the top half from Kalyubiya employed on average slightly less labor hours during the survey period than those ranked in the bottom half.

Tileries from Fayoum employed on average less aggregated total machine hours during the survey period than those firms from Kalyubiya, and firms ranked in the top half from Fayoum also used more aggregated total machine hours on average than those ranked in the bottom half. In Kalyubiya, only a slight difference in the average total aggregated machine hours used by tileries ranked in the top and bottom halves exists, with those in the top half using slightly less on average than those in the bottom half.

Replacement cost of machinery used in production can also be used as an indication of the size of a firm. The average value (using replacement cost) of machinery used in production among the Fayoum tileries is L.E. 1594 ($1594) and is slightly less than the average value of machinery used in production among the Kalyubiya firms (L.E. 1686). Fayoum tileries ranked in the top half used more capital stock in production (L.E. 1815) than those ranked in the bottom half (L.E. 1470). In Kalyubiya, the opposite is found; firms ranked in the top half have, on average, L.E. 1588 of machinery used in production, while those ranked in the bottom half have L.E. 1784 of machinery used in production.

Table 25 reports the size of tileries as compared to the rankings obtained from the absolute difference from one of the fixed effects (i.e., $\left| G_{i2} - 1 \right|$) obtained from the factor share equation when measured in antilogs. (When $G_{i2} = 1$, a firm is combining labor hours and machine hours in a least cost manner.) From Chapter 4, we found that the average estimated value for G_{i2} for the Fayoum tileries is 0.31 while the average for those in Kalyubiya is 0.65. This indicates that the Kalyubiya tileries are, on average, combining variable inputs more efficiently than those in Fayoum. Comparing the rankings obtained from the factor share equation's fixed effects to the total amount of square meters of tile produced during the survey period, one finds that larger tileries, in terms of quantity of output produced, are generally more efficient at combining variable inputs than those producing a smaller volume. Fayoum tileries, on average, produced 15906 square meters of aggregated tile; those in Kalyubiya produced on average about twice as much (3295 square meters). Within Fayoum, tileries ranked in the top half produced on average 16450 square meters of tile while those in the bottom half produced less (15083 square meters). The same relationship exists for the Kalyubiya tileries; those firms ranked in the top half on average produced 34874 square meters of cement floor tile while those in the bottom half produced 31024 square meters

The same association between firm size and the efficient allocation of variable inputs is seen when we use total aggregated labor hours as an indicator of size. Kalyubiya tileries are larger in terms of average total labor hours (9705 hours) used in production and are more efficient in combining variable inputs than those in Fayoum (6790 hours). Within each area, we find the same tendency; tileries ranked in the top half used more aggregated labor hours on average (6805 hours for Fayoum tileries; 10312 hours for Kalyubiya tileries) than those ranked in the bottom half (6672 hours for Fayoum tileries; 9099 hours for Kalyubiya tileries).

A different pattern emerges when one compares the efficiency rankings to the number of aggreated machine hours used in production during the survey period. Tileries in Fayoum used, on average, less aggregated machine hours than the Kalyubiya firms, but, within each area, tileries ranked in the top half used less aggregated machine hours during the survey period than those ranked in the bottom half. In Fayoum (Kalyubiya), those ranked in the top half employed on average 3107 (5748) aggregated machine hours while those in the bottom half employed 5215 (6339) hours on average; however, when comparing the efficiency rankings to the average value of machine stock used in production during the survey period, Fayoum tileries ranked in the top half employed more capital stock than those ranked in the bottom half, but the opposite is found for Kalyubiya tileries. Although those ranked in the top half employed more aggregated machine hours, on average, than those in the bottom half, they employed less capital stock (L.E. 1588) on average than those ranked in the bottom half (L.E. 1784). This means that, although Kalyubiya tileries ranked in the top half used a smaller stock of machinery than those ranked in the bottom half, they utilized their capital stock more heavily than those ranked in the bottom half.

5.5 Market Size and Location

In this section, we consider whether firms located in or near major urban area (a town with population over sixty thousand) are those with larger fixed effects from the production function or are more efficient at combining variable inputs. Table 26 reports the population of the towns in which the tileries are located, the distances of those towns from a major urban area, and their distances from Cairo and from Alexandria. Tileries in Fayoum governorate are listed first followed by those in Kalyubiya, and, within each area, they are listed according to their rankings in terms of their fixed effects from the production function.

