NEW MODEL FOR AVIATION HULL INSURANCE RATING

APPLYING CREDIBILITY THEORY

by

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TO MY PARENTS

A great Father I wish to resemble

A wonderful mother with endless power

to donate love and care.

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ABBREVIATIONS

AIOA	Aviation insurance offices association
AMI	Airline mutual insurance
BCAR	British civil airworthiness
FAR	The federal aviation regulation
FT	Fleet
IATA	International air traffic association
ICAN	International commission for air navigation
ICAO	The international civil aviation organisation
M.p.h	Miles per hour
IBNR	Incurred but not reported claims
T/L	Total loss.

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ABSTRACT

The prime concern of actuaries has been always life assurance. Nowadays, their active role is well recognised in non-life business and has gained more importance. Nevertheless, they have given aviation insurance the least of their attention, although the actuarial approach is highly needed. This could be due to the large number of different factors that influence this class of insurance, such as the difficulties of collecting the data, the revolutionary changes in the aviation field and the number of aircraft and the risks involved.

This research on aviation insurance aims at achieving premium rates for airline hull insurance based on scientific approach to and statistical analysis of the available data.

Technical developments of aircraft, international aviation associations and aviation risks represent the introduction to this research.

The aviation insurance policy, the factors affecting the premium rates, the general aspects and the model used to calculate the hull rates in London market will be studied as well.

This study indicates that the data of each airline is not by itself large enough to be used to calculate its premium rate. Therefore the rate for each airline is readjusted by the market's final result.

Credibility theory will be introduced as a statistical method for rating.

Its basic concept is similar to that used in the market, where collateral data is needed to adjust the calculated rate based on the data available for a particular risk.

The developments in credibility theory will be studied and introduced for application in aviation insurance premium rating.

CHAPTER ONE

INTRODUCTION

The first decade of the twentieth century witnessed the birth of aviation and the successive years marked its rapid and dramatic development which included aircraft technicalities, aviation associations, international agreements, and the airlines' financial systems.

1.1 Aircraft Technical Development:

Historically hopes and trials for aviation had started many years before the Wright brothers flew the first 'heavier than air' powered aircraft.

Almost fifteen years later, the engine was developed to an acceptable technical and commercial level, and the aircraft was accepted as a means of transport.

During these fifteen years, many aircraft factories were established e.g. Boeing in U.S.A and Rolls Royce in U.K.

In 1919, following the first World War, the need for aircraft for fighting and transport, triggered rapid developments.

The development took place in two main stages:

1.1.1 Aircraft Engine:

Many different engines were tried including the aircooled radial engine, Junker's engine and the Bristol Jupiter engine.

Up to 1939, the speed record figures was 469.142 m.p.h (German Messerschmitt Bf109R) for the maximum ceiling the recorded figure was 56,046ft (Italian Caproni I6I) and 7,158m for distance (British Vickers Wellesley)[1].

The Turbo-props Engine:

In the early 1950s, the Turbo-prop engine was fitted to the British Aerospace 1-11 to be used as a short/medium range aircraft with cruising speed 541 m.p.h at 21,000 ft and 2,500m maximum fuel and reserves. Within the next few years the Turbo-prop engine was so successful, that other major companies such as Antonov Bureau, Max Holstein and others began to use them.

1960 the Arrival Of Jet Power:

In the late 1950's, while the Americans were concentrating on developing the Piston four engines aircraft and improving the turbo prop engine, English aviation leaders were concentrating on developing the jet engine, which was designed at the end of the second world war.

One of the first turbo jet aircraft was the Aerospacial Caravel, Which flew in 1960 as a short/medium range transport plane and in less than two years American aviation changed to jet power starting a new generation of jet engine aircraft i,e B.707.

(1) For further reading see, G.Smith (1985) and D.Mondey 1980

Meanwhile Focker and Lockheed were manufacturing the F-28 which started to fly in 1969, and the L10-11 which started in 1972.

In 1979, English and French aviation introduced the faster super sonic aircraft called Concorde with cruising speed 1,354 m.p.h and maximum ceiling 60,000ft.

The Introduction Of The Jumbo Jets:

In 1969, a new generation of jet power was launched when Boeing flew the first wide-body jumbo jet B747, with maximum capacity 452 passengers for 5,988m fuel and reserves.

Two years later, Douglas launched its first wide-body aircraft DC-10 with 500 seats.

In Europe, France and Germany established together the airbus industry and produced the AB-300 in 1970, followed by the AB-310 in 1983 and AB-320 in 1986. (Bonn 1987)

More recently in June 1987, the airbus industry launched its new production programme for the long range AB-340, to be in service in 1992, and the medium/long range AB-330 to start flying in 1993. (Mondey 1983)

1.1.2. Aircraft Safety:

Systematic safety is defined as the system that observes and devolves failure, which might happen in any part of the aircraft while the engine is in motion.

Systematic safety was first introduced in 1940-1950. Most of the early systems were comparatively simple in design and self-contained. The failure of one part was not reported to other parts to enable them to adjust to its effect and consequently enable a journey to be safely completed.

The arrival of the turbine engine, in the early 1960s, had profound effects on systematic safety, mainly in respect of the automatic landing control and the fuel system. These systems were much more complicated. Also, there was a considerable increase in the number of interfaces and cross connections between systems and the effect of these on the aircraft.

For those early systems, the evaluation of success was based on their ability to satisfy the Airworthiness requirements such as, British Civil Airworthiness {BCAR} and Federal Civil Airworthiness requirements in the U.S.A.

However, the experience proved that these earlier requirements were too primitive and insufficient to secure safety. Therefore, it became necessary to have some basic, adequate and detailed objective requirements related to the level of safety. These requirements could be applied to any system or function.

In mid-1980, the Federal Aviation Regulation {FAR-25} in the U.S.A, and the Joint Airworthiness Requirement in Europe followed that new approach. Their objective requirements were supported when necessary by supplementary material relevant to particular types of systems. (Lloyd at al`1982)

The development of the aircraft engines from piston to turbo-prop and finally to turbo-jet, as above mentioned, was very fast, making remarkable changes in aircraft speed and maximum ceiling. Also, systematic safety systems followed to secure these developments.

1.2 Aviation Association and International Agreement:

Many questions were raised on the international level relating to aviation and its development, the aerospace rights of countries had to be defined and preserved and the responsibilities of airlines had to be clearly spelt out. These questions and problems were far beyond the ability of any individual government or airline to solve.

The international community have agreed to handle these matters through associations and international agreements.

1.2.1 The International Air Transport Association :

In 1919, with commercial air transport in its early stages of development, the International Air transport association (IATA) was founded by an agreement of six European airlines.

The association was formed with the aim of cooperation in the organisation of international aerial traffic and for the mutual interest of the international community.

Since the beginning, IATA was known as a free association of the interested companies, and no attempts were to be made to establish monopolies or to divide continents into spheres of influence. (Brancker 1977)

In 1939, the association opened its membership to other world airlines, and in 1947, the association provided for a new category of non-scheduled operators. Articles of membership are shown in Appendix 1.

IATA Activities:

IATA was faced with a large number of problems that needed to be solved. These problems have increased and become more widespread with the development of aviation. IATA continued to develop new methods and ways to tackle these problems and to set up bases for the various activities and fields such as: technical, financial, legal, traffic control, statistics and research activities. IATA publishes a yearly statistical periodical which includes a list of the IATA members, number of aircraft, flying hours, and number of passengers for each member.

In the early 1970s, IATA began to discuss insurance policies and the premium rates that were charged by insurers to cover the fleets. In 1985, IATA went further by resolving to launch a captive insurance company named Airline Mutual Insurance (AMI) (Airclaim 1987). The company started to operate in January 1987, with a maximum capacity of 5% from the memberships in hull and liability coverage and an aim to increase that share gradually. In the meantime, the association invited non member fleets to join it.

The idea behind AMI was to provide an extra capacity in the insurance market, to increase competition and to put pressure on the market to reduce premium rates.

The launch of AMI was timely because of the very good accident record of 1986, after which airlines asked underwriters to reduce premium rates, a request that was responded to favourably in 1987. Some of the airlines have already insured part of their fleet through the IATA company, while others are still considering the matter carefully.

1.2.2 The International Civil Aviation Organisation:

In 1919, nineteen European nations formed the first international association called " International Commission for Air Navigation " known as " ICAN ".

The association aimed at dealing with international flight problems but its sphere of activity was limited because air transportation was still in its early stages of development in Europe.

In 1944, the United States invited fifty five nations for a conference to be held in Chicago to discuss aviation problems.

The conference, attended by fifty two countries took important resolutions regarding a convention tabulating the privileges and restrictions of all contracting states arising from the adoption of international standards. Also, it recommended practices regulating air navigation, installation of navigation facilities by member states and the reduction of customs and immigration formalities.

A main aim of the conference was to establish "The right to any aircraft of any signatory power to fly over or to land for technical reasons in the territory of any other signatory state, also to forbid any aircraft to be registered in more than one signatory state".

The convention approved the establishment of a temporary organisation namely {PICAO} to start applying the convention articles until twenty six states had ratified the convention.

By 1947, the convention was ratified and a permanent organisation named ICAO came into existence with the following aims and objectives " (a) To ensure the safe and orderly growth of international civil aviation throughout the world; (b) to encourage the arts of aircraft design and operation for peaceful purposes; (c) to encourage the development of airways, airports, and air navigation facilities for international civil aviation; (d) to meet the needs of the peoples of the world for safe, regular, efficient and economical air transport; (e) to prevent economic waste caused by unreasonable competition; (f) to ensure that the rights of contracting states are fully respected and that every contracting state has a fair opportunity to operate international airlines; (g) to avoid discrimination between contracting states; (h) to promote safety of flight international air navigation (i) to promote generally the development of all aspects of international civil aeronautics". (Memorandum on ICAO 1987)

1.3 Airline Financial System:

1.3.1 Banking:

At the beginning of commercial flying, airlines were dependent financially on bank loans, since the aircraft cost and their operation's expenditure were high.

In the mid 1970s, the banks began a new involvement in aviation, when some airlines sold some of their aircraft to banks and leased them back. More recently, the airlines issued new aircraft orders through banks. The new system was applied and welcomed by both the airlines and the banks. The banks looked at it as a new profitable investment field and the airlines have saved the high loan interest and taxation which the aircraft owner used to bear .

This system might appear simple for the airlines, but for banks it was not the same, as it needed a complete understanding of all aspects of aviation, and the risk protection that had to be arranged.

In 1987, British Airways started selling its capital in the shape of public shares of which banks have taken a major part. Also, in 1989 Air Canada was privatised.

Thus, these trends have demonstrated the banks' increasing interest in aviation, especially in the last ten years.

1.3.2 Aviation insurance:

In 1911, Lloyd's of London issued the first policy to cover crash and third party legal liability. In 1912, a group of non-marine syndicates in Lloyd's agreed to share a part in aviation insurance cover. The small number of aircraft and relatively large losses persuaded the syndicate to withdraw from any further underwriting. In 1914, the first world war put an end to the interest in aviation insurance. After the war, many companies in the U.S.A and in the United Kingdom announced a comprehensive insurance programme for different aviation risks but once again the lack of experience and the bad losses curbed this programme .

After the second world war, a large number of fighter aircraft were moved to civilian flying. At the same time, the development in systematic safety and aircraft engines stimulated fast improvement in aviation insurance. Many insurance companies mainly in the U.S.A, United Kingdom, Germany, and France expanded considerably in size and volume increasing their interest in the aviation field.

1.4 Purpose of the study:

The purpose of this study is to calculate the pure premium rate for aviation hull insurance. This will involve investigating aviation risks, aviation insurance policy, and the insurance market, and choosing an appropriate statistical method to calculate the pure premium for different airlines.

1.5 Outline of the rest of thesis:

Chapter 2 provides an introduction to aviation insurance rating, aviation risks and the types of insurance policy.

Chapter 3 introduces American credibility theory, its basics and developments.

Chapter 4 deals with European credibility theory, introducing the Bayesian theory, its approach to credibility theory and the further development of the theory which led to the Empirical Bayes credibility theory.

Chapter 5 provides an introduction to the data sample, including the classification of the data into different groups and the subsequent analysis and fitting of the data .

Chapter 6 applies Empirical Bayes theory to the sample data from chapter five.

Finally, chapter 7 includes the conclusion and suggestions for further research.

1.6 SUMMARY:

The development in aircraft techniques, aviation associations international agreements, and airlines' financial systems which began early in this century creates a common need to provide insurance cover against the risks involved.

In aircraft techniques, the developments in engine from piston to turbo-prob and finally turbo-jet has led to a rapid improvement in aircraft range, size, and value. These developments have brought with them different types of risk.

The increase in the banking interest in aviation has developed rapidly.

On the aviation insurance side, owing to the high risks there were heavy losses in the early stages.

However the development of aviation, the increase in number of aircraft and the development in aircraft systematic safety have brought aviation insurance into being and affected its course of development.

CHAPTER TWO

Aviation Insurance Cover

2.1 Introduction:

Dreams to develop the manufacturing of aircraft to make them bigger, faster and fly higher have edged into reality. Each progress and development in this respect necessitated solutions for new problems, mainly regarding aircraft safety. So, systematic safety developments have taken place to mitigate the effect of risks surrounding the aircraft and to secure an acceptable level of its operation.

So far, aviation experience has proved that, despite the efforts to prevent or avoid risks, aircraft accidents still happen, so risk transfer through insurance is essential, and risk evaluation is required. This evaluation requires the careful definition of the risk and its assessment.

2.2 Risk Definition:

It is important to pay great attention to risk definition, such as uncertainty of the outcome, the possibility of loss and the chance of loss.

Until today, there is no universal definition of risk which can be applied for all different insurance branches.

In aviation insurance, risk may be defined as " Any situation arising out of an organisation's activities, which can give rise to loss, injury, damage, liability or impairment of growth in social, moral and financial terms." (Muckleston 1977)

However the following risk concepts should be fulfiled in the risk definition:

(A) The definition should be concerned with the possibility and the chance of loss arising after all the necessary measures taken to avoid the damage.

(B) It should define risk as an objective probability, that the actual occurrence of an event will differ significantly from the expected one.

(C) It should indicate the outcome in financial and non-financial terms.

In the above risk definition, concept (C) has been fully covered but for concepts (A) and (B) the definition did not fulfil these concepts.

Identifying the risks in insurance is prerequisite. It represents the first step which is followed by classifying them into groups. This enables the insurer to estimate the size of each risk and the chance of loss and to measure the equivalent pure premium to cover the risks.

In aviation insurance, the term "Aviation risks" could include War risks, Manufacturing risks and aeroplane operation risks. Accordingly, Aviation risks ought to be classified into groups and the insurance policy is issued to cover a specific group of risks.

2.3 Aircraft Types And Their Operation:

The study of aviation hull risks requires a classification into aircraft types, type of use, aeroplane operation.

2.3.1 Aircraft Types:

There are two types of aircraft (a): Lighter-than-air craft (b) : Heavier-than-air craft.

In general, the term lighter-than-air craft includes all types of aircraft that depend upon the buoyancy produced by the gases with which they are inflated, the kite, balloon and airship are examples of lighter-than-air craft.

To define Heavier-than-air craft, it may be advisable to explain the natural forces surrounding the aircraft body:

(a) Gravity: the name given to the downward pull, which forces all bodies towards the centre of the earth.

(b) Lift: is an upward force, which counteracts the pull of gravity produced by the action of air passing around an aircraft section such as the aeroplane wing.

(c) Drag: is the backward force, produced by the resistance of the air against the plane.

(d) Thrust: is the forward force produced by means of power to overcome the force of drag. (El Din 1978)

The action of the four forces in relation to flight may be summarised as follows; aircraft engines have to develop a sufficient thrust to exceed the drag, meanwhile, the aircraft wing must generate enough lift to exceed the force of gravity, so that the aircraft can fly.

In general, whenever the aircraft is designed to deal with these four forces it is named a heavier—than—air craft, such as the helicopter, seaplane, flying boat and aeroplane.

2.3.2 Categorisation By Usage:

According to this categorisation aircraft are classified as follows:

(a) Military aircraft, which include fighters and all military transport, passenger, and training aircraft; and

(b) Civilian aircraft, which are used for different purposes like agriculture, training, air taxi and airline scheduled services.

2.3.3 Aeroplane Operation:

Airplanes operations are usually classified as follows;

(A) ground operation, that includes aeroplanes in hangars, parked in the open and taxiing.

(B) air operation, that includes take-off, landing and during flight.

Table (2.1) shows number of classified accidents according to aeroplane operation.

Table (2.1)

Year	Number of accidents	take-off & landing	during flying	accidents on ground
1983	63	45	11	7
1984	68	35	16	17
1985	65	36	16	17
1986	56	36	11	9
1987	71	50	12	9
1988	54	43	11	-
1989	62	39	15	8

From the table can be seen the concentration of accidents during the take-off and landing [1].

The classification according to the aircraft types and their operation shows the different types and their diversity of usage.

This research is concerned only with the heavier-than-air planes, used in scheduled services, and the risk involved in their operation.

2.4 Aviation Risks:

According to the above points, aviation risks will be classified as follows;

