AN EVALUATION OF HOSPITAL EFFICIENCY IN NIGERIA: A STOCHASTIC FRONTIER APPROACH.

By

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Declaration

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

Signature: -------------------------------------- date: ---

Dedication

To Nwanneka, Chukwunweike, Chukwuemeka, Tobechukwu, Ozioma and Nkechinyelu- you give me wings.

Abstract

Some people have argued that there is no reason to expect economic efficiency in a government enterprise because the funds allocated to various ends have to be exhausted to meet targets. In a social and welfarist sense, this argument seems valid if in essence, such earmarked targets, to improve societal welfare, are met. However, in the face of rising hospital costs and insufficient government funds, the issue of effectively allocating government funds to alternative uses becomes paramount. The setting for this research paper is Nigeria. This research work aims at investigating how well financial resources are used in government hospitals in Nigeria. It not only explores the resources employed in hospitals, but also how well these hospitals use minimum resources to achieve maximum outpatient and inpatient output.

Hospital cost and expenditure data are collected from 40 government cottage and general hospitals in South East Nigeria (Anambra and Enugu states specifically). The data is collected by means of open-ended questionnaires, which are filled in by relevant administrators in the hospitals visited and also by ministry of health personnel at the state levels. The main research question asked is whether hospitals in this part of the country (and indeed Nigeria as a whole) are allocatively inefficient. A second question as to whether hospitals in Anambra State are more efficient than Enugu State is also posed.

The major component of the research involves using the cost and expenditure data to build cost functions for the entire hospitals studied. The main thrust of analysis is the stochastic frontier process, which also incorporates an efficiency effects model. The choice of this model, above all else, is because it provides numerical efficiency estimates and thus provides quantifiable proof of how well/poorly Nigerian hospitals fare.

It is found in the analysis of the data collected that the hospitals studied are generally inefficient, as 70 percent of them operate at costs above the average permissible cost frontier. A conclusion is however not drawn as to whether Anambra state hospitals are

more efficient than Enugu state hospitals, since no concrete evidence is seen to this effect. Thus it is recommended that effort be made to reduce costs of hospital operations, without necessarily reducing service delivery. The research acknowledges the fact that allocative efficiency/inefficiency does not imply social or technical efficiency. Some hospitals may exhibit allocative efficiency, but are technically inefficient. Worse still such a hospital may not provide socially acceptable services to the public because its managers have concentrated their energy in trying to be cost efficient. Thus a fervent call is made to anyone interested to investigate other sources of efficiency/inefficiency in Nigerian hospitals.

Preface

The crux of this research work is on evaluating allocative efficiency of government cottage and general hospitals in Nigeria. To this end, cost and expenditure data are collected primarily from 30 general hospitals and 10 cottage hospitals in Anambra and Enugu states in Nigeria. The data are analyzed using Ordinary Least Squares and Stochastic Frontier methods to estimate hospital cost relationships. This aids in the evaluation of hospital performance and efficiency, especially as numeric efficiency estimates are obtained through the stochastic frontier process. Some recommendations are made after it is discovered that 70 percent of the hospitals studied are not efficient (because they operate on costs above the aggregate hospitals' frontier cost estimates).

The research paper is presented in five related chapters. The first chapter is devoted to introduction of the topic, a statement of the problem, and the objectives of the study, hypothesis statement, and justification. Background information is also provided to build the setting for this project in Anambra and Enugu states.

A review of literature is done in the second chapter while chapter three presents the conceptual framework and methodology adopted for the investigation of this research. Sampling method and data sources form a part of this chapter, which also includes model specification and ethical consideration.

Descriptive results and the results obtained from the models specified in chapter three are presented and discussed in chapter four. An attempt is also made to evaluate the statistical and econometric estimation criteria assumed for model estimation. The hypotheses stated in the first chapter are also evaluated and necessary conclusions are made, based on the findings of the results of this research.

The last chapter provides the summary and conclusion for the entire research and for the first four chapters. Some policy recommendations are also made in a bid to augment present levels of hospital performance in Anambra and Enugu states, and indeed in Nigeria as a macro unit.

Acknowledgement

I am greatly indebted to all who have contributed to the successful completion of this project. Most of the time, I am tempted to take for granted the fact that God has given me the privilege to continue to stay alive and to continue to excel in every facet of life. I give God the glory for everything He has done for me.

I am very delighted to have received the funding for the Master's degree program in Health Economics from the Swedish International Development Agency (SIDA). My two supervisors, Professor Haim Abraham (School of Economics) and Ms Charlotte Muheki (Health Economics Unit) both in UCT, have all the credit for the success of my thesis. Their academic and sometimes parental guidance, not only for my thesis, but also for my little personal problems has meant that they will never be forgotten when I count my blessings. You two have been my sources of inspiration.

To my family, my mum and dad, Chief and Mrs. J.N Ikenwilo and to my brothers and sisters to who I have dedicated this thesis, I know how much you have always loved me and cared for and about me. This is a good opportunity to promise you one thing-I will never let you down. Thanks a trillion folks!

To all the people at the hospitals and ministries of health in Anambra and Enugu states and to all who helped in the data collection process, I will like you to know that you share in this success story. Thank you very much for your input. Also to my friends, too numerous to mention, I am overjoyed to know that you will always be there for me. To Professor and Mrs. Melvin Ayogu, Dr Reginald Chima, James Hodge, Werner and Lisa Vos, Jacques Van Niekerk. To Andy, Asanda, Benis, Dalitso, Lillian, Okore, I can never leave you guys out of my list, thank you for being my friends. When I count my blessings, I count you twice.

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CHAPTER ONE

INTRODUCTION

In 1995, I was down with typhoid fever and ran a temperature of 38 degrees centigrade. I needed urgent medical attention from one of the General hospitals in South East Nigeria and what I experienced was interesting. There was no doctor or staff nurse to attend to me. I had to wait for about an hour to get attention from a staff nurse, who promised to send for the doctor. Luckily, a doctor saw me two hours later. When I became healthier, I wondered why I had to wait that long. I also wondered why I had to be referred to a private laboratory for diagnosis and a private chemist for drugs. I had expected that these services be provided by the hospital. This led me to investigate how the hospital system works. The desire to explore how resources are used in the hospital thus developed from this personal experience and from similar experiences shared by some of my friends and classmates.

A friend of mine once told me that he had lost a relative who was involved in a motor accident in hospital. This was because there was no electricity supply in the hospital to perform a surgery on the victim. In another light, a classmate recounted his experience once when he was sick of malaria fever and had to seek medical attention in a General hospital. Also, concern about increasing hospital cost bothers the government and schemes to cut costs are continually being conceptualized. As Glaser (1987: 4) puts it, "while health spending rises in all countries faster than consumer prices and GNP, hospital spending usually rises faster than other health spending". This is probably due to enormous human and material resources that are expended into this kind of health care delivery service. In the face of these experiences, there is a dire need to assess efficiency of hospitals in order to find out if resources of capital and labour are used optimally. This forms the core of this research, which estimates a hospital cost function from the underlying production technology of hospitals in South East Nigeria (specifically in Anambra and Enugu States). The cost function is estimated using a stochastic frontier approach, to evaluate allocative efficiency. This approach (process) breaks the error term from a regression model into two parts. The one part is the unexplained variation in the model while the other part is a measure of efficiency. It is hoped that this process provides a modus to evaluate efficiency in hospitals in South East Nigeria (Anambra and Enugu States), and that it also serves as a veritable tool in validating economic theory.

1.1 Statement of the Problem

When financial resources are scarce, and health expenditure is constrained in a country like Nigeria, then it becomes a matter of necessity that we allocate resources optimally. Also, the rising cost of service provision in Nigeria has become a cause for concern (salaries have been recently increased by more than 500% for all levels of public servants). This means that the government spends more on all sectors of the economy and hospitals now than it used to in the past. This is especially true, as hospitals are more labour intensive in Nigeria, and supposedly in other parts of the world. The costs of hospital equipment are also rising in the face of inflation and currency devaluation (much of this equipment are imported from abroad and are paid for in foreign currency). In this regard, it becomes necessary that we know whether we are getting the best out of whatever meager resources that are committed to the operation of hospitals in the country. Thus, we need to know whether the factors employed in our hospitals are producing as much as the government spends on them. The concern about hospitals is basically because, as Glaser (1987) says, hospital spending constitutes a very significant component of health spending.

According to a World Bank report on Health in Nigeria (World Bank, 1995: 16), "total public expenditure on health has been declining in real terms because of budgetary constraints, inflation and currency devaluation".

A summary of health expenditure statistics is presented below.

Table 1.1: summary of public health expenditure statistics in Nigeria.

Government capital and recurrent expenditure for health in Nigeria				
Year	**Nominal (millions of Naira**	**Real (millions of Naira)**	**% change (nominal)**	**% change (real)**
1985	223.6	40.65455	40	42
1986	312.2	57.81481	-60	-79
1987	124.2	12.17647	366	24
1988	578.2	15.09661	38	29
1989	796.8	19.48166	3	463
1990	823.2	109.76	-6	-46
1991	771.3	59.33077	112	-38
1992	1634	36.7191	57	29
1993	2567.6	47.37269	11	9
1994	2843.1	51.4123	-5	-17
1995	2702.9	42.56535	-100	-100

Source: calculated from Central Bank of Nigeria ***Statistical Bulletin*** (1995)

Real expenditures on health are noted to have dropped by one hundred percent in 1995 alone. This follows from a steady drop in health expenditures since 1990. The same report (op cit.: 19) also notes that "far too much of the health expenditure is devoted to personnel". In order to justify this huge expenditure on personnel, it is necessary to assess personnel contribution to the production of health care in Nigerian hospitals, and also to measure the level of efficiency/inefficiency in the hospitals. That way, we will be able to justify governmental outlay. For instance, if we find that hospitals are over-capitalized rather than that there is an excess employment of labour, then policy can be advised on the possible line of action to take in order to reverse the trend (to achieve optimal results). Also, by evaluating efficiency in hospitals, we can be able to advise policy on how to restructure service provision.

1.2 Objectives of this research

This research aims at investigating this problem of sub-optimal hospital performance by carrying out an evaluation of hospital allocative efficiency using a stochastic frontier cost function approach. In pursuance of this broad objective, the study aims to achieve the following specific objectives;

1. Determine the various inputs employed in hospital production
2. Collect data on the different categories of personnel in Nigerian hospitals
3. Measure the extent of the relationship between the costs, inputs and the outputs produced, and to show how variations in the output and input prices influence total hospital costs.
4. Measure the average and marginal costs of output and of the factors of hospital production
5. Determine whether Nigerian hospitals are over-capitalized.
6. Determine the levels of efficiency for each hospital considered.
7. Use results obtained to provide possible policy suggestions around allocative efficiency.

1.3 Hypothesis Statement

The maintained hypothesis in this project is stated as follows;

H_0: Hospitals in South East Nigeria are inefficient

Against the alternative hypothesis

H_1: Hospitals in South East Nigeria are efficient.

The following hypotheses are also stated;

- Anambra state hospitals are less efficient than Enugu state hospitals
- Cottage hospitals are less efficient than General hospitals.

Other hypotheses concerning parameter estimates are stated as follows

- Labour costs have no significant contribution to total/average cost variations in Anambra and Enugu state hospitals.
- Capital costs have no significant contribution to total/average cost variations in the above-mentioned hospitals.
- Hospital output (inpatient day and outpatient visit) have no significant contribution to total/average cost variations in Anambra and Enugu state hospitals.

All hypotheses will be validated using likelihood ratio tests and Wald tests respectively with 95% confidence. The test of the maintained hypothesis will also require that at least 60% of the hospitals operate within the industry cost frontier.

1.4 Justification

Hospitals absorb, among other health services, the most proportion of government time, finance and concern around the world. This is not an exception in Nigeria. The need to efficiently allocate productive resources in the hospital sector cannot be overlooked when we consider the provision and development of health care for all in Nigeria. This implies that every available factor of production ought to be used in the best possible way (the most productive way) to obtain maximum possible output (in terms of inpatient care and outpatient visits). How else can we know how well resources are being used than to provide measurable estimates of cost-output, cost-input and input-output relationships? Such estimates can provide basis for evaluation of production in hospitals and it also helps us to know how efficiently resources have been used.

Also, the ability to quantify efficiency provides decision-makers with a mechanism with which to monitor the performance of the production system in our hospitals, and to make necessary changes for improved performance. This is very useful in providing much-needed information for the on going "transformation" that is happening in Nigeria. The country has had 15 years of military rule, characterized by so much corruption and seemingly complete neglect of government responsibility to its citizens. With the advent of civilian rule in April 1999, there has been a conscious effort by all Nigerians to put things "right", in terms of providing more responsible leadership and services to the nation. Among other things, a conscious effort is being made to reorganize government agencies and utilities to be more efficient. The stochastic frontier approach has been chosen to analyse data for this research because of its ability to provide numerical efficiency estimates.

The focus on hospitals is essentially because they (hospitals) treat a vast majority of severe cases. As human beings, we cannot completely avoid being sick, hence we would always require medical attention. Thus, hospitals are a veritable engine for good health for all, which should be the mandate of the Federal Ministry of Health in Nigeria.

1.5 Background Information

This research is aimed at evaluating efficiency and investigating the productivity of the various factors of production employed in Nigerian hospitals. The country, Nigeria, is a federal republic, and is situated along the West Coast of Africa. The country lies between latitude 40 degrees and 140 degrees North of the equator, and latitude 30 degrees and 140 degrees East of the Greenwich Meridian. It occupies a land area of 923,768 square kilometers (Giddepe, 1996), and is inhabited by over one hundred million men, women and children.

Politically, the country has a federal system comprising three-tiers of government; a central administration at Abuja, thirty-six states with their administrative capitals, and local government authorities with their respective administrative headquarters. The country is currently witnessing civilian rule, after fifteen years of military rule. It is multi-cultural, with three indigenous languages, Igbo, Hausa and Yoruba, though there are over two hundred other dialects and tribes. The English language serves to unite the different tribes as an official language.

"The public health services in Nigeria originated from the British Army Medical Services" (National Health Policy, 1996: 3). Following the integration of the Army with the Colonial Government during the colonial era, government offered to treat the local civil servants and their relatives, and eventually, the local population living close by government stations. Later on, various religious bodies and private agencies established hospitals, dispensaries and maternity centers in different parts of the country.

Formerly, the country was partitioned into four zones for purposes of health care delivery. The zones were North East, Northwest, Southeast and Southwest. Presently however, it is made up of 6 zones- the previous four, plus the North Central and the South-South. The National Health Policy and Strategy to achieve health for all Nigerians, which came into effect in October 1988, provided the establishment of a national health system that is wide in scope and has Primary Health Care as its central focus.

In Nigeria, the provision of health care is the joint responsibility of the three levels of government, and the private sector. However, the statutory responsibility of formulating national health policies, and the effective co-ordination, evaluation and monitoring of health policies throughout the federation is the exclusive preserve of the Federal Ministry of Health. The Federal Ministry of Health is also responsible for tertiary health care services and for training institutions "or other services of common usage among the states or of national concern or character" (National Health Policy, 1996: 52). The State Ministry of Health provides secondary health care (like general hospitals care services including outpatient care) and is responsible for the health care system and training institutions as required for the well being of the people of the state. The Local Government Health Department is responsible for providing Primary Health Care services, which include maternal and child welfare services, family planning, immunizations against infectious diseases. According to the statutory provision, "the Federal, state and local governments are supposed to work interdependently and in a co-ordinated manner, in order to provide Nigerians with effective health service at all levels"(Federal Ministry of Health, 1994/95: 9).

1.5.1 Disease(s) Pattern in Nigeria

"Most of the causes of death and serious illnesses which occur among Nigerians can be treated or prevented with simple remedies" (National Health Policy, 1996: 6). Communicable diseases, especially those that are associated with poor environmental sanitation, ignorance, superstition and lack of information, education and communication predominate and are often compounded by malnutrition. There is also an apparent increase in the prevalence of certain non-communicable diseases such as diabetes mellitus; hypertension, coronary artery diseases, malignancies and stress related illnesses. Similarly, there is increased recognition of the problem of genetic diseases such as sickle cell, Glucose-6-phosphate dehydrogenate deficiency. Sexually transmitted diseases and HIV/AIDS due to unprotected sexual activities and substance abuse constitute major public health problems.

The common causes of visits at clinics and outpatient departments of hospitals and the relative percentages of these causes are shown in the table below:

Table 1.2: visits to clinics and hospitals by disease category

Number	Cause	Percentage of cause
1	Infectious and parasitic diseases	38.2%
2	Nutritional and metabolic diseases	1.8%
3	Respiratory diseases	12.7%
4	Ill-defined conditions	9.2%
5	Skin diseases	8.4%
6	Digestive system	4.7%
7	Accidents	3.1%
8	Muscles and skeletal diseases	2.9%
9	Genito-urinary diseases	2.7%
10	Blood diseases- anemia, etc	2.5%
11	Diseases of nervous system and organ	9.9%
12	Others	3.9%

Source: Federal Ministry of Health (1994/95).

Furthermore, the causes of admission into hospitals, and the relative percentages are also shown below:

Table 1. 3: hospitals' admissions by disease category

Number	Cause of admission	Percentage of cause
1	Infectious and parasitic diseases	31.3%
2	Nutritional and metabolic diseases	2.8%
3	Pregnancy and child birth	23.1%
4	Respiratory diseases	9.8%
5	Genito-urinary diseases	5.8%
6	Accidents	5.3%
7	Digestive system diseases	5.0%
8	Diseases of nervous system	3.3%
9	Blood diseases	3.0%
10	Ill-defined conditions	3.2%
11	Skin diseases	2.4%
12	Others	5.0%

Source: Federal Ministry of Health (1994/95).

1.5.2 State of Health Services in Nigeria

It may not be an overstatement to opine that the state of health services as organised in Nigeria is not at its best. Categorically speaking, the coverage is inadequate, "with an estimated 54% of the population having access to modern health care services" by 1996 (National Health Policy, 1996: 4). In the present circumstances, the management of these services often shows major weaknesses (like the absence of staff at their duty posts, the unavailability of drugs and general lack of will among staff in public facilities) resulting in inefficiency. The financial resources allocated to the health services are inadequate to permit them to function well. The orientation seems to lean more on curative services as compared to preventive health services. It is necessary at this point to present a table of the situation in Anambra State, to corroborate the allegation of inadequate health services finances. The State forms part of the background for this research. The table shows how much of the State budget is allocated to the health sector and how much is finally released (spent) for this sector. The data spans a period of five (5) years, from 1996 to 2000.

Table 1.4: summary of Anambra State health budgetary allocation.

YEAR	♣TOTAL BUDGET ALLOCATION (NAIRA)	♦TOTAL ALLOCATION TO HEALTH SECTOR (NAIRA)	% ALLOCATION TO HEALTH SECTOR	AMOUNT RELEASED (NAIRA)	%OF ALLOCATION RELEASED
1996	453,782,608	31,000,000	6.8	7,036,559.00	22.7
1997	487,221,010	98,563,000	20	17,400,000.00	17
1998	530,434,780	122,000,000	20	9,399,995.00	7.3
1999	683,355,556	123,004,000	18	16,000,000.00	13
2000	1,508,000,000	377,000,000	25	94,250,000.00	25

Source: PRS, Ministry of Health Awka.

♣ *This is the total budget figure proposed for the state in a particular fiscal year*

♦ *This is the part of the total state budget that is proposed for the health sector.*

The difference between what is proposed and what is actually provided (released) for the health sector presents a very pathetic story of the state's concern for health.

From the table above, it is obvious that the state has never spent more than twenty-five percent of budgeted funds (from budgetary allocation) in the health sector. This impacts negatively on health care delivery in the State and thus creates enormous lapses in health programs .The highest actual expenditure was in the year 2000 and this may be thanks to the new democracy that was born in Nigeria in May 1999.

It is also necessary at this point to provide some socio-economic indicators of Nigeria; so as to give a clear picture of what obtains within the boundaries of the country and what challenges the hospital faces in the country.