In Fayoum governorate, only Fayoum City is considered a major urban area. From Table 26, it is clear that those Fayoum tileries ranked in the top half tend to be in Fayoum City; those in the bottom half tend to be from the outlying **markaz** (district) towns. The average population of the towns in which the top four ranked tileries in Fayoum are located is 130,100, while it is 63,927 for those in which the bottom four ranked ones are located. Kalyubiya has two major urban areas included in the survey area, Benha and Kalub. (The third major urban area in Kalyubiya, Shubra El Khayma, was excluded.) As in Fayoum, tileries ranked in the top half tend to be those located in the major urban areas. The average

TABLE 26

Population Size of Tilery Localities and Distance From Major Urban Areas[a]
(Ranked by Size of Fixed Effects From Production Function)

Firm Code	Area	Rank	Population of Locality	Distance From Major Urban Area	Distance From Cairo	Distance from Alexandria
216	Fay	1	166910	0	112	334
218	Fay	2	166910	0	112	334
217	Fay	3	166910	0	112	334
117	Fay	4	19671	25	110	332
215	Fay	5	166910	0	112	334
214	Fay	6	166910	0	112	334
2	Fay	7	20171	15	127	349
138	Fay	8	42010	14	98	320
208	Fay	9	26616	24	136	356
306	Kal	1	68552	0	15	206
552	Kal	2	11836	13	62	185
582	Kal	3	97238	0	49	172
72	Kal	4	97238	0	49	172
318	Kal	5	68552	0	15	206
535	Kal	6	97238	0	49	172
315	Kal	7	68552	0	15	206
116	Kal	8	22163	12	49	184
411	Kal	9	22163	12	37	184
59	Kal	11	12745	2	51	174
536	Kal	12	97238	0	49	172
312	Kal	12	68552	0	15	206
101	Kal	13	22163	12	37	184
314	Kal	14	68552	0	15	206
311	Kal	15	68552	0	15	206
355	Kal	16	35381	0	20	211

[a] All distances reported in kilometers.

population of the towns in which those tileries ranked in the top half are located is 66,421, while average is 49,418 for those of the tileries ranked in the bottom half.

Nearness to a major urban area also seems to be associated with the ranking of tileries in terms of the fixed effects on the production function. Tileries in Fayoum were on average located eight kilometers from a major urban area while those in Kalyubiya were on average only four kilometers from a major urban area. The tilery in Kalyubiya, Firm 355, having the smallest fixed effect for that area is located further from a major urban area than any other tilery in the Kalyubiya sample. For Fayoum tileries, the average distance from a major urban area of those ranked in the top half is six kilometers and is thirteen kilometers for those ranked in the bottom half; for Kalyubiya, the average distance from a major urban area for tileries ranked in the top half is three kilometers and is six kilometers for those ranked in the bottom half.

Tileries from Kalyubiya are closer to both Cairo and Alexandria than Fayoum's, and their average fixed effect is larger than that of the Fayoum tileries. Within an area, however, no consistent pattern is found between rankings and distances from either Cairo or Alexandria. In Fayoum, the average distance to Cairo and Alexandria of those ranked in the top half is slightly less than for those ranked in the bottom half; in Kalyubiya, the opposite is found.

Table 27 is similar to Table 26 except that, within each area, tileries are listed in the order of their rankings as to how efficiently they combine variable inputs. Within both areas, tileries ranked in the top half are, on average, in higher population areas. In Fayoum, those ranked in the top half are located in towns that have an average

TABLE 27

Population Size of Tilery Localities and Distance From Major Urban Areas[a]
(Ranked by Efficiency Measures From Factor Share Equation)

Firm Code	Area	Rank	Population of Locality	Distance From Major Urban Area	Distance From Cairo	Distance From Alexandria
216	Fay	1	166910	0	112	334
215	Fay	2	166910	0	112	334
2	Fay	3	20171	15	127	349
217	Fay	4	166910	0	112	334
117	Fay	4	19671	25	110	332
208	Fay	6	26616	24	136	356
138	Fay	7	42010	14	98	320
214	Fay	8	166910	0	112	334
218	Fay	9	166910	0	112	334
535	Kal	1	97238	0	49	172
315	Kal	2	68552	0	15	206
314	Kal	3	68552	0	15	206
312	Kal	4	68552	0	15	206
411	Kal	5	22163	12	37	184
101	Kal	6	22163	12	37	184
536	Kal	7	97238	0	49	172
306	Kal	8	68552	0	15	206
552	Kal	9	11836	13	62	185
72	Kal	10	97238	0	49	172
59	Kal	11	12745	2	51	174
582	Kal	11	97238	0	49	172
318	Kal	13	68552	0	15	206
355	Kal	14	35381	0	20	211
311	Kal	15	68552	0	15	206
116	Kal	16	22163	12	49	184