(1) Some of the accidents were caused by engine failure or other reasons during flight, forced the aeroplane to land. Where the crash was during landing, it has been classified under landing.

```
                              |- Bad weather
                              |
              |- Risk on      |- Runway risks
              |  the ground   |
              |               |
              |               |-Accumulation of
              |               | risks .
              |
              |                              |-Stalling
              |                              | speed
Aviation risks-|              |-Airplanes    |-Airplanes
              |               | hazards -----| equipment
              |               |              | failure
              |               |              |
              |               |              |-Type of
              |               |              | engine
              |               |              |-Airplanes
              |               |              construction
              |- Air          |
                 operation    |
                 risks----    |-Human error
                              |
                                               |-Icing
                              |-Weather and    |
                              | geographical   |-Bad
                              | area ---->     | weather
                              |                |-Wind storm
                              |                |
                              |                | Mountain
                              |-Other risks    |- range
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It should be noted that, war risks are not included in this risk clssification.

2.4.1 Risks On The Ground:

Although the chance of risk in flight is the most likely one, the chance of some risks on the ground still exists For example ; (A) Bad weather, such as strong winds, hailstorms and sand storms could cause a lot of damage especially for an aeroplane parked in open areas. The hailstorm at Munich airport on 12th July 1984 is a good example.[1]

(B) Runway risks, Although the development in airport traffic control has achieved a high level of security for aircraft while taxiing, the chance of collision is still possible. An example of this is the Tenerife accident of 27thMarch 1977[2].

Also, in operation runway lights and conditions could lead to accidents.

(C) An Accumulation of risk, e.g aeroplane collapse while under tow, fire inside the hangars, earthquake, typhoon or flood might lead to high losses especially in busy airports.

2.4.2 Air operation risks:

(A) Airplane hazards:

(I) Stalling speed: This is the minimum speed to support an airplane's lift. If the aeroplane speed falls below that minimum speed at any stage of flight, the gravity will be greater than the lift and will pull the plane down. The minimum speed varies from one aeroplane to another according to its weight. For example, a very light aeroplane requires 30 air miles per hour to fly, while that speed

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(1) In 12-7-84 a severe hailstorm at Munich airport caused damage to 24 parked aeroplanes, it is believed that the airport didn't succeed in warning the airplanes' owners. (AISL 1984)

(2) Two B747s operated by KLM and Pan American crashed on the runway. The cause of the accident was a combination of pilot error, airport tower error and bad visibility. (AISL 1977)

increases to 150 air miles per hour for a heavy aeroplane. The risk of failure to reach the stalling speed is greater during the take-off [1].

(II) Aeroplane equipment failure ;

Aeroplane stability during its operation could be affected by any failure in the aeroplane equipment, e,g doors, anti-icing systems, auto pilot, radio systems and radar.

One of the major factors that increases the aeroplane's equipment failure is the age. A study of the age of aeroplane[2] involved in accidents during twenty years is shown in Fig (2.1). This shows that the average age was less than six years for airplanes involved in accidents in the years from 1965 to 1975, whereas it was between six and fourteen years for the period that followed up to year 1985. That indicates the development and progress that took place in durability and age factor.

Aeroplane age on its own does not in general contain all the information related to the hazard. Other factors affecting the depreciation of the machine, such as number of takeoffs and flying hours[3] have to be considered.

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(1) On 18th Sep 1984 a DC-8-55f operated by AECA was reported to have lost power on take-off and crashed into a church at Quito. (AISL 1984)

(2) Aeroplane's age was fixed by using the manufacturers' delivery date, which is the date the new aeroplane was delivered to its first operator, and the accident date.

(3) In the U.S.A a large number of the flights are short trips, especially the internal ones which produce larger number of takeoffs and landings, while in Australia most of the flights are long trips recording larger number of flying hours. (IATA 1987)

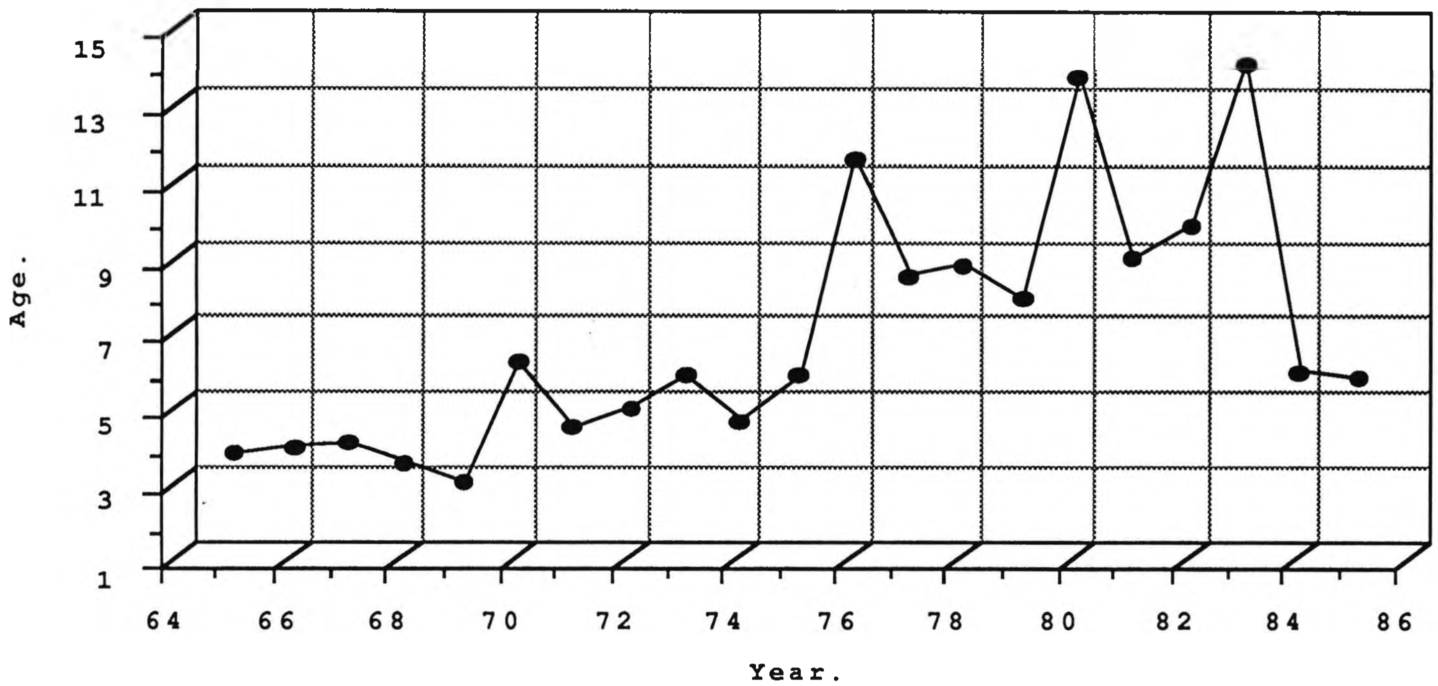

Fig 2.1 Average aeroplane age for
the accidents from 1965 to 1985.

(III) Type of engine. As discussed in chapter one, the aeroplane engine has passed through many developments until the turbo-prop and the jet engine were manufactured.

Today, jet aeroplanes represent the vast majority. Figure 2.2 represents a comparison between number of jet and turbo-prop aeroplane and the total loss accidents for each type of them, while the percentage of total loss to number of aircraft were calculated and represented in figue 2.3. From the two figures 2.2 and 2.3, it can be seen that the number of jet aircraft has increased faster than the turbo-prop, meanwhile the the percentage of jet total loss were less than that of the turbo-prop .

The development in jet engines has led to higher aeroplane speed, a wider range,a higher service ceiling and a larger number of passengers. These factors have affected the chance of losses by adding new risks, for example the need for long runways, and risks either when the aeroplane is on the runway or during high altitude flights.

Meanwhile, developments have improved aeroplane systematic safety and so reduced the chance of engine failure.

Also, the new jet aeroplanes have affected the size of risk as the price of a jet aeroplane is much higher than that of a Turbo-prop.

Table (2.2) demonstrates the development in jet aircraft and its prices. It include a list of different types of

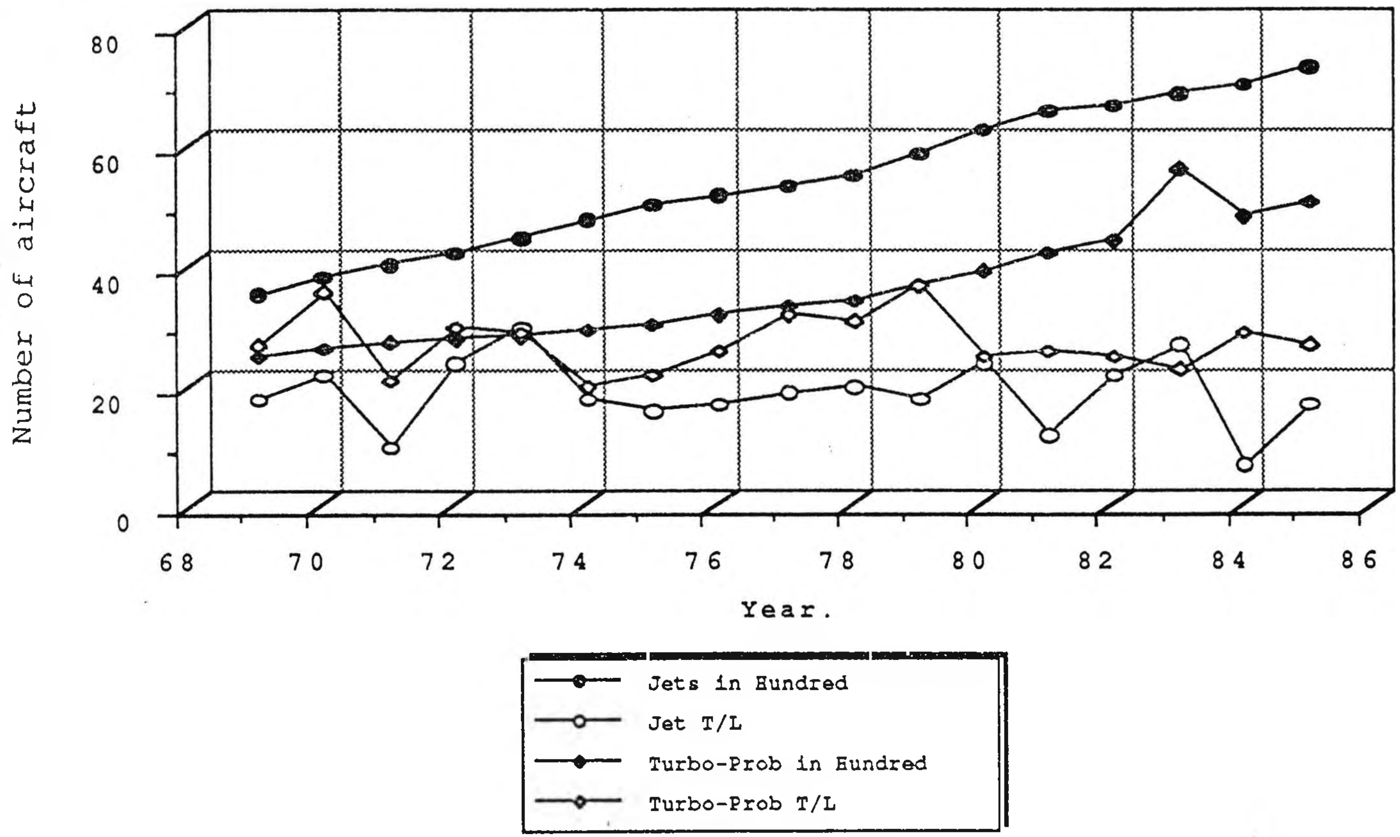

Fig 2.2. Number of Jet Aircraft in Servivce and their TL. and Number of Turbo-Prop Aircraft in Service and their TL.

Source of data: Brokerage insurance company.

Figure 2.3. Percentage of Jet Total Loss to number of Jet aircraft and Turbo-prop Total Loss to number of Turbo-prop aircraft.

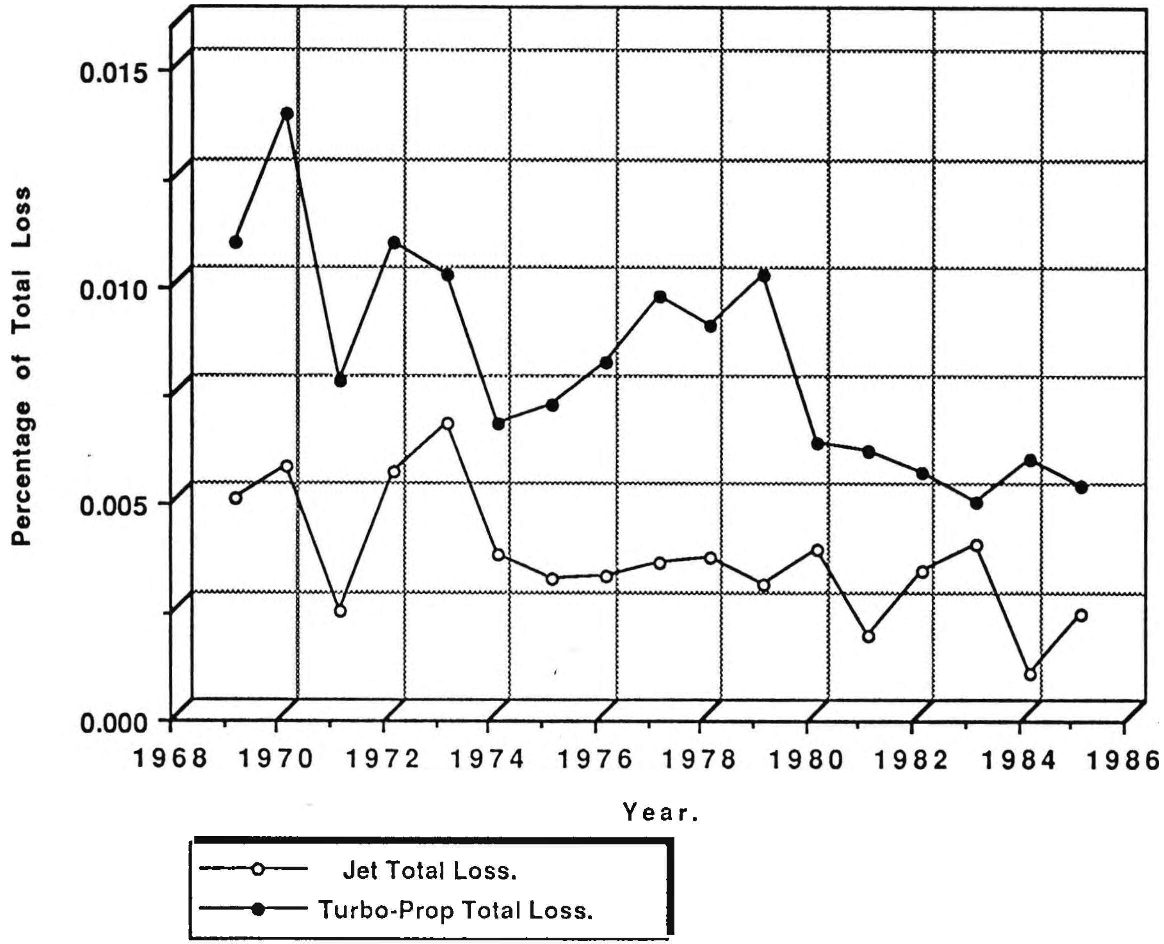

TABLE (2.2)

THE DEVELOPMENT IN JET AIRCRAFT.

AIR CRAFT TYPE	first fly	RANGE	MAXIMUM SPEED	SERVICE CEILING	PASS	NO OF ENGIN	FUEL RESERVE	RANGE OF PRICES US $ IN MILLION
B707	1958	L	627 mph	39,000ft	147	4	5,755m	0.1 1.5
A.S. caravel	1959	S-M	513 mph	25,000ft	50	2	2,153m	no price
DC- 8	1959	L	600 mph	30,000ft	--	4	4,500m	0.5 24.0
HS.COMET	1959	--	--	--	92	4	--	0.75 1.5
CONVAIR /880	1960	M	616 mph	41,000ft	160	4	5,400m	0.1 1.5
B727	1963	S-M	632 mph	30,000ft	--	3	2,303m	2.0 17.5
H-S TRIDENT	1963	S-M	605 mhp	30,000ft	100	3	2,500m	0.75 1.5
BAC 1-11	1965	S-M	541 mph	25,000ft	119	2	1,865m	1.0 3.0
DC- 9	1965	S-M	575 mph	30,000ft	132	2	2,065m	3.0 12.0
B747	1969	L	602 mph	45,000ft	452	4	5,988m	16.5 123.0
F -28	1969	M	298 mph	29,500ft	44	2	1,197m	2.1 12.0
DC- 10	1971	L	564 mph	30,000ft	500	3	7,490m	18.0 23.0
L10-11	1972	L	605 mph	30,000ft	413	3	5,683m	10.0 32.0
AB- 300	1974	L	566 mph	25,000ft	351	2	3,685m	18.0 66.0
CONCORDE	1980	L	1354mph	60,000ft	100	4	4,090m	no price
B757	1982	S-M	528 mph	38,400ft	224	2	2,380m	45.0 58.0
B767	1982	M	506 mph	39,000ft	289	2	3,200m	36.0 68.0
AB-310	1983	M-S	414 mph	----	234	2	2,110m	59.0 70.0
BAE-146	1983	S	500 mph	30,000ft	71	4	1,647m	23.0 41.6

Source of material:
1- Lloyd's aircraft types and price guidelines (1987).
2- Concise guide to commercial aircraft of the world

jet aircraft and the range, maximum speed, service ceiling, number of engines, fuel reserve and price for each type.

From the table it can be recognised the sharp developments in jet aircraft especially the Concorde aircraft.

In terms of number of passengers the DC-10 is capable of carrying 500 passengers.

In terms of aircraft maximum speed and service ceiling Concorde has reached 1354 m.p.h and 60,000 ft service ceiling.

While in terms of prices the B747 has been evaluated at $123.0 million.

(IV) Airplanes' construction:

The majority of the new jet aeroplanes [1] have been designed locating their engines down the wing where the fuel is stored.

From the insurance point of view, a greater risk could face the aeroplane due to that design, especially in the case of a belly landing or the engine catching fire.

<u>(B) Human error:</u>

Human error is a main factor that may result in disasters. Despite the minimum technical qualification rules for pilots, errors of judgment and mistakes are still made

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(1) The B707,727,737,747,757,767, DC-8, AB300 and AB310 are example of aircraft where engines are located down the wings

by the pilot who is responsible for the aeroplane, passengers and crew.

Cockpit crew members have an important role to play in supporting the pilot during flight. Because of human nature the chance of making mistakes is there causing disaster as well.(1)

(C) Weather and Geographical area:

Aviation accidents reports have proved that bad weather was an effective factor in aeroplane accidents.(2)

In some of the accidents weather was the main cause, while in the others it represented an additional factor that increases the risk. It takes different shapes as follows;

1- Icing. The main risk of icing is when it builds-up over the wings, changing the wing shape and adding extra weight to the aeroplane.

Another risk of icing is the ice forming on the aircrew blades or in the carburettor, thus reducing engine power output. (EL-DIN 1978)

2- Bad visibility. Bad visibility produces great risk to the aeroplane especially during take-off and landing.

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(1) On the 24th of January 1979, A Nord 262A operated by air Algeria experienced an accident. The report was "While on final approach the aircraft struck the ground about 15Km short of airfield. Possible factors were, failure to comply with prescribed procedure, lack of crew co-ordination, faulty functioning of the pilot's altimeter and crew fatigue". (AISL 1979)

(2) On the 21st of June 1982 a B707 operated by Air India experienced an accident. The report was "Left the runway after attempting to land in very heavy rain". (AISL 1982)

3- Wind storm and Sand storm. Severe risks are presented by the violent patterns of weather, which are not easy to predict by weather forecasting, even in those places where weather forecasting is well covered.

4- Mountain ranges. Usually mountain ranges are well identified, and the minimum flying altitude over the mountains are fixed. A combination of bad visibility with ice formations over the mountain can produce a new risk.(1)

(D) Other risks:

There are some other risks which could face the aeroplane during flight like a bird strike(2) , which can cause serious damage to the engine.

2.4.3 Aviation Risk Characteristics:

From the early study of aviation risks and accident reports the following risk characteristics could be noted:

1- There are multiple causes of most of the accidents.

2- According to the previous characteristic, classifying accidents according to the cause of loss and measuring the probability of a loss is a very difficult task.

3- In general terms, aviation hull risks produce high losses.

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(1) On the 1st of August 1980 a DC-9 operated by Aeromexico experienced an accident. The report was "Struck a mountain at about 8000ft, approximately 40Km from Zihuataenjo ". (AISL 1980)

(2) On the 4th of Sept 1985 a DC-10 operated by KLM experienced an accident. The report was" Bird strike during climb out from airport". (AISL 1985)

4- Aviation risks are affected by the developments in airplanes' design and its safety system. For example, some of the risks such as icing have been reduced by using anti-freezing systems.

2.5 Aviation Insurance Contract:

In aviation insurance, as in marine insurance, there is no standard form of policy to be used for the different airline risks.

The practice in the London market is to place the risk contract in written slips or policies. It is worth noting that the aviation contract varies according to the covered risk and sometimes it varies according to the insurers themselves. However, there are two policies frequently used in the London market i.e the Lloyd's Aircraft Policy and the Aviation Insurance Offices Association Policy (A.I.O.A).

The Lloyd's aircraft policy will be taken as a base for the study while comparison will be made to show examples of the differences and extra covers that could be provided. It is worth noting that the main concern of this research is the loss or damage to the aircraft section.

2.5.1 The Lloyd's Aircraft Policy Loss or Damage to Aircraft:

According to the policy, the underwriter has the option to pay for replacement or to make good the accidental loss of or damage to the aircraft from whatsoever cause arising whilst the aircraft is in flight, taxiing, on the ground or moored.

This option is only avilable to the underwriter for choosing between the methods of settling the claim, having the right to enquire with the insured if they wish.

The policy lists the covered operations, followed by the underwriters' right not to be liable for the cost of making good any element of" wear and tear" for any of the aircraft parts.

It excludes any loss or damage to the aircraft by burglary, theft, larceny or malicious damage, if it were caused by a servant or agent or person under the assured'scontrol.

Sometimes, the insurance contract is written on an agreed value basis in place of the market value.

In the case of aircraft total loss or constructive total loss, the policy deletes the above option giving the insured the right to claim the agreed value as described in the policy schedule while the liability of the underwriter under this section will be restricted by the agreed value as a maximum, less any amount to be borne by the assured.

General Exclusions

The policy has a number of exclusions that can be summarised as follow:

(I) There is an exclusion for illegal use, for any purpose other than that stated in the policy or out of the agreed geographical limits. But, if the aircraft needs salvage services, or in the case of force majeure the policy risks are held to be covered.

(II) There is an exclusion for aircraft flown by any person other than those mentioned expressly, or by implication, in the policy.

(III) There is an exclusion for aircraft being transported by any means of conveyance. An exception to this is that the required transportation after an accident would produce an admissible claim.

(IV) As the standard insurance policy covers the normal flying hazards, any abnormal flying which causes an increase in risk will be excluded.

(V) War risks are excluded. These would usually be insured under a special policy.

(VI) There is an exclusion in the case of any other policy covering the same subject matter. An exception would be if the other policy does not cover the whole of any claim.

(VII) There is an exclusion in the case of any damage done by the insured or any person under his control acting within the scope of his authority.

Warranties:

The policy includes two warranties. Firstly, the insured should comply with all airworthiness requirements and take reasonable steps to ensure the aircraft safety during every flight. Secondly, no insurance additional to the policy should be affected during the currency of this policy except, (A) Insurance on terms and condition identical with those contained in the policy; (B) Insurance for total loss only up to 10% of the value of the aircraft.

General Conditions:

The general conditions in the policy are the terms to secure the insurer's right during the period covered by the policy; for example, the insured must duly observe all the policy conditions, the insured must take the same protection as if he were not insured, the insured must protect the aircraft in the event of loss.

Schedule:

The Schedule is to be used to list the following risk details: the purpose for which the aircraft is to be used, geographical limits, pilot information and aircraft details.

Definitions:

The main intention is to dispel any misunderstanding regarding the main terms, for example the flight, taxiing, moored, ground, accident definition. Appendix (2) shows the Lloyd's aircraft policy.

2.5.2 The Aviation Insurance Offices Association Policy (A.I.O.A):

The A.I.O.A policy follows the Lloyd's policy in the general lines and differs in a few respects.

In the section covering loss or damage to the aircraft, the policy provides cover for the temporarily standard component parts to be used for aircraft being overhauled or repaired, which is not included in the Lloyd's policy. While the A.I.O.A policy excludes hydraulic breakage or breakdown, the Lloyd's form does not.

The policy covers the cost of removing the aircraft to a safe place after the forced landing even if no damage has been sustained, while the Lloyd's policy does not cover that cost. In the general conditions, the A.I.O.A policy also provides up to 10% in addition to the sum recoverable by the insured for the repairs for any action necessary to protect the aircraft after the accident.

2.6 The General Aspects In London Market:

The London Insurance Market accepts the two policies and uses them widely. Two main aspects are well recognised in the market.

The first is to consider the aircraft engine as a complete entity. According to this fact, the underwriter will not be liable for any engine mechanical failure under any of those policies. Whenever a part of the engine fails during any of the aircraft's operation, the damage would be excluded. An exception would be in the case of engine failure causing damage to the aircraft when the damaged part from the engine would be covered. The other exception is in the case of total loss or engine damage as a result of any risk other than mechanical such as a bird strike or a crash in which case the damage would be included.

The second issue is to fix minimum excesses to be borne by the insured.

For example the following minimum excesses have been applied for 1988 ;

Wide Body aircraft	Whilst in flight, taxiing or loading passengers 1% of value subject to a minimum of U.S $ 1 000 000 for each claim.
Other Jet Aircraft	Whilst in flight, taxiing or loading passengers 1% of value subject to a minimum of U.S $ 500,000 for each claim, and for groun risks subject to (other than loading passengers) a minimum of U.S $ 100,000 for each claim.

2.7 Placement procedure in London Market:

Placing the risk in London Market usually takes the following steps.

Firstly : The insured being an airline or an insurance company approaches the broker to handle the cover.

The broker collects the required risk data and information to fill the proposal form and the cover slip. He presents the slip to a leading underwriter, usually one who possesses the reputation in that type of risk.

The leading underwriter carries the responsibility to fix the premium, after studying the risk and negotiating the conditions with the broker.

The following model of fixing the rate, is used

$$\text{Rate} = \frac{(\text{Total claims}) \cdot (1 \pm K\%)}{\text{Average hull value during 3 or 5 or 7 years.}}$$

That model includes two important points. The first one is the experience period. Usually a three, five or seven year period is used. The importance of this point appears for example in the case of an insured who faced bad losses during the last three years while his record before that was good. In such a case it will be to his benefit to increase the experience period to five or seven years in order to decrease the rate.

The second point is the maximum or the minimum percentage to be added to total claims. This percentage is fixed by the leading underwriter according to the claim experience of the fleet.

The other formula often used is described as "70/30 or 80/20". This standard formula is used in case of the insured altering the aircraft values, so the rate should be divided into two parts, to cover the total loss of the aircraft and any partial loss. An example explaining this model is shown in appendix 3.

After calculating the rate on these bases the leading underwriter readjusts it according to two important factors i.e., the condition of the market and the airline's position.

The broker approaches other underwriters at Lloyd's or in the market, to complete placement. Each will sign for his share of the risk without any further negotiations for the rates, the terms or the conditions of the cover.

Once the risk is fully subscribed, the broker prepares the policy, informs the policyholder and collects the premium. Appendix 4 illustrates these procedures.

Meanwhile, the broker plays the same role in the case of any change in the risk[1] which requires a change in the risk cover. Also in the case of loss, the broker takes all the required steps to collect the claim as intermediary. Appendix 5A & 5B shows the steps the broker takes in case of any change of the risk cover and in case of loss. However, placing the risk as mentioned above brings up two questions, i.e.

What are the main factors that affect the rate ?

What is the result of applying the current rate model ?

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(1) Examples of changes in the risk could be, buying or selling some of the fleet's aircraft, or flying over a new geographical area not listed in the policy.

These questions are considered in the following paragraphs.

2.7.1 Factors Affecting The rates:

The factors affecting the rate which the leading underwriter takes into consideration could be classified as follows.

2.7.1.1 Factors related to the airline:

These factor are mainly:

(A) The airline's previous experience, which includes claim frequency and claim severity.

(B) New aircraft, which would involve either the airline flying a new type of aircraft with no experience for that type before, but known in the market or the airline flying a brand new model or generation with no market experience. The leading underwriter would take into consideration the airline size and its experience in flying different types in assessing the premium rate. Large fleets are assumed to have skilful pilots and satisfactory systems of training.

(C) Change in the number of aircraft from one year to another within the fleet, which affects the airline's experience record in terms of claim frequency . Changes can also occur as a result of buying, selling, leasing, having joint airlines on one insurance policy, or splitting compound airlines into smaller ones.

(D) Market pressure made by the airlines to reduce the rates or ensure no-claim bonus. That pressure could be exercised by the airlines individually or collectively through IATA as explained befor.

(E) Risks to be covered especially the geographical area. The study of the Lloyd's policy and the A.I.O.A policy in the earlier section shows some of the extra risks that could be provided which require extra premium. Special attention is paid by the underwriter to the geographical area. Although the majority of the airlines have a world-wide geographical limit, some areas are still taken into account, as they are exposed to constant bad weather.

2.7.1.2 Factors related to the market and underwriters:

Underwriters are usually concerned with the following:

1- Adequate premium to cover the risk and other extra cover expenses.

2- The deductibles borne by the airline.

2.7.1.2.1 The market capacity:

In general the market capacity is identified as the subtotal of all the underwriters limits.

In aviation insurance, underwriting limits vary from year to year according to the market result. After profitable years, underwriters retain profits to increase the reserve for unexpected loss and to increase the capacity for future bussiness which it is hoped will generate future profits. this helps to increase their underwriting limits. Also the

profitable market encourage other underwriters i.e marine underwriters to underwrite in aviation. Accordingly after profitable years, the market capacity increases and vice versa. These fluctuations will have an effect on the final premium rate.

2.7.1.2.2 The competition among insurance markets:

The London aviation market is considered to be one of the largest insurance markets in the world. Its capacity is able to absorb a large fleet policy without any need to resort to other markets. In 1991, the estimated maximum world aviation insurance capacity was 200%, while the USA market presented 40%, the European markets presented 60% and other world markets presented 10% of this capacity, London aviation market (including the Lloyd's) presented 90%. (Aviation research centre 1991)