Table 1.5: some socio-economic indicators

Indicator	Year	Value
GNP per capita	1997	**260 (US $)**
Life expectancy at birth	1997	Males = **52**; females = **55** (Years)
Infant mortality rate	1997	**74** (Per 1000):
Adult literacy rate:	1995	**43** (%)
Total fertility rate	1997	**5.8** (number)
Crude birth rate	1997	**41.3** (per 1000 pop.):
Crude death rate	1997	**13.3** (per 1000 pop.):
Rate of natural increase	1997	**2.8** (%):
Labour force, by sector	1996	(%)
Agriculture	"	**64**
Industry	"	**13**
Services	1996	**23**

(Source: African Development Report 1999).

Presented below is a table of the ratios of population to medical resources in Nigeria. This is compared with other categories.

Table 1.6: comparative summary of ratios of populations to medical resources

Country	Doctor	Nurse	Doctor/Nurse
Nigeria	6423:1	900:1	7:1:1
Sub-Sahara Africa	24600:1	2200:1	12:4:1
Developing countries	4800:1	1900:1	2:8:1
Industrial countries	500:1	100:1	4:2:1
World	4000:1	1600:1	3:1:1

(Source: Africa Technical Department, World Bank 1992; Denton and others, 1991. Nigeria data are for 1986. Other data refer to 1984.)

This research is conducted in South East Nigeria, specifically in what was known as Anambra state before 27th August 1991 (Anambra state was split into two separate states, Anambra and Enugu states, by the then military government). Of the six geo-political zones of the country, the South East parades the worst infrastructure and poor representation in Federal appointments (Tell, 2001) and this also means that hospital and other health facilities are not in their best states. This however has not stopped the people of this region from striving to provide for themselves-the hardest working and most resourceful Nigerians come from this part of the country. Separate profiles of these states are presented below;

1.6 Anambra State Profile

Anambra State came into being on August 27, 1991 following the last exercise for creation of states. It is one of the thirty-six states of Nigeria. It was created from the old Anambra State and derives its name from the Anambra River which itself is a tributary of the majestic River Niger. It shares boundary with Abia, Delta, Enugu, Imo and Kogi States.

Anambra State has a 1999 population of about 3,495,948. It has a population density of about 757 per sq. km. The 1999 total population of Anambra State for under 1 year is 60,049 representing 1.7%; under 5 years is 464,868 representing 13.3% and women within the reproductive age (i.e. 15 - 40) is 876,618 representing 25.1%. These are projected estimates. The sum of these three groups (1,401,535) represents about 40.1% of the population of the entire state and is the endangered species (Anambra State Ministry of Health Awka, 2001).

1.6.1 Anambra State Health status

The Health status of Anambra State is not encouraging. Its Infant mortality rate is still unacceptably high, standing at 145 per 1,000 for those under-5 years. Average birth rate stands at 95 per thousand (1,000). Average death rate is 65 per thousand (1,000). Childhood mortality rate is standing at 195 per thousand (1,000) for children between the ages of 1 and 4 years (source: PRS department, Ministry of Health Awka, 2001).

The above indicators show that the state is in dire need of a comprehensive overhaul of her health system. The state pursues a sound health policy, which is tailored around stated national objectives of health for all Nigerians, but the implementation lacks strength. Funding is one major constraint. Evidence of this is provided in table 1.3 above. We find that in the year 2000 for example, only 25% of the proposed funds were actually released for the health sector. This has been phenomenal in the State since 1996, with the least release witnessed in 1998. Another factor is the population growth rate (about 2.83%), which puts a lot of pressure on the scanty resources available.

Anambra State endorses the National Health Policy. The State has three administrative health zones. The State Ministry of Health (SMOH) has overall responsibilities for the policy and planning of health care delivery in the state. The SMOH operates within the limit of the National Health Policy and a Commissioner heads it. The SMOH is divided into eight departments and seven units. The State government facilities are managed directly by the Hospital Management Board (HMB) headed by the State Hospital Administrator. This officer reports to the Health Commissioner, who is the Chief Executive of the Ministry. The Chief Medical Officers heads the general/specialist hospitals and report to the Hospital Administrator.

Traditional medicine practice is significant in the State. Culturally, most sick people in the rural areas consult the native doctor before seeking Orthodox medical assistance. Utilization rate of traditional medical practitioners is quite high, probably owing to factors such as strong cultural beliefs, easy accessibility to native doctors, lower costs of native treatment and lack of information (and awareness) about opportunities (and effectiveness of such opportunities) for orthodox medical treatment. There exits a state traditional medicine board.

1.7 Enugu State Profile

As mentioned earlier Enugu State forms part of the background of this research. The state was created out of the old Anambra State on August 27th 1991. It was then delineated into three geo-political zones, which corresponded to three senatorial zones, namely, Abakaliki, Enugu and Nsukka. In August 1996, the Abakaliki zone was excised and joined with part of old Abia State to form what is now known as Ebonyi State. The present Enugu State is now made up of three senatorial zones- Enugu East, Enugu North and Enugu West. In all, the state has seventeen (17) Local Government Areas (LGA's). The state capital is Enugu (popularly known as the Coal City) and is centrally located.

At least 71% of the population of Enugu State dwell in the rural areas (this is not unusual since the state is largely a rural one). The state occupies a land area of 7,617,820 sq. kilometers and a population of 2,680,439 (Enugu State Ministry of Health Enugu). It is bound by six other states; Anambra state on the South West, Ebonyi State on the East, Abia and Imo States on the South and Benue and Kogi States on the North.

1.7.1 Enugu State Health status

The major causes of morbidity and mortality in the state are malaria, diarrhea, worm infestations. Some other diseases like filariasis, onchocerciasis, schistosomiasis, bacterial and other communicable diseases occur in significant proportions (Health Systems Fund.II, Enugu, 2001). The occurrence of these endemic diseases is preponderant among rural dwellers and the urban poor.

Life expectancy at birth is as low as 51 years. Infant Mortality Rate (IMR) stands at 90 per 1,000, while Maternal Mortality Rate (MMR) is 144 per 10,000. The table below presents the five (5) most common causes of morbidity in Enugu State in 1999;

Table 1.7: the most common causes of morbidity in Enugu State.

DISEASE	TOTAL
Malaria	32,702
Diarrhea	26,597
Cholera	10,124
Pneumonia	2,274
Small Pox	1,020

Source: PRS Dept., MOH Enugu.

Primary and secondary health facilities in the state are sparsely distributed and need to be increased in number and further strengthened. Enormous effort still needs to be made to educate the rural population, as well as the urban poor, to improve their use of hospitals and other health centers. This group of the population lacks the will to seek health care from orthodox health institutions rather than from quacks and herbalists. At present, the state has 792 health facilities, which include two hundred and seven (207) Primary Health Care centers, thirty-eight (38) secondary and three (3) tertiary Health Care institutions. The non-governmental, voluntary agency facilities are twelve (12) and there are fifty-two (52) private health facilities in the state. Enugu state judiciously endorses the National

Health Policy, especially as no separate health policy has been conceived for the state (there are moves however, to adopt a state-specific health policy in the near future). The Federal Government of Nigeria in the National Health Policy document encourages every state to adopt state-specific health policies, based on state-specific health needs.

Having presented the background and objectives of this research, the next chapter attempts a review of literature on efficiency evaluations, in a bid to see what other researchers have done. Such a review is necessary to provide relevant clues on how to do hospital efficiency analyses as set out in the objectives of this research.

CHAPTER TWO

LITERATURE REVIEW

Having provided the background on which this research is based, this chapter looks at the theory and empirical works of other researchers in efficiency evaluations. The review of literature is divided into three components, namely, hospital output, efficiency measurement (evaluation) and functional form of production and cost functions. These are the three main areas of controversy and focus for this type of research on hospital efficiency evaluation(s). First, the problem of measuring hospital (and other health) outcomes is addressed. Secondly, a review of the various methods that have been used to evaluate efficiency both in hospitals and outside the hospital sector is sought. Finally, the different functional forms that have been adopted by different researchers are reviewed.

2.1 Hospital Output

A basic controversy that has lingered around estimating hospital production and cost functions is that of conceptualising and measuring output. Hospital output has been variously defined, with each researcher choosing the definition that best suits his purpose (McGuire, 1987).

The decision as to what to include in measures of hospital output is not an easy one because of the difficulty associated with trying to measure such output. Hospital output can be broadly categorized into inpatient treatment, outpatient treatment and (in some hospitals) teaching (education) and research. Various units of measurement have been adopted for these output types; each with its inherent limitations, but all aiming to quantify treatment. The following attempts at measuring output exist.

1. The effectiveness of treatment of an episode of illness
2. The severity of an episode of hospitalization or treated cases
3. Patient days

These are as used by Evans (1971); Montfort (1981); Feldstein (1987); Vita (1990); Shiell et al (1993) and Wouters (1993).

Although the above measuring units have been used, the problem of homogeneity in hospital output remains. The problem of classifying hospital output arises because of the multi-product nature of inpatient treatment provided by a hospital. Therefore in a bid to homogenize hospital output, the following case-mix classification schemes have been sought by most reserachers:

1. **The International Classification of Diseases** (ICD), which is published by the W.H.O and which provides a mutually exclusive and exhaustive set of possible output categories for a hospital (U.S Department of Health, 1994). This classification however makes it difficult to estimate a hospital production function because of its inherent large number of output categories.

2. **Diagnosis- related group,** which is a construction, based on the definition of case-types, each of which could be expected to receive similar services from a hospital. The DRG patient classification system was first developed by Fetter as an instrument to group inpatients according to the diagnosis and resource use in order to facilitate utilization review activities (Fetter, 1991; quoted in Dismuke and Sena, 1997). It is noted however that this classification does not take into account, the number of diagnosis, procedures that each patient undergoes in his ailment. Because of this, the DRG lacks homogeneity and herein lies its setback as a hospital output classification tool.

McGuire (1987) maintains that measurement errors and output heterogeneity complicate the identification of inefficiency in the hospital sector. For this reason, he looks at the problem of measuring hospital output as a basis for estimating efficiency in the hospital sector. He (McGuire, 1987; 10) confirms "the extreme difficulty in defining and measuring hospital output", which is translated to the definition and estimation of the production procedures. Thus, such definitional problems entail that different researchers define output differently. For example, Feldstein (1967; 145) states that "output may legitimately and usefully be defined in any of four ways: by an index of the number of services provided, by the number of cases treated, by the number of successful treatments, or by various measures of the community's health".

Evans (1971; 198) recognizes the problem of defining the output of a hospital as a "notoriously difficult one, combining difficulties of aggregating dissimilar and ill-defined products, incorporation of both rendered service and readiness-to-serve capability and the thorny question of distinguishing between activities generating output and those generating waste motion". He suggests the choice of "treated cases" as a measure of output. Another problem faced is that for purposes of statistical investigation or for research into cost-output relationships like this one, the data may not be available. The data is usually not available in sub-Sahara Africa. Evans (1971) therefore focuses on inpatient care components of output, for a group of acute care hospitals in Ontario. He uses as output measures the number of days of care supplied by each institution and the number of separations (treated cases discharged or died).

Lave, Lave and Silverman (1978) utilize the ICD diagnosis classification in homogenizing output in their study, but encounter difficulty in interpreting their results. In attempting a description of the production structure of the hospital sector in the Netherlands, Van Montfort (1981) defines output in terms of weighted admissions, weighted patient days and intermediate production. In weighting admissions and patient days, patient care and hospital training programs are brought together. It is hoped that by so doing, heterogeneity in admissions and in patient days, the presence of outpatient clinics and the training programme are explicitly taken into account in measuring output. Furthermore, intermediate production is defined as "the sum of all patient days and treatments, such as operations, laboratory tests, outpatient visits, etc (Montfort, 1981).

Wouters (1993) considers inpatient admissions and outpatient visits to estimate a bi-product production function in a study of the cost and efficiency of public and private health care facilities in Ogun State, Nigeria. She finds the two output categories, considered in her study, to be inversely related. Hence, if one believes the traditional shape of the production possibility curve, and given limited resources, an increase in the production of one output (say inpatient admissions) will lead to a reduction in the production of the other output (in this case, outpatient visits).

In a related study of the performance of Belgian hospitals, Bosmans and Fecher (1995; 392), output is "classified inside a homogeneous group of pathologies called Diagnosis Related Group (DRG)". In their study, there are 133 of such DRG's, which have been clustered, in 23 medical specializations. However, because of the large number of these medical specializations, the following six specializations are selected; "ears, nose and throat", "respiratory system", " circulatory system", " digestive system", " muscular and skeletal system", and "gynecology". This is further proof of the difficulty associated with the conceptualization of hospital output.

Inpatient days and outpatient visits form the output variables used in estimating cost functions for hospitals in Kenya (Anderson, 1980; reported in Wagstaff and Barnum, 1992). In the same report, Dor (1987) is quoted as considering the number of admissions in estimating hospital cost functions in Peru. In empirically validating theory, Wagstaff (1989) captures output variations by six case-mix categories, namely, internal medicine, general surgery, gynecology, pediatrics, intensive care and other. He however acknowledges the limitations of his classification of case-mix as not being as satisfactory as other approaches, but of having the "attraction of not requiring a detailed breakdown of discharges by diagnostic category" (op cit.; 666).

Yong and Harris (1999) contend with the fact that the units commonly used to measure inpatient output are the numbers of cases treated and bed days. They go ahead to adopt Weighted Inlier Equivalent Separation (WIES), a case-mix adjusted measure of activity, as a measure of inpatient output in estimating efficiency models of hospitals in Victoria.

A considerable amount of time has been spent to review literature on the conceptualisation of hospital output. This is largely because of the controversy that is characteristic of measurements associated with hospital output. Both the number of inpatient days and the number of outpatient visits will be used simultaneously as output measures in this research. This is in a bid to minimize the problems that go with trying to classify output, for as we have seen; all such attempts have not been completely successful. Such output classification is also avoided because, in a country like Nigeria, such classifications are non-existent.

The use of such output measures (as inpatient days and outpatient cases) is common in research involving hospital output (Feldstein, 1967; Anderson, 1980; Montfort, 1981; Dor, 1987; Wouters, 1993 and Cookson, 1998). It is interesting to note that the incidence of death is also part of hospital output, since resources would have been expended on patients before they died. Consequently, this research also adopts the number of cases (treated or died) both in Anambra and Enugu State hospitals.

2.2 The Concept of Efficiency

Economists have defined efficiency in various ways. The Dictionary of Modern Economics (1984) defines allocative efficiency as "the production of the "best" or optimal combination of outputs by means of the most efficient combination of inputs". In another light, the Economist's Dictionary of Economics (1998) defines economic efficiency as "the state of an economy in which no one can be made better off without someone being made worse off". It further states that for there to be economic efficiency, three types of efficiency must hold. These are productive efficiency, allocative efficiency and distributional efficiency. Various researchers have defined and measured the term efficiency in different ways to suit their empirical evaluations. The following types of efficiency have been defined in the following way(s);

Allocative Efficiency: when resources are being allocated to the production of the goods and services the society most values (Bannock et al). It is also defined as the "ability of a firm to use inputs in optimal proportions, given their respective prices" (Ajibefun and Daramola, 1999: 13). Allocative efficiency "measures the firm's success in choosing an optimal set of inputs with a given set of market prices for inputs" (Sengupta, 1998: 13)
Technical Efficiency: the maximum possible outputs that can be produced from a given set of inputs by a firm (Ajibefun and Daramola, 1999). Also referred to as production efficiency, it is associated with the production frontier and "measures the firm's success

in producing maximum possible output from a given set of inputs" (Sengupta, 1998: 12). The term (productive efficiency) is also used when the output of an economy is being produced at the lowest cost (Bannock et al, 1998)

Distributional Efficiency: when output is distributed in such a way that customers would not wish, given their disposable income and market prices, to spend these incomes in any different way.

Humplick (1996) rather refers to infrastructure performance when he proposes three aspects of performance. These three aspects of infrastructure performance are, the service quality, the managerial or operational efficiency and the sectoral level where investments in infrastructure are important. Researchers have adopted other means of measuring efficiency, either in hospitals, firms or in other public or private institutions. For example, Griffiths (1978) uses both quantitative and qualitative methods to evaluate hospitals performance. The proposed summary measures of hospital performance are grouped in terms of service population, quantities of service, cost of services and quality of services (op cit). In the same light, the following measures are developed; relevance index, discharge rates, patient day rates, adjusted length of stay, inpatient cost per person per year, outpatient cost per person per year, hospital mortality morbidity and surgical procedure rate.

Various researchers have used other techniques of efficiency evaluation. These are Ratio Analysis (Pabon Laso, 1986, quoted in Barnum and Kutzin, 1993), Data Envelopment Analysis (Hayes, 1993; Dalmau-Matarrodona and Puig-Junoy, 1997; Chirikos and Sear, 2000) and Stochastic Frontier approach (Battese and Coelli, 1993; Bosmans and Fecher, 1995; Ajibefun and Daramola, 1999; Yong and Harris, 1999).

<u>**Ratio Analysis**</u>

Ratio analysis involves a piecemeal examination of different ratios like average cost per inpatient day or bed occupancy rates. Pabon Lasso (1986, quoted in Barnum and Kutzin, 1993) uses three interrelated hospital service indicators- bed occupancy rate, average length of stay and bed turnover rate- for assessing hospital performance based on the simultaneous analysis of these statistics. He devises a graphical technique to summarise the three-inpatient service indicators for similar levels of hospitals within a country in order to assess their relative performance. He plots bed turnover rate on the y-axis, and the bed occupancy rate on the x-axis. Because of the mathematical relationship among the three hospital performance indicators, a ray drawn from the origin that passes through any point on the graph represents a constant average length of stay. This measure increases monotonically from left to right across the top and down the right hand side of the graph. The graph is divided into four regions by two intersecting lines drawn from the mean values of the bed occupancy and turnover rates (which in turn identify the mean value of the average length of stay). Region 1 shows hospitals with low occupancy rates and low turnover rates. Region 2 has low occupancy and high turnover rates. Region 3 has high occupancy and high turnover rates, while region 4 has high occupancy rates and low turnover rates. This division of the graph into four regions (or quadrants) is used to identify hospitals that are outliers and demand specific attention.

This method sounds very appealing; however it must be noted that they do not provide a decisive measure of hospital efficiency. This is because, in drawing the quadrants, some hospitals, like psychiatric hospitals, may be classified as inefficient due to evidence of long length of stay. This may not be the case especially for the fact that patients in psychiatric hospitals are required to stay long enough, both for treatment and for rehabilitation. This research however adopts a non-graphical method in analyzing efficiency, and possibly avoid the problem encountered in Pabon Lasso's (op cit.) graphical method.

Data Envelopment Analysis

Data Envelopment Analysis (DEA) is a linear programming based technique for measuring the relative performance of an organisation/institution, where multiple inputs and outputs make comparisons difficult.

A comparison is made of the relative efficiency of hospital-based and other freestanding Home Health Agencies (HHAs) as a means of seeking evidence of production economies in hospitals-based HHAs (Hayes, 1993). Data Envelopment Analysis (DEA) is used to analyse Medicare cost report data from HHAs in Texas. In general, no statistically significant differences are found in relative efficiency of hospital-based and freestanding HHAs. This result is not surprising because the same production technology is assumed for both the hospital-based and freestanding HHAs. The freestanding HHAs would be more profit oriented than the hospital-based HHA and will therefore employ resources more efficiently to attain this objective.

Dalmau-Matarrodona and Puig-Junoy (1997) examine the potential effect of market structure on hospital technical efficiency as a measure of performance controlled by ownership and regulation. In their research, they obtain technical and scale efficiency scores for each hospital using Data Envelopment Analysis. According to the data, nearly two-thirds of the hospitals, in the region of Catalonia, operate under the production frontier, with an average score of 0.841. Finally, the determinants of the efficiency scores are investigated using a censored regression model. The results suggest that the number of competitors in the market contributes positively to technical efficiency, and there is some evidence that the differences in efficiency scores are attributed to several environmental factors such as ownership, market structure and regulation effects. It is still not clear why the censored regression model is used to estimate efficiency effects, since efficiency levels are observed for all the observations considered in the study.