[a] All distances measured in kilometers.

population size of 130,225 while those in the bottom half are located in towns that have an average population of 100,612; in Kalyubiya, those ranked in the top half are located in towns that have an average population of 64,126, while those in the bottom half are located in towns that have an average population of 51,713.

Distance from a major urban area seems to be slightly associated with how efficiently a firm combines its variable inputs. The average distance of tileries ranked in the top half among those in Fayoum is four kilometers while those ranked in the bottom half are on average ten kilometers from a major urban area. In Kalyubiya, those ranked in the top half are on average three kilometers from a major urban area, while those ranked in the bottom half are six kilometers, on average, from a major urban area.

Tileries in Kalyubiya are on average more efficient at combining variable inputs that those from Fayoum and are also closer to both Cairo and Alexandria than Fayoum's. Within an area, though, distance from Cairo or Alexandria does not seem to be associated with how efficiently a tilery combines its variable inputs. In Fayoum, the average distance from Cairo and Alexandria of tileries ranked in the top and bottom halves are essentially the same; in Kalyubiya, those ranked in the top half are closer to Cairo and further from Alexandria than those ranked in the bottom half.

5.6 Changes in Marketing and Production

In this section, we explore whether changes in marketing or production patterns are associated with the size of the fixed effects on the production function or with inefficiencies in combining variable inputs. One tends to associate a necessary learning period for a firm to adjust to new marketing strategies, production of new products, or changes in technology; however, offsetting this is that firms with better managers are those that tend to adjust more quickly to changes in markets and demand for their products so that firms recently making changes could still be those that are ranked higher in terms of the production function's fixed effects or in terms of the efficiency measures for combining variable inputs.

Table 28 reports the entrepreneurs' responses when asked if they had changed the extent of their marketing of output or the location of the markets in which they sell. Again, tileries in Fayoum are reported first, and, within each area, they are listed according to the size of the fixed effects on the production function. In Fayoum, only two tileries changed the extent of marketing their output, one being ranked in the top half, the other in the bottom half. In Kalyubiya, a definite pattern is found. Seven of the sixteen tileries had changed the extent of their marketing within the last year, with five of those being ranked in the top half and only two in the bottom half. None of the tileries in Fayoum had changed the location of their markets in which they were selling. In Kalyubiya, four had changed the location of their markets, and all of these were ranked in the top half.

Table 29 is similar to Table 28 except tileries within areas are listed according to how efficiently they combine variable inputs. The two Fayoum tileries that changed the extent to which they market their products are both ranked in the bottom half. Of the seven Kalyubiya tileries that reported changes in the extent of marketing their products, five of these are ranked in the bottom half; all seven are ranked sixth or less out of sixteen firms. For the three firms from Kalyubiya

TABLE 28

Changes in Marketing Strategy
(Ranked by Size of Fixed Effects From Production Function)

Firm Code	Area	Rank	Changes in Extent of Marketing	Changes in Marketing Locality
216	Fay	1	2	2
218	Fay	2	1	2
217	Fay	3	2	2
117	Fay	4	2	2
215[a]	Fay	5	-	-
214	Fay	6	2	2
2	Fay	7	2	2
138	Fay	8	2	2
208	Fay	9	1	2
306	Kal	1	1	1
552	Kal	2	1	1
582	Kal	3	1	2
72	Kal	4	1	1
318	Kal	5	1	1
535	Kal	6	2	2
315	Kal	7	2	2
116[a]	Kal	8	-	-
411	Kal	9	2	2
312[a]	Kal	10	-	-
59	Kal	11	1	2
536	Kal	12	1	2
101	Kal	13	2	2
314	Kal	14	2	2
311	Kal	15	2	2
355	Kal	16	2	2

[a] Tilery has data missing from entrepreneurial questionnaire.