However, the competition between the London market and the other aviation markets (for example, France, Germany, U.S.A) to write the business represents a pressing factor that will affect the premium rate.

2.8 Results of applying the current method of rating:

To indicate the result of applying the current method of rating both the changes in the gross hull rate[1] and the underwriters' final results will be used.

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(1) Gross rate: Rate inclusive of commission..........

2.8.1 Changes in the gross premium rates:

During the last few years, the aviation insurance market has experienced high fluctuations in the gross premium rate. To analyse the changes in the hull rate, The IATA members have been chosen as a sample to represent world fleet airlines. Data of 91 airlines were collected, mainly the premium rate for each airline for the period from 1982-83 up to 1986-87. The 91 airlines were classified geographically into five different groups. The changes in the gross premium rate were calculated for each airline then the yearly average for each group was calculated. Fig (2.4) Shows the change in average gross hull rate for the five groups while figure (2.5) shows London market total claim amount during the same period.

From the two graphs, a relation between the claim amount and the change in the hull rate can be seen: a 20-30% increase in the premium rate for 1983-84 followed the high loss record of 1983. In 1984, the claim amount dropped to the lowest level in the five years followed by a 3-10% increase in the premium rate. (Pitron 1985)

The year 1985 recorded a high level of losses but the increase in the rate in the previous year was enough to cover 1985 losses and to retain the hull rate for 1986 at the same level. A good claim experience was recorded in 1986, making 1986 a profitable year. As a result, it appeared that aviation underwriters extended their

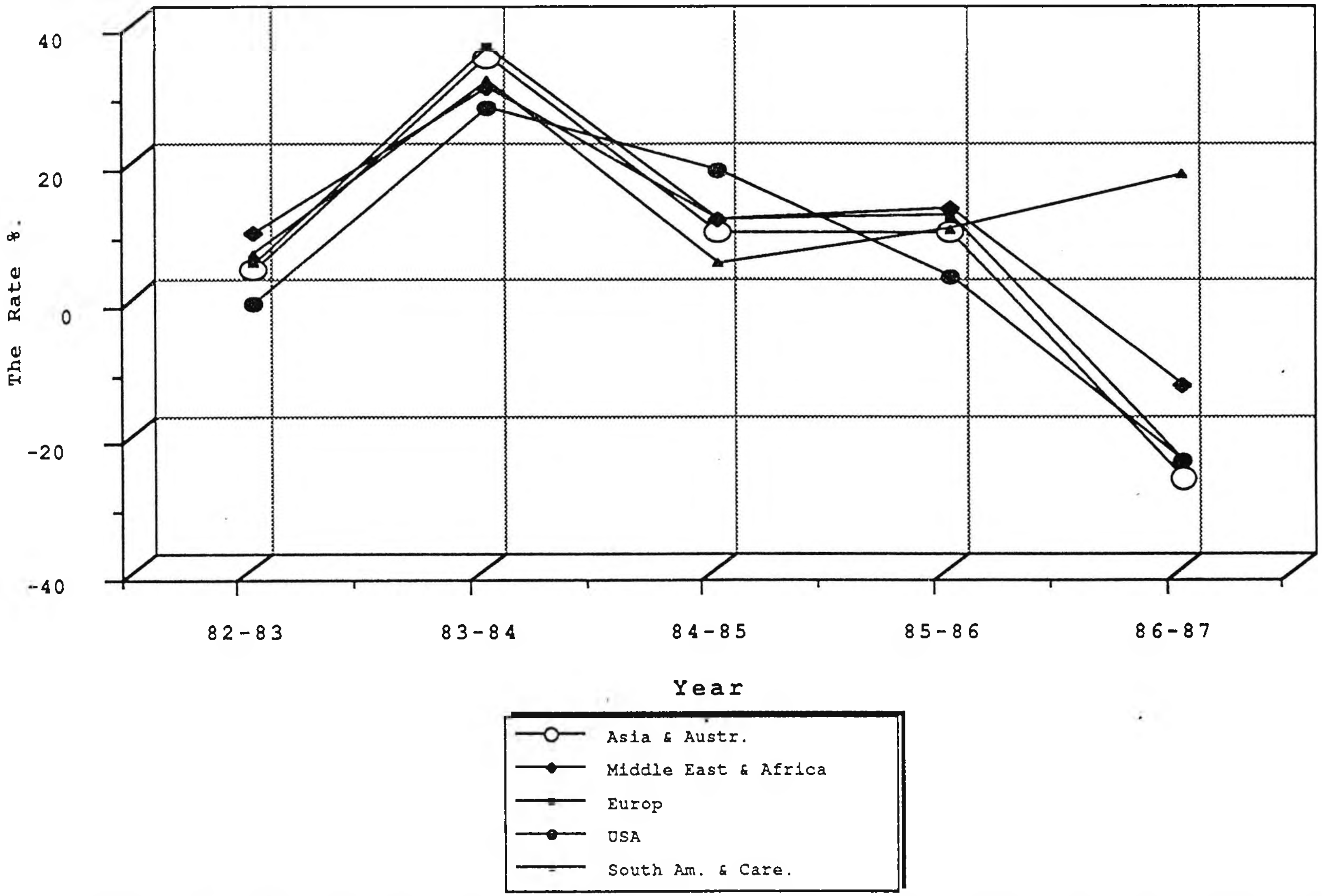

Fig 2.4. The change in the gross hull rate from 1982-1983 to 1986-1987.

Source of data: Brokerage insurance company.

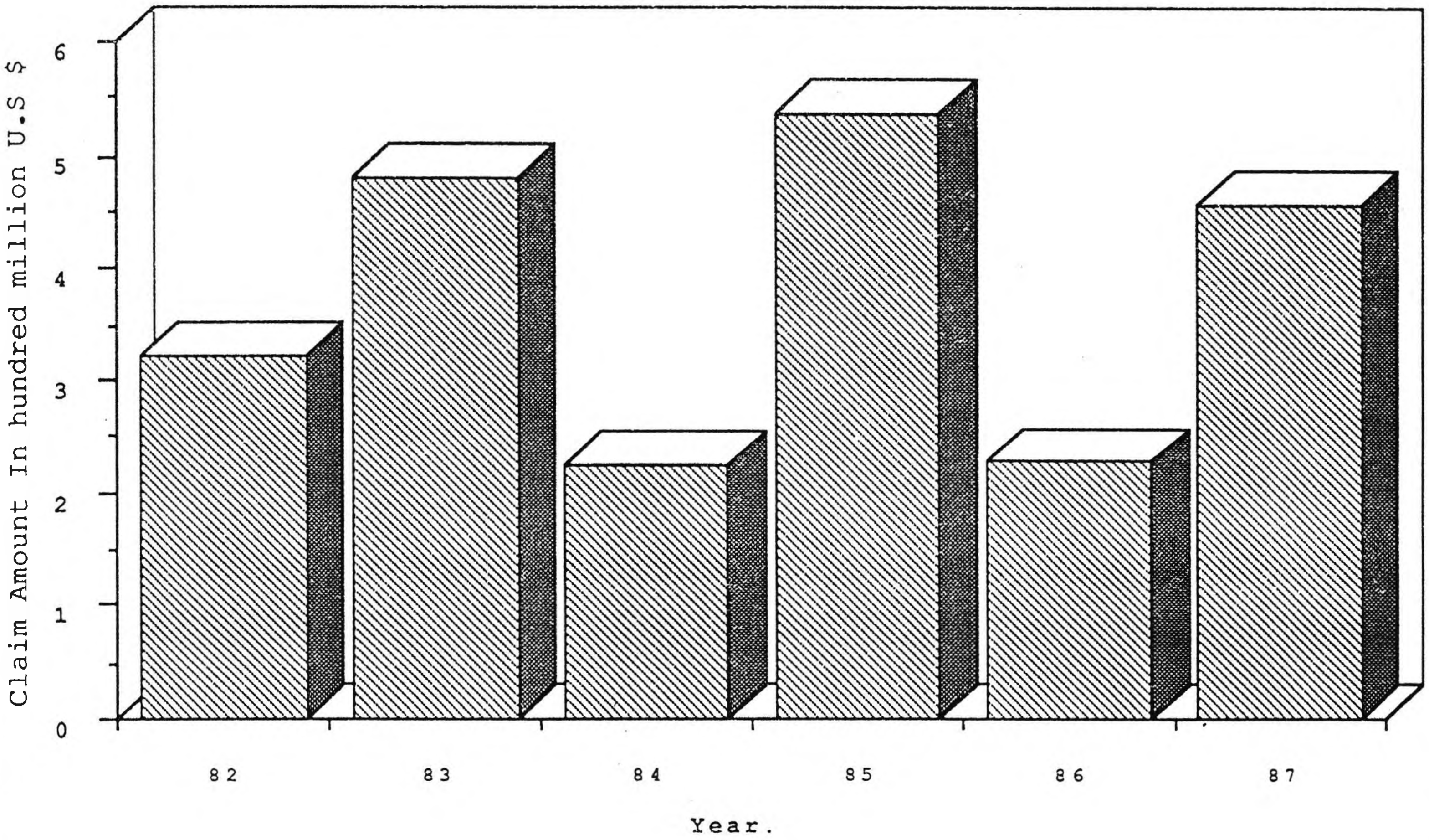

Fig 2.5. Total Claim Amount.

Source of data: Brokerage insurance company.

capacity, and some marine underwriters started to underwrite aviation insurance. This expansion of market capacity led to a sharp drop in the 1986/87 premium rate with an average decrease of 14-25% for all the groups, while some policies were renewed with 50% discount.

In 1987, the claim record was higher than 1986, even though the market indicated further discounts in the rate issued to insure the airlines for 1987/88.

It is worth noting that a yearly increase in the hull rate has to be taken into consideration to allow for inflation, therefore when a policy is renewed at a rate 10% lower than the previous year, the discount is the 10% + inflation %.

2.8.2 The underwriter's final Results:

It is a normal response for pressures to be exercised to reduce the rates when profits have been realised. The insureds show their concern regarding the previous years while the insurer is taking into consideration the probability of catastrophes that he might face in the coming years in addition to the airlines' previous experience.

Fig (2.6) shows the Lloyd's aviation underwriter's[1] position including transfer between years[2] and exclusive of both expenses, investment income and other debits and credits.

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(1) The Lloyd's results were studied as a sample of aviation market underwriter result.

(2) Lloyd's operate a three year open account.

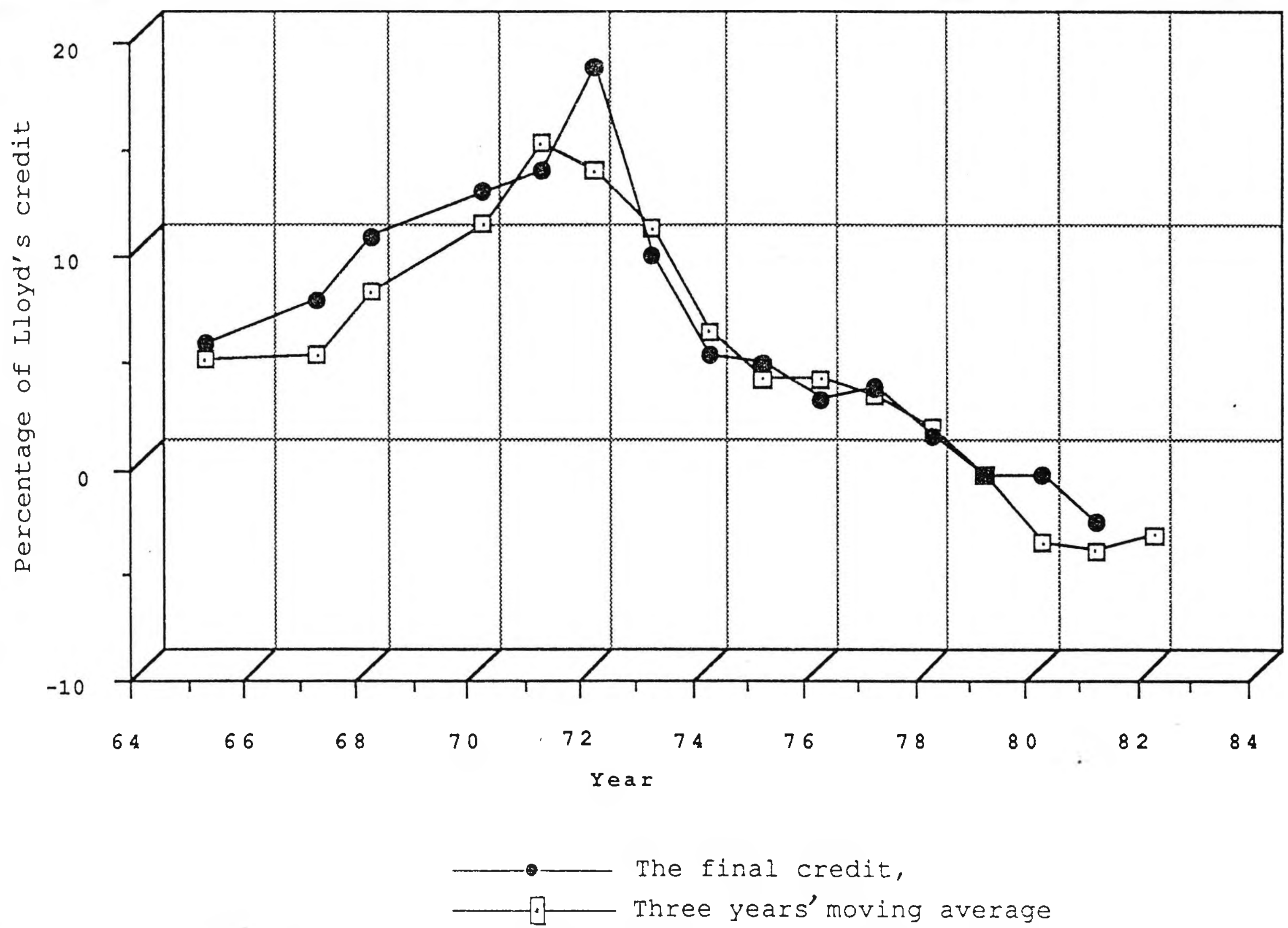

Fig 2.6 The Lloyd's Aviation Underwriter final credit

Source of data: Brokerage insurance company.

A three year's moving average was plotted to refine the fluctuation in the yearly curve. The curves could be examined in two parts: before and after 1972. The profit percentages before 1972 were clearly high, while after 1972 the percentages were falling as sums insured were increasing, with the arrival of jet aircraft especially the wide body ones. From 1977, the curve went down showing a loss for three successive years ended in 1981, while the moving average curve shows that the profit in 1981-82 have not been enough to cover the loss in the previous year. These fluctuations in the hull rate and the underwriters' final credit explain the need for a new rating model, which would rely on statistical methods that take into consideration both the airline's individual experience and the market experience.

Accordingly the credibility theory will be introduced and studied.

2.9 The Credibility Theory :

In this section the historical development in credibility theory will be studied, while the models developed within the theory will be studied in chapter 3 and chapter 4. Credibility theory was first introduced in North America earlier this century as a technique to solve some premium calculation problems.

Since the early papers in 1914 until recently, several detailed studies have been carried out to develop credibility theory and to apply the theory to real world problems.

In 1974 G.C Taylor revived the credibility theory. The paper discussed the aims of credibility theory and briefly reviewed " American credibility theory". "European credibility theory" was studied in detail, especially the Buhlmann-Straub model.

In 1974, a conference was held at The University of California under the topic of credibility theory and applications. The principal objective of the conference was to exchange ideas on the foundations of credibility and its applications to experience rating in life and casualty insurance. The application of credibility theory to group life insurance, reinsurance, and such casualty problems as the determination of reserves for claims incurred but not reported (IBNR) were also discussed. P.H.Khan edited the papers discussed in this conference in a volume published in 1975.

In 1979 a remarkable paper by R.Norberg presented a study of credibility theory and its approach to experience rating. The problem of experience rating and the objective of credibility theory were briefly introduced, while the European credibility theory was studied in detail. The difference between the Empirical Bayes theory and the Bayesian approach to credibility was included.

In 1986 a very useful source of reference was issued on credibility theory by the journal: " Insurance: Abstracts & Reviews". The issue consists of a bibliography with abstracts on credibility theory to cover publications using the word "credibility" or referring to credibility literature. Also, it contains concepts from credibility theory in connection with actuarial science or insurance.

In 1987 a note by H.Waters presented an introduction to credibility theory as part of the course of reading for the Institute and Faculty of Actuaries examinations. This note introduces the basic credibility technique of " American credibility theory ", and then studies the development in credibility theory by considering the Bayesian approach to credibility and Empirical Bayes credibility theory.

Recently, much research has been carried out to apply credibility theory to insurance problems.

In 1983, a Ph.D thesis by M. Kandil presented a study of credibility theory with application to fire insurance using Egyptian data.

In 1984, a study by J.Straub applied credibility theory to fire insurance using German industry data.

In 1986, B.Sundt published a paper titled "Some Credibility regression models for the classification of individual passenger car models ". The main object of this paper was to show how a credibility estimator based on data from only the most recent years may under very weak assumptions be improved by incorporating a credibility estimator based on older data.

In 1987, O.Hesselager presented a credibility model with random fluctuations in daily probabilities for the prediction of IBNR claims. A study of the Buhlmann-Straub model was followed by a model of the exact credibility, where the linear approximation of the premium turns out to be the optimal premium. Finally two applications were presented. The first application is a case of a loss reserving method in which IBNR claims are forecasted. The second application deals with the determination of the optimal trimming point in case the data contain outliers.

2.10 Summary:

Aviation hull insurance like any other insurance was produced to cover a group of risks. It has its own specific characteristics.

Firstly, Aviation risks vary from time to time according to different factors, causing difficulties in measuring the chance of loss.

Secondly, different types of aviation contracts have been used in the London market to cover the risk.

Thirdly, there is no tariff for aviation hull cover. So, in order to fix the basic rate, the leading underwriter uses the airline experience, while the final rate is fixed according to the leading underwriter's experience taking into consideration a group of factors.

Fourth, the difficulties in measuring the chance of loss, the method used to fix the rate and the factors governing the rate lead to a wide range of fluctuations in the hull rate and the underwriters' final results.

Credibility theory will be introduced in this thesis as a rating method that will take into consideration the airline experience as a unit and a similar group of air-lines' experience as a unit and measure the degree of correspondence between the two units to find the premium rate.

CHAPTER THREE

CREDIBILITY THEORY AND EXPERIENCE RATING

3.1 Introduction:

Premium rates for aviation insurance vary considerably from year to year. These fluctuations have negative effects on both insurance companies and airlines. To calculate the premium rate for an airline ,for a said year, one of the following methods may be used:

(1) The self-rating method ; by using the formula as explained in chapter two and giving full consideration to the previous experience of the said airline. That method is traditionally applied in practice. However, the result of the application may be misleading whenever the airline experience size is very small and the available data are not adequate.

(2) The usage of a wide range of data related to very similar airlines instead of using the available data of the specific airline. This method may appear better than the previous one but still has its weaknesses. Thus, it lessens the weight of experience of the said airline and the rate calculated accordingly may change yearly, with the possibility of wide fluctuations.

These two methods are not based on a mathematical approach which measures the level of reliability of the previous experience, and estimates how much it could be considered to determine the future net premium rate.

Therefore, the introduction and application of the credibility theory becomes of great importance to enhance the mathematical and statistical approach in calculating the aviation insurance rate.

3.2 Credibility Theory:

Credibility theory is a statistical method to test the reliability of data. It measures the weight of the risk experience and that of the collateral data.

When the test proves that the available data are sufficient and reliable the self rating method could be used confidently to attain a correct calculation of the pure premium rate. Conversely, when the test proves the sparseness and unreliability of data the lack of risk experience should be complemented by considering a similar source of data. The question of how much weight should be given to the risk experience and how much to the collateral data is also answered by the credibility theory.

3.3 Advantages of using the credibility theory:

Using the credibility theory has several advantages. It helps to utilise the risk experience no matter its size to calculate the premium rate. It also enables one to control the chance of a dramatic fluctuation in the premium rate that may happen in the case of having two or three major losses in one year. Also credibility theory might be used as an experience rating technique. In such a case, it has been called ' Great Accuracy Credibility'.

It could be used as well as a rate revising technique and it has been named ' Limited Fluctuation Credibility'.

(Norberg 1979)

Also, credibility theory has been applied successfully to fire and motor insurance for a long time in the U.S.A.

3.4 Development of credibility theory:

The beginning of credibility theory occurred in North America. One of the early papers about the theory was written by Moubry in 1914. The theory passed through many developments afterwards in the U.S.A, producing what is called now " American Credibility Theory".

The first step in applying the American Credibility is to measure the level of full credibility: actuaries believe that risk experience of one year or several years could develop a sufficient exposure to be self rated.

3.4.1 Level of full credibility :

The methods of determining the level of full credibility have been widely discussed(1) for a long time.

In the U.S.A the adopted method is based on assuming that the claim frequency is small, therefore it follows the Poisson distribution, where the probability of n claims during a given period is

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(1) For further reading see:L.Longley Cook 1962, A.Mayerson 1964, B.Benjamin 1977, M. Kandil 1983, and H.Waters 1987.

$$P(n) = \frac{q^n \cdot e^{-q}}{n!} \qquad 3.4.1$$

with mean = variance = q.

Using the normal distribution approach, the probability that the number of exposure units lie within $\pm$ 100K% of the expected number of claims will be,

$$P = \frac{1}{\sqrt{2\pi}} \int_{-k\sqrt{q}}^{k\sqrt{q}} e^{-t/2} \, dt \qquad 3.4.2$$

Where the standardised deviate is $K.\sqrt{M}$

The normal distribution is a two parameter distribution, but for credibility it is customary to assume that the mean and the variance are both equal to q. (Mayerson 1964)

By using the standard normal distribution table, and giving K and P the values 0.05 and 0.90 respectively(1) that will yield to q = 1082 In this approach, it is assumed that;

(A) The claim frequency will follow a Poisson distribution,

(B) The probability P is equal to 90%.

(C) It was also assumed that the mean and variance are both equal q.

Generally, the claim frequency in the long term may follow another distribution such as the binomial or negative

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(1) Longley-cook 1964 stated that, "In the U.S.A the credibility table commonly used for automobile liability insurance is based on P=90% and k=5%".

binomial distribution. Thus different models for the level of full credibility have been set up for the different distributions.

For the second assumption taking P equal to 90% could not be 100% accurate as the probability of accidents may change, especially in the case where the experience available refers to a long period. However a table for the number of expected claims using various combinations of the range parameter K and the probability p has been set up. This table can be seen in appendix (6). This table shows high variation in the number of expected accidents, having 30 accidents when P=90% and K=30% while the number of accidents becomes 108,274 when P=99.9% and K=1%. In other words, the number of claims required for full credibility depends critically on the choice of P and K . However, G.Taylor 1974 stated that the standard of at least 1082 expected claims for full credibility is a popular one.

Finally, assuming that the data mean is equal to the variance is not 100% accurate. In some cases the variance might exceed the mean. In such a case the negative binomial distribution will be more suitable.

3.4.1.1 Level of full credibility in terms of claim frequency and claim amount:

In the above method the claim frequency solely is used whereas both the claim amount and the claim frequency should be considered for the credibility for the pure premium.

To do so, let M represent the mean for the claim amount distribution with standard deviation S, the normal distribution formula will become:

$$P = \frac{1}{\sqrt{2\pi}} \int_{-k \cdot Mq\sqrt{\sigma}}^{k \cdot Mq\sqrt{\sigma}} e^{-x^2/2}\, dx \qquad 3.4.3$$

Where σ is the variance of (M.n)

It has been shown by Perryman (1932) that using the normal approximation, the number of claims required for full credibility will increase by a factor of $(1 + S^2)/S$ and the standard deviation then becomes,

$$M.q^{1/2} \left[\frac{1 + S^2}{q^2} \right]^{1/2} \qquad 3.4.4$$

If S = 0 the standard deviate becomes $q^{1/2}$. Accordingly

$$q_1^{1/2} \left[1 + \frac{S^2}{M^2} \right]^{-1/2} = q^{1/2} \qquad 3.4.5$$

$$q_1 = q \left[1 + \frac{S^2}{M^2} \right] \qquad 3.4.6$$

where q_1 represent the new number of claims.

Perryman also indicated that the factor S/M usually lies between 4 and 6, so the expected number of claims in the case of S/M=5, P = 90% and K = 5% is 27,000, while in the case of S/M = 4, P=90% and K=5% the number becomes 4325.

The previous methods of calculating the level of full credibility show that the number of observations required for full credibility is high and varies according to certain factors. In practice, the number of observations might be very small and far from the level of full credibility.

Therefore, a set of collateral data will be required and the model should be established to determine the level of partial credibility and the weight to be given to the risk experience and to the collateral data.

3.4.2 Partial credibility:

To calculate partial credibility different models have been formulated.

Good examples of these models are the following:

(1) Partial credibility rate revision

(2) The models of partial credibility experience rating plans

(A) Experience rating with non-split plan

(B) Experience rating with split plan and

(C) Experience rating with multi-split plan

(Perryman 1938)

3.4.2.1 Partial credibility - rate revision model:

This model was described by Longley-Cook (1962). It is used when the available data consist of loss frequency based on the past experience and similar[1] sets of data based on different experiences. The combination of the two sets of data will produce the new rate as follows. The probability of accident in the risk experience is $P_x=A_x/N_x$ and the probability of accident in the collateral data is $P_y= A_y/N_y$ where A_x, A_y represent the number of claims in the risk experience and collateral data respectively, N_x, N_y will represent the number of exposures in the risk experience and collateral data as well. Combining the two probabilities then P, the new probability, will be equal to:

$$P = \frac{A_x + A_y}{N_x + N_y} \qquad 3.4.7$$

However, this model is very simple and could be misleading as its mathematical base is very preliminary to produced P_x. Also, it does not produce P equal to P_y, when P_y has full credibility.

Therefore, the credibility factor Z could be added to the previous procedure, accordingly P will be equal to:

$$P = P_x(1 - Z) + P_y Z$$

or

$$P = P_x + Z (P_y-P_x)$$

$$0 < Z < 1$$

Replacing Z with the value of $N_y / (N_y + N_x)$.

$$P = P_x + \{ (N_y/ N_x+ N_y) . (P_y - P_x) \}$$

(1) The similarity among the data could be realised either through the similarity of type of business or the circumstances that control the claim frequency.

Different ratios could be used for the relationship between N_y and N_x such as 1:2 or 1:3.

3.4.2.2 Partial credibility experience rating plan:

The term " Experience rating plan" means that determining the rate for the risk depends entirely or partially on the self-experience of the risk. Perryman (1932) dealt with the question of partial credibility using the experience rating plan. This plan was developed initially for the premium rating of workmen's compensation risk.

3.4.2.3 Partial credibility with non-split plan:

The non-split plan is set up to calculate the pure premium rate using credibility theory and the underlying risk experience. Its main feature is its simplicity, as all losses are used with equal weight.

The ordinary formula for the modification is:

$$1 - Z + Z \, .A/E \qquad 3.4.10$$

Where P represent the premium rate, A and E represent the actual and expected losses and Z is the credibility factor. This formula is a simple linear model. In practice A and E are known but Z is an unknown factor.

In practice to calculate the value for Z the following formula has been widely used;

$$Z = E \ / \ (E + K) \qquad 3.4.11$$

It is obvious from (3.4.11) that the Z value will never reach one, and to calculate its value the constant K should be determined. It seems that no mathematical model was formulated for the calculation of K. However, Perryman (1938) stated that the value of the constant K is determined from the consideration of the risk size.

However, a group of general conditions should be observed so that Z should be satisfactory;

(1) The credibility factor Z should lie between zero and one, $0 < Z < 1$

(2) The Z value should differ according to the size of the risk and

(3) As the size of the risk increases the percentage charged for the inclusion of any loss of given size should decrease. (Perryman 1938).

The first and second conditions are fulfilled by formula (3.4.11). Note that K is a constant. Z gets closer to one as E gets larger. On the contrary Z gets closer to zero as E gets smaller.

The third condition is fulfilled as well from formula (3.4.11). (Z .A/E) is the charge for the actual loss. Its percentage will decrease as E gets larger.

<u>3.4.2.4 Partial Credibility with split plan:</u>

The idea behind the split plan is to divide the losses into normal and excess. In other words the risk size is divided into two ranges. The first range will include the small and usual losses. The second range will include the large losses which are severe but not frequent. The reason for this classification is to give more frequent losses much more weight than the less frequent ones.

According to this classification, each range will have a different rate and the final rate will be an aggregate of the two rates.

Assuming that E_n, A_n, Z_n represent the expected losses, actual losses, and credibility factor respectively for normal loss. E_e, A_e, Z_e represent them for the excess range

Then the formula for the new rate will be ;

$$\frac{E_n}{E} \; \frac{Z_n \, . \, A_n + (1 - Z_n) \, E_n}{E_n} + \frac{E_e}{E} \, . \, \frac{Z_e + A_e + (1 - Z_e) \, E_e}{E_e} \qquad 3.4.12$$

$$\frac{Z_n \, A_n + (1 - Z_n) \, E_n + Z_e \, A_e + (1 - Z_e) \, E_e}{E} \qquad 3.4.13$$

Note,

$$E_n + E_e = E \qquad \& \qquad A_n + A_e = A$$

As in the non-split plan the Z value could be estimated by using

$$Z_n = \frac{E_n}{E_n + K_n} \qquad \text{and} \qquad Z_e = \frac{E_e}{E_e + K_e}$$

Where K is the constant.

3.4.2.5 Credibility with multi-split plan:

In the previous model the expected loss were devided into two ranges the normal range and the excess range, and the credibility formula for the pure premium was calculated on the basic of given the normal range more weight than the excess range.

In the multi split plan the expected loss will also be divided into a normal and an excess range, but for the pure premium model the multi-split plan reduces the excess loss into a normal loss by deducting part of each loss in this range. It is assumed that, by reducing the claim amount in the excess range, the claim frequency in both the ranges will become equal. In other words all the losses will become normal.

However, in the multi-split plan, the first step is to decide the highest expected claim cost, which will be divided into ranges. In the first range the expected claim amount will be considered as a normal one. The expected claim amount in the second range will be adjusted to be less than that in the first range, and that in the third range will be adjusted to be less than that in both the first and second range. Therefore the plan deducts a percentage to be fixed of the claim cost for the second and third range.

For example, with a claim of $15 million and with three equal ranges, the first $5 million will be taken at its face value. Suppose we deduct $1/_3$ from claims in the second range and $5/_9(1/_3)$ from claims in the third range. Accordingly the amount which will be taken into consideration will be

$$5m + (5m \, . \, 2/_3) + (5m \, . 4/_9)$$

Applying the said method regadless of the percentages used the claim cost will be considered as normal. In other words the claim frequency will be considered a constant in the three ranges. It is noted that, the number of ranges, the size of each range and whether these ranges will be equal are left to be determined according to the risk size and the risk frequency.

The second step is to set the modification to calculate the premium rate. Assuming that:

- Z will represent the credibility factor
- E will represent the expected loss, S will represent the self rating point, where E is very large and Z = 1
- Q will represent an arbitrary point.

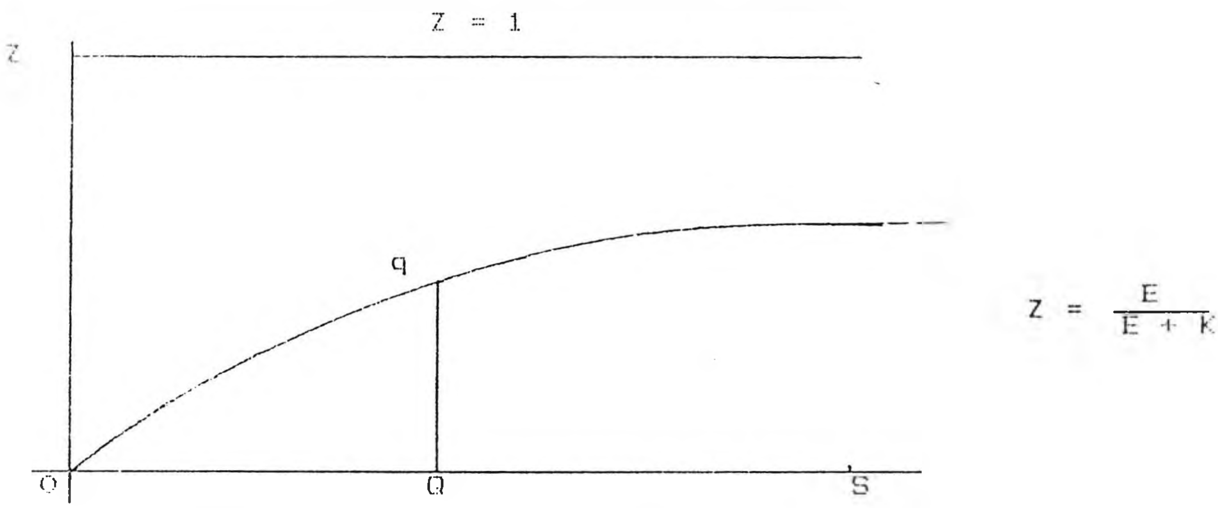

Figure 3.1 The relation between Z and E (after Perryman 1938)

The relation between Z and E has been plotted in figure 3.1. The figure shows that, if Z is plotted as a function of E, Z moves along a branch of an hyperbola which has Z=1 as an asymptote.

By choosing an arbitrary point Q ,where $0 < Q < S$, and drawing a vertical line at q the area under the curve will be split into two parts $E < Q$ and $E > Q$.

Accordingly, the modification for the pure premium will be calculated as follows:

Using formula (3.4.13), the credibility factor for the excess range was represented by Z_e. Using the multi-split plane this range has been reduced to normal, accordingly Z_e will equal to zero, and formula (3.4.13) will equal

$$\frac{Z_n A_n + (1 - Z_n) E_n + E_e}{E} \qquad 3.4.14$$

For simplicity, Z could be replaced by $E/_{(E+K)}$ instead of $E_n / (E_n + K_n)$, so the modification will equal

$$\frac{A_n + E_e + K}{E + K} \qquad 3.4.15$$

This modification will be used in the case of $E < Q$ and $Z_e=0$. Consequently, if $Q < E < S$, (in other words if the expected claim cost was higher than the arbitrary point Q) the previous modification would not fit. To represent the area from Q to E the value of $A - (A_n + E_e + K)$ or $A_e - E_e - K$ should be added to the numerator and subtracting (K+K)-K or K from the demoninator. The modification will be

$$\frac{A_n + E_e + K W (A_e - E_e - K)}{E + K - W.K} \qquad 3.4.16$$

where W is a function of E (to be determined) equal to zero for $E = Q$ and rising from 0 to 1 as E goes from Q to

S. The need for W is to make the credibility factors joins smoothly between $E < Q$ and $E > Q$. A mathematical model has been formulated to calculate the value of W. (Perryman 1938)

It should be noted that, if Q is made equal to 0, 3.4.16 will represent the area from 0 to S.

Different formulas could be set up for determining the modification using the multi split plan (Perryman 1938). But for the interest of this research, the previous modification might be sufficient to explain the basic idea of the plan.

3.5 Conclusion:

During the study of the American credibility theory in this chapter, some of the weaknesses have been identified. In particular:

(1) The lack of a statistical foundation. Most of the models were very simple. There is no clear method for estimating parameters from the data observed.

(2) The methods used for determining the level of full credibility have been discussed for a long time, epecially the relation between K and P. The result of this discussion was just a recommendation for the value that could be used, but no mathematical model has been formulated.

Furthermore, the methods used to determine the credibility factor Z in the case of partial credibility are not fully satisfactory. However, The American credibility theory has led to a distinct bifurcation in approach although it was useful in practice. It has been exposed to criticism mainly for the limitation of its statistical foundation.

In 1967, Buhlmann formulated some solutions for many of the problems of credibility theory, based on a formal statistical development and thereby establishing a new branch which is now known as the European credibility theory.

CHAPTER FOUR

EUROPEAN CREDIBILITY THEORY

4.1 Introduction :

European actuaries examined the merits and demerits of the credibility theory which had been established in America.

They started to evolve the basic foundation and the concepts of the theory. They linked Bayesian theory with credibility theory to overcome the lack of a statistical basis.

4.2 The Bayesian Theory :

To clarify and identify the aforementioned Bayesian theory, it may be advisable to recall that in the simple and basic classical statistical analysis, the observed data is fitted to one of the statistical distributions. Thus by using the distribution models, parameters could be estimated and used as an indication of the model which represents the data.

The Bayesian theory is a technique that merges prior news about the parameters with the distribution indicated by the observations to reduce a posterior distribution which reflects both the prior distribution and data distribution.

4.3 The Bayesian Approach to Credibility Theory :

Bailey (1950) was the first paper that indicated the relation between the Bayesian approach and the credibility theory. He examined the generalised Bayesian rule assuming that:

- An event H is a result of a set of mutually exclusive conditions $F_1, F_2, \ldots\ldots\ldots, F_n$

- K_x is the prior probability of the existence of F_x,
- P(H|X) is the prior probability that when F_x exists the event H will occur,

The problem under consideration is to obtain E(X|H), the expected value of a variable X which corresponds to the origin or cause of an observed event H.

Then, the posterior probability $P(F_a|H)$that the particular condition F_a was the origin of cause an event H will be

$$P(F_a|H) = K(a) \cdot P(H|a) / \Sigma (K(a) \cdot P(H|X)) \qquad 4.3.1$$

and when $F_1, F_2, \ldots, F_n$ has the value 1,2,... the expected value E(X|H) will be written as follows,

$$E(X|H) = \sum_x X \cdot P(X|H) = \frac{\Sigma\ X.K(X) \cdot P(H|X)}{\sum_x K \cdot (X) \cdot P(H|X)} \qquad 4.3.2$$

From equation 4.3.2 it could be seen that the expected value of E(X|H) will be the sum of X values and the probability of existence P(X|H). The true regression of X on H will result in a group of points that may produce a straight line or continuous curve. Bailey showed that under certain cases the regressionwould produce a straight line. Accordingly the formula Z.A + (1-Z).B could be derived.

The main concern of actuaries in insurance is to estimate the expected value E(X|H) in order to reach a balance between the premium and the claims. Bailey (1950) recommended the least squares method for estimating the expected value of X conditional on H, alleging that the use of maximum likelihood would not be an accurate method of estimation. Buhlman's (1967) approach was based on approximating the posterior mean by a linear function of the prior mean and the mean claims data. Credibility factors were obtained applying one of the Bayesian models, such as Beta-Binomial, Poisson-Gamma or Normal-Normal model.

Miller and Hichman (1975) asserted that the same results could be obtained using the linear multivariate exponential family with a suitably detailed mutual conjugate prior.

Generally, it appears that the data distribution and the prior distribution parameter should be known before using the Bayesian theory to credibility theory.

This issue provokes two important questions:

- First: How large should the data be in order to be considered reliable data ?
- Second: How is the prior probability distribution chosen ?

In a bid to answer these questions, the following explanation is given.

4.3.1 The Bayesian Approach and the concept of full credibility :

It is demonstrated in chapter three, that American actuaries were much concerned about the level of full credibility. Bayesian theory relies on the observed data to express its size through the analysis naturally. As the amount of collected data increases, Z will get closer to one and vice versa. It assumes that if the prior distribution H modified by some observed data is large enough, the probability $P(H|X)$ will remain closer to $P(X)$.

On the contrary, if the prior distribution H modified by some observed data is not large enough $P(H|X)$ will move closer to $P(H)$.

Mayerson (1964) indicated that when the data becomes larger, not only the family of prior data will increase, but also the independence of the posterior from the prior is substantially true and the only requirement will be to predict the number of claims to which our prior knowledge is equivalent.

However, the Bayesian approach does not take into consideration the probability of Z being equal to one, in other words, the term "full credibility " has no meaning in the Bayesian approach.

4.3.2 Choosing The Prior Probability Distribution :

Traditionally to calculate the prior probability, the previous premium rate will be assumed as the mean of the prior distribution to be modified by the experience of the individual risk. To achieve meaningful results not only the mean of the prior probability but also the variance of the expected losses should be estimated. (Mayerson (1964))

For example if the data are believed to be the result of a Bernoulli process, the probability $P(H)$ may be assumed to be a Beta function where:

$$P(h) = K\, h^{r}\, (1 - h)^{n-r} \qquad \text{where } 0 < h < 1 \qquad 4.3.2.1$$

with r favorable and n-r unfavorable outcomes, then h has mean

$$m = \frac{r + 1}{n + 2} \qquad 4.3.2.1$$

with variance

$$\sigma^2 = \frac{r + 1}{(n + 2)^2} \cdot \frac{(n - r + 1)}{(n + 3)} \qquad 4.3.2.3$$

$$= \frac{m\ (1 - m)}{n - 3} \qquad 4.3.2.4$$

The required number of claims n which is equal to the prior distribution could be achieved as a function of the mean and the variance

$$n = \frac{m\ (1 - m)}{\sigma^2} - 3 \qquad 4.3.2.5$$

Equation (4.3.2.5) shows that σ^2 will have a significant effect on the number of claims, as σ^2 gets larger the number of claims gets smaller.

However, once the prior distribution has been chosen and the data distribution is known the model for the pure premium rate will be derived as follow.

4.3.3 The Poisson-Gamma Model:

Assuming that,

n is the number of observations with number of claims X where $X = X_1, X_2, \ldots\ldots, X_n$

X is a random variable representing the number of claims in the coming year. Its distribution depends on the value of the unknown parameter λ.

λ will be recognised as a random variable taking any negative value, and will be regarded as a Gamma distribution with parameters α and β.

Finally, the marginal distribution of X will be recognised as Poisson with parameter λ. Estimating the unknown parameter λ will be the main concern in such a case.

The Bayesian estimate of λ with respect to a quadratic loss function given these data is $E(\lambda | X)$, and the posterior density of λ given X is proportional to,

$$\prod_{i=1}^{n} e^{-\lambda} \frac{\lambda^{x_i}}{x_i} \frac{\beta}{\Gamma(\alpha)} e^{-\beta\lambda} (\beta.\lambda)^{\alpha - 1} \qquad \lambda \geq 0 \qquad 4.3.3.1$$

To calculate the value of λ, which is the main concern, terms that do not involve λ will be ignored; accordingly this posterior density is proportional to

$$\exp\{-(\beta + n)\lambda^{A} \qquad 4.3.3.2$$

where $A = \alpha + \sum_{i=1}^{n} X_i - 1$.

From (4.3.3.2), it can be seen that the posterior distribution of λ is Gamma with parameters $(\alpha + \sum_{i=1}^{n} X_i)$ and $(\beta + n)$.

Hence

$$E(\lambda \mid \underline{X}) = \frac{(\alpha + \sum_{i=1}^{n} X_i)}{(\beta + n)}$$

which could be rewritten as follows,

$$E(\lambda \mid X) = Z\left(\sum_{i=1}^{n} \frac{X_i}{n}\right) + (1 - Z)\frac{\alpha}{\beta} \qquad 4.3.3.3$$

where $$Z = {}^{n}/_{(\beta + n)} \qquad 4.3.3.4$$

4.3.4 The Normal-Normal Model:

Waters (1987) has described the Normal-Normal model in his special note. It takes into consideration both the claim amount and claim frequency. This gives the model more importance since the concern of actuaries is to estimate not only the claim frequency but also the pure premium in particular for certain risks.

There for it will be assumed that:

X is a random variable denoting the total claims with mean μ and variance σ_1, the distribution of X depend on the value of unknown parameter θ. Although the value of θ is fixed for this risk, its value is not known. θ will be regarded as a random value.

It is important at this stage to note that,

X_1,s are identically (unconditionally) distributed, given θ, X_1,s are conditionally independent and both θ and $(X|\theta)$ distributions will be assumed to be normal.

Accordingly, The conditional distribution of X given θ is

$$X|\theta \sim N\ (\theta\ ,\sigma_1^2)$$

and the prior distribution of θ is

$$\theta \sim N\ (\ \mu\ ,\sigma_2^2\ )$$

Where σ_1, μ , σ_2 have Known values.

As in the previous model, the main issue is to estimate the pure premium $E(X|\theta)$. Which in this case will equal θ.

Also, it will be assumed that the number of observed data will equal n.

The Bayesian estimate of θ given X is $E(\theta|X)$ and posterior density of θ given X is proportional to,

$$\prod_{i=1}^{n} \exp\ (-\ 1/2\ (X_i\ -\ \theta\ )^2 /\ \sigma_1^2)\ ]\ \exp\ (-1/2\ \ (\theta\ -\ \mu\ )^2 /\ \sigma_2^2$$

4.3.4.1

To calculate the value of θ ,which is the main concern, terms that not involving θ will be ignored, accordingly this posterior density is proportional to,

$$\exp \{ - \frac{\sigma_1^2 + n\,\sigma_2^2}{2\,\sigma_1^2\,\sigma_2^2} [\,\theta - \frac{(\mu .\, \sigma_1^2 + \sigma_2^2 \sum_{i=1}^{n} X_i)}{\sigma_1^2 + n\,\sigma_2^2}\,]^2 \} \qquad 4.3.4.2$$

and from equation (4.3.4.2) the posterior distribution of θ given $\bar{X}$ is

$$\theta \mid X \sim N\left(\frac{\mu\,\sigma_1^2 + n\,\sigma_2^2\,\bar{X}}{\sigma_1^2 + n\,\sigma_2^2} \; , \; \frac{\sigma_1^2 .\; \sigma_2^2}{\sigma_1^2 + n\,\sigma_2^2} \right) \qquad 4.3.4.3$$

Where

$$\bar{X} = \sum_{i=1}^{n} X_i \,/\, n .$$

Hence

$$E \{ \theta \mid \underline{X} \} = (\mu\, \sigma^2_1 + n\, \sigma^2_1 \bar{X}) \,/\, (\sigma^2{}_2 + n\, \sigma^2{}_2) \qquad 4.3.4.4$$

Which can be rewritten as

$$E (\theta \mid \underline{X}) = Z\,\bar{X} + (1 - Z)\,\mu \qquad 4.3.4.5$$

where

$$Z = n\,\sigma_2^2 / \sigma_1^2 + n\,\sigma_2{}^2$$

The other Bayesian model used to obtain the credibility factor is Beta-Binomial. For the interest of this research, the study of the Poisson-Gamma model and the Normal-Normal model might be sufficient to explain the basic idea of the Bayesian approach.

On studying the Bayesian approach to credibility, the following points became evident:

Firstly, in comparison with the American credibility theory, the Bayesian approach does not require the premium decision probability P for the purpose of defining the volume of experience needed for credibility to equal one.

Secondly, partial credibility does not represent a problem within the Bayesian approach, as weighting the claim data and the prior mean to produce the posterior mean are handled automatically.

Finally, the Bayesian approach has left a question mark in case of the Poisson-Gamma model, where it was assumed that the value of β is known and also in the case of the Normal-Normal model where it was assumed that σ_1^2 and σ_2^2 have known values.

After applying Byes theorem to credibility theory, the development in the theory has taken a new direction leading to what is known as the Empirical Bayes credibility theory, which is the subject of section 4.4 and is applied to the case of aviation insurance premium rating in chapter 5.

4.4 Empirical Bayes credibility theory :

4.4.1 Introduction

The basic idea of the Empirical Bayes approach began with the work of Buhlmann (1971). This paper solved some of the difficulties in the theory, by making clear the assumptions made to derive the credibility premium formula.

Within the Empirical credibility theory, different models have been developed. The model that will be studied in this chapter is one of the most practical and useful models. This model traces its origins to Buhlmann's paper and is one of the models described in the Special Note of Waters (1987).

4.4.2. The credibility premium formula using the Empirical Bayes theory:

To calculate and form a formula using the Empirical Bayes theory, it will be assumed that:

(A) N represents a group of risks.

(B) $y_1, y_2 \ldots y_n$ represents aggregate claim amounts produced by each risk during n years where n= 1,2,3...

(C) p_1, p_2 .....is a corresponding sequence of known constants i.e number of aircraft inside each airline, or number of policies issued every year for the same risk .

(D) X_1, X_2.....X_n is a random variable where $X_j = y_j / p_j$

The distribution of X_j depends on the value of a parameter θ.

(E) θ is a random variable with unknown distribution function U( ).

(F) $X_j | \theta$ for j = 1,2,.... are independent

(G) It will be assumed that the mean and the variance of the $X_j|\theta$ are given by,

$$m(\theta)=E\ [\ X_j(\theta)\ ] \qquad 4.4.1.1$$

and

$$s^2(\theta) = p_j v\ [X_j(\theta)\ ] \qquad 4.4.1.2$$

So that neither $E\ [X_j|(\theta)]$ nor $p_j v[X_j|(\theta)]$ depend on j.

The target now is to estimate $m(\theta)$ given $\underline{X}$ where $\underline{X}$ is a set of n observed values, $X_1, X_2, \ldots. X_n$.

In the Bayesian approach the pure premium formula was achieved by estimating $m(\theta)$ with respect to a quadratic loss function leading to $E\ [m(\theta)|\underline{X}]$ 4.4.3

In the normal-normal model and the Poisson-Gamma model, 4.4.3 turned out to be linear in the observed values as demonstrated in sections 4.3.3 and 4.3.4, equation (4.3.3.1) and 4.3.4.1. In general (4.4.3) need not be linear in the observations.

In this model, the linear function of the observed values will be of the form :

$$a_o + \sum_{j=1}^{n} a_j\ X_j \qquad 4.4.4$$

where the a_j are constants to be determined for $j = 0,1,\ldots,n$.

The credibility theory premium will be defined to be such a linear function which gives the best approximation to E.

The question now is how to find the constants a_o, a_1, $a_2 \ldots a_n$.

The criterion used is to find the constant which minimizes

$$E\ \left\{ E(m(\theta)\underline{X}) - a_o - \sum_{j=1}^{n} a_j X_j \right\}^2$$

4.4.5

It can be proved (for example, see Waters(1987)) that equation 4.4.4 is equivalent to

$$E\,[(m\,(\theta) - a_o - \sum_{j=1}^{n} a_j\, X_j)^2] = 0 \qquad 4.4.6$$

By differentiating the expected value in (4.4.6) with respect to $a_o, a_1, a_2, \ldots. a_n$ and putting each of the (n+1) partial derivatives equal to zero, the result will be

$$E[\; m(\theta) - a_o - \sum_{j=1}^{n} a_j X_j \;] = 0 \qquad 4.4.7$$

$$E\,[X_k . m(\theta) - a_o X_k - \sum_{j=1}^{n} a_j\; X_j\; X_k\;] = 0$$

where k =1,2,....n

noting that

$$E\,[X_j] = E\,[\;E\,[\;X_j |\,(\theta)]\;] = E\,[m|\,(\theta) \qquad 4.4.8$$

$$E\,[X_k . m(\theta)] = E\,[\;E\,[\;X_k . m(\theta)\,|\theta)]\;] = V(m|\theta) + E^2(m|\theta)$$

$$E\,[X_k^2] = E\,[s^2(\theta)]/\; p_K + E\,[m^2(\theta)]$$

$$E\,[X_k . X_j] = E\,[m^2(\theta)]$$

4.4.6 and 4.4.7 could be tidied up to be

$$a_o = \{1 - \sum_{j=1}^{n} a_j\} \; E(m(\theta) \qquad 4.4.9$$

$$E[m^2(\theta) - a_o E\,[m(\theta)] - a_k E\,[s^2(\theta)]/p_k - \sum_{j=1}^{n} a_j\; E\,[\;m^2(\theta)] = 0 \qquad 4.4.10$$

substituting from (4.4.8) into (4.4.9)

$$p_k V\,[m(\theta)]\{\;1 - \sum_{j=1}^{n} a_j\} = a_k\; E\,[\;s^2(\theta)] \qquad 4.4.11$$

By summing 4.4.10 for k=1,2,......n then

$$\sum_{j=1}^{n} a_j = \sum_{j=1}^{n} p_j / \{ \sum_{j=1}^{n} p_j + E[s^2(\theta)] / V[m(\theta)] \quad 4.4.12$$

Using (4.4.12) in (4.4.9) and (4.4.11) the final model will be

$$a_0 = E[m(\theta)] . E[(S^2(\theta)] / V[m(\theta)] / \{ \sum_{j=1}^{n} p_j + E[S^2(\theta)] / V[m(\theta)] \quad 4.4.13$$

$$a_k = p_k / \{ \sum_{j=1}^{n} p_j + E[S^2(\theta)] / V[m(\theta)] \} \quad 4.4.14$$

replacing a_0 and a_k with its value in 4.4.3. the estimate of the pure premium will equal

$$E[m(\theta)] . E[(S^2(\theta)] / V[m(\theta)] + \sum_{j=1}^{n} y_j /$$

$$\{ \sum_{j=1}^{n} p_j + E[S^2(\theta)] / V[m(\theta)] \} \quad 4.4.15$$

For simplicity let F represent $E[S^2(\theta) / V(\theta)$ and D will represent $E[m(\theta)]$ then 4.4.14 will become,

$$\frac{D . F . \sum_{j=1}^{n} y_j}{F . \sum_{j=1}^{n} P_j} \quad 4.4.16$$

From 4.4.15 it could be seen that the model contains two main factors. The first factor is the total claim amount for one airline during the experience period represented by $\sum_{j=1}^{n} y_i$ and adjusted by F and D. The second factor is the total number of aircraft for the same airline during the same experience period adjusted by F. F and D will vary from one year to

another according to the group result, but it will remain the same for all the airlines within the group in one year.
By increasing the number of observation inside the sample and accordingly inside each group $E(m(\theta))$, $E(S^2(\theta))$ and $V(m(\theta))$ will be more accurate and reliable. It could also be noted that, decreasing the value of $V(m(\theta))$ will reduce the fluctuation in the pure premium. And most important of all, increasing the data from the airline , ($\sum_{j=1}^{n} Y_j$ and $\sum_{j=1}^{n} P_j$) will indirectly reduce the effect of D and F on the pure premium.

However from (4.4.15) it could be seen that, to calculate the pure premium the remaining difficulties that need to be concluded concern how to calculate the parameters $E(m(\theta))$, $E[S^2(\theta)]$ and $V[m(\theta)]$. These can be estimated from a suitable set of data as follows:

(A) The pure premium formula is set to rate a risk as part of a collective of N risks. The values y_{i1}, y_{i2} represent the aggregate claims where p_{i1}, p_{i2} will represent the corresponding sequence of risk volumes which are assumed to be known constants. $X_{i1}| \theta_i$, $X_{i2}| \theta_i$ are independent .

By assuming that,

(A) the distribution of X_{ij} depends on the unknown but fixed value of risk parameter θ_i.

(B) $\theta_1, \theta_2 .... \theta_N$ are independent and identically distribute

(C) (θ_i, X_{ij}) and θ_k, X_{kj} are independent where $i \neq k$

(D) $E[X_{ij}| \theta]$ and $v[X_{ij} | \theta]$ do not depend on i or j so that

$$E[x_{ij} | \theta_i] = m(\theta_i) \qquad 4.4.17$$

$$V[X_{ij} | \theta_i] = S^2(\theta_i) / p_{ij} \qquad 4.4.16$$

By denoting the data value as X_{ij} where $j = 1,2,.....n$ and $i = 1,2,.....N$ and assuming that the corresponding values of P_{ij} are known, then the required parameters can be estimated. Waters (1987) has demonstrated that the following estimates are appropriate.

$$E\, m(\theta) = \bar{X} \qquad 4.4.19$$

where $\bar{X} = \sum_{i=1}^{N} \bar{p}_i \bar{X}_i / \bar{p}$

$$p_i = \sum_{j=1}^{n} p_{ij}$$

$$\bar{p} = \sum_{i=1}^{N} \bar{p}_i$$

$$\bar{X} = \frac{\sum_{j=1}^{n} \bar{p}_{ij} \bar{X}_{ij}}{\bar{P}} = \frac{\sum_{i=1}^{N} \sum_{j=1}^{n} P_{ij} X_{ij}}{\bar{P}}$$

$$E(s^2(\theta)) = N^{-1} \sum_{i=1}^{N} (n-1)^{-1} \sum_{j=1}^{n} p_{ij} (X_{ij} - \bar{X}_i)^2 \qquad 4.4.20$$

$$V(m(\theta)) = p^{*\,-1} \{ (Nn-1)^{-1} \sum_{i=1}^{n} \sum_{j=1}^{n} p_{ij} (x_{ij} - \bar{X})^2 - N^{-1} \sum_{i=1}^{N} (n-1)^{-1} \sum_{j=1}^{n} p_{ij} (X_{ij} - \bar{X}_i)^2 \} \qquad 4.4.21$$

where $p^* = (Nn-1)^{-1} \sum_{i=1}^{N} \bar{p}_i (1 - \bar{p}_i / \bar{p})$

As a result of studying the Empirical Bayes theory, and in comparison with the Bayesian theory The Empirical Bayes might prove to be very useful. The following points summaries the advantages of the Empirical Bayes theory.

1- In the Bayesian approach, the model discussed assumes that the observed data is a linear function which cannot be generalised.

2- It is not known how to determine some of the parameters in the Bayesian pure premium formula i.e σ_1^2, σ_2^2 using the Bayesian theory. These parameters have been calculated using Empirical Bayes.

3- Using Empirical Bayes there is no assumption concerning the precise distribution of $X_{ij} | \theta_{ij}$ or θ_{ij} whereas in the Bayesian approach normal-normal model it is assumed that both the distributions were normal.

4-Applying the Empirical Bayes theory, the expected value of X_j given θ will be considered as a function of θ , $m(\theta)$, not just θ as in the Bayesian theory.

However the study of the credibility theory, starting with the American credibility theory, Bayesian approach and finally the Empirical Bayes theory shows the vast and rapid development in the theory.

In conclusion, each of the credibility models introduced has its own merits and demerits.

The size of data, and the statistical features of the data will decide the most appropriate method to be used.

Chapter Five

DATA COLLECTION AND ITS ANALYSIS

5.1 Introduction :

The aim of this chapter is to introduce the data which will be used to calculate the premium rate. It includes data analysis and introduction of the statistical distributions appropriate for claim frequency and claim amount.

5.2 Data Sample :

The IATA members have been chosen as a sample to represent the world airline fleets in order to avoid bias. IATA has imposed no restriction on the airline size, loss record or its operation for those airlines wishing to join. It has opened the door for all airlines to join as members. In 1987 IATA members reached one hundred and sixty airlines, either active or associated members. The data required for this research has been available for ninety one airlines.

5.3 Data Homogeneity and Its Classification :

Homogeneity is a very important concept in insurance. The basic premise of risk classification plans is that within a heterogeneous population of insured there are homogeneous groups of policy holders. For such groups the loss-producing characteristics are expected to be identical, and loss experience is expected to be similar. In aviation insurance, dividing the sample into homogeneous groups is not an easy target, with the different methods of classification and the lack of required statistical information creating considerable difficulties. Adding to that, is the difficulty of observing the realisation of the law of large numbers, when fixing the premium rate and applying the credibility theory.

In aviation insurance, most of the airlines are too small to be self rated. Therefore, grouping airlines of similar features and composition assists in applying the law of large numbers. Meanwhile, classifying the airlines into groups enriches the loss experience and helps to predict more reliably yearly averages and future losses.

The demerit of this approach is the reduction in the individual differences between the airlines. However, the advantages of classifying airlines into groups outweigh the disadvantages.

The classification could be done according to :

(A) Airline size.

(B) Aircraft types,

(C) Airline's loss ratio,

(D) The geographical area or

(E) A combination of these.