Chirikos and Sear (2000) compare the results of scoring hospital efficiency using two new types of frontier models. They employ both the Data Envelopment Analysis (DEA) and the Stochastic Frontier Regression (SFR) to study efficiency in Florida acute care hospitals in continuous operation over the period 1982 to 1993, using panel data. They find that DEA and SFR models yield convergent evidence about hospital efficiency at the industry level but divergent portions of the individual characteristics of the least efficient facilities. They therefore conclude that hospital policymakers should not be indifferent to the choice of the frontier model used to score efficiency relationships. The same results cannot be expected from two different estimation techniques, even if both techniques are applied to the same observations. The best that can be expected is that the two methods will provide evidence about the existence of efficiency/inefficiency, but will not estimate the same coefficients. This is especially so because, while the DEA is a linear programming tool, the Stochastic Frontier is a statistical tool.

The Stochastic Frontier Approach

The stochastic Frontier approach offers a statistical parametric method of evaluating efficiency of a production unit relative to a cost frontier obtained from a collection of similar units. Bosmans and Fecher (1995) employ the stochastic frontier approach to evaluate the performance of Belgian hospitals. To measure hospitals' efficiency, they estimate a resource function, which is defined as the relationship between medical fees incurred in the treatment of a patient and the patient's pathology. They find that some specializations, like circulatory system, involve more overproduction than others, and that the public hospitals are more efficient than the private ones. In the same light, they find that university hospitals use more resources than their regular counterparts.

The stochastic frontier approach is also adopted in evaluating efficiency of hospitals in Victoria under case-mix funding (Yong and Harris, 1999). The efficiency estimation involves a cost function in which inpatient output is found to explain the majority of inter-hospital variations in total cost. The study further goes to identify the determinants of such cost variations between hospitals as being related to administrative, medical support and hotel labour inputs. In a similar study, Miika (1999) quantifies the differences in hospital productivity and efficiency in Finland using various modeling techniques and goes ahead to find explanations for the observed differences. In addition, analysis and discussion of differences in methods used, in the measurement of hospital productivity and efficiency is done.

2.3 Hospital Production and Cost Functions

Any attempts at modelling cost functions for any production unit must necessarily begin with the underlying production function for that unit. There is no doubt that the concept of production and the production function is basically an economic one. Therefore, any attempt at reviewing literature on hospital production functions must necessarily consider what economic theory says about the production process and the production function. While the production process is about combining various proportions of factors to produce some given level of output, the production function is a purely technical relation that connects factor inputs and outputs. It describes the transformation of factor inputs into output at any given time period, and represents the technology of a firm in an industry or of the economy as a whole (Kuotsoyiannis, 1977). Thus, the production function in the traditional economic theory assumes the form

$$\mathbf{X = f(L, K, \nu, \gamma)}$$

Where **X** = output

L = labour input

K = capital input

ν = returns to scale which refers to the long run analysis of the laws of production, since it assumes change in the plant

γ = the efficiency parameter, which refers to the entrepreneurial-organisational aspects of production.

(Kuotsoyiannis, 1977)

According to Lipsey and Chrystal (1995; 192), the production function "describes the technological relation between what is fed into the productive apparatus by way of materials and the inputs of factor services and what is turned out by way of product". In this light, the production function is written as

$$\mathbf{q = q(f1, \ldots\ldots, fm)}$$

Where **q** = quantity of output of some good or service

And **f1.... fm** = the quantities of m different inputs used in the production of q.

It is interesting to note that the production process is a flow, and represents so many units per period of time. In this regard, we often refer to short run and long run periods in production. The short run is defined as the period of time over which the inputs of some factors cannot be varied (or changed). Such factors are often referred to as fixed factors. Thus, in the short run, production can only change by varying variable inputs (as opposed to the fixed inputs). Fixed factors are usually elements of capital such as plant and equipment, but " it might be land, or the services of management, or even the supply of skilled labour" Lipsey and Chrystal, 1995; 192). On the other hand, the long run is defined as the period long enough for the inputs of all factors of production to be varied, while in the very long run, the technology open to the firm can also vary.

In estimating production and cost functions, different technologies are assumed. Among these are the Constant Elasticity of Substitution (CES) technology, the Cobb-Douglas technology and the Leontiff technology. The Cobb-Douglas production function is of the form

$\mathbf{X = b^0 . L^{b1} . K^{b2}}$ (Varian, 1992)

Where **X** = output

L and **K** = inputs of labour and capital respectively

$\mathbf{b^0}$, $\mathbf{b^1}$ and $\mathbf{b^2}$ are parameter estimates.

The Leontiff technology is of the form

$f\mathbf{(x1, x2) = min\ (ax1, bx2)}$ (Varian, 1992)

The translog function can be stated as follows

$\ln X = b0 + \ln L\ b1 + \ln K\ b2$ (Evans, 1971; Montfort, 1981; Feldstein, 1987; Vita, 1990; Shiell et al, 1993;Wouters, 1993)

Where **X** = output
L and **K** = inputs of labour and capital respectively
b0, and **b1** are parameter estimates

Costs are derived functions and they are derived from the technological relationships implied by the production function (Kuotsoyiannis, 1979). It therefore follows that in studying hospital cost relationships, the inherent production technology is a vital prerequisite and involves maximizing output subject to cost constraints. The cost function is therefore expressed as a function of output, the prices of factors (such as labour and capital) and the production function coefficients (which measure returns to scale) (op cit.).

A distinction is made between the stochastic frontier and the non-stochastic (or deterministic) frontier processes. The difference between the two lies in the presence of the error term (in the stochastic frontier model) or its absence (in the deterministic frontier model) in production/cost models. The stochastic frontier cost model is an efficiency model, which runs a maximum likelihood estimation of output and resource inputs on the observed costs, to define cost relationships. It then divides the error term into two parts; one part capturing unexplained variations or statistical noise, and the other part measuring cost inefficiency. The stochastic frontier model can be expressed in the following form;

$$Y_i = X_i\beta + (V_i + U_i);\ i = 1, \ldots\ldots, n$$

Where
Y_i = the costs (or the logarithm of the costs) of the i-th hospital

X_i = a kx1 vector of (transformations of the) output and input quantities of the i^{th} firm

β = a vector of unknown parameters

V_i = random variables which are assumed to be iid. N (0, δv^2) and independent of the

U_i = which are non-negative random variables which are assumed to account for cost (allocative) inefficiency and are often assumed to be N (0, δv^2).

Cost efficiency of an individual firm is defined in terms of the ratio of the observed costs to the corresponding minimum frontier costs, given the available technology, that is,

$$\mathbf{EFF_i = E\ (Y_{*i} / U_i, X_i) / E\ (Y^*_i / U_i = 0, X_i)}$$

Where Y_{*i} = cost of the ith hospital, which will be equal to Y_i when the dependent variable is in original units and will be **exp** (Y_i) when the dependent variable is in logs. X_i, also in logs, represents the independent variable (s) used in estimating the stochastic frontier model. Thus the cost efficiency (allocative efficiency) value ($\mathbf{EFF_i}$) will take a value between one and infinity (Coelli, 1996). This process describes how efficiency in South East Nigeria hospitals will be evaluated in this research.

The remainder of this section reviews literature on functional forms of input variables and on general findings from modeling hospital production and cost. Different authors and researchers have used different functional forms in their investigations. The issue of functional form is reviewed specially in an effort to identify appropriate forms for this research.

The modern literature on efficiency measurement begins with Farrel (1957). Since then, several other attempts have been made at such efficiency measurements. These have been done using stochastic frontier analysis. Aigner, Lovell and Schmidt in 1977, and Meeusen and Van den Broeck (1977) first independently proposed the stochastic production function also in 1977(Battese and Coelli, 1993). Writing from the University of British Columbia, Evans (1971) estimates cost functions for hospitals in Ontario, using as output measures, the number of days of care supplied by each institution and the number of treated cases discharged or died. Direct costs of all non-inpatient activities such as education, research and outpatient care are subtracted from each hospital's total expenditure to derive costs of inpatient activity. Depreciation, interest and other capital costs are removed because "these components of costs vary across hospitals in an unsystematic way and are clearly unrelated to capital services used (Evans, 1971; 199). The present research considers total operating costs of hospitals. This includes costs of inpatient and outpatient services and for capital expenses as well. The research is about evaluating efficiency of resource use and therefore this makes it sacrosanct to include every input costs incurred.

Evans (1971) uses two types (definitions) of independent variables, namely average cost per day and average cost per case, concentrating on inpatient output. The independent variables used include those representing hospital size, total rated beds, short run scale effects (measured by using average occupancy rate, average length of stay and case-flow rates), levels of activity, patient diagnostic and age-sex mix.

In estimating production functions for general hospitals in the Netherlands, Montfort (1981) uses three different functional forms. He estimates the Cobb-Douglas, the Constant Elasticity of Substitution, and the more general Translog specifications, and compares the three of them. Data on 110 general acute hospitals are used. The inputs are represented as the number of beds, the number of specialists, the facility index, which is a scale index of the composition of infrastructure of the hospital, drugs, and the number of staff, subdivided into nurses and paramedical staff. The results are interpreted in terms of elasticities. In all, it is found that the more general Translog specification fits the data better than the others. Montfort (op cit.) employs a trial and error method to select a functional form that best approximates the data available. While recognising the fact that no single functional form may define hospital production function (Feldstein, 1967), a translog model will be estimated for this research.

Feldstein (1967, quoted in McGuire, 1987; 26) also experiments with a number of functional forms and concludes that "too little is known about the behavioral characteristics of hospital production for us to be certain that any particular stochastic specification is the correct one". Thus, noting that institutional, professional and social factors determine input substitution in hospitals, the estimation of hospital behavioral production functions could aid the analysis. Given the period in which these conclusions were reached (in the late 1960's), the enormity of this conclusion can be overlooked, since some statistical methods can be used in determining functional relationships between observations, without necessarily experimenting.

Wagstaff (1989) reports the results of an empirical comparison of three statistical cost frontier models using data from 49 Spanish public hospitals. The models estimated are the deterministic cost frontier, a cross-section stochastic cost frontier (SCF) in which inefficiency is assumed to follow a half normal distribution, and a panel data SCF in which inefficiency is assumed to remain constant over time. A non-frontier model is also estimated. The paper compares the estimates of average inefficiency obtained from the frontier models and their implied rankings of hospitals in terms of their "costliness" (actual cost as a proportion of "expected" cost). Ultimately, the paper seeks to throw light on the question of which measurement technique should be used to assess hospital efficiency. It is concluded that the frontier models represent an improvement over Feldstein's non-frontier approach and that the stochastic frontier model is to be preferred to the deterministic frontier model.

Wagstaff's (1989) comparison of three statistical models, using different sample types (and hence, different sample sizes) is questionable. The fact that the models are estimated under different sample conditions means that there is hardly any basis for comparison. The basic objective of this research is to measure hospital efficiency and not to compare statistical methods. In this guise, the stochastic frontier method is used as the only statistical evaluation model in this thesis.

Vita (1990) estimates a multi-product variable cost function using data on a sample of short-term general care California hospitals. He evaluates "the behavior of hospital costs using an eclectic approach that, while combining elements of both techniques, retains a distinct production theoretic flavor" (Vita, 1990; 2). The results obtained provide some useful insights into the advantages and disadvantages of the multi-product translog function for the analysis of hospital costs. For example, the translog function appears to provide reasonable estimates of the marginal costs of most of the outputs when evaluated at or near the sample means of the explanatory variables. The estimated function does not generate plausible cost estimates however when evaluated at points that are not in the neighborhood of the sample means and "infact exhibits a property that is not consistent with neoclassical production theory (namely, negative marginal costs over certain ranges of output)" (Vita, 1990; 3).

The following variable cost function is specified by Vita;

$\mathbf{C_v = C_v (Y, w, BEDS)}$,

Where $\mathbf{C_v}$ = total variable costs, **Y** = a vector of outputs, **w** = a vector of input prices and **BEDS** = is the number of beds, assumed to be fixed in the short run.

Also included in the cost function are variables measuring multi-hospital system affiliation, case-mix and profit/ not for profit status. The generalized translog multi-product cost function specification is chosen to estimate the variable relationships specified in the model. A question however arises as to why only variable costs are considered. Fixed costs also form part of the total hospital outlay in every case, no matter how little.

The maximum likelihood estimates obtained in Vita (1990) show that all first order output parameters are positive. Four of the five t-statistics are greater than 2, which make them statistically significant. The input price parameters all turn out positive and have coefficients " equal to the cost elasticity at the means of the corresponding variable" (Vita, 1990; 9). That is each coefficient is equal to the average cost share for the corresponding factor input. The own price elasticities of the factor demands are all negative. Dividing the estimated parameters by the cost share of the inputs employed derives the own-price elasticities. The paper's results do not provide strong evidence of either ray economies of scale or of weak cost complementarities. There is some evidence however, that the degree of scale economies may be underestimated.

Shiell et al (1993) consider whether or not community residential facilities have delivered the expected quality of health care services at the appropriate cost. Their paper presents the results of a cost function analysis of a random stratified sample of staffed community facilities in England, excluding London. The model of residential facility costs tested suggests that average cost of each facility is a function of its capacity and its rate of utilization, the mix of services provided, the physical characteristics of the facility, the quality of services provided and the characteristics of the residents. The costs of factor inputs are dropped because "there are no readily available indexes of regional costs for the UK" (Shiell et al, 1993; 248). The writers also opine that there is a priori evidence to suggest that factor prices do not differ by very much across the country once one excludes London. Little or no evidence is provided in black and white though, to buttress this assertion.

The researchers (Shiell et al, 1993) also make use of dummy variables. Six interactive variables are used and these refer to interaction between the agency variables and quality. The agency variables represent physical characteristics of the facilities studied. In selecting functional form, two models each of four versions are tested. These are linear, semi-log, log-linear and double log. The two models are the ***full model*** and the ***short model***. The full model contains four categories of variables, namely, capacity and utilization, physical characteristics of facility, quality of service and characteristics of residents. The short model is the model with interaction terms.

Both costs and quality of care are found to vary greatly amongst community residential facilities. The most important factors explaining differences in costs are case-mix factors relating to client age, dependency and length of stay. For example, the "age" variable, with coefficient of –2.165 is significant at the 99 percent level, while the average length of stay variable, with coefficient –0.038 is significant at 95 percent. The dependency variable has a coefficient of –0.662 and is statistically significant at the 90 percent level of significance. Facility characteristics such as the type of building, the internal layout and structural quality are not significant at either the 90%, 95% or 99% levels. Quality of service measures, such as the extent to which care regimes were client-oriented and made use of community services, are positively and significantly associated with costs. This research goes beyond mere cost function analysis, to attempt an evaluation of economic efficiency and resource use. This it does by estimating a cost function from the underlying hospital production technology in Anambra and Enugu states. It then employs the stochastic frontier technique to obtain numerical efficiency measures, in a bid to shed more light on what was done by Shiell et al (1993).

Cookson (1998) analyses the non-Medicare diagnosis-specific hospital inpatient length of stay experience in the state of Florida from the 1992 Hospital Discharge Patient Data. He evaluates the performance of all Florida HMOs combined and statistically measures their efficiency relative to private non-HMO payers combined, and to the well managed, efficient experience as reported in Milliman and Robertson, Inc.'s Health care Management Guidelines (HMG). The results of the study indicate that on the surface the average length of stay of Florida HMOs is 9% less than the length of stay for other private payers (4.69 and 5.15 days).

The comparison indicates that there is considerable room for many HMOs, hospitals and managed care entities in Florida to significantly improve the efficiency of their inpatient utilization management. This analysis, among others, allows the development of a ranking system for each hospital's efficiency by diagnosis category, after adjusting the data for severity. The study comes up with the LOS Efficiency Index, and this represents a proprietary database in Milliman and Robertson, Inc. The overall study results show that the Florida HMO LOS Efficiency Index is 1.46, which means that the average LOS is 46% longer than the adjusted, well managed model in the HMG's. The LOS Efficiency Index represents the ratio of the hospital relative LOS for each DRG to the corresponding case-mix adjusted well-managed LOS in the HMGs.

CHAPTER THREE

CONCEPTUAL FRAMEWORK AND METHODOLOGY

3.1 Conceptual framework

3.1.1 Introduction

Ajibefun and Daramola (1999: 11) define allocative efficiency as "the ability of a producer to use minimum cost to produce an output, given the available technology". It reflects the ability of a firm to use inputs in optimal proportions, given respective prices. This microeconomic cost concept is applied in the hospital sector because, like firms, hospitals employ the services of the factors of production (namely land, labor, capital and entrepreneur) to produce varying ranges of output (which may be in the form of inpatient care, outpatient care, research or public education). The employment of these resources (or factors of production) costs money. Different hospitals spend different amounts of money on the factors of production and also produce varying types (as well as quantities) of output. When one takes a sample of hospitals that produce similar output and that hire similar factor services like the case of government hospitals, it becomes necessary to look at the costs of specific hospitals in relation to other similar government hospitals. In so doing, one can build (or form) an industry (or a collection) of government hospitals that have similar characteristics. From this industry of hospitals, it is possible to form an aggregate (or average) industry cost frontier or boundary. This frontier represents the minimum cost obtainable for the industry. The costs for the individual hospitals that make up this industry can thus be adjudged relative to this industry cost frontier. It follows therefore that the deviations of any one hospital cost observation from the industry cost frontier can therefore be assumed to be due to allocative efficiency/inefficiency.

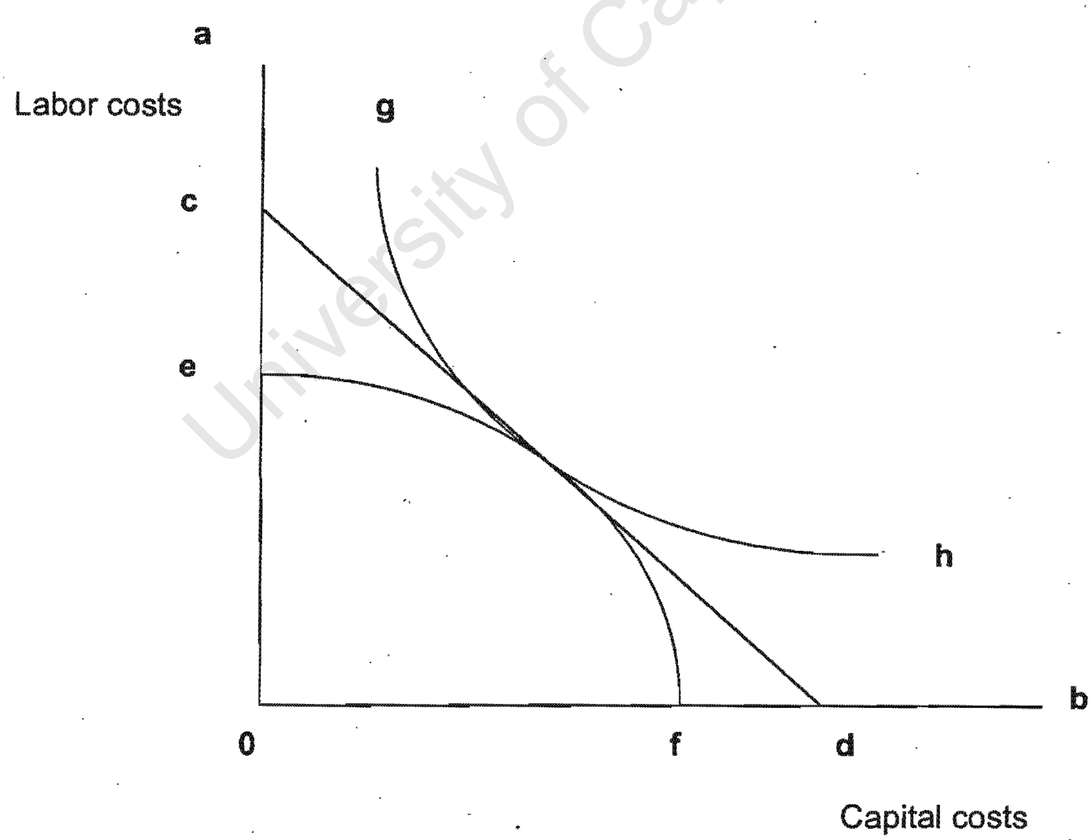
Efficiency of an individual firm is defined in terms of the ratio of the observed costs to the corresponding minimum frontier costs, given the available technology, that is,

$$\mathbf{EFFi = E\ (Y^*i/Ui,\ Xi)\ /\ E\ (Y^*i/Ui = 0,\ Xi)}$$

Where **Y*i** = cost of the i[th] hospital, which will be equal to **Yi** when the dependent variable is in original units and will be **exp (Yi)** when the dependent variable is in logs, **Xi** represents the independent variable(s) in the model. **E** is used to represent the expected value of the observed costs of any particular hospital, relative to the minimum cost frontier for all hospitals considered in the estimation (Coelli T. 1996).