RATE 1 = YES
RATE 2 = NO

TABLE 29

Changes in Marketing Strategy
(Ranked by Efficiency Measures From Factor Share Equation)

Firm Code	Area	Rank	Changes in Extent of Marketing	Changes in Marketing Locality
216	Fay	1	2	2
215[a]	Fay	2	-	-
2	Fay	3	2	2
217	Fay	4	2	2
117	Fay	4	2	2
208	Fay	6	1	2
138	Fay	7	2	2
214	Fay	8	2	2
218	Fay	9	1	2
535	Kal	1	2	2
315	Kal	2	2	2
314	Kal	3	2	2
312[a]	Kal	4	-	-
411	Kal	5	2	2
101	Kal	6	2	2
536	Kal	7	1	2
306	Kal	8	1	1
552	Kal	9	1	1
72	Kal	10	1	1
59	Kal	11	1	2
582	Kal	11	1	2
318	Kal	13	1	1
355	Kal	14	2	2
311	Kal	15	2	2
116[a]	Kal	16	-	-

[a] Tilery has data missing from entrepreneurial questionnaire.

RATE 1 = YES
RATE 2 = NO

reporting changes in the location of marketing their product, two are ranked in the bottom half, and all of them are ranked eighth or less.

Table 30 reports the entrepreneurs' responses to whether or not their tileries made the following changes within the last year: changes in product line, product style, product quality, production technology, or quantity of product produced. Tileries from Fayoum are listed first, and, within each area, they are listed according to the size of their estimated fixed effects on the production function. In Fayoum, two tileries reported changes made in product line and product style; one of these is ranked in the top half, the other in the bottom half. Three Fayoum tileries made changes in product quality, two of these being ranked in the top half, one in the bottom half. One tilery made a change in production technology and is ranked in the top half; four made changes in the quantity of products produced, two of which are ranked in the top half and two in the bottom half.

In Kalyubiya, five tileries made changes in product line with four of these being ranked in the top half. Five tileries also made changes in product style, four of which were ranked in the top half. Nine out of the sixteen tileries in Kalyubiya reported making changes in product quality, with six of these being ranked in the top half. Seven made changes in production technology; four of these being ranked in the top half. Eight tileries made changes in the quantity of output produced, with five of these being ranked in the top half.

When firms are ranked by how efficienty they combine variable inputs (Table 31), we find that those tileries that made changes are, in general, less efficient than those not making changes. In Fayoum, the two tileries that made changes in product line and product style are

TABLE 30

Changes in Product or Production
(Ranked by Size of Fixed Effects From Production Function)

Firm Code	Area	Rank	Change in Product Line	Change in Product Style	Change in Product Quality	Change in Production Technology	Change in Quantity of Product Produced
216	Fay	1	2	2	2	2	2
218	Fay	2	1	1	1	1	1
217	Fay	3	2	2	1	2	1
117	Fay	4	2	2	2	2	2
215[a]	Fay	5	-	-	-	-	-
214	Fay	6	2	2	2	2	1
2	Fay	7	2	2	2	2	2
138	Fay	8	2	2	2	2	2
208	Fay	9	1	1	1	2	1
306	Kal	1	1	1	1	1	1
552	Kal	2	1	1	1	2	1
582	Kal	3	2	2	1	1	1
72	Kal	4	1	1	1	1	1
318	Kal	5	1	1	1	2	2
535	Kal	6	2	2	1	1	1
315	Kal	7	2	2	2	2	2
116[a]	Kal	8	-	-	-	-	-
411	Kal	9	2	2	2	2	2
313[a]	Kal	10	-	-	-	-	-
59	Kal	11	1	2	2	1	2
536	Kal	12	2	2	1	1	1
101	Kal	13	2	1	1	2	1
314	Kal	14	2	2	2	2	2
311	Kal	15	2	2	2	2	2
355	Kal	16	2	2	1	1	1

[a] Tilery has data missing from entrepreneurial questionnaire.