Every one of these ways of classifying has its advantages and disadvantages. However, the geographical classification is considered more appropriate for the following reasons : First, the number and type of aircraft may differ largely from year to year, that might leave the airline in a different group every year. Although the geographical classification does not overcome the problem completely, it reduces its effects. Secondly it takes into account ,even indirectly, some of the rating factors, such as the number of takeoffs, flying hours and number of aircraft.

Thirdly, using the airline loss ratio might also leave the airline in a different group every year, while using the geographical classification and applying the credibility theory the airlines' loss ratio and aircraft types could be considered.

Fourth: using a compination of the above methods will increas data reliability and will help including most of the different rating factors. On the contrary data avilability will gepradise the use of this method.

Finally, there is a practical aspect in that great attention is currently paid to the geographical classification in the aviation insurance markets.

5.3.1 The Geographical Classification :

The standard geographical classification approved by the aviation insurance market and used in the IATA periodical is as follow:

Group (A) South America and the Caribbean,

Group (B) Asia and Australia,

Group (C) Europe

Group (D) Middle East and Africa.

Group (E) North America.

Within the said groups the IATA members have been classified as follow :

Group (A)

1- Aerolianes Argantina	AR
2- Aeromexico	AM
3- Avianca	AV
4- Cruzeiro de sull	SC
5- Cubana	CU
6- Lacasa Leneas	LR
7- Lan-Chile Lineas	LA
8- LLoyd Aero Boliviano	LAB
9- Mexican	MX
10-Trans Brasil	TR
11-Varig	RG
12-Vasp	VP
13-Viasa "Venezuela"	VA

Group (B)

1-Air India	AI
2-Air New Zealand	TE
3-Ariana Afghan Airlines	FG
4-Garuda Indonesian airways	GA
5-Indian Airline	IC
6-Iran Air	IR
7-Japan Airlines	JL
8-Pakistan International	PK
9-Philippine Airlines	PR
10-Trans Australia	TAA
11-Talair PTY ltd	GV

Group (C)

1-Air Lingus	AL
2-Air France	AF
3-Air Malta	KM
4-Alitalia Linee aere	AZ
5-Australian Airline	QS
6-Aviaco	AO
7-British Airways	BA
8-British Midland	BM
9-British Caledonian Airways	BR
10-Iberia Lineas	IB
11-Iceland Air	FI
12-Jugosloveski Aerot Transport	JAT
13-Nether Lines	BV-WU
14-Polskie Linie Lotnicze	LOT
15-Lufthansa	LH
16-Maleve	MA

17-Olympic Airways	QA
18-The Royal Dutch	KLM
19-Sabena, Sobelair	SN
20-Scandinavian Airlines	S.A.S
21-Swissair	SR
22-Turkish airline	THY
23-Union Des TransPort	U.T.A

Group (D)

1- Air Afrique	RK
2- Air Algeria	AH
3- Air Liberia	NL
4- Air Mali	MY
5- Air Tanzania	TC
6- Air Zaire	QC
7- A Lyemda	
8- Cameron Airways	UY
9- Comair- Commercial Airways	MN
10-Cyprus Airways	CY
11-Egypt air	MS
12-Israel Airline	EL-AL
13-Ethiopian Airline	ET
14-Ghana Airways	GH
15-Gulf Air	GF
16-Iraqi Airways	IA
17-Jamahirya Air-transport	LN
18-Kenya Airways	KQ
19-Kuwait Airways	KU
20-Lesotho Airways	
21-Linkas Aereas De Mocambique	LAM
22-Nigeria Airways	WT
23-Royal Air Morocco	AT
24-The Royal Jordanian	ALIA
25-Saudi Arabian Airlines	SV
26-Solair Solomon Island Airways	SSA
27-Somali Airlines	HH
28-South African Airways	SD
29-Syrian Arab Airline	RB
30-TAAG Angola Airlines	DT
31-Yemen Airways	IV
32-Zambia Airway	QZ

Group (E)

1-Air Canada	AC
2-Air Nuigini	PX
3-American Airlines	AA
4-CALM Air International	OX
5-Continental	CO
6-CP_AIR	CP
7-Eastern Airlines	PV

8-Flying Tigers	FT
9-Pan American World Airways	PA
10-Quebec-air	QB
11-Trans World Airlines	TWA
12-United Airlines	UA

After having the sample defined and classified, the data was collected as follows.

5.4 The experience period :

The collected data covered a period from 1979 to 1989. The eleven year period has been considered in order to have a reasonable experience period that gives a better idea about the loss ratio and increases the degree of accuracy for the predicted loss as a yearly average. In the meantime, enormous changes and developments have been taking place in the world of aviation and the aircraft industry. Many old types of aircraft have been shifted from civilian flight into cargo service, and some are not flying at all. Therefore, taking an eleven year period ,as from 1979, ensures the continuity of the still reliable data. In addition it was extremely difficult to obtain data from years before 1979.

The collected data mainly included number of aircraft of each airline, number of accidents and the claim amount for each accident. Before starting to analyse the data, the following points are worth mentioning :

(1) One of the main characteristics in aviation insurance is the small number of units and accidents in comparison

with other types of insurance such as motor or fire insurance.[1]

(2) As the IATA members have been chosen to represent the world airline fleets, the Russian airlines are not included.

(3) Number of aircraft in each airline was collected mainly from the IATA yearly periodical. In each year there were a few figures not published (not known). In this case, figures were collected from World airline fleets hand book, World airline fleets and airline-fleets.

(4) For the accident record and the claim amount, personal contact has been carried out with different brokerage companies, insurance companies and Information service offices in the London insurance market to collect the required data. Because of data confidentiality only three insurance brokerage companies two insurance underwriter companies and two information offices have greed to supply the data[2].

(5) Using different sources of data has its merits and demerits. Thus, it fills the gaps that might be found in one source and ensures the data accuracy through cross-checking. On the other hand different sources usually use different methods of calculation. For the data collected

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(1) The yearly number of aircraft is around 7000 aircraft while number of accidents from 1958 up until 1987 is around 2000 accidents.

(2) Also because of data confidentiality the names of the data supplier will not be listed.

in this research the claim record and claim amount figures will not change from one source to another. For the number of aircraft, each figure was checked through two or three different sources.

(6) The claim amounts for some of the accidents were very difficult to trace either due to their small size or because of their being uninsured. Therefore, these claims have been dropped from the claim amount tables.

The actual number of aircraft and accidents are given in table 5.1 and 5.2 and the claim amount distribution is shown in table 5.3.

Table 5.1 included the number of aircraft inside each airline in the five groups. Table 5.2 includes the yearly total number of aircraft with no accidents and those aircraft with one accident in each group.

In table 5.3, the claim amount distribution is divided into 5.3a claim amount distribution for claims within the range of 0 up to $15 million, for each group, while table 5.3b includes a claim amount distribution for claims within the range of $16 million up to $64 million for the five groups. The Minitab Statistical package will be used to analyse the data.

5.5 The Claim frequency Distribution :

A study of the accident record ,the aircraft nationality registration marks (REG) proved that none of the airlines' aircraft has faced more than one accident in one year.

Table 5.2 Yearly Number of Aircrafts For Each Airline in G(A)

	1979	80	81	82	83	84	85	86	87	88	89
1	32	34	35	35	32	35	36	35	36	35	35
2	26	37	39	37	40	42	43	47	43	42	43
3	26	29	28	32	27	25	28	26	27	27	27
4	14	16	16	15	14	14	14	14	14	14	14
5	32	34	34	35	33	37	41	45	45	37	39
6	8	7	5	6	5	5	4	4	5	5	5
7	11	8	13	14	12	11	7	11	9	10	10
8	10	10	11	12	10	9	11	11	10	10	10
9	34	42	45	41	43	44	46	45	45	44	45
10	14	17	17	20	23	19	32	42	22	20	21
11	52	47	52	55	54	60	56	59	71	63	64
12	27	32	32	32	31	29	30	31	33	30	30
13	12	16	11	13	18	15	7	9	9	9	9
Total	287	321	325	333	330	334	348	368	360	336	342

Table 5.2 Yearly Number of Aircrafts

For Each Airline in G(B)

	1979	80	81	82	83	84	85	86	87	88	89
1	17	17	17	19	18	18	17	20	19	28	28
2	35	34	35	30	31	31	33	33	34	31	32
3	3	4	4	3	3	3	2	2	3	3	3
4	61	69	70	77	76	74	74	75	73	74	74
5	42	47	45	45	5	48	48	52	47	66	66
6	25	24	24	27	26	24	25	25	26	28	28
7	81	80	83	82	84	83	82	90	88	83	85
8	29	30	27	28	32	31	34	36	39	33	36
9	43	48	42	38	38	37	36	36	37	31	35
10	39	34	36	32	32	29	29	29	31	28	30
11	42	40	39	41	47	48	46	47	48	63	60
Total	417	427	422	422	392	426	426	445	445	468	477

Table 5.2 Yearly Number of Aircrafts

For Each Airline in G(C)

	1979	80	81	82	83	84	85	86	87	88	89
1	18	21	19	20	19	22	22	22	24	22	23
2	95	96	93	85	90	91	93	98	105	97	98
3	7	5	8	8	7	6	6	6	7	7	8
4	60	67	61	56	53	54	86	66	139	139	124
5	14	14	16	18	19	19	17	19	19	19	19
6	27	27	29	32	31	30	30	31	25	25	28
7	181	176	162	138	137	137	136	147	131	131	135
8	29	30	25	27	25	25	29	28	31	31	30
9	94	90	88	88	88	86	85	76	86	86	86
10	74	12	8	9	8	10	11	11	10	10	11
11	25	28	26	28	26	26	27	32	39	39	39
12	53	53	52	51	52	51	52	58	51	51	51
13	46	46	47	40	38	39	40	42	51	51	51
14	91	94	96	100	105	101	110	112	101	101	161
15	17	19	19	24	24	22	22	24	24	24	23
16	42	40	44	48	50	51	53	48	48	48	50
17	25	26	26	24	23	24	24	25	30	30	30
18	76	83	86	86	85	84	95	96	101	101	102
19	48	51	50	51	54	48	50	58	48	48	48
20	22	21	22	27	29	30	29	30	37	37	37
21	20	20	20	15	17	12	10	10	12	12	12
Total	997	1019	997	975	980	968	1027	1039	1119	1109	1166

Table 5.2 Yearly Number of Aircrafts

For Each Airline in G(D)

	1979	80	81	82	83	84	85	86	87	88	89
1	11	12	13	13	11	11	9	15	8	11	11
2	32	26	28	35	27	27	25	25	21	31	29
3	10	10	10	9	9	9	9	7	8	2	6
4	5	5	6	6	7	7	7	5	6	6	6
5	13	12	11	9	8	8	8	8	8	8	8
6	11	11	11	11	11	11	10	11	11	11	11
7	121	14	18	19	18	18	16	17	18	18	18
8	5	5	5	5	6	6	6	6	6	6	6
9	4	4	7	7	7	7	7	9	9	9	9
10	20	16	10	10	8	8	9	9	9	9	9
11	17	20	23	24	28	28	27	27	28	28	32
12	18	19	17	18	21	21	21	21	22	21	21
13	17	15	19	18	22	22	28	27	28	22	22
14	6	3	4	4	4	4	5	4	4	4	4
15	22	21	23	21	20	20	20	21	29	20	20
16	11	11	13	16	14	14	14	16	16	64	62
17	9	23	20	22	28	31	31	28	33	31	31
18	10	10	8	8	7	7	10	10	10	9	9
19	12	14	14	17	17	21	18	24	21	21	21
20	8	10	10	12	9	9	8	7	7	9	9
21	9	9	8	5	4	5	5	6	5	5	5
22	7	6	5	5	5	4	4	4	5	4	4
23	20	22	21	21	20	14	14	12	14	19	19
24	25	25	25	30	28	39	39	17	17	28	28
25	13	13	16	17	17	17	18	19	21	21	20
26	48	48	57	61	61	76	85	92	107	107	76
27	8	8	7	6	6	5	4	4	5	5	5
28	6	6	5	3	3	3	3	6	5	5	7
29	38	38	40	40	40	39	40	41	43	43	39
30	13	13	9	12	12	10	10	10	11	11	10
31	9	8	10	11	11	14	14	13	14	14	11
32	14	18	25	25	25	29	29	21	23	23	20
33	9	13	8	7	7	7	7	8	7	7	7
34	9	9	8	5	5	5	5	6	6	6	6
Total	481	497	514	532	526	556	565	556	585	638	601

Table 5.2 Yearly Number of Aircrafts

For Each Airline in G(E)

	1979	80	81	82	83	84	85	86	87	88	89
1	116	114	117	118	117	117	115	116	111	123	119
2	14	13	14	13	12	10	8	8	9	9	9
3	252	264	256	231	234	260	267	259	410	260	263
4	10	9	6	6	8	10	10	7	8	22	16
5	66	83	84	86	102	96	109	115	153	113	119
6	28	30	36	31	31	31	40	42	39	31	31
7	250	270	272	260	283	284	289	290	284	284	286
8	29	39	36	31	43	39	34	37	37	36	37
9	98	98	128	137	133	120	109	117	125	120	122
10	16	18	13	13	15	17	16	16	17	20	20
11	199	204	194	160	156	158	165	116	213	158	169
12	334	318	296	317	329	317	325	243	378	317	302
Total	1412	1460	1277	1403	1463	1459	1487	1366	1684	1493	1493

Table 5.2 The Actual Number Of Aircraft And Its Accidents.

Year	G(A)		G(B)		G(C)		G(D)		G(E)	
	Zero Acc	one Acc	Zero Acc	one Acc	Zero Acc	one Acc	Zero Acc	one Acc	Zero Acc	one Acc
1979	282	5	409	8	990	7	477	4	1403	9
1980	313	8	421	6	1012	7	487	10	1453	7
1981	317	8	416	6	990	7	506	8	1270	7
1982	327	6	415	7	968	7	519	13	1395	8
1983	327	3	388	4	970	10	514	12	1455	8
1984	325	5	417	9	960	8	550	6	1456	3
1985	342	2	422	4	1023	4	558	7	1483	4
1986	363	5	442	3	1035	4	546	10	1361	5
1987	355	5	442	3	1115	4	580	5	1678	6
1988	332	4	466	2	1106	3	633	5	1490	3
1989	335	7	473	4	1101	5	595	6	1486	7
Total	3684	67	4767	61	11336	72	6160	96	16252	71

Acc = Accident.

Table 5.3a The Actual Number of Claim Amounts Distribution.

Range in Million	G(A)	G(B)	G(C)	G(D)	G(E)
0.0- 3.0	25	27	36	44	32
3.0- 6.0	10	13	13	17	15
6.0- 9.0	7	8	9	7	6
9.0- 12.0	6	2	4	5	2
12.0-15.0	2	1	3	4	3

Table 5.3b The Excess Of Loss

Range	Frequency
16.0- 24.0	21
24.0- 32.0	8
32.0- 40.0	7
40.0- 48.0	3
48.0- 56.0	2
56.0- 64.0	2

It should be noted that, no accident were recorded between the range of U.S $15.00 and 16 million.

This leads to a claim frequency distribution with zero or one accident [1].

Accordingly the binomial distribution might be suggested to be fitted to the actual data. But the result of this attempt was poor in terms of goodness of fit.

From the statistical analysis of the actual data in table 5.1, it can be shown that the difference between the sample mean and the variance is very small in the five groups. This fact is an indication of the suitability of the Poisson distribution.

Consequently, this distribution will be fitted to the actual data as follows.

5.5.1 The Poisson Distribution :

The Poisson distribution is a non-negative, integer-valued distribution which plays a prominent role in statistical theory. In insurance the Poisson distribution plays an important part in describing the claim frequency and measuring the probability of accidents. (Hossack et al (1983)).

The random variable X is said to have the Poisson distribution with parameter q if,

$$P(X=x) = e^{-q}\, q^{x}/x! \qquad (x=0,1,2,...,n)$$

(1) However there is the possibility of having more than one accident but it did not appear in the record due to :
(A) The difference between calendar year and policy year.
(B) The possibility of having more than one accident for the same aircraft, but with different insurance policies in the case of the aircraft being sold to a new owner.

The parameter q must be positive, and the mean and the variance of the distribution will be equal to:

$$E(X) = V(X) = q.$$

5.5.1.1 The Test For goodness of Fit :

The Poisson distribution was tested to the actual data using the common chi-square test as can be seen in table 5.4. The result of that test was acceptable. Even with one degree of freedom the goodness of fit was higher than 90% in the five groups, and the actual data were believed to be following the Poisson distribution.

5.5.2 The Claim Amount Distribution

The main aim of this section is to fit a statistical distribution to the observed claim amounts.

The claim amounts recorded from 91 airlines were found to be laying within the range of 0 up to $92 million. Within this range the claim amount may be distributed into three classes. The first class includes claims less than $15 million, table 5.3a. The second class includes claims more than $16million and less than $ 64 million. Within this class, out of five groups only 44 claims were recorded, an average of 8 claims per group. Accordingly, these claims were gathered in table 5.3b, which will represents the excess of loss class for the five groups.

The third class, includes claims of more than $64 million. Within this class only three accidents were recorded, these accidents were dropped from the analysis.

Table 5.4 X^2 test for goodness of fit for the claim frequency distribution:

For group (A)

Range	(1)	(2)	(1) - (2) = (3)	$(3)^2$ = (4)	(4) / (1) = (5)
0	4041	4041.42	-0.58	0.3364	0.00
1	67	66.58	0.42	0.1764	0.002
Total	4108				0.002

Number of intervals=2
D.F = 2 - 1 = 1

$X^2_\alpha = 90\% = 0.01579$

For group (B)

Range	(1)	(2)	(1) - (2) = (3)	$(3)^2$ = (4)	(4) / (1) = (5)
0	5147	5147.42	-0.58	0.3364	0.00
1	61	60.58	0.42	0.176	0.1764
Total	5208				0.1764

Number of intervals=2
D.F = 2 - 1 = 1

$X^2_\alpha = 90\% = 0.01579$

For group (C)

Range	(1)	(2)	(1) - (2) = (3)	$(3)^2$ = (4)	(4) / (1) = (5)
0	12833	12883.6	-0.4	0.16	0.00
1	72	71.4	0.6	0.36	0.005
Total	12955				0.005

Number of intervals=2
D.F = 2 - 1 = 1

$X^2_\alpha = 90\% = 0.01579$

For group (D)

Range	(1)	(2)	(1) - (2) = (3)	$(3)^2$ = (4)	(4) / (1) = (5)
0	6287	6287.79	-0.79	0.624	0.00
1	96	95.21	0.21	0.0441	0.0005
Total	6383				0.0005

Number of intervals=2
D.F = 2 - 1 = 1

$X^2_\alpha = 90\% = 0.01579$

For group (E)

Range	(1)	(2)	(1) - (2) = (3)	$(3)^2$ = (4)	(4) / (1) = (5)
0	17953	17953.13	-0.13	-0.172	0.00
1	71	70.15	0.15	0.0245	0.003
Total	18024				0.003

Number of intervals=2
D.F = 2 - 1 = 1

$X^2_\alpha = 90\% = 0.01579$

However, this classification will leave us with two sets of claim amount distribution to be fitted.

The first step in fitting the distribution is to present the observed data: see figures 5.1 to 5.6

The graphical representation of the actual data shows a sharp drop in the curve. This fact could be used as an indication that the data might follow an exponential distribution.

5.5.3.1 The Exponential Distribution :

A random variable Y taking non-negative values is said to have an exponential distribution with parameter B if : the cumulative probability function is:

$$P(y) = 1 - e^{(-y/B)}$$

The probability density function is

$$f(Y) = 1/_B \, e^{-(y/B)} \qquad B > 0$$

Given the value of this parameter the entire distribution is determined.

The mean of the exponential distribution is equal to B.

The actual data was tested to the exponential distribution using chi-square test.

The result of this test was not perfect because of the small number of intervals, which was reflected in the number of degrees of freedom, and because of the kink in the middle

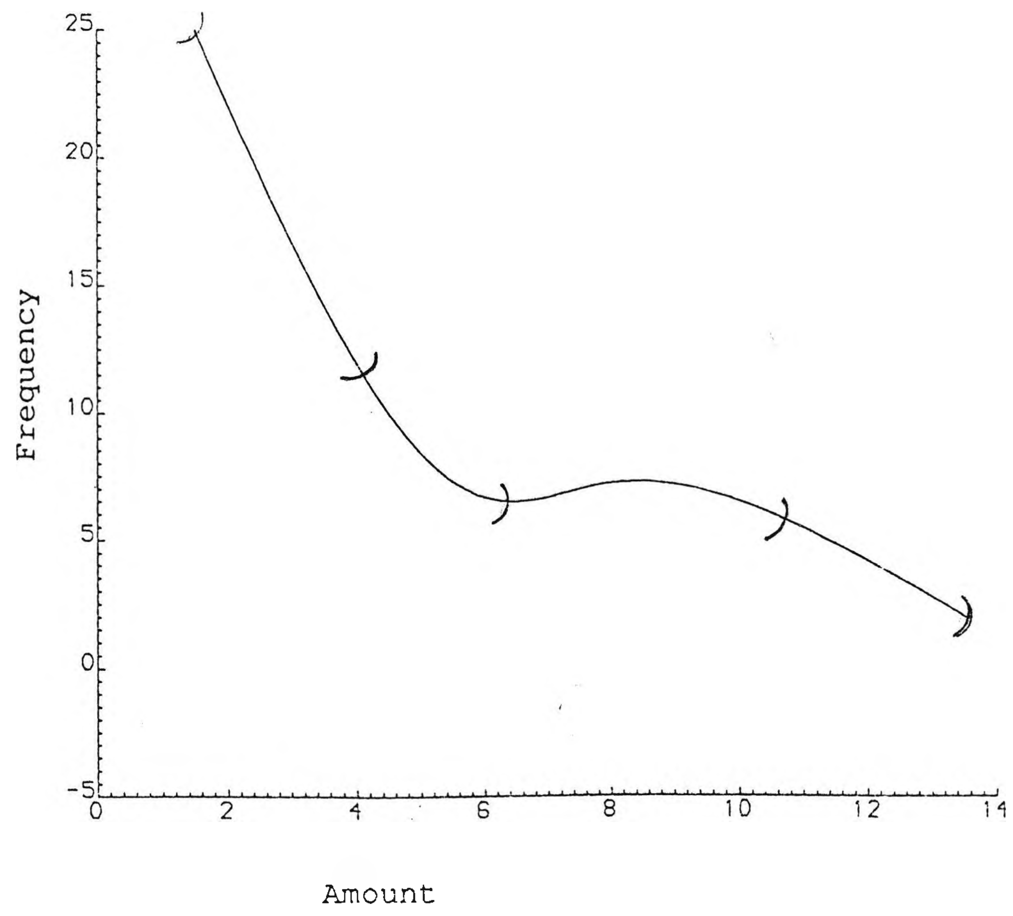


Figure (5.1) Claim amount curve fitting for group (A)

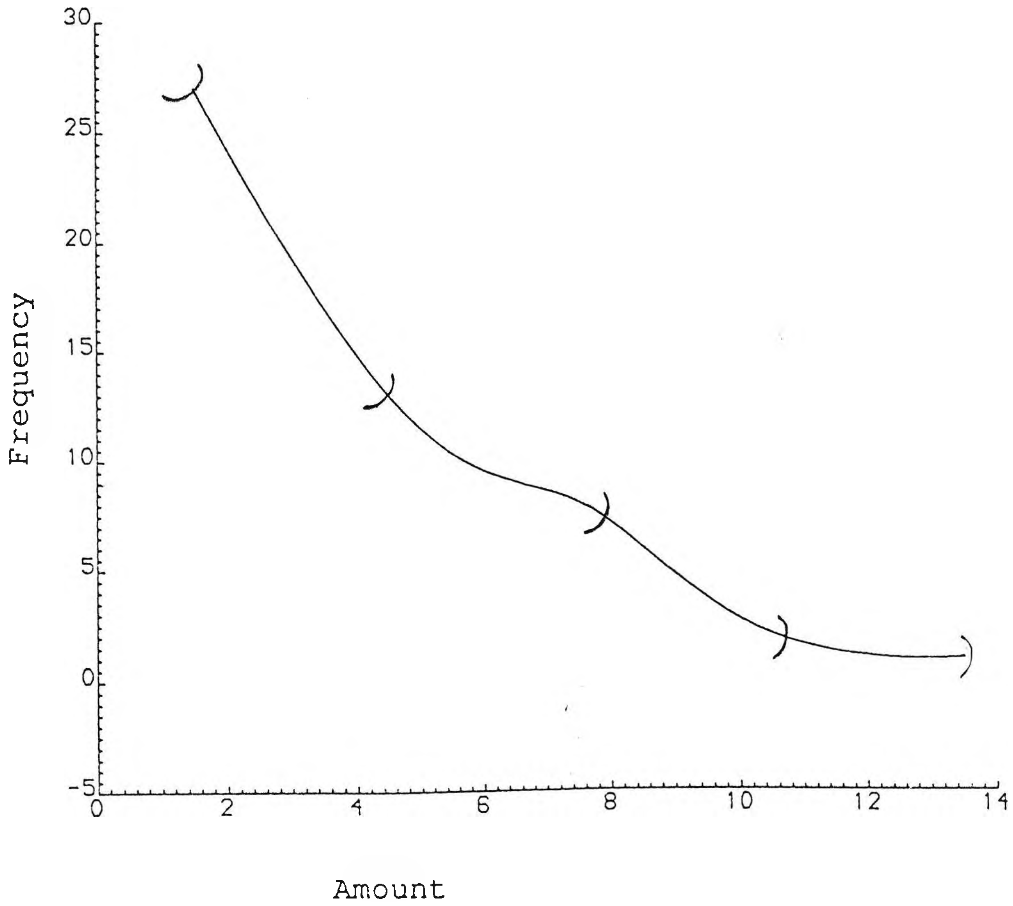


Figure (5.2) Claim amount curve fitting
for group (B)

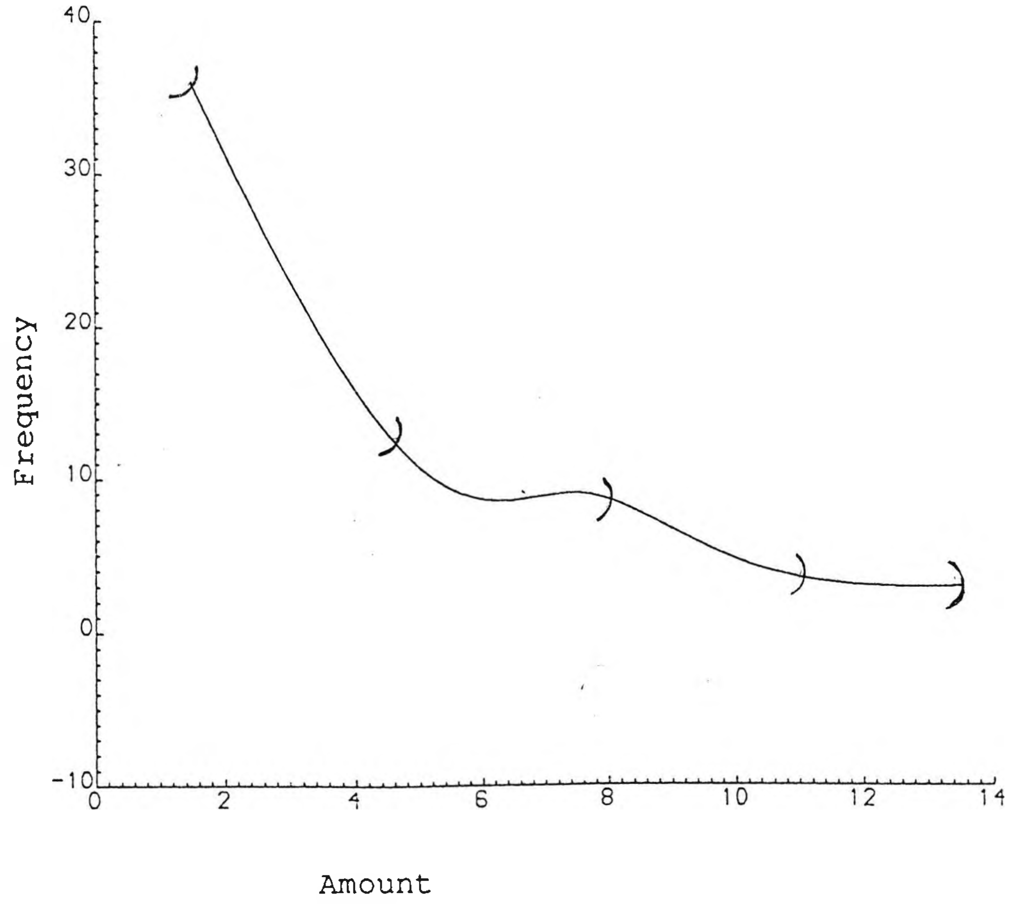


Figure (5.3) Claim amount curve fitting
for group (C)

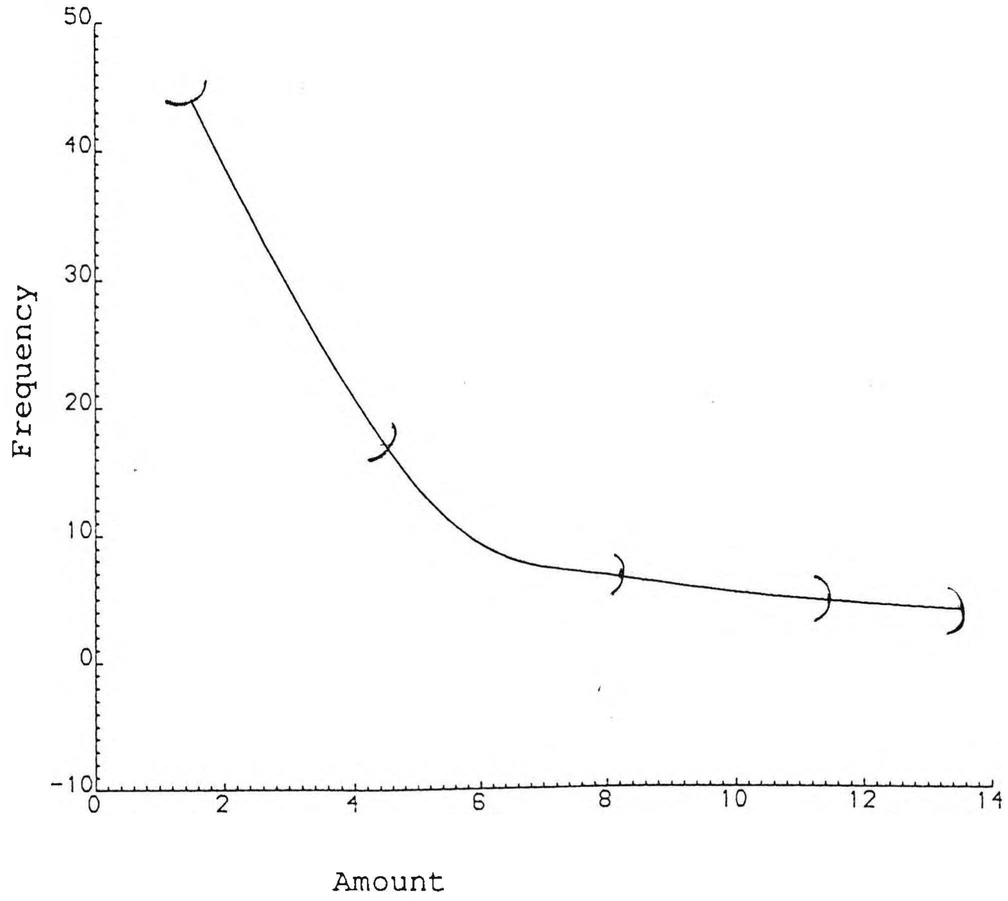


FIGURE (5.4) Claim amount curve fitting

for group (D)

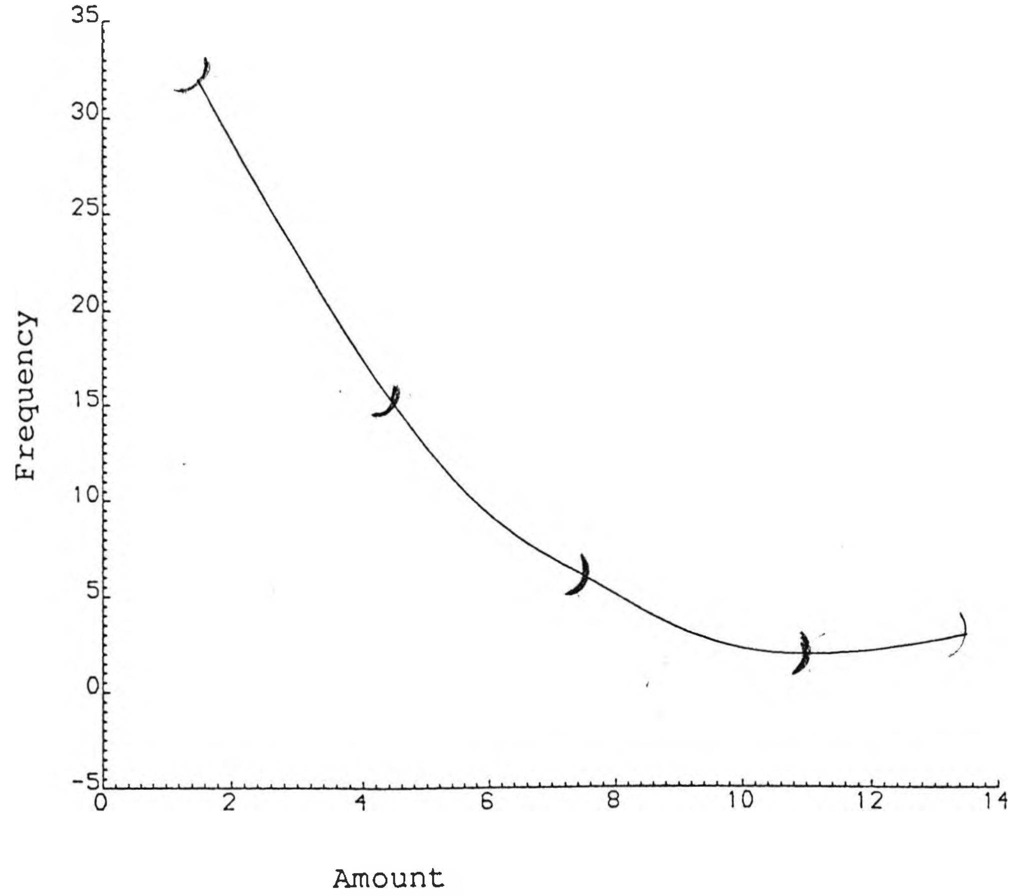


Figure (5.5) Claim amount curve fitting

for group (E)

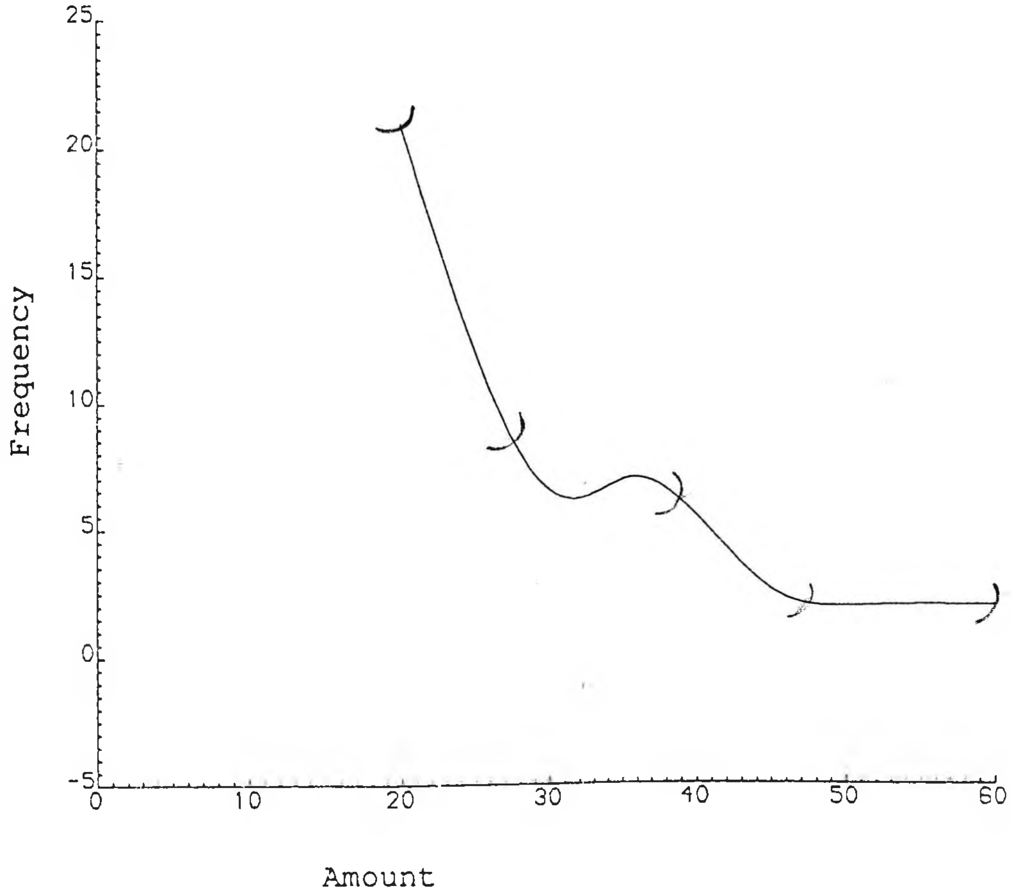


FIGURE (5.6) Claim amount curve fitting for the excess of loss class

The X^2 statistic test for the goodness of fit for the claim amount distribution

G(A)

Mid.Point	(1)	(2)	(1)-(2)= (3)	$(3)^2$=(4)	(4)/(1)= (5)
1.5	25	24.4	0.6	0.36	0.0144
4.5	10	12.5	-2.5	6.25	0.625
7.5	7	6.39	0.605	0.366	0.13396
10.5	6	3.27	2.73	7.452	1.2
13.5	2	1.677	0.323	0.104	0.052
Total	50				2.0252

Number of intervals =5
D.F = 5 -1 = 4

$X^2_{\alpha=50\%} = 3.357$

G(B)

Mid.Point	(1)	(2)	(1)-(2)= (3)	$(3)^2$=(4)	(4)/(1)= (5)
1.5	27	28	-1	1	0.037
4.5	13	12.5	0.5	0.25	0.0192
7.5	8	6.14	1.862	3.467	0.433
10.5	2	3.32	-1.32	1.74	0.056
13.5	1	0.81	0.195	0.031	0.031
Total	51				0.5832

Number of intervals =5
D.F = 5 -1 = 4

$X^2_{\alpha=95\%} = 0.711$

G(C)

Mid.Point	(1)	(2)	(1)-(2)= (3)	$(3)^2$=(4)	(4)/(1)= (5)
1.5	36	34.078	1.922	3.69	0.1026
4.5	13	16.49	-3.49	12.18	0.937
7.5	9	7.59	1.41	1.988	0.2209
10.5	4	3.76	0.24	0.0576	0.0144
13.5	3	1.717	1.28	0.164	0.5486
Total	65				1.8236

Number of intervals =5
D.F = 5 -1 = 4

$X^2_{\alpha=50\%} = 3.357$

G(D)

Mid.Point	(1)	(2)	(1)-(2)= (3)	$(3)^2$=(4)	(4)/(1)= (5)
1.5	44	41.2	2.8	7.84	0.178
4.5	17	19.17	-2.17	4.7089	0.276
7.5	7	8.906	-1.906	3.633	0.519
10.5	5	4.139	0.861	0.7413	0.148
13.5	4	1.925	2.075	4.305	1.076
Total	77				2.197

Number of intervals =5
D.F = 5 -1 = 4

$X^2_{\alpha=50\%}$ = 3.357

G(E)

Mid.Point	(1)	(2)	(1)-(2)= (3)	$(3)^2$=(4)	(4)/(1)= (5)
1.5	32	31.11	0.89	0.792	0.025
4.5	15	14.4	0.6	0.36	0.024
7.5	6	6.59	-0.599	0.359	0.0598
10.5	2	3.027	-1.027	1.055	0.527
13.5	3	1.385	1.615	2.608	0.8694
Total	58				1.505

Number of intervals =5
D.F = 5 -1 = 4

$X^2_{\alpha=80\%}$ = 1.649

The excess of loss class

Mid.Point	(1)	(2)	(1)-(2)= (3)	$(3)^2$=(4)	(4)/(1)= (5)
20	21	24.145	-3.145	9.891	0.471
28	8	9.8	-1.8	3.24	0.405
36	7	3.449	3.55	-12.6	1.801
44	3	2.616	0.384	0.147	0.049
52	2	1.986	0.014	0.0001	0.0009
60	2	1.5	0.5	0.25	0.125
Total					2.8519

Number of intervals =6
D.F = 6 -1 = 5

$X^2_{\alpha=70\%}$ = 3.00

of the curve specially in group (C), (D) and the excess of loss class.

However, the chi-sq test supports the hypothesis that the the actual data follow the exponential distribution as shown in table 5.5 .

5.6 The Result of The Data Analysis :

The previous data analysis included three section,

(A) Classifying the data into different groups,

(B) Fitting a statistical distribution to the claim frequency,

(C) Fitting a statistical distribution to the claim amount

In the first section, the study of the different methods of classification i.e airline size, aircraft types, airline loss ratio and the geographical classification, it was believed that the geographical classification would be more reliable for aviation data than the other methods of classification .

From the second section, it was realised that, the number of aircraft vary considerably from year to year. Merging airlines, changing the airline plan and replacing large aircraft with smaller ones, leasing aircraft from one fleet to another, growing small airlines and financial difficulties facing large fleets, or the effect of outside factors such as the war between Iraq and Iran and its effect on airlines are some of the factors that might cause the fluctuation in number of aircraft inside the fleets from one year to another. This fluctuation was reduced by using the geographical classification. Leasing or selling an aircraft from one airline to another airline in the same group and merging airlines in the same group will not change the total number of aircraft in this group, also expansion of the smaller airline on one hand and financial difficulties facing large fleets on the other hand will reduce the level of fluctuation.

However the Poisson distribution was fitted successfully to the actual data on claim frequency.

From the third section, fitting the claim amount into one distribution was a difficult task. This is because of the nature of aviation accidents. The small number of accidents, the small number of intervals, the large gap between the claim amounts and the large range produced difficulties in fitting the claim amount distribution. Also, the table of the excess of loss, which includes claims from the five groups, has produced difficulties.

Statistically, using the maximum likelihood method the data of two distributions could be joined together. To apply that method to the table of excess of loss jointly with the claim amount distribution of each group will need an assumption that the table of the excess of loss is the result of each group. This assumption will not be acceptable.

The other alternative is to calculate the pure premium in two parts. The first part represents claims less than $15 million, and the second part represents claims in the range between $16m up to $64m.

The second method is preferable to the first method. Some of the accidents were higher than $64 million. Both the methods have neglected these claims.

5.7 Conclusion:

Among the results the following points might be concluded,

Firstly: the nature of aviation insurance data includes a high level of variation from year to year.

Secondly: The data from each airline is very small and cannot be used on its own.

Thirdly: Merging the airline data into groups might help decrease the variation from year to year with the risk of producing a heterogeneous group. However, using the earlier classification and applying the Empirical Bayes credibility theory ,where the main factor in calculating the pure premium is the airline experience, will reduce the risk of heterogeneity among the group.

Fourth: the difficulties in producing a distribution that represents all the claim amounts might also suggest the use of the Empirical Bayes credibility theory where no assumption was made concerning the data distribution.

Finally: In view of the previous four points it might be concluded that the Empirical Bayes credibility theory will be the most appropriate method for calculating the pure premium for aviation insurance.

Accordingly applying the Empirical Bayes theory will be the subject of the next chapter.

CHAPTER SIX

AN EMPIRICAL STUDY

6.1 Introduction:

Recalling the aviation insurance market method of rating as mentioned in chapter two of this study and the credibility theory included in chapters three and four, the similarity between both appears quite clear. Applying the market method the rate is calculated primarily according to the airline experience and amended increasingly or decreasingly due to the overall market result in terms of either profit or loss, whereas the credibility theory stresses that the reliability of the data could be increased by using collateral data.

The main difference lies in the type of the statistical analysis and the mathematical approach. Therefore the credibility theory has been chosen to be used.

Following on from chapters three and four, where different credibility models have been studied, and the results of the analysis of the data collected and the result of this analysis in chapter five, recommended the Empirical Bayes theory to be the most reliable to be applied to aviation insurance.

Accordingly, the Empirical Bayes model will be used to calculate the pure premium using the following assumptions.

1- Each airline is insured under one policy.

2- Leased aircraft whether it is dry lease or wet lease[1] are insured under the same airline policy.

3- Using the Empirical Bayes theory, the pure premium will be calculated for each airline in its own group.

4- The final pure premium will represent the pure premium for each aircraft inside each airline.

5- To calculate the pure premium using 4.4.14 it will be assumed that:

N will represent number of airline inside each group, where N = 1,2,....

n will represent the number of policies issued to each airline during the experience period. where n = 1,2,...

Y_{ij} will represent the claim amount produced by airline i in year j,