The allocative efficiency value (EFFi) will take a value between one and infinity. In this research, cost of the i[th] hospital will be equal to **exp (Yi),** since the dependent variable and all other independent variables will be in logs. This is in order to examine the marginal effects of the independent variables used. The diagram below (figure 3.6) attempts a graphical representation by which hospitals will be judged as either being efficient or inefficient.

Figure 3.1: Hospital cost frontier diagram



The diagram above is used to represent the hospital industry production and cost relationships. Capital input costs are shown on the x-axis while labor input costs are represented on the vertical or y-axis. The combination of inputs used in producing hospital output is represented by the isoquant **gh** while the isocost line **cd** represents the least cost (or reasonable cost) within which inputs can be combined in production. Therefore, the minimum cost frontier is represented within the boundaries and is denoted by the curve **ef.** This curve defines the industry average cost of production (in this case, the hospital average cost of production).

The stochastic frontier process helps us to build this frontier and rank hospital costs accordingly. In the cost function estimated in this research, the U_i defines how far the hospital operates above the industry cost frontier. Since technical efficiency is assumed, the U_i is closely related to allocative inefficiency. Those costs that fall within the frontier are considered as efficient while those that fall outside the frontier are designated as inefficient. For this research work, the researcher will expect at least 60 percent of the hospitals studied (or 24 out of 40 hospitals) to operate at costs within the frontier, as a basis for branding them as efficient. This is the basis on which efficiency is evaluated in this study and has been chosen arbitrarily. A description of how the cost frontier is developed is presented in the appendix.

3.1.2 Model Specification

The following models are specified for the attainment of the objectives of this research. The models represent different versions of cost functions. Varian (1992; 53), defines the cost function as the "minimal cost at the factor prices *w* and output level y; that is, c (**w**, y) = **wx** (**w**, y)" According to Lave and Lave (1972), most empirical studies of the short run cost function for hospitals have found an L-shaped relation. Lave and Lave (1972; 381) also argue that "a functional form consistent with the L-shaped short run average cost is the generalized Cobb-Douglas or linear in logarithms form". A basic assumption for the models in this research work is that the hospital variables assume linear relationships. That is, the dependent variable is linearly related to the independent variables considered. Therefore, the first model assumes this form.

Model 1

This model specification represents the basic tenets of cost functions, with an addition of the hospital size and utilization variables. The independent variables found in this specification have also been used by T.W Grannemann et al (1986), Vita (1990) and Yong and Harris (1999).

$$\mathbf{C_p = C_p(Y, w, k, occ, BEDS, \mathit{S}, \mathit{h})},$$

Where

C_p = cost per patient-day equivalent. This variable is a measure of inpatient and outpatient costs.

Y = a vector of outputs: the outputs considered are inpatient days and outpatient visits.

w = a vector of labour input costs: this comprises a sum of the salaries paid to the various staff employed in hospitals.

k = a vector of capital input costs: includes such costs as drugs, electricity, water, bed linen.

occ = occupancy rate (a measure of hospital utilization rate) and

BEDS = is the number of beds (a measure of hospital size)

S = is a vector of dummy variables to determine state status (whether Anambra or Enugu state). This is also a dummy to represent the effect of location on hospital cost.

h = is a vector of dummy variables to determine hospital status (whether general or cottage hospital)

Model 2

This model differs from model 1 because it follows a frontier estimation process. The model is formulated following the Battese and Coellli (1995) specification.

$Y_i = X_i\beta + (V_i + U_i); i = 1, ..., n$

Where

Y_i = the logarithm of the unit costs of the i-th hospital. The model is estimated with cost per patient-day equivalent as the dependent variable.

X_i = a kx1 vector of (transformations of the) output and input prices of the i^{th} hospital: the outputs considered are inpatient days and outpatient visits. The labour input price comprises a sum of the salaries paid to the various staff employed in hospitals. The capital input prices: includes such costs as drugs, electricity, water, and bed linen.

β = a vector of unknown parameters

V_i = random variables which are assumed to be iid. N (0, δv^2) and independent of the

U_i = which are non-negative random variables which are assumed to account for allocative inefficiency and are often assumed to be independently distributed as truncations at zero of the N (m, δv^2) distribution; where:

$U_{it} = z_{it}\,\delta,$

Where z_{it} is a px1 vector of variables, which may influence the efficiency of a hospital. In this model, two dummy variables are used to investigate economic efficiency effects. These are the location dummy and the hospital status dummy. The location dummy variable is used to represent hospital location (whether Anambra or Enugu state). This is also a dummy to represent the effect of location on hospital cost. The status dummy variable to shows hospital status (whether general or cottage hospital). The efficiency term obtained from the model (after estimation) will take a value between one and infinity in the cost function. This model is known as the efficiency effects model and was proposed by Battesse and Coelli (1995).

For all the models, we would expect positive relationships between total cost and input. As Varian (1992; 76) puts it, "the cost function is nondecreasing in factor prices". As the prices of labour and capital inputs increase, hospital costs are also expected to increase and vice versa. For example, if staff salaries rise like it did in the country recently, then hospital operational expenditures will also increase as a result. This is especially so because factor prices are exogenously determined outside the confines of the hospital industry. We expect all hospital output categories to be negatively related to costs. An increase in inpatient days for example will lead to lower average/unit costs for hospitals. An example to explain this would be that the more people that are treated per unit of input (or resource) the more the cost is spread over many units, so that average costs tend to fall. In like manner, the patient staying in a hospital incurs high costs on the first few days. However, when such a patient stays longer, his/her costs are spread among the extra number of days that are spent. Therefore, costs per inpatient day will be lower in successive days than they previously were.

The relationship between beds and average patient day equivalent costs can go either way (they can either be positive or negative). In one way, they can be positively related in that the more beds a hospital has the more the costs it will incur in terms of maintaining those beds. On the other hand, the more beds a hospital has the more such maintenance costs are spread among the more beds, thereby reducing average inpatient costs. Table 3.2 below presents the signs expected from the variables after the models have been estimated.

Table 3.1: signs expected from variables after model estimation

#	Variable	Expected sign
1	Inpatient day (hospital output 1)	-
2	Outpatient visits (hospital output 2)	-
3	Labor prices	+
4	Capital prices	+
5	Beds (size variable)	±
6	Occupancy (utilization variable)	±
7	Location dummy (Anambra /Enugu state)	±
8	Status dummy (cottage or general hospital)	±

3.1.3 Estimation Procedure

Coefficients for all the models stated above will be estimated using the two statistical processes.

1. The ordinary least squares method. This is chosen because of its statistically viable properties, which are Best Linear and Unbiased (Gujarati, 1995). The ordinary least squares method fits a line through a sample of observations to approximate their relationship. It therefore provides parameter estimates that describe such relationships. The OLS estimation is done using Stata computer software.

2. The stochastic frontier process, which provides maximum likelihood estimates of parameters. It also provides numerical efficiency estimates. The stochastic frontier cost model is an efficiency model, which runs a maximum likelihood estimation of output and resource inputs on the observed costs, to define cost relationships. It then divides the error term into two parts; one part capturing unexplained variations or statistical noise, and the other part measuring allocative inefficiency. The stochastic frontier estimation is done using the Frontier 4.1 computer software. The program follows a three-step procedure in estimating the maximum likelihood estimates of the parameters of the stochastic frontier cost function. The three steps are:

1. Ordinary Least Squares (OLS) estimates of the function are obtained. All β estimators with the exception of the intercept will be unbiased.
2. A two-phase grid search of γ is conducted, with the β parameters (excepting β_0) set to the OLS values and the β_0 and σ^2 parameters adjusted according to the corrected ordinary least squares formula. Any other parameters are set to zero in this grid search.
3. The values selected in the grid search are used as starting values in an iterative procedure (Using the Davidon-Fletcher-Powell Quasi-Newton method) to obtain the final maximum likelihood estimates. (Coelli, 1996)

Having built the framework on which the data will be analyzed, it becomes necessary to present the research methodology.

3.2 Methodology

3.2.1 Sampling Method

A compromise has had to be made between having the ultimate sample size and what is feasible within the time, manpower transport and money available for this research. Instead of covering the entire Nigerian hospitals, only two states have been covered in the South East of Nigeria. These states are Anambra state and Enugu state, which jointly account for 6,176,387 people or about 7 percent of the population of Nigeria (this is calculated at the 1999 population figures). These two states were randomly chosen and sampled.

Within the states however, a random sample of 40 hospitals was taken from the hospitals found in Anambra and Enugu states. Since this research concentrates on government hospitals, almost all the hospitals found in Anambra state fall into the criteria considered, hence more than 90 percent of hospitals in this state were covered. Some of the hospitals in Enugu state were left out because they did not offer inpatient services. In all, 24 hospitals were visited in Anambra State. 22 of these were general hospitals and the other 2 were cottage hospitals. 8 general hospitals and 8 cottage hospitals were visited in Enugu state. There were a total of 22 general hospitals, 8 comprehensive health centers, 2 cottage hospitals, 1 psychiatric hospital and 1 mobile clinic in Anambra state. In Enugu state, there were 15 cottage hospitals, 12 comprehensive health centers, 8 general hospitals, 1 polyclinic and 1 dental centre. These are the categories of secondary health facilities that are found in these states. All the general and cottage hospitals in Anambra state were visited. All general hospitals in Enugu state and 8 out of 15 cottage hospitals were visited. The number and percentage of health facilities visited are presented in tables 3.1a and 3.1b below.

The criteria for inclusion considered included the following: the hospital had to be government owned, it had to offer both inpatient and outpatient services. This was in a bid to get data with some degree of homogeneity in terms of ownership and control. Hospital cost (and outlay) information was collected through questionnaires administered to the hospital managers and ministry of health personnel. Personnel at the state ministries of health were contacted because the hospital managers did not have information on staff salaries, and other hospital expenditure. Expenditure control for these items was done centrally, across all hospitals, by the finance department of the state ministries of health.

Table 3.2a: hospitals visited in Anambra state (December 2000–March 2001)

Number	Health facility	Number of facilities	Number visited	Percentage visited
1	General hospital	22	22	100
2	Cottage hospital	2	2	100
3	Comprehensive health center	8	0	0
4	Psychiatric hospital	1	0	0
5	Polyclinic			
6	Dental centre			
7	Mobile clinic	1	0	0

Table 3.2b: hospitals visited in Enugu state (December 2000-March 2001)

Number	Health facility	Number of facilities	Number visited	Percentage visited
1	General hospital	8	8	100
2	Cottage hospital	15	8	53
3	Comprehensive health center	12	0	0
4	Psychiatric hospital			
5	Polyclinic	1	0	0
6	Dental centre	1	0	0
7	Mobile clinic			

3.2.2 Data Sources

Data for this research were sourced from government general and cottage hospitals in Anambra and Enugu states by means of questionnaires. Hospital managers and ministry of health personnel completed the questionnaires (a copy of the questionnaires can be found in the appendix D of this research paper). The data collected were monthly estimates from the last quarter of the year 2000 and the first quarter of 2001 (this was the most that could be collected within the time and resources at the researcher's disposal). A total of forty hospitals were visited. Of these, thirty were general hospitals while ten were more beds and employed more staff than cottage hospitals. For example, none of the cottage hospitals visited had more than 19 beds.

The cost information obtained for the hospitals considered in this study is total operating expenditure. This means that this cost covers both inpatient and outpatient services. The hospitals studied did not have separate data for total inpatient costs and outpatient costs. It was not possible to disaggregate this total operating expenditure into total inpatient costs and total outpatient costs. Therefore, cost per patient-day equivalent is used in the remainder of this research to refer to a sum of inpatient and outpatient cost equivalents.

3.2.3 Ethical Consideration

Consideration is given to the fact that the informants' anonymity must be protected. Therefore, no mention is made whatsoever of the identities of those who helped to fill in the questionnaire used to gather information for this research. No direct reference is made of hospital names and it is hoped that this research will be very useful for better hospital operations in Nigeria.

The next chapter presents the results of the models sepecified in this chapter. Chapter four will also present tests of statistical and econometric criteria for models estimated, as well as an evaluation of the working hypothesis stated in the first chapter.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Descriptive Results

The data collected for the hospitals selected for this study are monthly estimates. This section discusses descriptive results of data collected. Three output categories are investigated namely; the number of inpatient cases, the number of outpatient visits and the number of inpatient days. All costs and prices are calculated in Naira terms, the local Nigerian currency.

The key variables used in this research are represented in the table 4.1 below. It is necessary to describe (or define) these variables as they have been used for the models estimated in this research. Some of the variables were transformed into logs. The variables used are described as follows;

Table 4.1: a description of the variables used in estimating models for this research

Variable	Definition
lcpde	Log of cost per patient-day equivalent, calculated in Naira terms
loutpat	Log of the number of outpatient visits
linpat	Log of the number of inpatient cases
lnpatdys	Log of the number of inpatient days
llab	Log of labor costs. A measure of total costs of labor (personnel salaries)
lcap	Log of capital costs. A measure of total costs of capital items
lbeds	Log of the number of hospital beds. A measure of hospital size

Hosptype	A location dummy of whether the hospital is found in Anambra or Enugu state
occ	Occupancy rate. A measure of hospital utilization. "Occupancy rate measures the percentage of total available beds that are occupied by patients" (Barnum and Kutzin, 1993: 91)

Before the models are estimated, a correlation matrix of all the variables used is sought. This is supposed to help us know the interrelationships that exist between the variables and also to know which combination of variables to include in the models in order to avoid the problem of multicolinearity.. The correlation matrix is presented in table 4.1 below.

Table 4.2: Correlation matrix of variables used

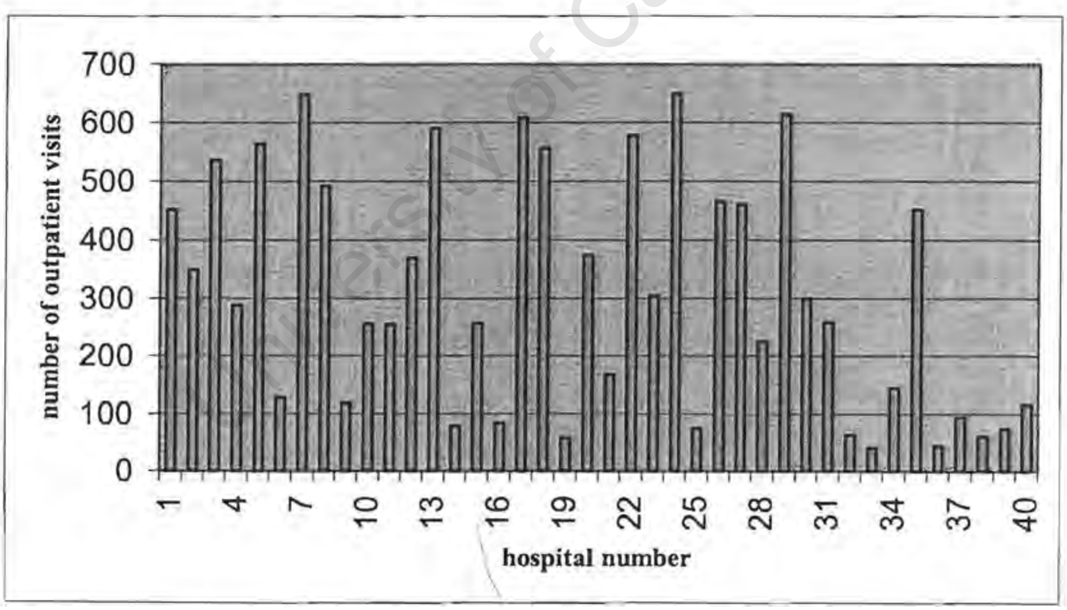
	lcpde	loutpat	linpat	lnpatdys	llab	lcap	cogh
lcpde	1.0000						
loutpat	-0.8517	1.0000					
linpat	-0.3531	0.5567	1.0000				
lnpatdys	-0.2932	0.5991	0.8757	1.0000			
llab	-0.0107	0.4929	0.6088	0.7332	1.0000		
lcap	-0.1395	0.3549	0.2823	0.3391	0.1628	1.0000	
cogh	-0.2806	0.5507	0.8230	0.9054	0.6410	0.3943	1.0000
lbeds	-0.2611	0.5879	0.7854	0.9353	0.7348	0.3854	0.9052
occ	-0.1451	0.1597	0.3761	0.3297	0.1420	-0.0273	0.1471
Hosptype	0.0245	0.1477	0.4427	0.4396	0.4254	0.0150	0.4714

	lbeds	occ	Hosptype
lbeds	1.0000		
occ	-0.0214	1.0000	
Hosptype	0.4392	0.0661	1.0000

Some important discoveries are worthy of note in the above correlations. Firstly, the high correlation between the number of inpatient cases and the inpatient days (0.8757) means that the use of the one in a model must necessarily preclude the use of the other. Otherwise, there will obviously be a problem of multi collinearity. The least correlation coefficient (-0.0107) is recorded between the cost per patient-day equivalent and labor cost. This shows that the cost per patient day equivalent is not very much related to labor costs. However, this conclusion cannot be drawn especially since labor costs take up the greatest percentage of total hospital expenditure. The highest correlation (0.9353) occurs between the number of inpatient days and the number of beds. The rest of the correlation coefficients represent normal relationships that can be expected between them.

Figure 4.1a below shows the estimated monthly number of outpatient visits to hospitals in both Anambra and Enugu States. Hospital number 24 (this is a general hospital located in Anambra state) records the highest visits of 650 outpatients a month. This is greater than the average number of outpatient visits for all hospitals in Anambra and Enugu states combined. Alternatively, the least visits (42 visits) is recorded by hospital number 33; not surprisingly though, this is a cottage hospital. The monthly number of outpatient visits for all 40 hospitals studied is calculated at 307 visits.

Figure 4.1a: average monthly number of outpatient visits to cottage and general hospitals in Anambra and Enugu States(December 2000-March 2001)



Figures 4.1b and 4.1c represent the monthly number of outpatient visits in Anambra and Enugu states respectively. An average of 322 monthly outpatient visits are recorded for all the hospitals in Anambra state. This number is higher than the average number of outpatient visits for all hospitals from both states combined (which is 307 outpatient

visits). Hospital number 24 records the highest outpatient visits. This also represents the highest visits to all the hospitals studied for this research. Hospital number 16 records the least number of outpatient visits in the state (84 outpatient visits). The least number of outpatient visits for Enugu state is recorded by hospital number 33. The are a total 42 outpatients visits recorded in this hospital (that is in hospital number 33).

For Enugu state hospitals average outpatient visits per month is 284, with the highest state outpatient visits of 648 recorded by hospital number 7. The average monthly outpatient visits for Enugu state is lower than the average monthly outpatient visits for the combined Anambra and Enugu state hospitals (307 visits).