RATE 1 = YES
RATE 2 = NO

TABLE 31

Changes in Product or Production
(Ranked by Efficiency Measures From Factor Share Equation)

Firm Code	Area	Rank	Change in Product Line	Change in Product Style	Change in Product Quality	Change in Production Technology	Change in Quantity of Product Produced
216	Fay	1	2	2	2	2	2
215[a]	Fay	2	-	-	-	-	-
2	Fay	3	2	2	2	2	2
217	Fay	4	2	2	1	2	1
117	Fay	4	2	2	2	2	2
208	Fay	6	1	1	1	2	1
138	Fay	7	2	2	2	2	2
214	Fay	8	2	2	2	2	1
218	Fay	9	1	1	1	1	1
535	Kal	1	2	2	1	1	1
315	Kal	2	2	2	2	2	2
314	Kal	3	2	2	2	2	2
312[a]	Kal	4	-	-	-	-	-
411	Kal	5	2	2	2	2	2
101	Kal	6	2	1	1	2	1
536	Kal	7	2	2	1	1	1
306	Kal	8	1	1	1	1	1
552	Kal	9	1	1	1	2	1
72	Kal	10	1	1	1	1	1
59	Kal	11	1	2	2	1	2
582	Kal	11	2	2	1	1	1
318	Kal	13	1	1	1	2	2
355	Kal	14	2	2	1	1	1
311	Kal	15	2	2	2	2	2
116[a]	Kal	16	-	-	-	-	-

[a] Tilery has data missing from entrepreneurial questionnaire.

RATE 1 = YES
RATE 2 = NO

ranked in the bottom half. Of the three that reported making changes in product quality, two are ranked in the bottom half. The one Fayoum tilery that reported a change in production technology is ranked last. For the four tileries that reported changes in the quantity of output they produced, three are ranked in the bottom half.

In Kalyubiya, four of the five tileries reporting a change in product line are ranked in the bottom half. Five tileries also reported making changes in product style, three of which are ranked in the bottom half. Nine tileries reported changes in product quality within the past year, and five of these are ranked in the bottom half; four of the seven tileries reporting changes in production technology are ranked in the bottom half. Half of the sixteen Kalyubiya tileries reported making changes in the quantity of output produced, and it is only in this case that less than the majority of tileries reporting changes were ranked in the bottom half; even in this case, four of the eight are ranked in the bottom half, and all but one of the eight is ranked fifth or less out of sixteen.

5.7 Summary

As seen in the preceeding sections, tileries in Fayoum ranked highest in terms of fixed effects on the production function tend to be larger, closer to a major urban area, have entrepreneurs who spent more time managing the firm, and to have been in operation for at least five years. Those in Kalyubiya ranked highest tend to be slightly larger (in terms of production), closer to a major urban area, more likely to have recently changed their marketing stragegy or production process, and have entrepreneurs who spend slightly more time managing the tilery and less time working outside the firm. When comparing tileries in the two governorates, tileries in Kalyubiya have larger fixed effects on average than those in Fayoum and tend to be larger, closer to major urban areas, more likely to have recently changed their marketing stategy and production process, and have entrepreneurs who spend more time managing the firm and less time working outside the firm.

In Fayoum, tileries ranked highest in terms of efficient allocation of variable inputs tend to be larger (in terms of production and labor usage), established earlier, more likely to have recently made changes in their marketing and production process, and have entrepreneurers with more formal education. Those ranked highest in Kalyubiya tend to be larger, closer to a major urban area, less likely to have recently made changes in their marketing stategy or the production process, and have entrepreneurs with less formal education. When comparing tileries in the two governorates, tileries in Kalyubiya combine variable inputs more efficiently on average than those in Fayoum and tend to be larger, closer to major urban areas, established earlier, and have entrepreneurs who spend more time managing the firm and less time working outside the firm.

CHAPTER VI

Conclusions

The thesis has accomplished its goals as stated in Chapter 1. The primary data collected in Egypt over the period of April 1981 through March 1983 has greatly increased the information available on Egyptian small-scale manufacturing establishments, particularly small-scale floor tileries, relative to what had previously existed in the official Egyptian statistics on this subsector. The estimation of firm-specific measures of differences in production among tileries for a stochastic production function and the generalization of a fixed-effect Cobb-Douglas system to include firm-specific measures of failure on the part of firms to maximize profit and to combine variable inputs in a least cost manner are advancements in the estimation of this type of model. Rankings of tileries in terms of differences in production and efficient allocation of variable inputs have been obtained and are considered to be quite reasonable.