P_{ij} will represent the number of aircraft inside airline i in year j,

Finally; the parameter $E\{S^2(\theta)\}$ and $V\{m(\theta)\}$ will be calculated using formula 4.4.19 and 4.4.20.

(1) Dry lease: when the airline leases only the aircraft . Wet lease: when the lease contract includes the aircraft with the pilot and the crew.

In table 6.1, $\overline{P}_i, \overline{X}_i, \overline{X}$ and $P(1-P_i/P)$ will be calculated where $\overline{P}_i$ represents the total number of aircraft inside airline i.

$\overline{P}$ represent the total number of aircraft inside the group,

$\overline{X}_i$ represents the claim amount per aircraft for airline i , $\left(\frac{\text{Total claim amount}}{\text{total number of aircraft}}\right)$

P^* represents weighted average of number of aircraft for airlines included in the group.

In table 6.2 the expected value $E(S^2(\theta))$ was calculated, using equation 4.4.19 , while in table 6.3 the variance $V(M(\theta))$ was calculated.

Finally, using equation 4.4.14 the pure premium for each airline was calculated in table 6.4.

Table (6.1) Parameter estimation for

Group (A)

	$\bar{P}_i$	$\bar{X}_i$	$\bar{X}$	$\bar{P}_i\ (1 - \bar{P}_i/\ \bar{P}\ )$
1	340	0.0335	0.00304	309
2	439	0.0695	0.008	387
3	302	0.0625	0.0055	277.6
4	172	0.044	0.002	164
5	412	0.01214	0.00133	366.6
6	55	0.1091	0.0016	54
7	116	0.1035	0.00331	112.4
8	114	0.1224	0.00373	110.5
9	474	0.036	0.00456	413.9
10	220	0.170	0.00999	207
11	633	0.0348	0.005886	525.9
12	337	0.2098	0.02114	306.6
13	128	0.000	0.0000	123.6

Where $\bar{P} = \sum_{i=1}^{N} \bar{P}_i = 3742$

$$\bar{X}_i = \sum_{j=1}^{N} P_{ij}\ X_{ij}\ /\ \bar{P}_i$$

$$\overline{X} = \sum_{i=1}^{N} \overline{P}_i\ \overline{X}_i / \overline{P} = 0.07008$$

$P^* = 23.65$

$n = 11$

$N = 13$

Table (6.1) Parameter estimation for

Group (B)

	$\bar{P}_i$	$\bar{X}_i$	$\bar{X}$	$\bar{P}_i\ (1 - \bar{P}_i / \bar{P})$
1	218	0.255	0.01157	208
2	359	0.005	0.00037	332
3	33	0.227	0.00155	32.99
4	797	0.069	0.01145	664.77
5	551	0.099	0.01136	487.8
6	282	0.0471	0.0028	265.45
7	921	0.0597	0.01145	744.4
8	355	0.187	0.0138	328
9	421	0.0101	0.00088	384.1
10	346	0.003	0.00029	321
11	521	0.0033	0.00036	464

$n = 11$

$N = 11$

$\bar{P} = 4804$

$\bar{\bar{X}} = 0.06588$

$P^{*} = 35.2709$

Table (6.1) Parameter estimation for

Group (C)

	$\bar{P}_i$	$\bar{X}_i$	$\bar{X}$	$\bar{P}_i \; (1 - \bar{P}_i / \bar{P})$
1	232	0.0418	0.00086	227.2
2	1041	0.1959	0.018	944.5
3	75	0.00	0.00	74.46
4	680	0.0211	0.0013	638.8
5	187	0.01614	0.00268	183.9
6	320	0.0281	0.00079	310.9
7	1631	0.0188	0.00223	1586.5
8	306	0.00	0.00	297.6
9	950	0.033	0.00279	869.7
10	109	0.0381	0.00379	107.9
11	329	0.0234	0.000696	319.4
12	578	0.0574	0.00295	548.26
13	522	0.0134	0.00062	497.7
14	1153	0.0513	0.0053	1034.7
15	240	0.0387	0.00083	234.9
16	527	0.0154	0.0007	502
17	287	0.0251	0.00064	279.66
18	999	0.011	0.00097	910
19	558	0.0179	0.00089	530
20	513	0.063	0.0017	489.5
21	195	0.339	0.00059	191.6

$n = 11$

$N = 21$

$\bar{X} = 0.04258$

$\bar{p} = 11234$

$P^* = 46.86$

Table (6.1) Parameter estimation for

Group (D)

	$\bar{P}_i$	$\bar{X}_i$	$\bar{X}$	$\bar{P}_i\ (1 - \bar{P}_i/\ \bar{P}\ )$
1	136	0.00	0.00	132.9
2	306	0.00	0.00	283
3	91	0.06	0.0009	89.6
4	65	0.0115	0.00012	64.3
5	99	0.010	0.0016	97.4
6	109	0.078	0.0014	107
7	293	0.036	0.00176	283.4
8	61	0.057	0.0005	60.4
9	79	0.0317	0.0042	77.96
10	118	0.0398	0.00078	115.7
11	282	0.613	0.0288	268.8
12	219	0.00	0.00	211
13	238	0.0084	0.00	228.6
14	46	0.043	0.00033	45.6
15	130	0.13	0.0028	127
16	251	0.00	0.00	240
17	287	0.01567	0.00075	273
18	18	0.021	0.00034	17.8
19	200	0.01	0.00033	199.99
20	98	0.0117	0.000191	96.4
21	66	0.106	0.00116	65.3
22	56	0.00	0.00	55.5
23	201	0.0162	0.0054	194
24	303	0.308	0.01553	287
25	190	0.006	0.00019	183.99
26	799	0.07	0.009	692
27	62	0.019	0.0003	61.36
28	55	0.117	0.00107	54.5
29	439	0..25	0.0183	406.9
30	110	0.0322	0.0006	107.9
31	123	0.014	0.00028	120.5
32	244	0.31	0.01258	234
33	86	0.0186	0.0004	84.8
34	75	0.033	0.00042	74.06

$n = 34$
$\underline{N} = 11$
$\bar{X} = 0.10592$
$\bar{P} = 6008$
$p^{*} = 15.03$

Table (6.1) Parameter estimation for

Group (E)

	$\bar{P}_i$	$\bar{X}_i$	$\bar{X}$	$\bar{P}_i\ (1 - \bar{P}_i / \bar{P})$
1	1283	0.0178	0.0014	1181.9
2	139	0.00	0.00	138
3	2956	0.0344	0.00624	2419.6
4	112	0.0134	0.00	111.23
5	1126	0.0046	0.00323	1048
6	370	0.00	0.00	361.6
7	3052	0.01512	0.00283	2480
8	398	0.2324	0.00567	388.28
9	1307	0.022	0.001765	1202
10	181	0.0099	0.001	178.9
11	1892	0.0029	0.00034	1672.3
12	3476	0.0117	0.0025	2734.4

$n = 12$

$N = 11$

$\bar{X} = 0.04258$

$\bar{p} = 11234$

$P^* = 106.2$

TABLE 6.2 Estimation of

$P_{ij} (X_{ij} - \bar{X}_i)^2$ For Group (A)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.0359	0.497	0.003	0.0393	0.0359	0.0393	0.0404	0.124	0.035	.0008	0.010
2	0.1256	0.179	3.873	0.179	0.1932	0.2029	0.2077	0.8267	0.211	0.203	0.208
3	0.1016	0.003	0.093	0.003	0.293	0.1054	0.098	0.0926	.0002	0.165	0.122
4	0.027	0.031	1.154	0.029	0.2812	0.027	0.027	0.027	0.027	0.027	0.027
5	0.0047	0.005	0.005	0.0052	0.0049	0.0055	0.4174	0.0066	0.007	0.006	0.008
6	0.095	0.034	0.091	0.07	0.0595	0.0595	0.0476	0.0476	0.059	0.691	0.059
7	0.1178	0.086	0.139	0.1499	0.1285	0.1178	0.0749	0.1178	13.6	0.107	0.107
8	0.0015	0.176	0.068	0.0018	0.0015	14.414	0.0017	0.0017	0.002	0.002	0.002
9	0.044	0.006	0.058	0.0256	0.056	0.0077	0.0596	2.17	0.058	0.057	0.058
10	0.0405	0.262	0.49	0.578	0.665	0.262	0.663	0.694	7.992	0.578	4.14
11	1.513	0.057	0.027	0.067	0.0654	0.006	0.0279	0.029	11.98	0.024	6.97
12	0.0106	2.84	2.842	7.787	0.515	1.276	0.766	0.0079	1.45	1.321	6.262
13	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00

$E\ (S^2(\oplus)) = 11^{-1} \cdot 13^{-1} \cdot 106.5976 = 0.8074$

TABLE 6.2 Estimation of

$P_{ij} (X_{ij} - \bar{X}_i)^2$ For Group (B)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	1.1	1.1	1.1	1.1	0.59	1.17	0.72	1.3	1.235	1.82	1.82
2	0.0008	.0008	.0008	0.0008	0.0008	0.0008	0.0008	0.0008	.0008	.0008	.0007
3	0.154	0.087	6.48	0.154	0.154	0.154	0.154	0.154	0.1	1.00	1.54
4	0.505	0.03	0.002	0.0019	0.0006	0.647	0.35	0.357	0.058	0.352	.0003
5	0.0047	0.005	0.005	0.0052	0.0049	0.0055	0.4174	0.0066	0.007	0.006	0.008
6	0.677	0.001	0.101	0.108	0.47	0.212	0.292	4.68	0.45	0.00	0.355
7	0.055	0.637	0.053	3.066	0.2	0.053	0.053	0.057	0.057	0.062	0.062
8	0.2887	0.288	0.29	0.292	0.0002	0.1443	1.0002	0.32	0.314	0.296	0.301
9	0.25	1.05	35.89	0.979	1.119	1.1	1.077	4.74	1.363	1.153	0.063
10	0.004	0.005	0.015	0.009	0.0039	0.1198	0.0037	0.0037	0.004	0.003	0.077
11	.00035	.0003	.0003	0.025	0.0003	0.0003	0.0003	0.0003	.0003	.0003	.0003
12	0.00	.0005	.0004	.0004	.0004	.0005	.0005	.00059	0.48	.0007	.0007

$E (S^2(\theta)) = 11^{-1} . 10^{-1} . 77.48 = 0.7$

TABLE 6.2 Estimation of

$P_{ij} (X_{ij} - \bar{X}_i)^2$ For Group (C)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.0315	0.037	0.026	0.8669	0.033	0.0384	0.0384	0.6496	0.042	0.041	0.041
2	3.569	3.607	3.496	1.5152	3.38	3.419	46.53	3.761	4.03	3.723	54.08
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.0267	0.294	0.027	0.025	0.0234	0.024	0.0383	0.0294	0.395	0.062	0.055
5	0.0036	0.004	0.004	0.0047	0.0049	0.0002	0.0044	0.0049	0.005	0.005	0.005
6	0.0212	0.021	0.023	0.025	2.133	0.0235	0.0235	0.0243	0.024	0.019	0.022
7	0.0319	0.062	0.229	.00006	0.0484	1.39	1.394	0.052	1.027	.0009	0.918
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.276	0.098	0.096	0.095	0.26	0.0937	0.0705	0.005	0.094	0.094	0.094
10	0.0102	0.034	0.066	0.0131	0.0116	0.0145	0.0159	0.232	0.017	0.015	0.016
11	2.0178	0.015	0.014	0.0153	0.014	0.014	0.0148	0.0175	0.018	0.021	0.021
12	0.175	0.175	0.171	0.168	2.0067	0.68	0.0791	0.191	0.178	0.168	1.486
13	0.0083	0.077	0.319	0.0072	0.0068	0.007	0.0072	0.0075	0.007	0.009	0.009
14	0.0597	0.247	0.253	0.263	11.4	0.496	0.2895	0.295	0.334	0.266	0.305
15	0.0255	0.028	1.94	0.036	0.036	0.033	0.1235	0.036	0.033	0.036	0.034
16	0.0099	0.48	0.01	0.0114	0.0012	0.0011	0.0126	0.0114	0.013	0.011	0.035
17	0.0157	1.184	0.005	0.0151	0.0145	0.0151	0.0151	0.0157	0.017	0.017	0.017
18	0.0092	0.01	0.01	0.01	0.0104	0.0295	0.0115	0.0032	0.197	0.012	0.012
19	1.74	0.016	0.016	0.0163	0.0173	0.054	0.016	0.0186	0.017	0.015	0.015
20	0.594	0.083	0.087	0.1072	3.928	0.0159	0.0265	0.1191	0.123	0.147	0.147
21	2.298	2.298	2.298	1.724	1.95	1.38	0.7344	1.149	1.264	1.38	1.38

$E\ (S^2(\oplus) = 12^{-1} \cdot 11^{-1} \cdot 196.23 = 1.4866$

TABLE 6.2 Estimation Of

$P_{ij} (X_{ij} - X_{ij})^2$ For Group (D)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.036	0.036	0.036	0.033	0.005	0.095	0.032	0.025	0.029	0.007	0.022
4	.0006	.0006	.0008	.0008	.0005	.0009	.0041	.0006	.0008	.0008	.0008
5	0.001	0.001	0.001	0.009	0.009	0.001	0.008	0.008	0.008	0.008	0.008
6	0.067	0.007	0.067	0.067	0.012	2.404	0.06	0.067	0.067	0.067	0.067
7	7.808	0.085	0.023	0.025	0.025	0.025	0.011	0.022	0.023	0.023	0.023
8	0.016	0.016	0.016	0.98	0.016	0.02	0.072	0.02	0.02	0.02	0.02
9	0.004	0.004	1.535	0.007	0.007	25.18	.007	0.009	0.009	0.009	6.66
10	0.513	.0002	0.002	0.002	0.002	0.002	0.013	0.013	0.013	0.013	0.013
11	6.388	7.033	8.64	0.916	10.52	10.52	10.14	0.836	11.36	10.52	12.02
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	.0013	.001	.0013	.0013	.0014	.0015	.0019	.0019	.0019	.0015	.0015
14	.0069	.0035	.0046	.0046	.0046	.0046	.0058	.0046	.0046	.835	.0046
15	0.372	0.355	0.389	0.355	8.53	0.338	0.338	0.355	0.321	0.338	0.338
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
17	.0022	.0056	.0049	.0054	.589	.0076	.0076	.0069	.0081	.0076	.0076
18	.0044	.0044	.0035	.0035	.0031	.004	.0044	.0044	.0044	.004	.364
19	.0012	0.139	.0014	.0017	.0017	.0021	.0018	.0024	.0021	.0021	.0021
20	.0011	.0014	.0014	.0016	.0012	.0012	.0011	0.163	.0009	.0012	.0012
21	0.01	0.01	0.089	0.056	18.92	0.056	0.056	0.067	0.056	0.056	0.056
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.324	0.356	0.131	0.34	0.043	0.307	0.227	0.194	0.227	0.308	0.308
24	2.372	1.299	1.904	1.176	0.407	3.889	3.699	1.613	210.1	4.42	1.339
25	.00047	.0005	.0006	.0005	.0006	.0006	.0007	0.051	.0008	.0008	.0007
26	0.235	54.91	0.279	0.314	0.298	0.37	0.288	0.451	0.524	0.372	0.417
27	0.0025	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.002	0.002	0.002
28	0.068	0.109	1.367	0.068	0.041	0.041	0.041	0.109	0.068	0.096	2.43
29	2.25	5.92	2.5	2.625	2.5	2.44	2.5	2.56	131.7	2.44	2.56
30	0.01	0.014	0.009	0.344	.001	0.015	0.01	0.086	0.01	0.01	0.01
31	.00176	.0016	0.011	0.39	2.134	0.002	0.003	0.003	0.003	0.002	0.002
32	0.096	1.085	0.303	0.435	1.822	3.042	1.039	1.709	2.21	1.922	2.018
33	0.003	0.005	0.003	0.004	0.002	1.47	0.002	0.002	0.003	0.002	0.002
34	0.0098	0.01	0.067	0.008	.0005	.007	.005	.007	.007	.008	.008

TABLE 6.2 Estimation of

$P_{ij} \, (X_{ij} - \bar{X}_i)^2$ For Group (E)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.0367	0.036	1.917	0.247	0.522	0.037	0.036	0.0367	0.035	0.039	0.003
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	3.185	0.312	0.303	0.0273	0.2769	0.1098	0.0545	1.88	0.485	1.33	0.163
4	0.0018	0.002	0.001	0.336	0.0014	0.0018	0.0018	0.0013	0.001	0.004	.0029
5	13.604	0.57	0.178	0.0246	0.216	0.203	0.231	0.2433	0.060	0.239	0.117
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.0127	0.062	0.036	0.059	0.0003	0.0649	0.9	0.0033	0.078	0.065	0.065
8	3.2928	1.259	0.887	1.237	0.0064	2.899	1.83	1.99	1.00	1.937	63.35
9	0.0184	0.039	0.039	0.065	0.763	0.008	0.053	0.0566	0.06	0.058	0.059
10	0.0122	0.002	0.001	0.0203	0.0017	0.0016	0.0073	0.0016	0.002	0.002	0.002
11	.00017	.0002	.0016	0.0013	0.0013	0.0013	0.0098	0.0098	.0266	.0013	.0014
12	0.0308	0.044	0.041	0.4339	0.0104	0.0434	0.0449	0.0125	0.052	0.125	1.823

$E \, (S^2(\oplus) = 12^{-1} \, . \, 10^{-1} \quad 111.276 = 0.9273$

TABLE 6.3 Estimation of

$P_{ij} \; (X_{ij} - \bar{X})^2$ For Group (A)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.157	0.811	0.026	0.172	0.157	0.172	0.177	0.009	0.152	0.060	0.018
2	0.1277	0.182	3.858	0.1817	0.196	0.206	0.2112	0.82	0.207	02063	0.211
3	0.1277	0.776	0.083	0.0037	0.252	0.133	0.1228	0.137	0.001	0.135	0.957
4	0.0687	0.078	0.94	0.0736	0.1872	0.0687	0.0687	0.0687	0.069	0.069	0.069
5	0.157	0.166	0.167	0.172	0.162	0.1817	0.1103	0.22	0.22	0.182	0.192
6	0.0393	0.073	0.084	0.0295	0.074	0.074	0.0196	0.0196	0.024	2.664	0.025
7	0.054	0.039	0.064	0.0687	0.0589	0.054	0.0344	0.054	14.36	0.049	0.049
8	0.049	0.075	0.005	0.0589	0.049	13.13	0.054	0.054	0.049	0.049	0.049
9	0.167	0.021	0.221	0.0034	0.2112	0.0987	0.226	1.55	0.22	0.216	0.221
10	1.0188	0.853	0.083	0.098	0.1129	0.006	0.1129	0.1179	10.86	0.098	5.79
11	0.1067	0.231	0.008	0.27	0.265	0.1712	0.275	0.289	0.125	0.309	0.475
12	0.633	0.157	0.157	12.82	2.237	0.1424	0.1916	0.752	0.162	0.147	10.68
13	0.0589	0.079	0.054	0.0638	0.088	0.0737	0.0344	0.044	0.044	0.044	0.044

$V \; (n \; (\theta) = \{ (13^{-1} \; . \; 11^{-1} - 1) \quad 98.749 \quad \} - 0.8074 \; . \; 22.65^{-1} = 0.66465$

TABLE 6.3 Estimation of

$P_{ij} (X_{ij} - \bar{X})^2$ For Group (B)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.736	0.736	0.736	.0028	0.0778	0.0021	15.83	0.0865	0.082	0.121	0.121
2	0.1498	0.147	0.149	0.1298	0.134	0.134	0.1428	0.1428	0.147	0.134	0.138
3	0.0129	0.382	8.23	0.0129	0.0129	0.0129	0.0129	0.0068	0.007	0.013	0.013
4	0.54	0.04	0.04	0.0071	0.017	0.0029	0.32	0.33	0.71	0.32	44.87
5	1.078	0.028	0.153	0.1947	0.1947	0.096	0.111	5.774	0.151	0.112	0.6
6	0.081	3.46	0.078	2.73	0.1245	0.078	0.081	0.081	0.081	0.112	0.112
7	0.35	0.32	0.359	0.0049	0.0052	0.051	10.64	0.389	0.383	0.359	0.368
8	1.33	0.129	43.84	0.3194	0.1385	0.1372	0.13	8.44	0.169	0.143	.0003
9	0.186	0.208	0.057	0.06	0.1644	0.1587	0.01	0.01	0.16	0.134	0.003
10	0.169	0.147	0.01	0.0387	0.1255	0.1255	0.1255	0.134	0.134	0.121	0.129
11	0.182	0.179	0.168	0.1817	0.203	0.2076	0.199	0,199	0.044	0.273	0.259

$V (n (\oplus) = \{ (11^{-1} . 11^{-1} - 1) \; 264.414 \} - 0.7 \; . \; 32.54^{-1} = 0.046$

TABLE 6.3 Estimation Of

$P_{ij} (X_{ij} - \bar{X})^2$ For Group (C)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.033	0.038	0.027	0.861	0.034	0.39	0.39	0.64	0.044	0.039	0.042
2	0.172	0.174	0.169	6.993	0.163	0.165	68.88	0.177	0.19	0.176	78.7
3	0.013	0.009	0.015	0.015	0.013	0.011	0.011	0.011	0.013	0.013	0.015
4	0.109	0.134	0.111	0.102	0.096	0.098	0.156	0.119	0.041	0.252	0.225
5	0.025	0.025	0.029	0.033	0.034	0.034	0.031	0.034	0.033	0.034	0.034
6	0.049	0.049	0.052	0.058	1.93	0.054	0.054	0.056	0.054	0.045	0.051
7	0.249	0.319	0.002	0.083	0.248	10.55	01265	0.267	0.274	0.059	0.244
8	0.053	0.054	0.45	0.049	0.045	0.045	0.053	0.051	0.049	0.056	0.054
9	0.187	0.163	0.159	0.048	0.158	0.156	0.316	0.657	0.15	0.156	0.156
10	0.013	0.029	0.09	0.016	0.015	0.018	0.019	0.218	0.022	0.002	0.019
11	1.76	0.051	0.047	0.051	0.047	0.047	0.049	0.058	0.059	0.071	0.071
12	0.096	0.096	0.094	0.093	2.45	0.092	0.049	0.105	0.098	0.093	0.95
13	0.083	0.006	0.133	0.072	0.069	0.071	0.073	0.076	0.073	0.091	0.091
14	0.107	0.170	0.174	0.181	12.02	0.627	0.199	0.203	0.23	0.183	0.210
15	0.031	0.034	1.889	0.044	0.044	0.039	0.33	0.044	0.039	0.044	0.042
16	0.76	0.272	0.079	0.087	0.091	0.026	0.096	0.087	0.096	0.087	0.042
17	0.045	0.998	.0004	0.044	0.417	0.044	0.044	0.045	0.054	0.054	0.054
18	0.138	0.15	0.156	0.156	0.035	0.138	0.172	0.134	0.014	0.183	0.185
19	1.32	0.092	0.091	0.906	0.091	0.098	0.087	0.105	0.094	0.087	0.87
20	0.75	0.038	0.039	0.049	4.376	.0002	0.003	0.054	0.056	0.067	0.067
21	0.036	0.036	0.036	0.027	0.031	0.022	3.219	0.018	0.019	0.022	0.022

$V (n (\odot)) = (11^{-1} \cdot 21^{-1} - 1) \cdot 219.14 - (1.4866 \cdot 46.86^{-1}) = 0.921$

TABLE 6.3 Estimation Of

$P_{ij} (X_{ij} - \bar{X})^2$ For Group (D)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.124	0.134	1.750	1.75	0.247	0.123	0.101	0.168	0.089	0.123	0.123
2	0.359	0.292	0.314	0.339	0.35	0.303	0.28	0.286	0.236	0.348	0.325
3	0.1122	0.112	0.112	0.101	0.502	0.022	0.101	0.078	0.089	0.022	0.067
4	0.056	0.56	0.067	0.067	0.027	0.79	0.035	0.056	0.067	0.067	0.067
5	0.146	0.135	0.123	0.101	0.101	0.003	0.089	0.089	0.089	0.089	0.089
6	0.123	0.063	0.123	0.123	0.04	2.09	0.112	0.123	0.123	0.123	0.123
7	5.58	0.16	0.202	0.213	0.19	0.212	0.035	0.19	0.202	0.202	0.202
8	0.056	0.056	0.056	0.776	0.056	0.067	0.022	0.404	0.404	0.404	0.404
9	0.045	0.045	2.76	0.078	0.078	1.823	0.078	0.101	0.101	0.101	5.5
10	0.177	0.069	0.112	0.112	0.112	0.089	0.101	0.101	0.101	0.089	0.101
11	0.191	0.16	0.258	11.98	0.314	0.314	0.303	2.96	36.65	0.314	0.359
12	0.202	0.213	0.191	0.202	0.224	0.236	0.236	0.236	0.247	0.236	0.236
13	0.191	0.168	0.13	0.202	0.224	0.247	0.314	0.027	0.314	0.25	0.23
14	0.067	0.034	0.045	0.045	0.045	0.045	0.056	0.045	0.045	0.621	0.045
15	0.247	0.24	0.26	0.24	9.222	0.224	0.224	0.24	0.213	0.224	0.224
16	0.123	0.123	0.146	0.179	0.16	0.16	0.16	0.179	0.179	0.72	0.696
17	0.101	0.258	0.224	.0.25	0.048	0.35	0.095	0.314	0.37	0.348	0.348
18	0.112	0.112	0.089	0.089	0.78	0.78	0.112	0.112	0.112	0.101	0.266
19	0.135	0.019	0.157	0.191	0.191	0.236	0.202	0.27	0.24	0.24	0.24
20	0.089	0.112	0.112	0.135	0.101	0.101	0.089	0.024	0.079	0.079	0.101
21	0.101	0.101	0.089	0.056	10.81	0.056	0.056	0.067	0.056	0.056	0.056
22	0.078	0.067	0.056	0.056	0.056	0.079	0.045	0.045	0.056	0.045	0.045
23	0.224	0.25	0.017	0.236	0.213	0.459	0.157	0.135	0.157	0.213	0.213
24	0.281	0.017	0.137	.0005	2.915	0.459	0.437	0.191	234.9	10.06	0.008
25	0.146	0.146	0.179	0.168	0.191	0.191	0.202	0.044	0.236	0.236	0.224
26	0.54	49.6	0.64	0.72	0.68	0.85	0.75	1.032	1.2	0.853	0.954
27	0.079	0.089	0.078	0.067	0.067	0.056	0.045	0.089	0.056	0.056	0.056
28	0.056	0.067	1.426	0.056	0.034	0.034	0.034	0.067	0.056	0.078	0.899
29	0.404	11.03	0.449	0.47	0.449	0.437	0.449	0.459	154.3	0.44	0.459
30	0.112	0.146	0.101	0.117	0.135	0.157	0.112	0.004	0.123	0.112	0.112
31	0.101	0.089	0.002	0.122	3.836	0.123	0.157	0.145	0.154	0.123	0.146
32	1.15	3.64	2.47	0.178	5.62	4.942	0.006	5.028	0.258	0.22	0.236
33	0.101	0.146	0.089	0.067	0.078	0.105	0.079	0.089	0.79	0.079	0.079
34	0.101	0.101	0.003	0.079	0.188	0.067	0.056	0.067	0.067	0.079	0.079

$V(n(\odot)) = (11^{-1} \cdot 34^{-1} - 1) \cdot 650 - (1.8677 \cdot 15.03^{-1}) = 2.26$

TABLE 6.3 Estimation of

$P_{ij} (X_{ij} - \bar{X})^2$ For Group (E)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.067	0.065	0.012	0.183	0.429	0.067	0.066	0.067	0.064	0.071	0.016
2	0.008	0.008	0.008	0.0075	0.0069	0.0057	0.0046	0.0046	.0052	.0052	.0052
3	0.799	0.153	0.148	0.1335	0.135	0.027	0.16	2.369	0.237	1.743	0.056
4	0.0057	0.005	0.004	0.306	0.0046	0.0057	0.0057	0.004	0.005	0.013	0.009
5	14.95	0.789	0.48	0.0022	0.0589	0.0555	0.069	0.0066	.0007	0.065	0.01
6	0.0162	0.017	0.02	0.018	0.018	0.018	0.023	0.024	0.023	0.018	0.018
7	0.0643	0.156	0.002	0.15	0.0278	0.164	0.636	0.044	0.017	0.016	0.017
8	8.61	0.03	0.094	0.002	2.084	0.0226	0.0196	0.021	0.07	0.02	85.09
9	0.0134	0.031	0.048	0.053	0.722	0.0127	0.165	0.1775	0.189	0.182	1.85
10	0.0028	0.104	0.008	0.0075	0.0076	0.0098	0.0093	0.0007	0.009	0.012	0.012
11	0.0814	0.118	0.112	0.09	0.09	0.913	0.0298	0.067	.0211	0.091	0.098
12	0.162	0.184	0.171	0.183	0.106	0.183	.0001	0.0925	0.218	0.018	1.29

$V (n (\oplus) = \{ (11^{-1} . 12^{-1} - 1) \ 111.2767 \} - 0.9273 . 106.2^{-1} = 0.7$

Table 6.4 The Pure Premium For The Five Groups

GROUP (A)		GROUP (B)		GROUP (C)		GROUP (D)		GROUP (E)	
N	P.P	N	P.P	N	P.P	N	P.P	N	P.P
1	0.02707	1	0.2834	1	0.0418	1	0.52177	1	0.5277
2	0.05609	2	0.0328	2	.2052	2	0.00112	2	0.8438
3	0.13608	3	0.3755	3	0.0009	3	0.00005	3	0.3249
4	00.0356	4	0.0829	4	0.02115	4	0.0616	4	0.8598
5	0.00979	5	0.216	5	0.01627	5	0.0137	5	0.535
6	0.088	6	0.0634	6	0.02819	6	0.01156	6	0.734
7	0.0835	7	0.0695	7	0.0188	7	0.0606	7	0.314
8	0.0988	8	0.1542	8	0.00022	8	0.0363	8	0.77376
9	0.02896	9	0.03975	9	0.03107	9	0.0616	9	0.49104
10	0.1376	10	0.032	10	0.03816	10	0.3176	10	0.8407
11	0.02806	11	0.0074	11	0.0235	11	0.041	11	0.3937
12	0.1694			12	0.0574	12	0.237	12	0.27528
13	0.00631			13	0.01349	13	0.0007		
				14	0.05138	14	0.00904		
				15	0.03877	15	0.0465		
				16	0.0136	16	0.1317		
				17	0.0252	17	0.0006		
				18	0.01066	18	0.0336		
				19	0.0179	19	0.14515		
				20	0.0383	20	0.0108		
				21	0.0313	21	0.0642		
						22	0.1079		
						23	0.00274		
						24	0.0169		
						25	0.34787		
						26	0.0066		
						27	0.06988		
						28	0.0217		
						29	0.11946		
						30	0.2666		
						31	0.0336		
						32	0.06776		
						33	0.03105		
						34	0.02033		

Coments on the analysis:

Using the Empirical Bayes theory to calculate the pure premium of the five groups of airline, the following points have been noted:

(1) The variance calculated in table 6.3 for the five groups and the number of aircraft listed in table 5.1 show that the largest sample and the smallest variance is that of group (E).

(2) The variance in group (C) has been inflated due to the large claims such as that of airline number 2 i.e Air France "U.S $ 28 million in 1982, $84 million in 1985 and $ 92 million in 1989".

(3) In group (D) the variance was also high as a result of the small number of aircraft.

Finally: taking one of the airlines in any group say airline number 11 in group (D) (Egypt Air) and from table 5.2, it will be seen that, the number of aircraft in this aircraft lie in the range of 17 to 28 aircraft. From table 6.3 it will be noted that the number represent part of the variance fluctuat between 0.191 and 3.59 but in 1982 and 1987 the number jumps up to 11.98 and 36.65. The reason for that is the large claims in these years. This means that, the variance of each group fluctuates according to the number of aircraft in each airline, the total number in the group and according to the claim severity as well. The pure premium rate will decrease if the number of aircraft increases, also when the claim severity decreases and vice versa.

CHAPTER SEVEN

CONCLUSION

The fast development in aircraft manufacturing in the last six decades ,mainly the invention of turbo-prop and jet power, has led to revolutionary changes in the aviation field.

On the one hand aircraft speed and the maximum ceiling have increased remarkably, while aircraft safety system have developed to control and reduce aviation risks. On the other hand, aviation associations such as IATA and ICAO have been established to tackle and overcome problems associated with aviation.

Aviation insurance has passed through many developments to secure the required cover for all aviation risks.

The final results of the aviation market have fluctuated from one year to another, consequently the premium paid by the individual airlines have also fluctuated. These fluctuations have been caused by the following factors:

(A) The movement within the airline i.e changing aircraft prices, number of aircraft, aircraft type, flying hours and numbers of take offs. These factors have a great effect on the kind of risk and probability of accident.

(B) The absence of a fixed tariff and the tendency to rely on the experience of the lead underwriter to evaluate the risk and to calculate the hull rate using a simple pricing model.

(C) The competing pressures produced by the airline and aviation associations from one side and the aviation underwriter and market capacity from the other side.

In a bid to reduce the fluctuation in the pure premium which in consequence might reduce the fluctuation to the market final results, this research was carried on.

To overcome the difficulties of the small number of aircraft and their record of accidents, to take into consideration the numerous factors that affect the rate and to utilise a formal scientific and statistical approach, an approach to premium rating based on credibility theory has been introduced in this thesis.

Within the study of the three branches of credibility theory different models have been introduced.

Each one of these branches has its own merits and demerits.

The American credibility theory is the simplest one, but it lacks a formal statistical foundation.

The Bayesian credibility theory is a statistical method, but there is a serious and unanswered question as to how to estimate some of the critical parameters.

The Empirical Bayes credibility theory is also a statistical method that overcomes the lack of statistical foundation in the American credibility theory and also provide a way of estimating the parameters not calculated by the approach of Bayesian credibility theory.

The choice of a sample of one hundred and forty one air lines ,even with the possible data for only ninety one airlines, and classifying them in five different groups increases data reliability and reduces the fluctuations among the yearly rates.

The study of credibility theory and analysis of the data have indicated the advantages of applying Empirical Bayes theory to aviation insurance premium rating.

Accordingly, the Empirical Bayes credibility was applied to the data.

As a result the pure premium for each airline has been calculated, taking into consideration for each airline the experience of claim amounts and the number of aircraft adjusted by the experience of its own group.

Finally, in chapter 6, the changes in number of aircraft and claim severity have shown its effect on the calculated variance in each group, which affected the calculated pure premium. However, the pure premium has been calculated for each airline of the 91 airlines included in the data sample.

7.2 Suggestion for further research:

In this research, the researcher relied on London market, insurance underwriters, insurance offices and aviation brokers for collecting the data. It is believed that all the required data is handled among these three sources.

Success in collecting the data was limited because of confidentiality nature of some of the data.

However, there are a few suggestion for further research if the data become available.

Firstly, the geographical classification was used in this research. Different bases for classification such as airline size might be useful.

Secondly, each airline in this research has been considered to be a single unit. Research could be carried out into classifying the sample fleets into subgroups identified by type of aircraft i.e small, medium, and large aircraft.