Figure 41b: average monthly number of outpatient visits to cottage and general hospitals in Anambra state Nigeria (December 2000-March 2001)

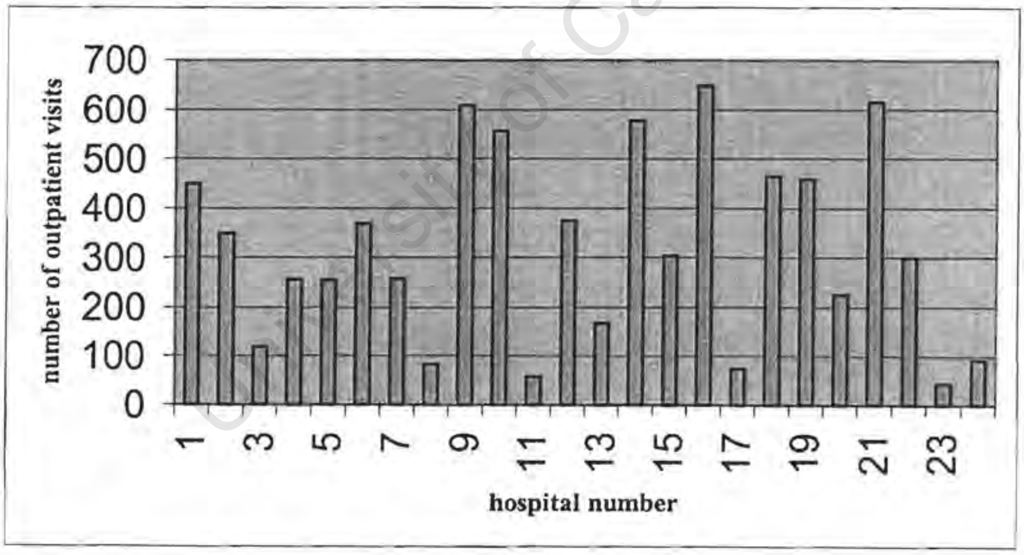
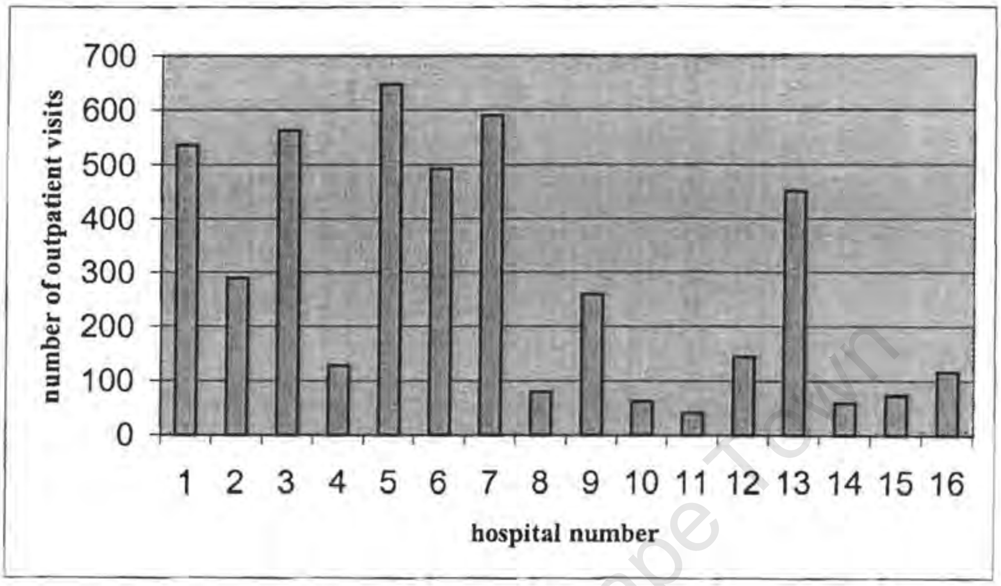


Figure 4.1c: average monthly number of outpatient visits to cottage and general hospitals in Enugu state Nigeria (December 2000-March 2001)



The diagram below (figure 4.1d) shows the monthly number of inpatient cases. As expected, there are fewer inpatients than there are outpatients. The average monthly number of inpatient cases for all hospitals is 36. Hospital number 21 (a general hospital in Anambra state) records the highest number of inpatient cases (86 cases). The least number of inpatient cases (4 cases) is found in hospital 39. This is a cottage hospital in Enugu state. It is obvious therefore that the cottage hospitals do not only have less number of beds and staff, but also have fewer people utilizing their services.

Figure 4.1d: average monthly number of inpatient cases in cottage and general hospitals in Anambra and Enugu states of Nigeria (December 2000-March 2001)

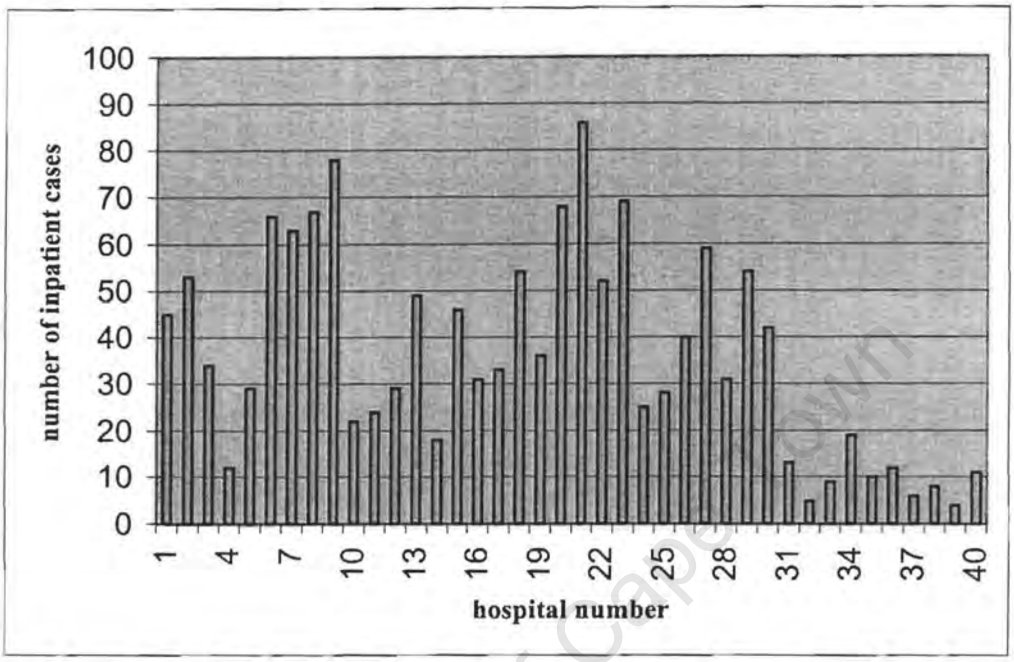
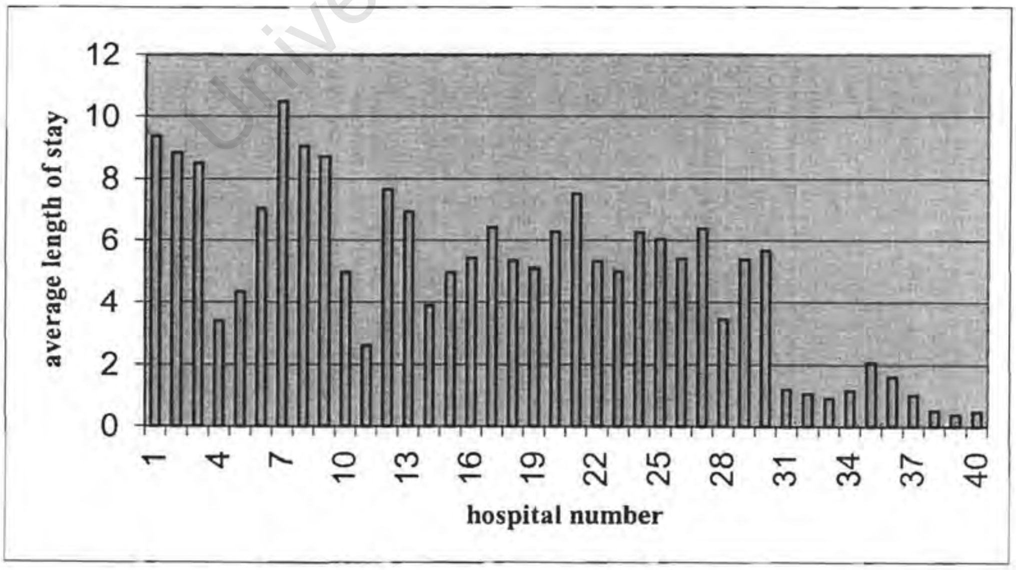


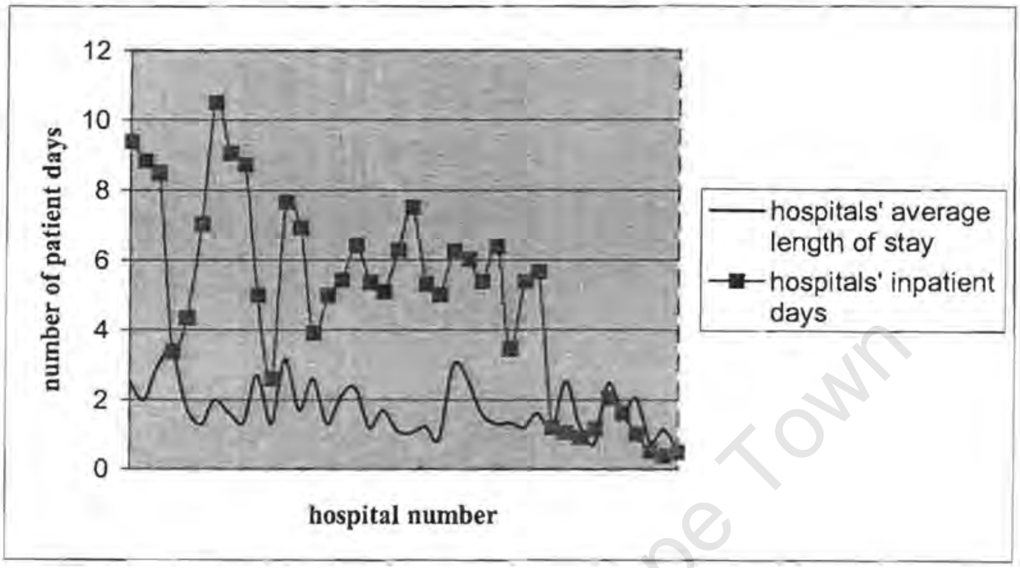
Figure 4.1e: monthly average length of stay Anambra and Enugu States (December 2000-March 2001)



Because of the wide range of illnesses for which inpatient services are recorded, it is necessary to look at the average length of stay (ALOS) for inpatients in each hospital. Figure 4.1e above shows the average length of stay for all the 40 hospitals from both states. The ALOS is an indicator of the efficiency of hospital resource use. However, there is no reason to conclude that longer stays contribute to higher quality care. "Without information about case-mix and severity it is difficult to use length of stay as a direct indicator of efficiency for individual hospitals, but stays that are usually long raise questions regarding efficiency" (Barnum and Kutzin, 1993:99). The highest ALOS recorded is 10.5 days (for hospital number 7, a general hospital in Enugu state). This is in great contrast to 0.5 days (half a day or about 12 hours) in hospital 39 (a cottage hospital, also in Enugu state). The question of whether hospital 7 keeps patients for too long or hospital 39 for too short a period cannot be answered at this point. This is because information on the type of patients and the type of illnesses treated in these hospitals is sacrosanct to such an investigation.

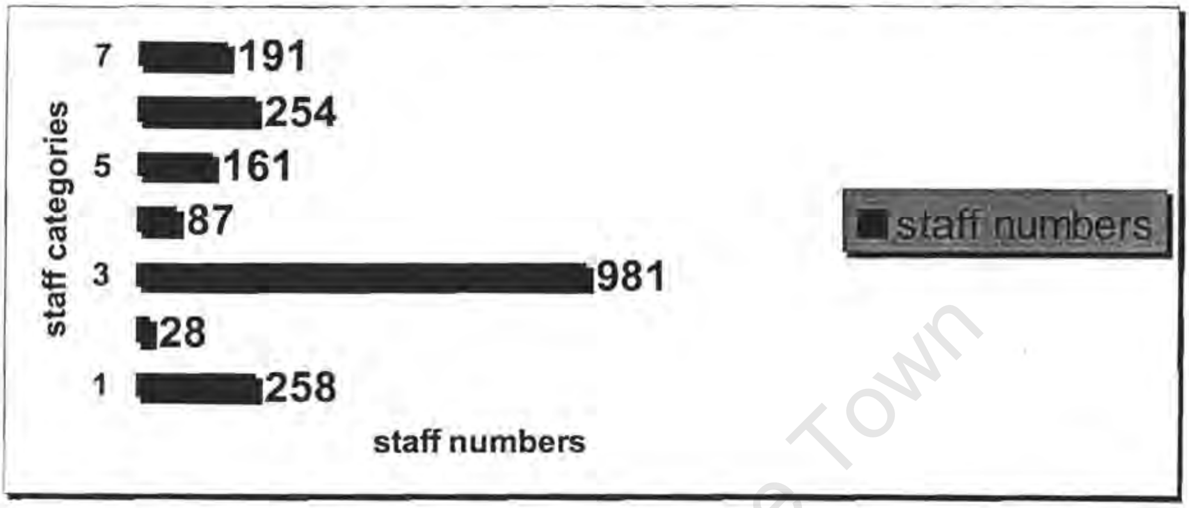
A look at the similarities and/or differences between the number of patient days and the average length of stay (per month) for each hospital shows some very peculiar trends. First, the monthly average length of stay is almost evenly distributed across all the hospitals, irrespective of location or status. The values for average length of stay range from about half a day (or 0.54 days specifically) to about three and a half days (3.4 days). Evidence of this is provided in figure 4.1f below.

Figure 4.1f: comparison of monthly hospital average length of stay and inpatient days in Anambra and Enugu State hospitals (December 2000-March 2001)



Hospital number 40 has the least value in terms of monthly average length of stay (ALOS = 0.54 days) while hospital number 4 has the highest monthly average length of stay ALOS = 3.4 days. Hospital number 40, a cottage hospital in Enugu state, also has a monthly average of 11 inpatient cases, and this number falls within the least 17.5 percent inpatient cases recorded in all 40 hospitals studied. On the other hand, hospital number 4 records the highest monthly average length of stay among all hospitals studied. This is a general hospital located in Enugu State. There is little wonder therefore that this hospital (number 4) records the least number of inpatient cases (12 inpatient cases, and this forms the least 22.5 percent of inpatient cases recorded for all hospitals studied).

Figure 4.2: number of different staff categories in Anambra and Enugu State hospitals (December 2000-March 2001)



Where **1** = full time doctors, **2** = part time doctors, **3** = registered nurses, **4** = auxiliary nurses, **5** = paramedics, **6** = cleaners and **7** = administrative staff.

The number of the different staff employed in Anambra and Enugu state hospitals are represented in figure 4.2 above. We find that registered nurses dominate in terms of numbers. There are more registered nurses in these hospitals than there are doctors, or paramedics or cleaners or administrative staff. The least of these are auxiliary nurses. Most of the hospitals visited do not have auxiliary nurses as part of their staff.

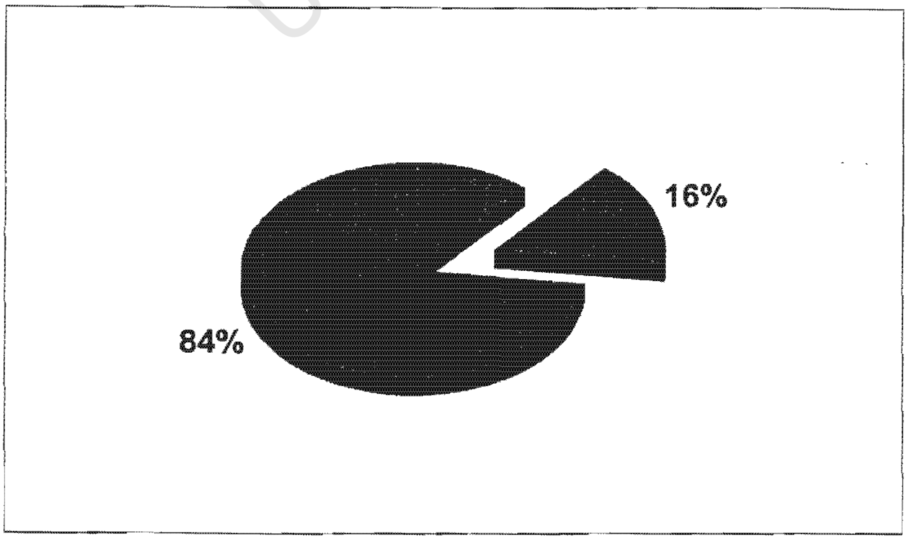
The calculated staff ratios presented in table 4.3 elucidates the differences between the number of different staff employed in Anambra and Enugu state hospitals.

Table 4.3: calculated monthly average hospital staff ratios for Anambra and Enugu state hospitals (December 2000-March 2001)

Staff category	Ratio
Doctor – nurse	1: 3.7
Doctor – paramedics	1: 0.6
Doctor – cleaners	1: 0.9
Doctor – admin staff	1: 0.7
Nurse – paramedics	1: 0.2
Nurse – cleaners	1: 0.2
Nurse – admin staff	1: 0.2

The ratios above serve to confirm that nurses are by far the most employed staff in Anambra and Enugu state hospitals, having the highest ratios in all comparisons. The least ratios are calculated between nurses and paramedics, nurses and cleaners and between nurses and administrative staff. This stands at 1: 0.2 for the above-mentioned staff ratios.

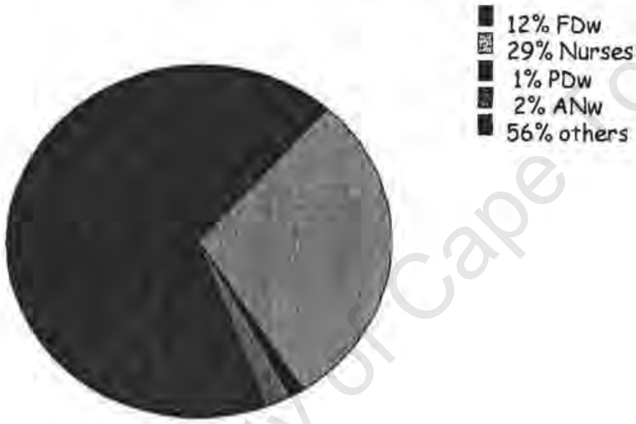
Figure 4.3a: average monthly operating expenditure (Naira) in Anambra and Enugu State hospitals (December 2000-March 2001)



Key
16 % - expenditure on capital items
84 % - expenditure on personnel salaries

A look at the total hospital operating expenditure above shows that labor costs take up 84 percent. Labor costs include the costs of salaries for such hospital personnel as doctors, nurses, paramedics, cleaners and admin staff. This is further proof of the World Bank assertion of excessive dependency on labor inputs by Nigerian hospitals that we saw in the first chapter of this project. Figure 4.4b shows exactly how personnel costs accrue and how much costs are accounted by the various staff categories.

Figure 4.3b: hospital personnel costs by staff categories in Anambra and Enugu States (December 2000-March 2001)



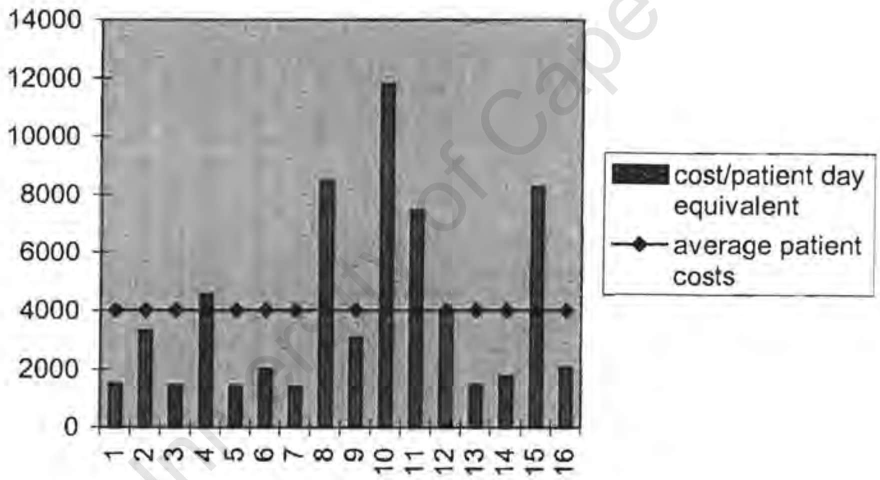
The diagram above shows how the different staff categories account for all hospitals personnel costs. FDw means full time doctors' salaries, Nurses stands for salaries of registered nurses. PDw is par time doctors' salaries, while ANw is auxiliary nurses' salaries. Other staff categories include such other staff as paramedical staff, pharmacists, drivers, cleaners and administrators. These staff, put together, account for more than half of hospital labour costs. A concise breakdown of the salaries of individual staff categories could not be obtained for this research. Nurses (both registered and auxiliary) by far, incur (or take up) the greatest individual category costs. This is not surprising since they form the highest population of staff employed in Anambra and Enugu state hospitals.