General findings are that many more small-scale manufacturing firms and their employees are participating in manufacturing activities in rural Egypt than had previously been recognized in official Egyptian statistics, that the participation of women in these manufacturing enterprises is quite prevalent and widespread, that, though returns for individual firms may seem quite small, small-scale manufacturers support and supplement the income of a substantial number of persons in the rural areas, and that, when taken as a whole, they contribute substantially and significantly toward the national gross product (GNP). In terms of policy issues, it is essential to distinquish household enterprises from micro enterprises as the two groups have characteristics which are highly different from each other, so that policy prescriptions for one group will not in general be appropriate for the other group.[1]

From the analyses of Egyptian small-scale floor tileries in Fayoum and Kalyubiya governorates, major findings are that they produce under constant returns to scale; that there are differences in production among tileries, both within and between the two areas, but these differences are generally not great from an economic point of view; that tileries on average are failing to maximizing profit by employing too little capital and too little labor; and that tileries on average are not combining labor and capital efficiently as they employ too much capital relative to the amount of labor they employ, though the cost of this inefficiency is small. From the above, it is concluded that tileries should be increasing the size of their operations by employing more capital and more labor, but that the capital to labor ratio should be decreasing. It is comforting to note that during or just prior to the survey period, tileries were generally attempting to adjust to the changing demand for their product by expanding their operations by purchasing more capital and labor.

The estimates of differences in production among tileries show that tileries in the more highly urbanized and industrialized Kalyubiya governorate produce more output from the same set of measured inputs than

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[1]Policy prescriptions for Egyptian small-scale manufacturing firms can be found in Mead, Davies, and Seale (1984).

do those in the less developed and lower-income Fayoum governorate. Within each area, tileries ranked highest in terms of the fixed effects on the production function are those, in the judgement of the author, that tended to be larger, better organized, have higher quality workers, and have more stability in terms of worker turnover. They also tended to be tileries with a high and steady demand for their output due to being located in or near major urban areas (populations over 60000) or in areas where the Egyptian government was constructing administrative centers.

In this author's view, the model performed quite well in estimating actual differences in production among the tileries. Rankings in terms of the fixed effects in the production function are quite similar to a priori rankings made by the author based on his firsthand knowledge of the tileries over a two year period. Although the actual estimated values of the fixed effects were sensitive to corrections made in the labor data, the relative sizes of the fixed effects and the tilery rankings based on the effects were quite stable.

The estimates measuring failure to maximize profit and to combine variable inputs efficiently also seem reasonable. Restrictions on the availability of capital funds (see Clark, 1958) and dynamic changes in the demand for cement floor tiles and in the labor market--as Egyptian workers emigrate to other Arab countries for employment--help explain why tileries are generally failing to maximize profit and to combine labor and capital efficiently. In equilibrium, all firms should be maximizing profit and combining variable inputs in a least cost manner; in disequilibrium where restraints on the availability of inputs are found, this need not be the case, particularly if it takes time for firms to make appropriate adjustments. The market for Egyptian cement floor tiles was quite dynamic during the survey period with increased demand being driven by increasing incomes. Tileries were definitely in transition and were adjusting to the market dynamics by increasing the size of their operations by purchasing more capital and labor, although this adjustment was hampered by the unavailability of capital funds and of labor at the prevailing wage rates.

The author does want to caution that the model may not perform so well for all types of activities. It is well known that fixed factors in production will be captured by the fixed effects in the production function. This could be particularly troublesome in the case of agricultural production, since the fixed effects will be sensitive to quality differences in soil types and genetic differences in animals. In a relatively simple manufacturing process such as employed by Egyptian small-scale floor tileries, this problem should not be as great. One possible source of fixed factors may be the buildings in which production takes place, although it can be argued that, in Egypt, cement floor tiles can be produced just as efficiently outside as under a veranda or in a building. Also, the machinery used in production is generally of two types: manual hydraulic presses and electric hydraulic press; and "doughnut" polishing machines and "newer" polishing machine. Within a machine type, the quality of machinery is quite similar. Probably, a machine from a tilery producing on a lower subproduction function could be exchanged for the same type of machine from a tilery producing on a higher subfunction without changing their relative rankings in terms of the fixed effects in the production function; this would not be the case for switching soil types from a more productive to a less productive farm.

Also, firms in the same geographic market (e.g., Fayoum City, Kalub, Benha) had relatively similar fixed effects from the production function while those in smaller, more isolated markets had measures generally smaller than that of tileries from or near a major urban area. This result is as expected, since firms outside larger urban areas are protected from competition by significant transportation costs; thus, they can still remain viable and profitable even though they are producing on a lower subproduction function than tileries from the major urban areas. The question of whether a firm should move to a higher or lower subproduction function is an economic question. If a firm is on a lower subproduction function than other firms with which it is directly competing, it may pay for the firm to move to a higher subproduction function; if the firm is located in an isolated **markaz** (district) town such as the tilery from Ibshaway, it probably does not pay to make the change to a higher subproduction function unless the marketing or transportation systems change.