Thirdly, in statistics it is well known that the larger the data the more confident the result will be. The researcher hopes to apply the same research using a larger number of airlines.

Finally, during the last five years the idea of establishing an international insurance pool for some Arab and Middle -East airlines to insure their fleets under one policy has been under discussion. This idea is likely to be faced with difficulties. The smaller fleet tries to encourage the larger one to join the pool whereas the larger fleets are always trying to avoid that. Using a approach based on credibility theory, it is likely that these difficulties could be avoided.

THE Articles of Association of IATA were adopted in the English text by the International Air Transport Operators Conference at Havana, Cuba, April 16—19, 1945, at which the Association was founded. The French and Spanish translations were approved by the subsequent First Annual General Meeting of IATA at Montreal in October, 1945. Since that time, succeeding Annual General Meetings have enacted a number of amendments which have been incorporated in the English, French and Spanish texts here reproduced.

Source of data Branckek, j.w.s 1977

v) Approve the budget for the succeeding year and may

vi) Direct that technical or other committees be organized by the Executive Committee as provided in Article IX, Section 6.

Consideration of matters not included on Agenda.

vii) Transact such other business as may be on the agenda for the meeting or as may be proposed by the Executive Committee. Any other matter may be considered at the meeting only upon a two-thirds vote of the active Members present.

** THE 27TH ANNUAL GENERAL MEETING APPROVED THE FOLLOWING TERMS OF REFERENCE FOR THE NOMINATING COMMITTEE.*

1. Before the conclusion of an Annual General Meeting the President shall appoint a Nominating Committee to make recommendations to the following Annual General Meeting for appointments to the Executive Committee.

2. Such Nominating Committee shall be composed of 10 appointees; 5 from the current membership of the Executive Committee and 5 from outside the Committee. In addition, the President of IATA at the time of the appointment of the Nominating Committee shall be ex officio a member of the Committee and shall serve as its Chairman.

3. Members of the Nominating Committee shall serve for a period of one year and shall themselves be ineligible for nomination to Executive Committee membership during that period.

4. At a date subsequent to 1st January of the year following the appointment of the Nominating Committee, Members shall be asked to submit names of suitable candidates for consideration. When submitting such names, Members shall furnish background information on candidates similar to that required for nominees to Standing Committees.

The Executive Committee

2. The Executive Committee elected by the General Meeting, as provided in these Articles of Association, shall exercise the executive functions of the Association within the framework of these Articles and with such additional powers as may from time to time be vested in it by resolution of the General Meeting.

ARTICLE VIII

GENERAL MEETINGS

Determination of date and venue.

1. a) A General Meeting of the Association shall be held annually at a place and time determined at the preceding General Meeting or at a General Meeting two years earlier. If no place and time have been determined at either of such prior meetings, they shall be determined by the Executive Committee.

Notice

Submission of items for Agenda.

b) Notice of the Annual General Meeting, including the Agenda of the matters to be submitted at such Meeting as prepared by the Executive Committee shall be mailed to the Members not less than thirty days prior to the date of the Meeting. Active Members may submit to the Executive Committee matters for inclusion in the Agenda not less than sixty days prior to the date of the Annual General Meeting. Any matter so submitted by an Active Member which shall not have been included in the Agenda may be considered at the meeting upon a majority vote of the Active Members present.

Functions

c) The General Meeting shall:

i) Elect the President.

ii) Elect the members of the Executive Committee.*

iii) Receive and consider reports of the Executive Committee or other committees or officers of the Association.

iv) Pass upon the accounts for the past year.

ARTICLE VI

MEMBERSHIP DUES AND BUDGET

Date and method of assessment

Active Members

1. The annual dues of Active Members shall be fixed annually for the next calendar year by the Annual General Meeting upon the recommendation of the Executive Committee and shall bear, as far as is practicable, a fair relation to the amount of such Members' international air operations. The dues for an Active Member for any year shall not be less than the amount fixed under Section 2. for Associate Members.

Associate Members

2. The annual dues of all Associate Members shall be a sum determined from time to time by the General Meeting on recommendation of the Executive Committee.

Entrance fee

3. The entrance fee to be paid by Active or Associate Members will be determined from time to time by the General Meeting.

Interest on outstanding obligations.

Waiver of interest provision

4. Interest shall accrue and fall due at the rate determined from time to time by the Executive Committee, according to prevailing market rates, upon any dues, fees, subscriptions and/or any other amounts owed by Members, from the day appointed by the Executive Committee for payment of any such dues, fees, subscriptions and/or amounts, unless in exceptional circumstances the Executive Committee waives this requirement.

Notice that interest payable.

5. The dues of all Members shall be computed annually in terms of United States Dollars. The Executive Committee shall notify the Members of the amount of dues payable as soon as possible after this amount has been determined and the Members shall pay such dues within such reasonable time after receipt of this notice as may be specified by the Executive Committee. This notice shall also specify that dues payable to the Association shall bear interest at the rate determined from time to time by the Executive Committee if not paid on or before the day appointed by the Executive Committee for the payment thereof.

Requisition of data

Failure to provide data.

6. The Executive Committee, through the Director General, shall be entitled to require of all active Members such reports and data as may be found by it necessary to calculate such dues. Failure or refusal of a Member to furnish full and correct data so required may be considered by the Executive Committee as a breach of these Articles.

Failure to pay dues.

7. The failure to pay such dues within the time specified by the Executive Committee, and failure to pay interest on the same at the rate so fixed may be considered by the Committee as a breach of these Articles.

Submission and contents of annual budget.

Approval of annual budget

8. The Executive Committee shall, prior to the annual meeting of the Members, prepare a budget for the succeeding calendar year, showing the estimated expenses and revenues, which shall be submitted to the Active Members at their annual meeting. The budget expenses shall include the costs of establishing and maintaining the Head Office and branch offices set up by the Executive Committee; the salaries and expenses of the executive officers and the secretariat; the expenses of the business sessions of the General Meeting; the transportation costs of the members of the Executive Committee while travelling on business of the Executive Committee; and such other expenses as may be authorized by the Executive Committee or any General Meeting. The Active Members shall approve the budget for the succeeding calendar year.

Whether monies paid by Member repayable on cessation of Membership.

9. On the cessation of membership by resignation or otherwise, a Member shall not be entitled to the return of any monies paid into the Association provided, however, that the Executive Committee may authorize the return of a pro rata part of current Membership Dues for the year in which the membership ceases.

ARTICLE VII

AUTHORITY

General Meeting

1. The ultimate authority of the Association is vested in the General Meeting, composed of representatives of the Active Members of the Association.

after appointment of the third arbitrator. The decision of the majority of such arbitrators shall be final and binding on the Association and the Member concerned. If the decision of the arbitrators is in favor of the Association, the membership of the Member concerned shall immediately terminate and such Member shall bear costs of such arbitration. If the decision of the arbitrators is in favor of the Member, the decision of the Executive Committee which gave rise to the arbitration shall become void and costs of such arbitration shall be borne by the Association.

Cost of arbitration

ARTICLE V (A)

LIMITATIONS ON RIGHTS OF MEMBERSHIP

Failure to meet financial obligation

The membership rights of a Member which shall fail to pay any fee, fine or other financial obligation to the Association within 180 days of the date upon which such fee, fine or other financial obligation became payable, and shall fail to make arrangements within such 180 days satisfactory to the Executive Committee to pay such obligations shall be automatically limited until such fee, fine or other financial obligation be paid. The Secretary shall notify all Members of such limitation. A Member whose membership rights have been limited may continue to attend all meetings and conferences which it was entitled to attend prior to limitation, but shall have no right to vote at any such meeting or conference, nor shall its representative act as a member of any committee, including the Executive Committee; otherwise its rights, duties and obligations under these Articles or Provisions for the regulation and conduct of IATA Committees and Conferences shall not be abated by the limitation of its membership rights. A Member which has made arrangements satisfactory to the Executive Committee to pay any fee, fine or other financial obligation to the Association shall be automatically limited upon failing to comply with the terms of such arrangements.

Effect of limitation.

Attendance at meetings.

Voting rights and service on Committees.

Failure to comply with arrangements for setting financial obligation.

Readmission after exclusion of Member's State from ICAO

ii) Notwithstanding any other provisions of these Articles as to eligibility to membership, a Member whose membership has been terminated under this section shall not be re-admitted to membership of the Association until the State under whose flag it operates scheduled air services ceases to be excluded from membership in the International Civil Aviation Organization.

Exclusion where Member operates under flags of two States and both States excluded from ICAO.

iii) In any case, where a Member of the Association operates a scheduled air service under the flags of two or more States the provisions of sub-paragraphs 2. b), i) and ii) shall not apply to or in respect of that member unless all the States under whose flags it so operates have been excluded from membership in the International Civil Aviation Organization and such exclusion is recognized to the extent contemplated in the proviso to the said sub-paragraph 2. b), i).

Effectiveness of termination

Request for arbitration

Decision by majority of arbitrators.

3. The sole recourse of any Member air transport enterprise whose membership the Executive Committee has determined should be terminated under Section 2. of this Article shall be to seek arbitration as hereinafter in this Section 3. provided. Such termination shall take effect and become final sixty days after notice in writing to the Member concerned of such determination unless within that period the Director General has received from such Member a written demand for arbitration, which demand shall contain the name of an arbitrator chosen by such air transport enterprise prepared to serve. Within thirty days after receipt of such demand, the Executive Committee shall designate its arbitrator prepared to serve. The two arbitrators so named shall designate a third arbitrator, also prepared to serve, and in case of their failure or inability to agree on such third arbitrator within thirty days, he shall be chosen by the President of the International Chamber of Commerce. The arbitrators shall proceed without delay to consider all matters submitted by the Member of the Association and must hand down a decision within ninety days

TERMINATION OF MEMBERSHIP

Resignation.

Effectiveness of resignation.

1. Any Member may resign by giving notice to the Director General of such resignation either by registered letter or by cable. Such resignation shall be effective thirty days after the transmission of such resignation by registered letter or by cable, but the effectiveness of such resignation shall not discharge the obligations of such Member to the Association for membership or other dues which are owing by such Member on the date when the resignation becomes effective.

Termination by Executive Committee

2. a) The active or associate membership of a Member may be terminated by the Executive Committee after providing the Member with adequate notice and a hearing, for the following reasons:

Breach of Articles

i) A breach by the Member concerned of one or more Articles of the Association, or a regulation adopted pursuant thereto;

Breach of Conference Regulations

ii) Failure by the Member concerned to comply with any procedures of the Association adopted to deal with breaches of Traffic Conference action;

Bankruptcy

iii) A Member is declared bankrupt, placed in a receivership or makes an assignment for the benefit of its creditors or ceases to hold the authority under which it is operating.

Exclusion of Member's State from ICAO

b) i) The Executive Committee shall terminate the active or associate membership of any Member operating under the flag of a State excluded from membership of the International Civil Aviation Organization; provided that all the members of the said Organization under whose flag scheduled air services are operated by the Members of the Association, other than the State exclud- ed, recognize such exclusion as valid and binding upon them.

Associate

3. Any air transport enterprise as defined in the Act of Incorporation which is operating an air service as defined in the Act of Incorporation is eligible for membership as an Associate Member provided that it is not eligible for membership as an Active Member.

Cessation of eligibility

Transfer

Change of operation

4. Six months after a Member ceases to be eligible for the class of membership it holds, such membership shall be automatically terminated, unless during such period the Member shall have applied to the Executive Committee for transfer to the class of membership for which it is eligible; in the latter event, the existing membership shall remain in force until the Executive Committee has approved or disapproved the application for transfer to a different class of membership. Any Member which changes its operation in such a manner as to change its eligibility for membership shall notify the Secretary in writing; provided, however, the absence of such notice shall not cause this paragraph to be ineffective.

Application

Effectiveness

5. Application for membership in the Association shall be submitted to the Head Office in the form and detail required by the Executive Committee for the consideration and action of the Executive Committee. If the application is found in order, and the applicant eligible for election to the Association, the applicant shall be duly elected by the Executive Committee to the class of membership to which it is entitled, otherwise the application shall be rejected. The election to membership shall be effective upon payment of entrance fees and dues for the current year.

Appeal Procedure

6. Any applicant for membership whose application is rejected by the Executive Committee may appeal to the Association at the next General Meeting of Members, and the action taken at that time shall be final.

NAME

Name

The name of this Association is INTERNATIONAL AIR TRANSPORT ASSOCIATION.

ARTICLE II

LOCATION

Head Office

The Head Office of this Association shall be maintained in the city in which the Headquarters of the International Civil Aviation Organization is located, or at such other place as the Association may determine by amendment of the Articles from time to time.

ARTICLE III

AIMS AND OBJECTS

The aims and objects of this organization shall be:—

Promotion of safe, regular & economical air transport

1. To promote safe, regular and economical air transport for the benefit of the peoples of the world, to foster air commerce, and to study the problems connected therewith;

Collaboration among air transport enterprises.

2. To provide means for collaboration among the air transport enterprises engaged directly or indirectly in international air transport service;

Cooperation with ICAO

3. To co-operate with the International Civil Aviation Organization and other international organizations.

ARTICLE IV

MEMBERSHIP

Categories

1. Members of the Association shall be classified as follows:— a) Active, and b) Associate.

Active

2. Any air transport enterprise as defined in the Act of Incorporation which is operating an air service as defined in the Act of Incorporation between the territories of two or more States, is eligible for membership as an Active Member.

LLOYD'S AVIATION UNDERWRITERS' ASSOCIATION

Standard Policy Forms, Proposal Forms and Clauses, Etc.

Included is a selection of Forms and Endorsements commonly used in the Aviation Market and reproduced by kind permission of Lloyd's Underwriters' Non-Marine Association and the respective Underwriters and Companies.

Second Edition, 1971

LLOYD'S
LIME STREET, LONDON, EC3M 7HA

Secretary:
E. W. Dalby

Telephone:
01-623 8527

Form approved by Lloyd's Aviation Underwriters' Association.

No Policy or other Contract dated on or after 1st Jan., 1924, will be recognised by the Committee of Lloyd's as entitling the holder to the benefit of the Funds and/or Guarantees lodged by the Underwriters of the Policy or Contract as security for their liabilities unless it bears at foot the Seal of Lloyd's Policy Signing Office.

FOR SIGNATURE BY UNDERWRITING MEMBERS OF LLOYDS ONLY — LLOYD'S ACTS 1871 TO 1951

LLOYD'S AIRCRAFT POLICY

(Subscribed only by Underwriting Members of Lloyd's all of whom have complied with the requirements of the Insurance Companies Act, 1958, as to security and otherwise.)

Any person not an Underwriting Member of Lloyd's subscribing this Policy, or any person uttering the same if so subscribed, will be liable to be proceeded against under Lloyd's Acts.

Printed at Lloyd's, London, England.

Whereas

of

(hereinafter called "the Assured") has/have made or caused to be made to us a written Proposal dated (warranting the truth of the statements contained therein) which is the basis of this Contract and is deemed to be incorporated herein, and has/have paid to us (hereinafter called "the Underwriters") a premium of

to insure the Aircraft as specifically described in the Schedule hereto against accidental Loss and/or Damage as hereinafter defined actually occurring during the period

beginning and ending

both days inclusive and in addition against all sums which the Assured shall become legally liable to pay as compensation as hereinafter set forth for accidental bodily injury or damage actually occurring during the said period.

We the Underwriters, will indemnify the Assured as follows:—

SECTION I.—Loss of or Damage to Aircraft.

The Underwriters will at their option pay for replace or make good accidental loss of or damage to the Aircraft from whatsoever cause arising whilst the Aircraft is—

(A) in FLIGHT;
(B) TAXYING;
(C) on the GROUND;
(D) MOORED,

but the Underwriters shall not be liable for the cost of making good wear and tear, gradual deterioration, structural defect, electrical or mechanical breakage or breakdown, or for loss or damage arising from such electrical or mechanical breakage or breakdown other than loss or damage caused by fire, explosion, or impact of the Aircraft with an external object.

The cover under this Section shall not include loss of or damage to the Aircraft by burglary, theft, larceny, or malicious means if it be proved such loss or damage was caused by a servant or agent or person under the control of the Assured.

It is a condition of this Insurance that save in the event of the replacement or the total loss of the Aircraft the Assured shall bear in respect of each Aircraft described in the Schedule hereto:—

the first of each and every claim under (A) and
the first of each and every claim under (B) and
the first of each and every claim under (C) and
the first of each and every claim under (D)

The liability of the Underwriters under this Section shall not:—

Exceed in respect of any Aircraft the value stated in the Schedule against such Aircraft less any amount to be borne by the Assured.

Extend to indemnify the Assured in respect of salvage services (as defined) rendered to the Aircraft general average contributions or sue and labour charges.

SECTION II.—Third Party Liability.

The Underwriters will indemnify the Assured for all sums which the Assured shall become legally liable to pay, and shall pay, as compensation, including costs awarded, in respect of accidental bodily injury (fatal or non-fatal) or accidental damage to property provided such injury or damage is caused directly by the Aircraft or by objects falling therefrom.

The liability of the Underwriters under this Section shall not exceed in respect of any one accident or series of accidents arising out of one event, and further shall not exceed in respect of all claims hereunder during the currency of this Policy. The Underwriters will in addition defray any Law Costs incurred with their written consent in defending any action which may be brought against the Assured in respect of any claim arising under this Section, but should the amount paid to dispose of such claim exceed the sum insured hereunder then the liability of the Underwriters in respect of the said Law Costs shall be limited to that proportion of the Law Costs which the sum insured hereunder bears to the amount paid to dispose of the claim.

EXCEPTIONS.

1. The cover under this Section shall not extend to indemnify the Assured in respect of injury (fatal or non-fatal), damage or loss caused to or sustained by—

   (a) Any sub-contractor of or member of the household or family of the Assured.

   (b) Any person in the service of or acting on behalf of the Assured or of any such sub-contractor or member, whilst engaged in his duties as such.

   (c) Any passenger whilst entering into, being carried in, or alighting from the Aircraft.

   (d) Any pilot or member of the crew of the Aircraft or any person working in, on, or about the Aircraft.

2. The indemnity hereunder shall not extend to any property or animals belonging to or in the custody or control of the Assured, his servants or agents.

SECTION III.—Legal Liability to Passengers (Bodily Injury).

The Underwriters will indemnify the Assured for all sums which the Assured shall become legally liable to pay, and shall pay, as compensation including costs awarded, in respect of accidental bodily injury (fatal or non-fatal) to passengers whilst entering into, being carried in, or alighting from the Aircraft.

PROVIDED always that each passenger carried in any aircraft insured hereunder operating for hire or reward shall be carried subject to the terms of a ticket which shall be issued by the Assured to the passenger before the commencement of the flight and that such ticket shall have printed in a conspicuous manner a condition that the Assured will not be liable for any personal injury howsoever caused in so far as such condition is not contrary to law or to any international agreement.

The Cover under this Section shall not extend to indemnify the Assured in respect of injury (fatal or non-fatal), damage or loss caused to or sustained by—

(a) any sub-contractor of or member of the household or family of the Assured.

(b) Any person in the service of or acting on behalf of the Assured or of any such sub-contractor or member whilst engaged in his duties as such.

(c) Any pilot or member of the crew of the Aircraft or any person working in, on, or about the Aircraft.

The liability of the Underwriters under this Section shall not exceed in respect of any one passenger, in respect of any one accident or series of accidents arising out of one event, and further shall not exceed in respect of all claims hereunder during the currency of this Policy. The Underwriters will in addition defray any Law Costs incurred with their written consent in defending any action which may be brought against the Assured in respect of any claim arising under this Section, but should the amount paid to dispose of such claim exceed the sum insured hereunder then the liability of the Underwriters in respect of the said Law Costs shall be limited to that proportion of the Law Costs which the sum insured hereunder bears to the amount paid to dispose of the claim.

GENERAL EXCLUSIONS.