The next three figures represent monthly patient day equivalent cost situations in Anambra and Enugu states. Figure 4.4a shows a graph of cost/patient day equivalent for

Enugu state, figure 4.4b shows the cost situation in Anambra state, while figure 4.4c shows the cost/patient day equivalent for both states combined.

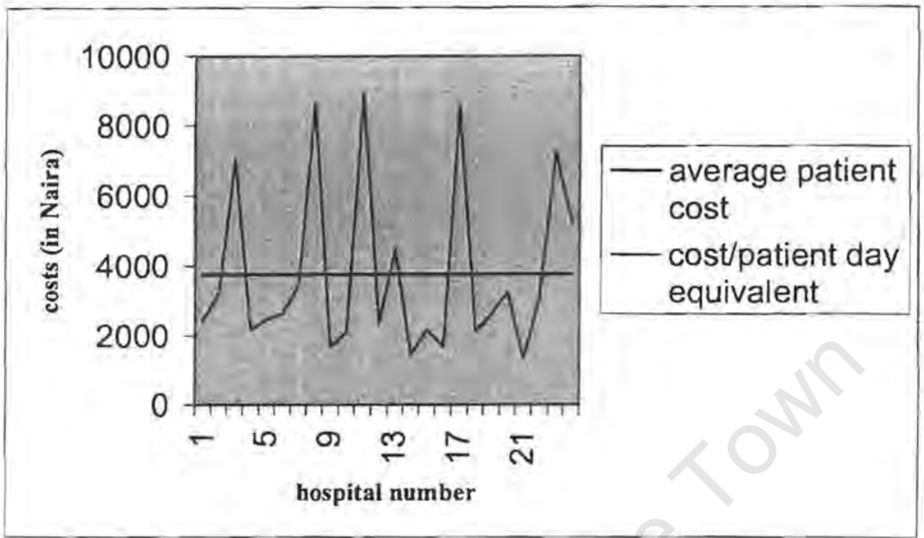
The highest cost/patient day in Enugu state (11,832.66Naira) is recorded by hospital number 32. This is larger than the average for Enugu state hospitals, which is calculated at about 4,015.61 Naira. On the other hand, hospital number 13 has the least cost/patient (that is 1,400 Naira), which is less than 35 percent of the Enugu state average cost per patient (this is calculated at 4,015.61 Naira).

Figure 4.4a: monthly cost/patient day equivalent (in Naira) for hospitals in Enugu State (December 2000-March 2001)



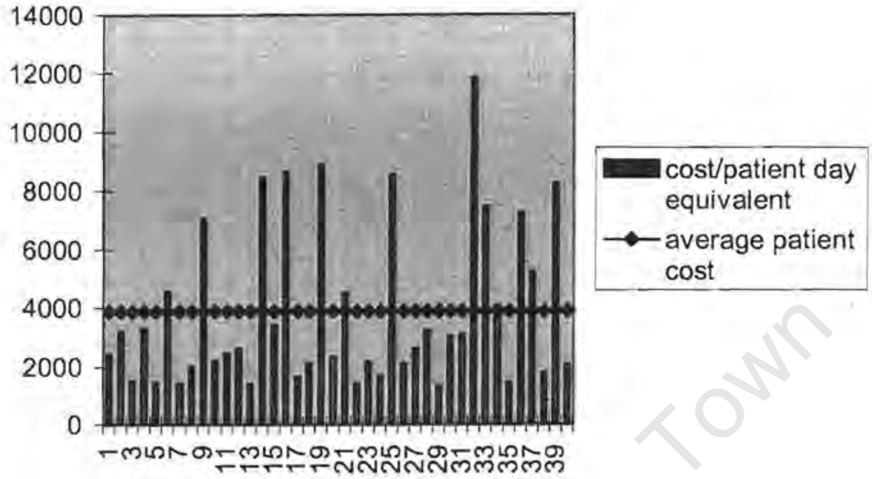
Similarly, hospital number 19 records the highest cost/patient day in Anambra state (8,895.73 Naira). This is higher than the state average of 3,761.2 Naira. Alternatively, hospital number 29 records an average patient cost of 1,339.8 Naira, which is only about 36 percent of the state average cost per patient day equivalent.

Figure 4.4b: monthly cost/patient day equivalent (in Naira) for hospitals in Anambra State (December 2000-March 2001)



The overall states' average cost/patient day equivalent (as seen in figure 4.4c below) is calculated at 3,862.965 Naira. This average is less than the Enugu state average (4,015.61 Naira), but greater than the Anambra state average (3,761.2 Naira). In all, 72.5 percent of all the hospitals studied (from both states) have average patient costs that are less than the overall average for both states (which is 3,862.965 Naira). Of this, 45 percent are Anambra state hospitals, while 27.5 percent are Enugu state hospitals. Looking at this from the individual states' point of view, 75 percent of Anambra state and 61 percent of Enugu state hospitals operate at less than the overall average cost per patient day equivalent.

Figure 4.4c: Average monthly allocation of cost/patient day equivalent (in Naira) for hospitals in Anambra and Enugu States (December 2000-March 2001)



4.2 Regression Results

The results of the models specified in chapter three (two models in all) are presented in this section. Both robust regression and OLS (ordinary least squares) methods have been used to estimate coefficients for the first model in a bid to get the best possible fits in each case. The choice of robust regression estimation technique is informed by the need to get more significant coefficients (it is known that the robust process produces very little standard errors). The robust regression has been introduced because the method (of robust regression) takes the best fit from an array of fitted lines, using the same set of observations. This it does through an iterative process. This is not to say this method does not have its shortcomings although prima facie, it presents itself as a veritable estimation process.

However, only the Ordinary Least Squares (OLS) results are presented in this chapter. The results from the robust regression can be found in appendix E. The models have been estimated using both outpatient visits and inpatient days as hospital output. The dependent variable in each case is the cost per patient day equivalent, which is an average cost measure that incorporates all patient types (that is both inpatients and outpatients).

Model 1 Results

Results from model 1 are estimated from Sata software, while model 2 results are estimated from Frontier 4.1.

Source	SS	df	MS
Model	15.8744959	8	1.98431198
Residual	.230424585	31	.007433051
Total	16.1049204	39	.412946678

Number of obs	=	40
F(8, 31)	=	266.96
Prob > F	=	0.0000
R-squared	=	0.9857
Adj R-squared	=	0.9820
Root MSE	=	.08622

lcpde	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
loutpat	-.8566809	.0211926	-40.423	0.000	-.8999036	-.8134582
lnpatdys	-.0291343	.3197036	-0.091	0.928	-.6811742	.6229055
llab	.767882	.0453515	16.932	0.000	.675387	.860377
lcap	.1929175	.0233518	8.261	0.000	.1452911	.2405439
occ	-.600988	5.376627	-0.112	0.912	-11.56669	10.36472
lbeds	-.010364	.3519627	-0.029	0.977	-.7281968	.7074687
Hosptype	-.0186135	.0331664	-0.561	0.579	-.0862568	.0490297
cogh	-.0912014	.084845	-1.075	0.291	-.2642439	.0818411
_cons	.4026283	.5808421	0.693	0.493	-.782007	1.587264

The first model is a cost estimation for hospitals using a sample of cross section data for 40 Anambra and Enugu state hospitals. The dependent variable in this model is the cost per patient day equivalent. In all, eight regressors are used in the model. These are outpatient visits and inpatient days (which are measures of hospital output), labor and capital (which are measures of input prices), occupancy (a measure of hospital utilization), beds (which is a measure of hospital size), and two dummy variables, (representing hospital location and hospital status). The output variables both have negative signs, which is compatible with economic a priori expectations. The more patients that are treated with a given unit of input, the more costs are spread among the lot, leading to reduced average costs of production. Thus, the negative relationship obtained from the output variables in the OLS regression shows that when output increases, average costs reduce. The variable on outpatient visits is very significant at all levels considered (that is at 1, 5 and 10 percent levels respectively). The outpatient variable has a negative sign, to mean that the more the number of outpatient visits the lower the unit costs of treating these patients. It is like administering vaccinations against polio. The more visits from outpatients there are, the lower the costs, since the more people can share the costs of say a 500 mg bottle of the vaccine. It is more costly to vaccinate one person with a 500mg bottle of polio vaccine than it is to administer this same bottle (of 500mg) to say 50 outpatients The inpatient days variable is however not significant.

The input variables show positive cost relationships in the model. This is especially relevant since the cost function is "nondecreasing in input prices" (Varian, 1992; 72). In this model (model 1), labor contributes more to average cost per patient day than capital and this is seen by this variable's (labor) higher coefficients. The labor input variable has a parameter estimate of about 0.768 while the coefficient for capital inputs stands at about 0.193. Both input variables are statistically significant at all the levels of significance chosen for this research (these levels are 1, 5 and 10 percent).

Model 1 produces negative signs for the coefficients of the size and utilization variables. From the foregoing these negative signs can be appreciated by borrowing a leaf from economic theory. Firm size (or hospital size in this case) is supposed to represent scale of operations. The larger firms are supposed to reap economies of scale in the long run and this has the effect of reducing average costs. However, the analysis in this research examines the short run, during which time economies of scale are not feasible. In this situation, one is tempted to believe that larger scale operations tend to cause average patient cost reductions, as has been demonstrated in model 1 result.

The same is also true for the utilization variable, since higher utilization means that the hospitals have to provide more inputs and more infrastructures. This leads to higher costs in the short run. Average patient cost reductions can only be achieved in the long run when input proportions can be varied to accommodate increases in hospital size and utilization. Both the size variable and the utilization variable are not statistically significant and therefore do not truly explain short-run cost relationships in this model (and hence in the hospitals so analyzed). The notion of reduced average patient costs brought about by increasing size and utilization (as shown in model 1) is therefore dropped.

A look at model 1 above shows that all things being equal, the monthly cost per patient day equivalent is not affected by the location of the hospital. The location as used in this estimation is a dummy variable saying whether the hospital is in Anambra state or in Enugu state. This is because the coefficients (from the model results shown above) for this dummy variable is not statistically significant. It is interesting however to note the sign assumed by the coefficient for the location dummy (in model 1). The location variable has a negative sign. What this means is that monthly cost per patient day equivalent can be reduced when we select the "right" location for the hospital. The question of where the "right" location is cannot be answered in this research and is therefore an opening for further research

A variable on hospital status is also introduced in the model. There are two categories of hospitals that have been studied in this research. These are cottage and general hospitals respectively. The basic difference between these two categories is in the number of beds (hospital size) and the staff strength. Decision-making in these two types (cottage and general hospitals) is done centrally by the hospitals' management board, which is coordinated at the state level. Like the location dummy, the hospital status dummy variable is not significant in model 1. This is evaluated at 1 percent, 5 percent and 10 percent levels of significance. The Ordinary Least Squares regression (estimated in model 1) shows a negative sign for the hospital status dummy.

The constant term shows a positive average costs per patient day equivalent. All things being equal, all hospitals have positive unit costs. Hospital costs constantly increase (at the margin) by about 0.403 Naira every month, irrespective of whether patients are being treated or not. This is probably because of certain capital and/or labor costs that have to be incurred irrespective of whether the hospital is producing or not. The positively signed constant term may also be due to inflation, which unfortunately has been an integral part of the Nigerian economy. However, the constant term in model 1 is not statistically significant.

Model 2 Results

The second model in this chapter is estimated using the Frontier 4.1 software. The model has firm effects, which are assumed to be distributed as truncated normal random variables. The firm effects assumed here are hospital location and hospital status. This is in a bid to ascertain whether these two variables have any significant influence on hospital efficiency and also to answer the question posed in the hypothesis stated in the first chapter. The dependent variable used in this model is cost per patient day equivalent. The coefficient for the location variable is represented by delta 1 while hospital status is represented by delta 2. The output is presented below (the full model output is found in the appendix);

```
the final mle estimates are :

                 coefficient     standard-error    t-ratio

  beta 0          0.10941084E+00  0.21953336E+00  0.49837911E+00
  beta 1         -0.84577986E+00  0.18213521E-01 -0.46436921E+02
  beta 2         -0.82734958E-01  0.28277862E-01 -0.29257855E+01
  beta 3          0.17189301E+00  0.20109365E-01  0.85479084E+01
  beta 4          0.79286497E+00  0.39603959E-01  0.20019841E+02
  delta 1        -0.11199144E+00  0.11256327E+00 -0.99491990E+00
  delta 2        -0.32583136E-01  0.88276787E-01 -0.36910197E+00
  sigma-squared   0.34322266E-02  0.22139109E-02  0.15503003E+01
  gamma           0.82035807E+00  0.16306564E+00  0.50308457E+01

log likelihood function =    0.80432832E+02

LR test of the one-sided error =    0.37414354E+01
```

The output above is the final frontier output following the Davidon-Fletcher-Powell iterative maximization process. It contains maximum likelihood estimates of the parameters estimated in this model. The coefficient estimates show percentage change in costs per patient day equivalent as a result of percentage changes in the independent variables used. The various beta coefficients represent the independent variables used. In this particular case, beta 0 is the constant term, beta 1 is the coefficient for outpatient visits, beta 2 is for the inpatient days variable, beta 3 is for the capital input prices and beta 4 is for labor input prices. The constant term is positively signed, which means non-negative prices even when no output is produced in hospitals. This is an indication that the hospitals must always continue to treat patients; otherwise, they will be constantly incurring some unnecessary costs (shown by the constant term). The labour and capital input price variables both have positive coefficients, which is compatible with our earlier predictions (and the results seen in models 1 above) that they contribute positively to hospital average patient costs. Both variables are also statistically significant at the 10 percent level. However, the capital inputs coefficient is not significant at the 1 and 5 percent levels. The labor coefficient is higher showing that increase labor costs add more to average patient day costs than increase capital costs. This is obviously the reason why the World Bank (World Bank, 1995: 19) report complained that far too much of the health expenditure is devoted to personnel (see chapter one).

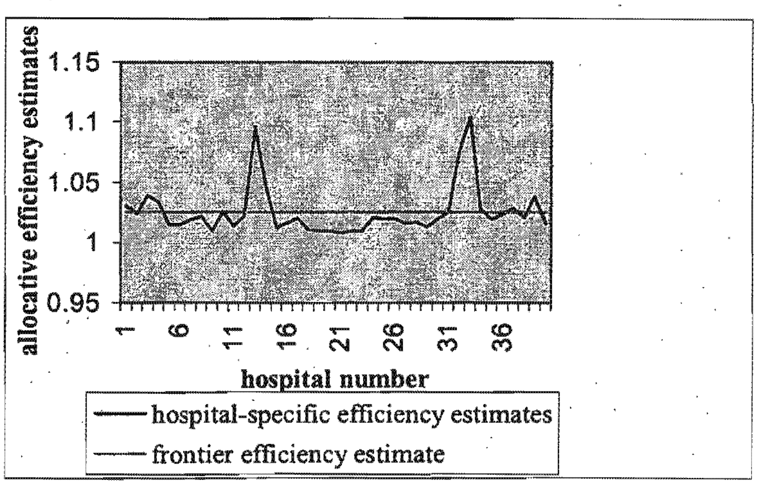
Both output coefficients have negative signs and this means that at a certain output level, hospital costs are widely, evenly spread, so that average patient costs tend to reduce. Thus above a certain level for example, the longer the patient stays in hospital, his average inpatient costs will reduce by about 8.27 percent of the initial costs. What this suggests is that keeping the patient longer in hospital can reduce average inpatient costs. This will also help the patient to recover fully before he/she gets discharged. However, the variable on inpatient days is not statistically significant, while that of outpatient visits is.

The efficiency effects variables are both negatively signed. The location variable assumes the value 1 when the hospital is in Anambra state and 0 when the hospital is in Enugu state. In the same light, the status variable assumes the value of 1 for general hospitals and 0 for cottage hospitals. The negative sign for the location variable is an indication that Anambra state hospitals do not add to efficiency, relative to Enugu state hospitals. It does not however mean that Enugu state hospitals are more efficient. A further investigation is therefore required before this question can be answered with much more certainty. The status variable also shows that general hospitals do not add to efficiency, rather, they reduce efficiency. However, drawing categorical conclusions here will not serve the best purpose. One thing is certain however; general hospitals are not more efficient than cottage hospitals. Both location and status dummy variables are not statistically significant. This means that both efficiency effect variables do not contribute to determine hospital efficiency in this model.

Looking at the overall significance of the model, we find that the estimates for the sigma and gamma parameters are significant. The gamma parameter is quite large, representing about 82 percent of the relative magnitude of the variance associated with the frontier model. The Likelihood Ratio test of the one-sided error shows that the calculated value is about 3.74. Evaluated at the 5 percent level of significance, following the chi square distribution, this shows that the one-sided error is statistically significant and is necessary in the model.

The figure below represents the estimates of allocative efficiency calculated from the sample of hospitals considered in this research. The full efficiency estimates for each of the hospitals are found in the appendix (in the full frontier model output).

Figure 4.5: hospital allocative efficiency estimates



The highest hospital efficiency estimate is recorded by hospital 33 at 1.1036 while the least estimate is recorded by hospital 21 at 1.0075. This means that a cottage hospital (hospital 33 is a cottage hospital) has the highest short run allocative efficiency while the least short run efficiency is recorded by a general hospital (hospital 21). The efficiency estimates represented in the figure above show that 30 % of all hospitals are above mean efficiency levels of 1.025. This means that 70 percent of the hospitals have unit costs that fall outside (or go beyond) the hospital frontier (mean costs). This 70 percent includes some cottage and some general hospitals. Anambra state hospitals make up 25 percent of the efficient hospitals while Enugu state hospitals make up 75 percent. The twelve efficient hospitals (beginning with the most efficient) are hospital 33, 13, 32, 14, 3, 39, 4, 1, 37, 34, 10 and 31. Six of these hospitals are cottage hospitals and the other six are general hospitals.

Furthermore, 8.3 percent of cottage hospitals and 16.7 percent of general hospitals in Anambra state are efficient. Similarly, 41 percent of cottage hospitals and 33 percent of general hospitals in Enugu state are efficient. A total 30 percent of the hospitals' costs fall within the industry cost frontier. This is an indication that most of the hospitals are not efficient (following the framework set out in the previous chapter which says that we can adjudge efficiency only when at least 60 percent of all hospitals operate within the industry cost frontier). By these results, only 30 percent of all hospitals considered operate within the confines of the cost frontier represented by the boundary **ef** in figure 3.1. A full model output from the stochastic process is found in the appendix of this research paper.

4.3 Evaluation of Statistical and Econometric Estimation Criteria

The statistical and econometric criteria that are mentioned here are those that form the assumptions underlying the use of the Least Squares method in estimating parameter. The criteria to be evaluated here are those that are permissible within the framework of cross-sectional data as we have in this research. The primary objective of this research is to build a cost frontier through which hospitals in Anambra and Enugu states will be evaluated. While recognizing the need for optimal outcomes, the focus here is to get the best possible behavioral cost models that will provide the backbone on which hospital efficiency can be evaluated. Thus, not all the criteria will be evaluated here. The most important and most relevant ones are evaluated.

4.3.1 Statistical Criteria

The statistical criteria involve evaluating the significance of the estimated coefficients and of the entire models. The criterion for evaluating the statistical significance of the coefficients is done using the *t*-statistic. The following null hypothesis is stated for the coefficients;

H_o: $\beta_i = 0$,

against the alternative,

H_1: $\beta_i \neq 0$

This is tested at a 5 percent level of significance (that is $\alpha = 0.05$) and involves a 2-tailed test. There may also be need to evaluate coefficients at 1 percent or 10 percent levels.