Taking into account the above arguments plus the fact that a priori rankings assigned by the author to tileries based on firsthand knowledge of the tileries over an extend period are quite similar to those obtained from the analysis, this author does indeed feel that the fixed effects on the production function are measuring actual difference in production among firms. He also believes that, at least in for the Egyptian small-scale floor tileries, the methodology used to measure differences in production and efficiency differences in combining variable inputs is reliable enough to be used by industry extension persons or policy makers to obtain rankings of firms, and then to use these rankings to systematically explore what is causing the differences in production among tileries. Hopefully, our knowledge of production and firm management will be further increased, and we may learn how to make firms more efficient in their production of output and in the allocation of inputs. This is not to say that, once differences in production among firms are identified, one can expect to correct them freely. If it were that easy, the firm would have already done it.

APPENDIX A

APPENDIX A

The questionnaire is paraphrased in English below. Next to each question is a description of allowable answers to that question. The questionnaire first requires that the enumerator fill in three numbers:

A village number,
Product number for primary and secondary products, and
An enterprise number.

The enumerator then asked the name of the respondent and sketched a map showing the location of the workplace or took the address. After this there are nine questions as follows:

1. Form of ownership — three choices: private, cooperative, or public.

2. Sex of the entrepreneur — two choices: male or female.

3. Place of business — two choices: near or in the home, or away from home.

4. Type of building — four choices: arisha, kiosk, mud brick, or red brick.

5. Type and number of workers employed — numbers entered for male, female, total, and also for the number of family, hired, and apprentices working in the firm at the time of the survey.

6. Total number of machines — boxes numbered 1-8, and 9 or more.

7. The value of the most sophisticated machine, and the total value of all equipment and tools — For both parts of the question, there are choices to be made from the following categories: less than L.E. 50, L.E. 50-99, L.E. 100-199, L.E. 200-499, L.E. 500-2000, greater than L.E. 2000. This question concerns current book value; i.e., original cost less depreciation. In some cases, the valuation was done by enumerator concensus concerning values of frequently observed pieces of equipment such as sewing machines.

8. Use of power — choices: yes or no.

9. Seasonality of production — 12 choices, one for each month. Respondents were asked whether any production took place during each month, if so, the enumerator fills in the box for that month.

APPENDIX B

APPENDIX B

Towns and Villages Surveyed

Population Stratum	Fayoum	Kalyubiya
0-2,999	Maasaret Ahrafa Kafr Ameera Manshat El Gazaar Maagoon El Hamidiya Kafr Hamman Khalwit Sinhura Kafr Saleem Kafr Haddadin Kafr Abou Zahra Kafr Saad Kafr Ali Sharaf El Deen	Kafr Shorafa El Kibili Kafr Farsees Kafr El Sheikh Ibrahim Kafr Nekhla Manshat Diyab
3,000-5,999	Kasr Biad Forqas El Ruba El Maqatlah El Fahmiya El Siliyeen* Abgeeg* Garfis* Aalam* Manshat Abdela*	Kafr El Gimal El Moniera Zawiet El Naggar Namoul El Zaha Weiem Kafr Azab Houneim Geziret El Ahrar El Manzala Kafr El Regalat El Shuback Kafr Atalla Tersa*
6,000-11,999	Biahmu El Adwa El Azeeziya El Gharoq El Gharoq Qably Manshat Beni Osman Kaaby El Gideeda Naqalifa El Nazla	El Asheesh Kafr Abyan Shalakan El Hessa Damallu Tant El Gezira Geziret Beli Kafr Shukr** El Khousous Kafr Mansour
12,000-19,999	Manshat El Doctor El Gimal Kakh El Mishrak Qably Tatoon Tubhar* El Meniya* Fedemeen* El Agameen*	Moshtohor Arab Eleat Tanaan El Ramla Aghour El Kubra Syniyown*

20,000-39,000	Sanhur	El Kalag
	Itsa**	Meet Kanana
	Ibshaway**	El Khanka**
	Tamiya**	Tukh**
40,000+	Sinouris**	Kalyub**
	Fayoum City**	Benha**

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* Specialized Village

** Markaz Town

APPENDIX C

Appendix C

Regressions for Machine Hours

Data were not collected by machine type for machine hours used in producing floor tiles until week forty-one of the survey making it necessary to construct a variable that spanned the entire survey period (sixty-six weeks) that is highly correlated with actual machine hours and can be used as a proxy for it. For weeks forty-one through sixty-six, the data collected for the number of hours of each machine used in producing tiles within a firm were aggregated by machine type and over each production period (three weeks) into the variable, machine hours.

There are five types of machinery used in producing floor tiles by the tileries in the sample: manual hydraulic presses, electric hydraulic presses, "doughnut" shaped polishers, "modern" polishers, and fine polishers. Manual presses are assigned the weight of one, and electric presses are weighted by two. This is because, on average, a manual press combined with three workers (the usual number with this machine) can produce about forty square meters daily while an electric press combined with four workers (the usual number with this machine) can produce about eighty square meters of tiles daily. "Doughnut" shaped polishers are given a weight of 0.75 and "modern" polishers are given the weight of 1.5 since they can polish daily at least twice as many tiles as can the "doughnut" polishers. The fine polishers are given a weight of 0.4 since they are not used to polish tiles except for special orders.

For the weeks that machine hours was collected, machine hours is regressed on the following variables:

man.press - The number of manual presses in the tilery;

elec.press - The number of electric presses in the tilery;

polisher - The number of "doughnut" type polishers in the tilery;

fine.polish - The number of fine polishers in the tilery;

mod.polish - The number of "modern" polishers in the tilery;

val.rep - Replacement cost of all machines owned by the tilery;

black.cement - Quantity of black cement bought by the tilery during the period;

white.cement - Quantity of white cement bought by the tilery during the period;

powder - Quantity of white powder used in mixing cement that was bought by the tilery during the period;

sand - Quantity of sand bought by the tilery during the period;

gravel - Quantity of gravel bought by the tilery during the period;

dye - Quantity of dye used in producing colored tiles that was bought by the tilery during the period;

price.a - Price of black cement;

price.b - Price of white cement;

price.c - Price of white mixing;

price.d - Price of sand

Equation 1 below was choosen as giving the "best fit" and was used in constructing the variable machine hours for weeks one through forty. Equation 2 below is the same as Equation 1 except a correction was made to the data for Firm 355.[1] The variable, machine hours, for weeks forty-one through sixty-six is as collected during the latter part of the longitudinal survey.

EQUATION 1

machine hours = −	39.1155		+	99.1196 (21.9297)	man.press
+	313.5800 (23.7579)	elec.press	+	173.9834 (30.0249)	polishers
+	65.7814 (18.5317)	fine.polish	+	319.1999 (51.4861)	mod.polish
−	.0522 (.0093)	val.rep	+	2.3171 (2.9842)	black.cement
−	2.0240 (1.3408)	white.cement	+	1.1251 (1.4187)	powder
+	.9173 (.6967)	sand	+	.2307 (1.3915)	gravel
−	19.9324 (8.7088)	dye	+	.3095 (.0945)	price.a
−	.1702 (.3281)	price.b	+	1.9429 (1.3958)	price.c
+	11.6867 (6.9266)	price.d			

Standard Error	83.52
R^2	.83
Multiple R	.91
Regression Sum of Squares	4073868.23
Sum of Squared Errors	865106.88
Total Sum of Squares	4938975.10

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1 See Section 4.2 for a description of how and why the correction was made to Firm 355's data for machine hours and also how the Equations 1 and 2 were used in constructing machine hours for weeks one through forty.

EQUATION 2

machine hours = - 27.5583 + 99.4736 man.press
(23.9899)

+	309.1070 (26.1556)	elec.press	+	183.2724 (32.0754)	polisher
+	66.6869 (19.8384)	fine.polish	+	327.4921 (55.0992)	mod.polish
-	.0539 (.0099)	rep.val	+	3.2176 (3.1879)	black.cement
-	2.3163 (1.4354)	white.cement	+	1.4895 (1.5194)	powder
+	.6311 (.7455)	sand	+	.3078 (1.4893)	gravel
-	19.3046 (9.3226)	dye	+	.3384 (.1010)	price.a
-	.0745 (.3515)	price.b	+	1.4287 (1.5018)	price.c
+	8.8481 (7.4948)	price.d			

Standard Error of estimate	89.40
R^2	.80
Multiple R	.89
Regression Sum of Squares	3947859.46
Sum of Squared Errors	991115.64
Total Sum of Squares	4938975.10

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