Inference from the student *t*-table with varying degrees of freedom leaves us with the following critical values;

Table 4.4: critical *t* values

Model	Degrees of freedom	1 percent Critical *t* value	5 percent Critical *t* value	10 percent Critical *t* value
Model 1	(6, 33)	±2.75	±2.04	±1.697
Model 2	(7, 32)	±2.75	±2.04	±1.697

Decision rule: if the calculated *t* statistic > the critical t or < the negative of the critical *t*, we reject the null hypothesis and accept that the estimate β_i is statistically significant. In other words, we reject H_o if the calculated t statistic falls into the critical region. An alternative would be to consider the probabilities of the calculated t statistics, given in the model output. A probability that is close to zero means that we reject the null hypothesis and consider the coefficient estimate statistically significant. The estimated parameters are statistically evaluated according to the models as follows:

Model one: In model 1, the outpatient, labor prices and capital price coefficients are significant at the 5 percent level. On the contrary, all the other variables are not significant, that is, inpatient days, occupancy, beds, location and status.

Model two: The outpatient, capital and labor variables are also significant in model 2 (that is the stochastic frontier model). These three variables are significant at all levels considered (that is 1, 5 and 10 percent respectively). In addition, the gamma parameter is significant at all levels of significance. The gamma parameter shows the relative magnitude of the variance associated with the frontier model.

In testing the overall significance of the regression results, the F statistic can be used. We test the null hypothesis

$$\mathbf{H_o : \beta_1 = \beta_2 = \beta_3 = ... = \beta_n = 0}$$

Against the alternative hypothesis

$$\mathbf{H_1: \text{not all } \beta_i\text{'s are zero.}}$$

Also at the 1, 5 and 10 percent levels. Alternatively, we could compare the probabilities calculated from the F statistics, which are reported in the model output. A quick glance at the F probabilities clearly shows that the overall models estimated are statistically significant at the 5 percent level. The tabulated values of F are presented in the table below.

Table 4.5: critical F values

Model	Degrees of freedom	1 percent Critical F value	5 percent Critical F value	10 percent Critical F value
Model 1	(6, 33)	≅ 3.47	≅ 2.42	≅ 1.98
Model 2	(7, 32)	≅ 3.30	≅ 2.33	≅ 1.93

In testing the explanatory power of the entire regression, the coefficient of multiple determination is used. A high coefficient (greater than 0.5) shows that the model explains substantial variations in the dependent variable (or the variable being studied). None of the models estimated has a coefficient of determination of less than 0.8, even when this coefficient is adjusted relative to difference and seasonals. This is good for the estimations for it connotes that the models capture substantial hospital cost variations. A detailed analysis of the individual coefficients will follow in the net section of this chapter.

4.3.2 Econometric Criteria

The econometric criteria, otherwise known as second-order tests (Kuotsoyiannis, 1977) involves the test of the assumptions about the distribution of the random variable from models estimated. Some of these assumptions are validated in the following lines;

The assumption of randomness of μ

The first assumption concerning μ is that it is a random variable and can assume various values in a chance was. The property of randomness is considered present on a priori grounds, since as Kuotsoyiannis (1977: 179) contends, "no formal test for this assumption exists".

The assumption of zero mean of μ

For example, E (μ) = 0 for all observations (I = 1, 2, 3, …., 40)

The essence of the zero mean assumption is that we take as axiomatically true that the positive and negative values of μ sum up to zero. Kuotsoyiannis (1977: 180) writes that this assumption is "imposed on us by the stochastic nature of economic relationships because it will be impossible to mathematically estimate them"

The assumption of Homoscedasticity

The third assumption about μ is that its probability distribution remains the same over all observations of X and in particular that the variance of each μ_i is the same for all values of the explanatory variable. This test is conducted individually for each of the models estimated in this project work. Using the Cook-Weisberg test for heteroscedasticity, the following hypotheses can be tested in Stata.

We test the null hypothesis **H_0: p = 0**

Against the alterative hypothesis **H_1: p ≠ 0**

(The null hypothesis denotes homoscedasticity while the alternative hypothesis means the presence of heteroscedasticity. The Cook-Weisberg test follows the Chi square distribution and so is evaluated using the Chi square statistic and its corresponding probability. The test results are presented as follows;

Model 1

Cook-Weisberg test for heteroscedasticity using fitted values of lcpde

Ho: Constant variance

chi2(1) = 0.00

Prob > chi2 = 0.9758

The above test produces a chi square probability of about 0.98, which is a very large chance of homoscedasticity in this model. The above model has been tested for heteroscedasticity using chi square probabilities calculated from the Cook-Weisberg test. From the foregoing it is obvious that the assumption of homoscedasticity holds for the model. This leads us to accept the null hypothesis.

The assumption of normality of μ

The assumption on normality also means that the random variable has zero mean and constant variance. The normality test can be done by many different approaches. For this research and for software compatibility, the Skewness and kurtosis test for normality is adopted. The results of the tests are presented below.

Skewness/Kurtosis tests for Normality

			------ joint ------	
Variable	**Pr(Skewness)**	**Pr(Kurtosis)**	**adj chi-sq(2)**	**Pr(chi-sq)**
e	**0.947**	**0.407**	**0.72**	**0.6983**

The probability that the error term obtained from model 1 is normally distributed is 0.69 (or approximately 0.7). Reading the estimates from the chi square probability, we find that the error term obtained from model 1 is normally distributed.

The assumption of no Autocorrelation

The problem of autocorrelation is specific to time series data. This is due to economic growth, business cycles and sometimes inflation. The data used for the analyses in this research is cross-sectional and therefore the problem of autocorrelation does not pose any serious hazards.

The assumption of Multicollinearity

The term multicollinearity originally means the existence of a "perfect" or exact linear relationship among some or all of the explanatory variables in a regression model. Both *Kuotsoyiannis* (1977) and Gujarati (1995) suggest that the most practical ways to detect the presence of multicollinearity in a regression model is by various rules of thumb. Among the various options for detecting this problem, a simple method is by comparing the correlation between any two explanatory variables with the overall coefficient of determination. If the correlation between any two independent variables is greater than the overall R^2 then there is serious multicollinearity. Other ways of detecting multicollinearity is when we have a high R^2 but few significant t ratios (Gujarati, 1995: 335). Evidence of strong multicollinearity also exists when we notice the very high correlations between independent variables used in some of the models. For example, the variable on inpatient days shares a correlation coefficient of 0.9054 with the hospital status dummy and 0.9353 with the hospital size variable. The following variables also show high correlations, hospital status and beds (0.905).

4.4 Evaluation of Working Hypotheses

Hypotheses are tested from the estimated models in a bid to evaluate the hypotheses specified in the first chapter of this research. First, we will test hypotheses on the variables used in the models. The following hypotheses are tested in Stata using Wald tests.

The first hypothesis test is a test of the significance of all the parameters used in model one. The null hypothesis is states that all the parameters are equal to zero, as stated below.

(test one) loutpat lnpatdys llab lcap occ lbeds Hosptype cogh

(1) loutpat = 0.0

(2) lnpatdys = 0.0

(3) llab = 0.0

(4) lcap = 0.0

(5) occ = 0.0

(6) lbeds = 0.0

(7) Hosptype = 0.0

(8) cogh = 0.0

F(8, 31) = 266.96

Prob > F = 0.0000

The joint probability that these variables are equal to zero is itself zero. This is seen by reading out the F probability obtained from the Wald test result presented above. For example, the probability that the outpatient variable is equal to zero (in other words, not statistically significant) is zero. The same is true for all the other variables tested above. Thus, going by this test, all the variables used in model 1 are statistically significant in the model and contribute to variations in cost per inpatient day.

It is not enough however to test joint probabilities since the influence of one or two variables in the group may aid some otherwise insignificant variables to become significant. The next couple of hypotheses are intended to solve the puzzle posed by the hypothesis in chapter one, which is about the significance of the output and input variables. Test two presents hypothesis test on the outpatient day's variable. The test results show that outpatient days have a significant influence on the average patient costs. The F probability in this case is zero and shows that the variable is significantly different from zero.

(test two) loutpat

(1) loutpat = 0.0

F(1, 31) = 1634.06

Prob > F = 0.0000

(test three) lnpatdys

(1) lnpatdys = 0.0

F(1, 31) = 0.01

Prob > F = 0.9280

The hypothesis test on inpatient days shows that the variable is not statistically different from zero. This is so when we use the cost per patient day equivalent variable as the dependent variable (as in model 1). Thus, a probability of 0.928 (shown in test three) shows clearly that inpatient days do not contribute to patient cost variations.

Test four below tests the hypothesis that both labor and capital input prices are equal. However the results lead us to accept the alternative, since the probability that labor and capital are equal is zero. Thus, based on model 1 estimated in this research, labor and capital input prices are different.

(test four) llab=lcap

(1) llab - lcap = 0.0

F(1, 31) = 157.72

Prob > F = 0.0000

(test five) llab

(1) llab = 0.0

F(1, 31) = 286.69

Prob > F = 0.0000

(test six) lcap

(1) lcap = 0.0

F(1, 31) = 68.25

Prob > F = 0.0000

The above two tests are on labor and capital input prices. These tests show that both labor and capital contribute significantly to variations in cost per patient day equivalent.

(test seven) Hosptype

(1) Hosptype = 0.0

F(1, 31) = 0.31

Prob > F = 0.5787

There is a 57 percent chance that the hospital location variable is equal to zero. The conclusion can therefore be reached that this variable is not statistically significant at the 5 percent level. This conclusion is supported by the t statistic estimated from the coefficient of this variable in model 1. Hence, there is not enough evidence to prove that Anambra state hospitals are more efficient than Enugu state hospitals.

Test eight provides a not so glaring test of hypothesis on the hospital status variable. The question of whether general hospitals are more efficient than cottage hospitals (or vise versa) is not very clear. The coefficient seems to be statistically significant at 5 percent level. The probability that the status variable is not statistically significant is about 30 percent (although, it may be necessary to consider 30 percent high enough to accept the null hypothesis). This is in contrast to earlier estimations in models 1 and 2. The hospital status variable was found to be statistically insignificant in both models estimated (in both the Ordinary least squares and stochastic frontier estimations).

(test eight) cogh

(1) cogh = 0.0

F(1, 31)	=	**1.16**
Prob > F	=	**0.2907**

Following the conceptual framework developed in the third chapter, a conclusion can be reached that hospitals in South East Nigeria are inefficient. This is because only 30 percent of the hospitals studied operate within the cost efficiency frontier and therefore also operate above the mean hospital efficiency level of 1.025. The target set in the conceptual framework is that 60 percent of all hospitals have to operate within the cost frontier.

CHAPTER FIVE

POLICY IMPLICATIONS, RECOMMENDATIONS AND CONCLUSION.

5.1 Policy Implications

A summary of the results obtained from the two models is presented in table 5.1 below. *t*-statistics for each coefficient are given in brackets. Table 5.1 contains model results for which the dependent variable is the cost per patient day equivalent variable. The independent variables used in model 1 are the number of outpatient days, the number of inpatient visits, the total costs of labor inputs, the total costs of capital, occupancy rate, number of beds, location and status dummy variables. Model 2 has the same variables, although the location and status variables are used in a different context-to evaluate efficiency effects. Note that model 1 follows the Ordinary Least Squares (OLS) estimation process, while model 2 is the Stochastic Frontier model.

Table 5.1a: summary of results (*cost per patient day equivalent*)

Variables	Inpatient days	Outpatient visits	Total capital	Total labor	Occupancy (utilization)	Location	Beds	Status
Model 1 (OLS*)	-0.029 **(-0.09)**	-0.856 **(-40.42)**	0.192 **(8.26)**	0.767 **(16.93)**	-0.601 **(-0.11)**	-0.018 **(-0.56)**	-0.01 **(-0.02)**	-0.09 **(-1.07)**
Model 2 (SFM[a])	-0.082 **(-1.29)**	-0.845 **(-46.43)**	0.171 **(1.85)**	0.792 **(20.01)**		-0.119 **(-0.99)**		0.032 **(-0.36)**

Table 5.1b: summary statistics of results

Statistics	Constant	Beta 0	R^2	Sigma squared	Gamma
Model 1 (OLS)	0.299 **(2.04)**		0.9925		
Model 2 (SFM)		0.109 **(0.49)**		0.003 **(1.55)**	0.82 **(5.03)**

**OLS is Ordinary Least Squares*
[a]SFM is Stochastic Frontier Model

First and foremost, a positive or increasing constant cost per patient day means that, irrespective of patient status or hospital operation, some costs are incurred. Model 1 shows a constant increase in costs of 29 percent while model 2 shows a constant increase of about 11 percent. Irrespective of what model we are looking at, one thing is certain, hospital patient day costs are ever increasing. The government therefore has a responsibility to keep hospitals operational (in terms of accepting patients and rendering other necessary services). This will, in a way, justify the expenditure on the constant costs that these hospitals incur. This constant cost increases could also be linked to the level of price increases in the macro economy. Therefore, to keep these constant costs down (or otherwise reduced), there may be a need for government to pursue contractionary fiscal/monetary policies to keep inflation rates down.

Next a variable-by-variable summary of findings is presented. The dependent variable in both models is the cost per patient day equivalent.

Inpatient days: The log of the number of inpatient days was not statistically significant in both models estimated. However, it has the expected sign, confirming that the greater the number of inpatient days the lower the average cost per patient day. Obviously, the costs will be high on the first day, but as the patient stays longer in hospital, then his/her costs are spread among the more days and ultimately, the average cost per patient day reduces. An extra inpatient day spent in the hospital causes the average cost per patient day to reduce by 2 % in model 1 and by 8 % in model 2. Although these differ, the basic truth shared by both models was the fact that an increasing number of inpatient days led to a reduction in the average cost per patient day in Anambra and Enugu state hospitals. The fact that the inpatient day variable was not statistically significant means that there is very little (if any) that government can do to influence average costs per patient day, by affecting changes in this variable.

Outpatient visits: The variable on outpatient visits has negative signs in both models estimated. The negative signs showed that the greater the number of outpatients per unit of time, the lower the average cost per outpatient visit. A lot of money can be saved in hospitals if more and more outpatients visit our hospitals. This is because, with increasing numbers, the unit costs of outpatient hospital services will be reduced. This result is useful to apply in hospital health care provision. Fro example, in conducting immunization against certain diseases like polio, measles and meningitis, costs per outpatient can be reduced by 85 percent (following model 1) or 84 percent (following model 2) with every extra outpatient that is immunized per volume of vaccine. The variable on outpatient visits is statistically significant; hence its variations are expected to have significant effect(s) on average costs per outpatient day.

Total capital: the variable on capital expenditure (costs) was found to be positively related to cost per patient day equivalent. This result was as expected in economic theory, which stipulates that costs are non-decreasing in factor prices. An increase in the cost of capital items increased hospital costs by 19 percent in model 1 and by 17 percent in model 2. The lesson learnt in all the models is that capital inputs will add more to average inpatient and outpatient costs. Relative to the labor input prices, capital inputs do not add much to average patient day costs.

Total labor: the labor variable had higher coefficients than the capital variable in all models estimated. This meant that labor inputs contributed more to higher average patient costs than capital inputs. For example, in model 1, a Naira increase in labor costs resulted in a 77 percent increase in costs per patient day. A possible explanation for this may be because the hospitals in Anambra and Enugu states use more labor inputs than capital inputs. In other words, hospital operations in these two states are more labor intensive, hence the higher contributions of labor and labor-related inputs to average costs per patient day. Also in the frontier model, the labor input coefficient showed a higher marginal effect (of 0.7929) on average cost per patient day than the capital input coefficient (which was 0.1719). This meant that labor inputs added more to average patient costs than capital inputs. Labor inputs add 57.5 percent more (from model 1) or 62 percent more (from model 2) to variations in cost per patient day. This means that any attempts by government to reduce hospital patient costs must necessarily be more labor-focused if any successful impacts are to be attained. One way of reducing costs may be to employ more auxiliary nurses and more resident (full time) doctors. By so doing, government will be reducing average patient day costs considerably by at least 59 percent.

Utilization: the utilization rate was represented by the occupancy rate. The variable on occupancy rate showed a negative sign in the Ordinary Least Squares regressions (as seen in model 1). However, the Ordinary Least Squares results for this variable (showing a negative sign) were not statistically significant at 1, 5 or 10 percent levels. This is an indication that the utilization variable does not significantly influence average patient cost variations in the short run. However, going by the negative sign of the coefficient, an agreement could be reached about the fact that the higher the utilization of hospitals, the lower the average patient cost.

Beds: hospital size was represented by the beds variable. The beds variable also showed a negative sign. Allocative efficiency would require an overall reduction in the number of hospital beds. The government could reduce the number of beds by gradually downsizing all hospitals or by reducing the size of some general hospitals. The variable was however not statistically significant at all the levels of significance considered in this thesis work (the levels considered were 1, 5 and 10 percent respectively).

Location: the last two variables, location and hospital status, were dummy variables that were meant to represent slope dummies to investigate whether hospital location and status had a significant contribution to average costs per patient day equivalent. The location variable was introduced in models 1 and 2. The location variable was used (in model 2) to explain efficiency/inefficiency in hospitals. It was found that the location variable was not statistically significant at all levels (that is 1, 5 and 10 percent level). This meant that hospital location did not contribute to explaining hospital efficiency. It also did not answer the question as to whether Anambra state hospitals are more efficient than Enugu state hospitals, since the variable was not significant. This result cannot therefore enable a categorical conclusion to be reached as to whether Anambra state hospitals are more efficient than Enugu state hospitals.

Status: the hospital status variable was used as a dummy variable to determine whether a hospital was a general hospital or a cottage hospital. The variable, which was introduced in model 1 and model 2, was found to be statistically not significant in both models. The signs obtained from the two estimation techniques were the same. The model results showed that the status variable was negatively related to cost per patient day equivalent. Like the location dummy, the status variable fails to answer the question as to whether general hospitals are more efficient than cottage hospitals. With this outcome, one could however refute the fact that general hospitals are more efficient than cottage hospitals in Anambra and Enugu states.

5.2 Limitations of the Study

A conscious attempt has been made in a bid to evaluate hospital efficiency in Nigeria (specifically in Anambra and Enugu states) by analyzing hospital cost information. This research is probably limited by the quantity and quality of hospital data used in the analyses. The resources available for this research and the time within which it had to be completed, also served to limit the extent to which the research could be pushed. It is therefore recommended that other researchers take up the challenge provided by this lead to investigate the subject matter. The stochastic frontier process is one approach in an eminent array of methods that could be used in evaluating hospital efficiency. It is therefore recommended that further research be done in this regard using other existing approaches.

It is also necessary to acknowledge the fact that cost efficiency does not mean that the efficient hospitals are delivering the services that they are supposed to deliver. A hospital may exhibit allocative efficiency but may not be technically or socially efficient. Hence such a hospital may not be meeting the dire needs of the greater majority of Nigerians whose health needs are supposed to be met. In this regard, it becomes necessary that consideration be given also to technical efficiency and the societal needs of these seemingly efficient hospitals.

5.3 Policy Recommendations

The first basic recommendation that I want to make is for all levels of government strengthen the database for health services. The federal, state and local governments should ensure that all the necessary machinery is put in place to collect analyze and disseminate health and hospital-related data. This will be very useful, not only for policy planning, but also for research work like this. It was absolutely frustrating at first for me to discover that there was very limited information available in Anambra and Enugu State hospitals to carry out this research. Therefore about 70 percent of the information required had to be sourced primarily.

One way of improving on data collection and analysis is to employ statisticians or health economists in ministries of health and equip them with computers and other software suitable for data analysis. This way, it will be easier and more convenient to get more reliable health and hospital information. This will also help government to plan better and researchers to get better results. Of course, improved data collection can only be possible at higher costs to the government. International organisations could be approached to sponsor projects on data collection. An alternative way to look at the costs involved is to consider such costs as investment costs. The rewards of such investment can be reaped in terms of better-informed policy (through research) in future.

In order to reduce hospital costs, and consequently costs to governments, it may also be necessary to employ more auxiliary nurses, relative to registered nurses. By so doing, personnel costs will be relatively reduced.

It may also be necessary to have more resident doctors, as opposed to part time or contract doctors. This is because it costs much more to employ part time (or contract) doctors than it is to employ resident (full time) doctors. This is in a bid to reduce personnel costs as well.

Attempts should also be made to locate hospitals in relatively urban areas in order to reap the fruits of better-organised and cheaper factor markets that exist in these areas. Most personnel are reluctant to work in rural and usually remote places, and so the government is forced to provide incentives to encourage work in rural areas. Such incentives are usually in the form of higher salaries and allowances. The question may be asked as to whether this means that hospitals will not be built (established) in rural/remote places.

Far from it, the suggestion is that the government should help to develop these rural areas by providing necessary infrastructure that will attract urban dwellers and therefore also attract potential hospital personnel. In the interim however, mobile clinics and ambulatory services could be provided to these rural communities, especially in Enugu state where a majority of the people live in rural areas.

Another option to deal with the problem of rural areas is to provide more mobile clinics and ambulatory services to these areas, instead of establishing hospitals where the utilization rates are very low (and which the established hospitals will merely be incurring costs more than treating patients). By providing mobile clinics and ambulatory services rather than hospitals, some costs can be saved which could be channeled to alternative health needs.

Governments in Anambra and Enugu states, and indeed the federal government should endeavor to establish hospitals in areas where such hospitals are actually necessary. Some of the times, hospitals have been established in certain localities, more because of political expediency than for health care delivery. In such a situation, the government continues to incur costs, which could otherwise have been avoided. Some of the hospitals visited for this research almost looked like "abandoned properties". There were hardly any beds or drugs in these hospitals, yet they were either branded general hospitals or cottage hospitals.

Conclusion

Data for this research were collected from two types of government hospitals; general hospitals and cottage hospitals. The hospitals considered are located in Anambra and Enugu states. 30 general hospitals and 10 cottage hospitals combined are evaluated in this research.

The various inputs employed in these hospitals were grouped into labor and capital inputs. Labor inputs are human capital and include various staff categories such as, doctors (part time and resident), registered nurses, auxiliary nurses (found in some hospitals), paramedics (including laboratory technicians and pharmacists), administrative staff, cleaners and drivers. The capital items include cost of maintenance of buildings and vehicles, electricity, water, drugs and cost of linen and sheets for hospital beds.

The costs were grouped together as hospitals' total operating expenditure. Two broad categories of hospital output were considered. Inpatient days and outpatient visits were the only two outputs considered because some other hospital output like public education, were difficult to quantify. Average costs per patient day equivalent were estimated from hospitals' total operating expenditure and these (and all other inputs and output variables) were transformed into logs to represent marginal changes. The results from the estimated models showed that Nigerian hospitals were not overcapitalized, as purported at the beginning of this research. This was seen by the coefficient for capital (marginal cost of capital), which was less than 1 in all models estimated. The ratio of factor intensity (3.98) calculated from model 1 showed that Nigerian hospitals adopted a labor-intensive method of producing hospital inpatient and outpatient outputs.

The majority of hospitals fell below the mean allocative efficiency level. The results showed that only 30 percent of the hospitals studied are efficient, while the remaining 70 percent are not efficient. Anambra state hospitals made up 25 percent of the efficient hospitals while Enugu state hospitals made up 75 percent. Also, 8.3 percent of cottage hospitals and 16.7 percent of general hospitals in Anambra state were efficient while 41 percent of cottage hospitals and 33 percent of general hospitals in Enugu state were efficient. Of this number, 6 cottage hospitals and 6 general hospitals, from both states were efficient.

Policy recommendations about hospitals have been made from the results obtained in this research. It is hoped that someone in the appropriate place would read this and apply some useful recommendations at the right time, for the betterment of hospital operations in Nigeria.

Appendices

A) The table below provides the names of the hospitals visited and evaluated, according to state and according to categories (whether general or cottage hospital).

Table 3.1: Hospitals visited and evaluated

Serial number	Hospital name	State	Category
1	General hospital Awka	Anambra	General hospital
2	General hospital Umuleri	‘’	‘’
3	General hospital Onitsha	‘’	‘’
4	General hospital Mbaukwu	‘’	‘’
5	General hospital Amanuke	‘’	‘’
6	General hospital Enugwu-ukwu	‘’	‘’
7	General hospital Nimo	‘’	‘’
8	General hospital Ifitedunu	‘’	‘’
9	General hospital Nando	‘’	‘’
10	General hospital Ogidi	‘’	‘’
11	General hospital Ossomala	‘’	‘’
12	General hospital Oraifite	‘’	‘’
13	General hospital nnokwa	‘’	‘’
14	General hospital Nnobi	‘’	‘’
15	General hospital Ichi	‘’	‘’
16	General hospital Ukpor	‘’	‘’
17	General hospital Okija	‘’	‘’
18	General hospital Agulu	‘’	‘’
19	General hospital Aguluzoigbo	‘’	‘’
20	General hospital Ekwulobia	‘’	‘’
21	General hospital Umuchu	‘’	‘’
22	General hospital Orumba	‘’	‘’
23	General hospital Awgu	Enugu	‘’
24	General hospital Enugu Ezike	‘’	‘’
25	General hospital Ikem	‘’	‘’
26	Parklane general hospital Enugu	‘’	‘’
27	General hospital Agbani	‘’	‘’
28	General hospital Nsukka	‘’	‘’
29	General hospital Oji River	‘’	‘’
30	General hospital Udi	‘’	‘’
31	Amechi cottage hospital Amechi	‘’	Cottage hospital
32	Cottage hospital, Obeleagu Umana	‘’	‘’

33	Cottage hospital Aku	‘’	‘’
34	Cottage hospital Itchi	‘’	‘’
35	Cottage hospital Obimo	‘’	‘’
36	Cottage hospital obollo Afor	‘’	‘’
37	Cottage hospital ukpabi Nimbo	‘’	‘’
38	Cottage hospital Ubahu	‘’	‘’
39	Cottage hospital Umunze	Anambra	‘’
40	Cottage hospital Enugwu-Abor-Ufoma	‘’	‘’

B) In defining the Cobb-Douglas technology, Varian (1992; 4) presents the following;

Let a be a parameter such that $0 < a < 1$

$Y = \{(y, -x1, -x2)$ in $R3: y \le x1^{a}, x2^{1-a}\}$

$V(y) = \{(x1, x2)$ in $R2+: y \le x1^{a}, x2^{1-a}\}$

$Q(y) = \{(x1, x2)$ in $R2+: y \le x1^{a}, x2^{1-a}\}$

$Y(z) = \{(y, -x1, -x2)$ in $R3: y \le x1^{a}, x2^{1-a}, x2 = z\}$

$T(y, x1, x2) = y - x1^{a}, x2^{1-a}$

$F(x1, x2) = x1^{a} x2^{1-a}$

The Leontief technology is defined in the following manner.

$Y = \{(y, -x1, -x2)$ in $R3: y \le \min(ax1, bx2)\}$

$V(y) = \{(x1, x2)$ in $R2+: y \le \min(ax1, bx2)\}$

$Q(y) = \{(x1, x2)$ in $R2+: y \le \min(ax1, bx2)\}$

$T(y) = y - \min(ax1, bx2)$

$f(x1, x2) = \min(ax1, bx2)$

The above two technologies basically provide information on the Constant Elasticity of Substitution technology.

C) **<u>The Frontier Programme</u>**

The Frontier programme (version 4.1) is the software that is used for estimation of the stochastic frontier model in this research work. Frontier 4.1 is a computer programme for Stochastic Frontier Production and Cost Function Estimation. It was developed by Tim

Coelli, of the Centre for Efficiency and Productivity Analysis, in the University of New England, Australia.

The programme follows a three-step procedure in estimating the maximum likelihood estimates of the parameters of a stochastic frontier production/cost function, unless starting values are specified. These three steps are:

1. Ordinary Least Squares (OLS) estimates of the function are obtained.
2. A two-phase grid search of γ is conducted, with the β parameters (except the constant) set to the OLS values. Any other parameters (for example, μ, η or δ's) are set to zero in this grid search.
3. The values selected in the grid search are used as starting values in an iterative procedure to obtain the final maximum likelihood estimates, using the Davidon-Fletcher-Powel Quasi Newton method.

The grid search is conducted across the parameter space of γ. Values of γ are considered from 0.1 to 0.9 in increments of size 0.1. The first order partial derivatives of the log-likelihood functions are obtained in the process. Many of the gradient methods used to obtain maximum likelihood estimates, such as the Newton-Raphson method, require the matrix of second partial derivatives to be calculated. To avoid this, the Qusi-Newton methods are used, because they only require the vector of first partial derivatives to be derived. The Davidon-Fletcher-Powell Quasi-Newton method is selected because it appears to have been used successfully in a wide range of econometric applications and was also recommended by Pitt and Lee (1981). For more on the Frontier programme, see CEPA Working Paper 96/07 by Tim Coelli.

D) QUESTIONNAIRE

1. What type of hospital is this? (tick one)

a) Federal: ---------------

b) State: -----------------

2. How many outpatients visit this hospital (on average) in a month? ------------*(Outpatient visits are the number of consultations a patient has with a staff member, e.g. Doctor, nurse, paramedic)*

3. How many inpatients are admitted in this hospital (on average) in a month? ------------

(*Inpatients are those patients who spend at least a night in hospital*)

Information on capital

4. How much does this hospital spend per month on the following items?

a) Building maintenance: --------------------------

b) Vehicle maintenance: ---------------------------

c) Electricity: --

d) Water: --

e) Beds maintenance: ------------------------------

f) Equipment maintenance: -----------------------

g) Drugs: --

5. How many beds do you have in this hospital? -----------------

Information on labour

6. How many of the following staff is employed in this hospital?

	Full time	part time
a) Specialists (doctors):	-------------------------	-----------------------
b) Registered nurses:	-------------------------	-----------------------
c) Auxiliary nurses:	-------------------------	-----------------------
d) Paramedical staff:	-------------------------	-----------------------
e) Cleaners:	-------------------------	-----------------------
f) Administrative staff:	-------------------------	-----------------------

7. Please state the average number of working hours per day for these staff categories.

	Full time	part time
a) Specialists (doctors):	------------------------	---------------------
b) Registered nurses:	------------------------	---------------------
c) Auxiliary nurses:	------------------------	---------------------
d) Paramedical staff:	------------------------	---------------------
e) Cleaners:	------------------------	---------------------
f) Administrative staff:	------------------------	---------------------

(Full time staff are those who are permanent employees of this hospital while part time staff are those who visit this hospital)

8. How much money is spent on staff salaries per month? ---------------------

9. What is the total operating expenditure for this hospital per month (***including recurrent costs and cost of salaries for last year 2000***)?

Interviewed by: -------------------------------- Date: ----------------------

E) The results from the robust regression estimation of model 1

```
rreg  lcpde loutpat lnpatdys llab lcap occ lbeds Hosptype cogh

   Huber iteration 1:  maximum difference in weights = .22009788
   Huber iteration 2:  maximum difference in weights = .03897614
Biweight iteration 3:  maximum difference in weights = .14513119
Biweight iteration 4:  maximum difference in weights = .00808803

Robust regression estimates                          Number of obs =      40
                                                     F(  8,     31) =  228.20
                                                     Prob > F       =  0.0000
```

lcpde	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
loutpat	-.8594308	.022998	-37.370	0.000	-.9063354	-.8125262
lnpatdys	-.0491147	.3469377	-0.142	0.888	-.7566988	.6584694
llab	.7756837	.0492148	15.761	0.000	.6753095	.8760579
lcap	.1906383	.0253411	7.523	0.000	.1389548	.2423217
occ	-.267416	5.834637	-0.046	0.964	-12.16724	11.63241
lbeds	.0057598	.3819448	0.015	0.988	-.7732218	.7847414
Hosptype	-.0191025	.0359917	-0.531	0.599	-.092508	.054303
cogh	-.0826055	.0920725	-0.897	0.377	-.2703887	.1051776
_cons	.3364613	.6303214	0.534	0.597	-.9490876	1.62201

Below is another estimation of model 1 without the hospital status variable (cogh). This variable is noted to have high correlations with some of the other independent variable, hence its elimination from the original estimation of model 1. The removal of the status variable however, does not affect the model results significantly. It can be said therefore that its inclusion/exclusion does not matter in model 1. Because of this, the results of model 1 presented in chapter 4 include the hospital status variable (although this is not significant).

```
. reg  lcpde loutpat lnpatdys llab lcap occ lbeds Hosptype
```

Source	SS	df	MS		
				Number of obs =	40
				F(7, 32) =	303.46
Model	15.8659073	7	2.26655819	Prob > F =	0.0000
Residual	.239013099	32	.007469159	R-squared =	0.9852
				Adj R-squared =	0.9819
Total	16.1049204	39	.412946678	Root MSE =	.08642

lcpde	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
loutpat	-.8565837	.0212439	-40.321	0.000	-.899856	-.8133113
lnpatdys	-.0294166	.3204791	-0.092	0.927	-.6822112	.623378
llab	.7772703	.0446105	17.423	0.000	.6864017	.8681389
lcap	.1896253	.0232063	8.171	0.000	.1423557	.2368949
occ	-.9689511	5.378736	-0.180	0.858	-11.92508	9.987176
lbeds	-.0562565	.3502112	-0.161	0.873	-.7696135	.6571004
Hosptype	-.0267587	.0323675	-0.827	0.415	-.0926892	.0391718
_cons	.4247232	.5818865	0.730	0.471	-.7605409	1.609987

F) Full Model Output (Stochastic Frontier Model)

```
Output from the program FRONTIER (Version 4.1c)

instruction file = terminal
data file =         a:div2.txt

Tech. Eff. Effects Frontier (see B&C 1993)
The model is a cost function
The dependent variable is logged

the ols estimates are :

                 coefficient      standard-error    t-ratio

  beta 0          0.20291050E+00  0.23204919E+00  0.87442880E+00
  beta 1         -0.85465587E+00  0.19789364E-01 -0.43187636E+02
  beta 2         -0.88216220E-01  0.24526784E-01 -0.35967299E+01
  beta 3          0.19072270E+00  0.20518042E-01  0.92953654E+01
  beta 4          0.76987056E+00  0.38994608E-01  0.19743001E+02
  sigma-squared   0.13169309E-02

log likelihood function =    0.78562114E+02

the estimates after the grid search were :
```

```
 beta 0          0.16876526E+00
 beta 1         -0.85465587E+00
 beta 2         -0.88216220E-01
 beta 3          0.19072270E+00
 beta 4          0.76987056E+00
 delta 1         0.00000000E+00
 delta 2         0.00000000E+00
 sigma-squared   0.23182121E-02
 gamma           0.79000000E+00

iteration =     0  func evals =      19  llf =  0.78953019E+02
    0.16876526E+00-0.85465587E+00-0.88216220E-01 0.19072270E+00 0.76987056E+00
    0.00000000E+00 0.00000000E+00 0.23182121E-02 0.79000000E+00
gradient step
iteration =     5  func evals =      43  llf =  0.79987362E+02
    0.16574188E+00-0.84886594E+00-0.84845865E-01 0.17498268E+00 0.78207464E+00
   -0.40362951E-01-0.93414576E-02 0.26819830E-02 0.79070554E+00
iteration =    10  func evals =      65  llf =  0.80300512E+02
    0.73754803E-01-0.84543776E+00-0.92059543E-01 0.17365839E+00 0.79890136E+00
   -0.62399368E-01-0.94507323E-02 0.32052118E-02 0.84851726E+00
iteration =    15  func evals =     170  llf =  0.80428942E+02
    0.10766019E+00-0.84483613E+00-0.82953327E-01 0.17096429E+00 0.79353629E+00
   -0.10978927E+00-0.34121307E-01 0.35618250E-02 0.83044981E+00
iteration =    20  func evals =     272  llf =  0.80432832E+02
    0.10941084E+00-0.84577986E+00-0.82734958E-01 0.17189301E+00 0.79286497E+00
   -0.11199144E+00-0.32583136E-01 0.34322266E-02 0.82035807E+00
iteration =    21  func evals =     275  llf =  0.80432832E+02
    0.10941084E+00-0.84577986E+00-0.82734958E-01 0.17189301E+00 0.79286497E+00
   -0.11199144E+00-0.32583136E-01 0.34322266E-02 0.82035807E+00

the final mle estimates are :

                   coefficient     standard-error    t-ratio

 beta 0            0.10941084E+00  0.21953336E+00  0.49837911E+00
 beta 1           -0.84577986E+00  0.18213521E-01 -0.46436921E+02
 beta 2           -0.82734958E-01  0.28277862E-01 -0.29257855E+01
 beta 3            0.17189301E+00  0.20109365E-01  0.85479084E+01
 beta 4            0.79286497E+00  0.39603959E-01  0.20019841E+02
 delta 1          -0.11199144E+00  0.11256327E+00 -0.99491990E+00
 delta 2          -0.32583136E-01  0.88276787E-01 -0.36910197E+00
```

```
  sigma-squared  0.34322266E-02  0.22139109E-02  0.15503003E+01
  gamma          0.82035807E+00  0.16306564E+00  0.50308457E+01

log likelihood function =   0.80432832E+02

LR test of the one-sided error =   0.37414354E+01
with number of restrictions = 3
[note that this statistic has a mixed chi-square distribution]

number of iterations =     21

(maximum number of iterations set at :   100)

number of cross-sections =     40

number of time periods =      1

total number of observations =     40

thus there are:      0  obsns not in the panel

covariance matrix :

  0.48194895E-01   0.27042006E-03   0.44548302E-02  -0.17663481E-02  -0.80055133E-
02
 -0.42197718E-02 -0.38855115E-02  0.64125386E-05 -0.40122065E-02
  0.27042006E-03   0.33173236E-03  -0.27168487E-04  -0.12698617E-03  -0.71300080E-
04
 -0.13011365E-03 -0.47998191E-03  0.15621255E-04  0.12373485E-02
  0.44548302E-02  -0.27168487E-04   0.79963748E-03  -0.16657895E-03  -0.81745886E-
03
 -0.13595136E-02 -0.12412300E-02  0.15247114E-04  0.35938850E-04
 -0.17663481E-02  -0.12698617E-03  -0.16657895E-03   0.40438658E-03   0.54513459E-
04
  0.63327390E-03  0.44569593E-03 -0.14750291E-04 -0.97765741E-03
 -0.80055133E-02  -0.71300080E-04  -0.81745886E-03   0.54513459E-04   0.15684736E-
02
  0.47957250E-03  0.80073986E-03 -0.64221141E-06  0.81139921E-03
 -0.42197718E-02  -0.13011365E-03  -0.13595136E-02   0.63327390E-03   0.47957250E-
03
  0.12670491E-01  0.51819978E-02 -0.83273655E-04 -0.26859350E-03
```

-0.38855115E-02 -0.47998191E-03 -0.12412300E-02 0.44569593E-03 0.80073986E-03

0.51819978E-02 0.77927910E-02 -0.14700447E-03 -0.71439464E-02

0.64125386E-05 0.15621255E-04 0.15247114E-04 -0.14750291E-04 -0.64221141E-06

-0.83273655E-04 -0.14700447E-03 0.49014015E-05 0.31062490E-03

-0.40122065E-02 0.12373485E-02 0.35938850E-04 -0.97765741E-03 0.81139921E-03

-0.26859350E-03 -0.71439464E-02 0.31062490E-03 0.26590403E-01

cost efficiency estimates :

firm	year	eff.-est.
1	1	0.10300707E+01
2	1	0.10232579E+01
3	1	0.10384698E+01
4	1	0.10335954E+01
5	1	0.10143466E+01
6	1	0.10100190E+01
7	1	0.10185406E+01
8	1	0.10215418E+01
9	1	0.10092237E+01
10	1	0.10253822E+01
11	1	0.10130989E+01
12	1	0.10215995E+01
13	1	0.10959121E+01
14	1	0.10478416E+01
15	1	0.10117578E+01
16	1	0.10160559E+01
17	1	0.10199391E+01
18	1	0.10096898E+01
19	1	0.10091407E+01
20	1	0.10092979E+01
21	1	0.10075387E+01
22	1	0.10090684E+01
23	1	0.10093180E+01
24	1	0.10203747E+01
25	1	0.10192762E+01
26	1	0.10193015E+01

27	1	0.10156824E+01
28	1	0.10167643E+01
29	1	0.10122487E+01
30	1	0.10190689E+01
31	1	0.10253270E+01
32	1	0.10740732E+01
33	1	0.11036056E+01
34	1	0.10278061E+01
35	1	0.10185250E+01
36	1	0.10233732E+01
37	1	0.10281310E+01
38	1	0.10202449E+01
39	1	0.10378004E+01
40	1	0.10148472E+01

mean efficiency = 0.10250289E+01

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