The Underwriters shall not be liable to indemnify the Assured under any Section of this Policy in respect of any loss or damage, bodily injury (fatal or non-fatal), or liability howsoever caused—

1. Whilst the Aircraft is being used for any illegal purpose or for any purpose or purposes other than those stated in the Schedule hereto or whilst outside the geographical limits named therein unless due to *force majeure*. Nevertheless the Underwriters agree to hold covered the risks insured by this Policy in the event of the Aircraft rendering salvage services (as defined) provided immediate notice be given to the Underwriters and any additional premium required be paid.
2. Whilst the Aircraft is being piloted by any person or persons other than those stated in the Schedule hereto, but this exclusion shall not be deemed to apply whilst the Aircraft is being taxied and/or otherwise operated by competent licensed Engineers other than for the purpose of flight (as defined).
3. Whilst the Aircraft is being transported by any means of conveyance except as the result of an accident giving rise to a claim under Section 1 of this Policy.
4. Whilst the Aircraft is using unlicensed landing areas unless due to *force majeure* or covered by special endorsement hereon.
5. Due to or arising out of or directly or indirectly connected with—
   (a) Racing, record attempts, speed trials, aerobatics, aerial seeding or fertilisation, dusting, spraying, fish spotting or any other form of flying involving abnormal hazards.
   (b) Test flights after construction or reconstruction.
   (c) Leaving the Aircraft unattended in the open without taking reasonable precautions for its safety.
6. Which, at the time of the event giving rise to such loss or damage, bodily injury, or liability is insured by or would, but for the existence of this Policy, be insured by any other Policy or Policies except in respect of any excess beyond the amount which would have been payable under such other Policy or Policies had this Insurance not been effected.
7. Arising from liability assumed or rights waived by the Assured by agreement unless such liability would have attached to the Assured in the absence of such agreement.
8. Directly or indirectly occasioned by, happening through or in consequence of war, invasion, acts of foreign enemies, hostilities (whether war be declared or not), civil war, rebellion, revolution, insurrection, military or usurped power, martial law, strikes, riots, civil commotions, or confiscation or nationalisation or requisition or destruction of or damage to property by or under the order of any government or public or local authority.
9. Should the total number of passengers carried in the Aircraft at the time of the happening of such bodily injury, loss or damage or liability exceed the Declared Passenger Seating Capacity stated in the Schedule.

WARRANTIES.

WARRANTED THAT—

1. The Assured will comply with all air navigation and airworthiness orders and requirements issued by any competent authority and will take all reasonable steps to ensure that such orders and requirements are complied with by his/their agent(s) and employees and that the Aircraft shall be airworthy at the commencement of each flight.

2. No additional insurance on any interests on or in relation to any Aircraft described in the Schedule, save such as may be required to cover personal accident and legal liability, has been or shall be effected to operate during the currency of this Policy by or for account of the Assured, Owners, Managers, Mortgagees or hirers except:—

(a) Additional Insurance on terms and conditions identical with those contained in this Policy.

(b) Additional Insurance on Total Loss Only or any conditions other than those stated in (a) above, whether Policy Proof of Interest, Full Interest Admitted, or otherwise, but only to cover in respect of any one Aircraft an amount not exceeding 10 per cent. of the Total Value of that Aircraft as stated in the Schedule of this Policy.

Provided always that a breach of this Warranty shall not afford Underwriters any defence to a claim by a Mortgagee who has accepted this Policy without knowledge of such breach.

GENERAL CONDITIONS.

1. All requisite log books and/or documents shall be kept fully completed up to date and shall be produced to the Underwriters or their Agents on request in support of all or any claim(s) hereon.

2. The Assured shall use due diligence and do and concur in doing everything reasonably practicable to avoid or diminish any loss hereon but shall not make any admission of liability or payment or offer or promise of payment without the written consent of the Underwriters.

3. In the event of the Aircraft sustaining damage whether covered by this Policy or not the Assured or his/their Agent(s) shall forthwith take steps as may be necessary to ensure the safety of the damaged Aircraft and its equipment and accessories. No dismantling or repairs shall be commenced without the written consent of the Underwriters excepting such as may be necessary in the interests of safety and to prevent further damage.

4. The Underwriters shall be entitled at any time and for so long as they desire to take absolute control of all negotiations and proceedings and in the name of the Assured to settle or defend or prosecute any claim.

5. Immediate notice of any event likely to give rise to a claim under this Policy shall be given to

to whom the Assured shall furnish full particulars in writing of such event and shall forward immediately notice of any claim by a Third Party or Passenger and any letters or documents relating thereto and shall give notice of any impending prosecution. In all cases the Assured shall render such further information and assistance as the Underwriters may reasonably require and shall not act in any way to the detriment or prejudice of the interests of the Underwriters.

6. In the event of the Underwriters exercising their option under Section I to replace the Aircraft the replacement shall be by an Aircraft of the same make and type and in reasonably like condition.

7. The Aircraft shall at all times remain the property of the Assured save that in the event of the replacement or the total loss of the Aircraft the Underwriters shall be entitled at their option to take over the remains of the Aircraft as salvage.

8. If the Assured shall make any claim knowing the same to be false or fraudulent as regards amount or otherwise this Policy shall become void and all claims thereunder shall be forfeited.

9. If any dispute or difference shall arise between the Assured and the Underwriters in connection with this Insurance such difference or dispute shall be submitted to Arbitration in London in accordance with the Statutory provision for Arbitration for the time being in force.

10. Should there be any change in the circumstances or nature of the risks which are the basis of this contract the Assured shall give immediate notice thereof to the Underwriters and no claim arising subsequent to such change shall be recoverable hereunder unless such change has been accepted by the Underwriters.

11. This Policy may be cancelled at any time by the Underwriters giving 10 days' notice in writing of such cancellation. In such event, the Underwriters will return in respect of the unexpired period, a *pro rata* portion of the premium. There will be no return of premium in respect of any aircraft on which a loss under this policy, adjustable on the basis of a total loss, has occurred.

12. This Policy shall not be assigned in whole or in part except with the consent of the Underwriters verified by endorsement hereon.

13. In the event of loss whether or not covered by this Policy the value of the Aircraft stated in the Schedule shall be reduced as at the time and date of loss by the amount of such loss and such reduced value shall continue until repairs are commenced. The value of the Aircraft shall then be increased by the value of the completed repairs until the value of the Aircraft is fully reinstated to that stated in the Schedule or until the Policy has expired.

14. The due observance and fulfilment of the terms, provisions, conditions and endorsements of this Policy shall be conditions precedent to any liability of the Underwriters to make any payment under this Policy.

Now Know Ye That We the Underwriters, Members of the Syndicates whose definitive numbers in the after-mentioned List of Underwriting Members of Lloyd's are set out in the attached Table, hereby bind ourselves each for his own part and not one for another, our Heirs, Executors and Administrators, and in respect of his due proportion only, to pay for, replace or make good to the Assured or the Assured's Executors, Administrators or Assigns or to indemnify him or them against all such Loss, Damage or Liability as aforesaid subject always to the terms, conditions and limitations contained herein or endorsed hereon or attached hereto, and the due proportion for which each of us, the Underwriters, is liable shall be ascertained by reference to his share, as shown in the said List, of the Amount, Percentage or Proportion of the total sum assured hereunder which is in the Table set opposite the definitive number of the Syndicate of which such Underwriter is a Member AND FURTHER THAT the List of Underwriting Members of Lloyd's referred to above shows their respective Syndicates and Shares therein, is deemed to be incorporated in and to form part of this Policy, bears the number specified in the attached Table and is available for inspection at Lloyd's Policy Signing Office by the Assured or his or their representatives and a true copy of the material parts of the said List certified by the General Manager of Lloyd's Policy Signing Office will be furnished to the Assured on application.

In Witness whereof the General Manager of Lloyd's Policy Signing Office has subscribed his name on behalf of each of us.

LLOYD'S POLICY SIGNING OFFICE,

Dated in London, the

GENERAL MANAGER.

THE SCHEDULE.

AIRFRAME					ENGINE(S)	VALUES			
Make, Type and Series Number	Year of Construction	Licensed Passenger Seating Capacity	Declared Passenger Seating Capacity for the purpose of this Insurance	Identification Marks	Number and Type	Aircraft with Standard instruments and equipment	Details of extra equipment and accessories		Total Value
								Value	

Pilot(s)...

Purposes for which the Aircraft will be used...

Geographical Limits...

DEFINITIONS.

"FLIGHT" shall be deemed to mean from the time the Aircraft moves forward in taking off or attempting to take off for the actual air transit, whilst in the air, and until the Aircraft completes its landing run after contact with the earth and/or water.

"TAXYING" shall be deemed to mean when the Aircraft is moving along the ground whether under its own power or momentum or in process of being towed but not in flight as defined; but in the case of aircraft whilst afloat, "TAXYING" shall be deemed to mean when such Aircraft is not in flight or moored as defined.

"ON THE GROUND" (not applying to aircraft whilst afloat) shall be deemed to mean whilst the Aircraft is not in flight or taxying as defined.

"MOORED" shall be deemed to mean whilst the Aircraft is afloat and safely secured and shall include the risks of launching and hauling up.

"AIRCRAFT" shall be deemed to mean the Aircraft specified in the Schedule hereto together with its engine(s) and standard instruments and equipment including any extra equipment or accessories specifically mentioned in the Schedule.

"SALVAGE SERVICES" shall be deemed to mean any services rendered by or in relation to the Aircraft in, on or over the sea or any tidal water or on or over the shores of the sea or any tidal water, in all cases in which they would have been salvage services, whether maritime or under contract, had they been rendered by or in relation to a vessel.

FOR SIGNATURE BY UNDERWRITING MEMBERS OF LLOYD'S ONLY
LLOYD'S ACTS 1871 TO 1951

Lloyd's Aircraft Policy

Whereas the Insured named in the attached Schedule has paid the premium specified in the Schedule to the Underwriting Members of Lloyd's who have hereunto subscribed their Names (hereinafter called "the Underwriters"),

Now We the Underwriters hereby agree to insure against loss, damage or liability arising from an Accident occurring during the Period of Insurance to the extent and in the manner hereinafter provided.

Now know Ye that We the Underwriters, Members of the Syndicates whose definitive numbers in the after-mentioned List of Underwriting Members of Lloyd's are set out in the attached Table, hereby bind ourselves each for his own part and not one for another, our Heirs, Executors and Administrators and in respect of his due proportion only, to pay or make good to the Insured or to the Insured's Executors or Administrators or to indemnify him or them against all such loss, damage or liability as herein provided, after such loss, damage or liability is proved and the due proportion for which each of Us, the Underwriters, is liable shall be ascertained by reference to his share, as shown in the said List, of the Amount, Percentage or Proportion of the total sum insured hereunder which is in the Table set opposite the definitive number of the Syndicate of which such Underwriter is a Member AND FURTHER THAT the List of Underwriting Members of Lloyd's referred to above shows their respective Syndicates and Shares therein, is deemed to be incorporated in and to form part of this Policy, bears the number specified in the attached Table and is available for inspection at Lloyd's Policy Signing Office by the Insured or his or their representatives and a true copy of the material parts of the said List certified by the General Manager of Lloyd's Policy Signing Office will be furnished to the Insured on application.

In Witness whereof the General Manager of Lloyd's Policy Signing Office has subscribed his Name on behalf of each of Us.

LLOYD'S POLICY SIGNING OFFICE.
General Manager

FOR EMBOSSMENT BY • LLOYD'S POLICY SIGNING OFFICE •

AVN. 1A 14.11.73
Form approved by Lloyd's Aviation Underwriters' Association.
Printed at Lloyd's, London, England by Lloyds of London Printing Services Ltd.

SECTION I LOSS OF OR DAMAGE TO AIRCRAFT

Coverage

1. (*a*) The Underwriters will at their option pay for, replace or repair, accidental loss of or damage to the Aircraft described in the Schedule arising from the risks covered, including disappearance if the aircraft is unreported for sixty days after the commencement of flight, but not exceeding the amount insured as shown therein and subject to the amounts to be deducted shown below.

(*b*) If the Aircraft is insured hereby for the risks of Flight, the Underwriters will, in addition, pay reasonable emergency expenses necessarily incurred by the Insured for the immediate safety of the Aircraft consequent upon damage or forced landing, up to 10 per cent. of the amount specified in Part 2(5) of the Schedule.

Exclusions applicable to this Section only

2. The Underwriters shall not be liable for

Wear and tear, breakdown

(*a*) wear and tear, deterioration, breakdown, defect or failure howsoever caused in any Unit (hereinafter defined) of the Aircraft and the consequences thereof within such Unit.

(*b*) damage to any Unit by anything which has a progressive or cumulative effect but damage attributable to a single recorded incident is covered under paragraph 1 (*a*) above.

HOWEVER accidental loss of or damage to the Aircraft consequent upon 2 (*a*) or (*b*) above is covered under paragraph 1 (*a*) hereof.

Conditions applicable to this Section only

3. (i) If the Aircraft is damaged

Dismantling Transport and Repairs

(*a*) no dismantling or repairs shall be commenced without the consent of the Underwriters except whatever is necessary in the interests of safety, or to prevent further damage, or to comply with orders issued by the appropriate authority.

Payment or Replacement

(*b*) The Underwriters will pay only for repairs and transport of labour and materials by the most economical method unless the Underwriters agree otherwise with the Insured.

(ii) If the Underwriters exercise their option to pay for or replace the Aircraft

(*a*) The Underwriters may take the Aircraft (together with all documents of record, registration and title thereto) as salvage

(*b*) the cover afforded by this Section is terminated in respect of the Aircraft even if the Aircraft is retained by the Insured for valuable consideration or otherwise

(*c*) the replacement aircraft shall be of the same make and type and in reasonably like condition unless otherwise agreed with the Insured.

Amounts to be deducted from claim

(iii) Except where the Underwriters exercise their option to pay for or replace the aircraft, there shall be deducted from the claim under paragraph 1 (*a*) of this Section:—

(*a*) the amount specified in Part 6 (B) of the Schedule and

(*b*) such proportion of the Overhaul Cost (hereinafter defined) of any Unit repaired or replaced as the used time bears to the Overhaul Life (hereinafter defined) of the Unit

No Abandonment

(iv) Unless the Underwriters elect to take the Aircraft as salvage the Aircraft shall at all times remain the property of the Insured who shall have no right of abandonment to the Underwriters.

Other Insurance

(v) No claim shall be payable under this Section if other Insurance which is payable in consequence of loss or damage covered under this Section has been or shall be effected by or on behalf of the Insured without the knowledge or consent of the Underwriters.

See also Section IV

SECTION II LEGAL LIABILITY TO THIRD PARTIES (OTHER THAN PASSENGERS)

Coverage

1. The Underwriters will indemnify the Insured for all sums which the Insured shall become legally liable to pay, and shall pay, as compensatory damages (including costs awarded against the Insured) in respect of accidental bodily injury (fatal or otherwise)

Headings and marginal captions are inserted for the purpose of convenient reference only and are not to be deemed part of this insurance.

and accidental damage to property caused by the Aircraft or by any person or object falling therefrom.

Exclusions applicable to this Section only

2. The Underwriters shall not be liable for claims arising from

Employees and others

(i) injury (fatal or otherwise) or loss sustained by any director or employee of the Insured or partner in the Insured's business whilst acting in the course of his employment with or duties for the Insured.

Operational Crew

(ii) injury (fatal or otherwise) or loss sustained by any member of the flight, cabin or other crew whilst engaged in the operation of the Aircraft.

Passengers

(iii) injury (fatal or otherwise) or loss sustained by any passenger whilst entering, on board, or alighting from the Aircraft.

Property

(iv) loss of or damage to any property belonging to or in the care, custody or control of the Insured.

Noise and Pollution and Other Perils

3. The Underwriters shall not be liable for claims directly or indirectly occasioned by happening through or in consequence of:—

(*a*) noise (whether audible to the human ear or not), vibration, sonic boom and any phenomena associated therewith,

(*b*) pollution and contamination of any kind whatsoever,

(*c*) electrical and electromagnetic interference,

(*d*) interference with the use of property;

unless caused by or resulting in a crash fire explosion or collision or a recorded in-flight emergency causing abnormal aircraft operation.
Nothing in this paragraph shall override exclusion 9 of Section IV (A).

Limits of indemnity applicable to this Section

4. The liability of the Underwriters under this Section shall not exceed the amounts stated in Part 6 II (C) of the Schedule, less any amounts under Part 6 II (B). The Underwriters will defray in addition any legal costs and expenses incurred with their written consent in defending any action which may be brought against the Insured in respect of any claim for compensatory damages covered by this Section, but should the amount paid or awarded in settlement of such claim exceed the limit of indemnity then the liability of the Underwriters in respect of such legal costs and expenses shall be limited to such proportion of the said legal costs and expenses as the limit of indemnity bears to the amount paid for compensatory damages.

See also Section IV

SECTION III LEGAL LIABILITY TO PASSENGERS

Coverage

1. The Underwriters will indemnify the Insured in respect of all sums which the Insured shall become legally liable to pay, and shall pay, as compensatory damages (including costs awarded against the Insured) in respect of

(*a*) accidental bodily injury (fatal or otherwise) to passengers whilst entering, on board, or alighting from the Aircraft and

(*b*) loss of or damage to baggage and personal articles of passengers arising out of an accident to the Aircraft.

Provided Always that

Documentary Precautions

(i) before a passenger boards the Aircraft the Insured shall take such measures as are necessary to exclude or limit liability for claims under (*a*) and (*b*) above to the extent permitted by law

(ii) If the measures referred to in proviso (i) above include the issue of a Passenger Ticket/Baggage Check, the same shall be delivered correctly completed to the passenger a reasonable time before the passenger boards the aircraft.

Effect of Non-Compliance

In the event of failure to comply with proviso (i) or (ii) the limit of indemnity by the Underwriters under this section shall not exceed the amount of the legal liability, if any, that would have existed had the proviso been complied with.

Exclusions applicable to this Section only

2. The Underwriters shall not be liable for injury or loss sustained by any

Employees and others

(i) director or employee of the Insured or partner in the Insured's business whilst acting in the course of his employment with or duties for the Insured.

Operational Crew

(ii) member of the flight, cabin, or other crew whilst engaged in the operation of the Aircraft.

Limits of indemnity applicable to this Section

3. The liability of the Underwriters under this Section shall not exceed the amount stated in Part 6 III (C) of the Schedule, less any amounts under Part 6 III (B). The Underwriters will defray in addition any legal costs and expenses incurred with their written consent in defending any action which may be brought against the Insured in respect of any claim for compensatory damages covered by this Section, but should the amount paid or awarded in settlement of such claim exceed the limit of indemnity then the liability of the Underwriters in respect of such legal costs and expenses shall be limited to such proportion of the said legal costs and expenses as the limit of indemnity bears to the amount paid for compensatory damages.

See also Section IV

SECTION IV (A) GENERAL EXCLUSIONS APPLICABLE TO ALL SECTIONS

This policy does not apply:—

Illegal Uses

1. Whilst the Aircraft is being used for any illegal purpose or for any purpose other than those stated in the Schedule and as defined in the Definitions.

Geographical Limits

2. Whilst the Aircraft is outside the geographical limits stated in the Schedule unless due to force majeure.

Pilots

3. Whilst the Aircraft is being piloted by any person other than as stated in the Schedule except that the Aircraft may be operated on the ground by any person competent for that purpose.

Transportation by other Conveyance

4. Whilst the Aircraft is being transported by any means of conveyance except as the result of an accident giving rise to a claim under Section I of this Policy.

Landing and Take-off Areas

5. Whilst the Aircraft is landing on or taking off or attempting to do so from a place which does not comply with the recommendations laid down by the manufacturer of the Aircraft except as a result of force majeure.

Contractual Liability

6. To liability assumed or rights waived by the Insured under any agreement (other than passenger ticket/baggage check issued under Section III hereof) except to the extent that such liability would have attached to the Insured in the absence of such agreement.

Number of Passengers

7. Whilst the total number of passengers being carried in the Aircraft exceeds the declared maximum number of passengers stated in the Schedule.

Non-Contribution

8. To claims which are payable under any other policy or policies except in respect of any excess beyond the amount which would have been payable under such other policy or policies had this insurance not been effected.

Radioactivity

9. To loss, damage or liability directly or indirectly caused by or contributed to by or arising from ionising radiations or contamination by radioactivity.

War, Hijacking and Other Perils

10. To claims caused by

(*a*) War, invasion, acts of foreign enemies, hostilities (whether war be declared or not), civil war, rebellion, revolution, insurrection, martial law, military or usurped power or attempts at usurpation of power.

(*b*) Any hostile detonation of any weapon of war employing atomic or nuclear fission and/or fusion or other like reaction or radioactive force or matter.

(*c*) Strikes, riots, civil commotions or labour disturbances.

(*d*) Any act of one or more persons, whether or not agents of a sovereign Power, for political or terrorist purposes and whether the loss or damage resulting therefrom is accidental or intentional.

(*e*) Any malicious act or act of sabotage.

(*f*) Confiscation, nationalisation, seizure, restraint, detention, appropriation, requisition for title or use by or under the order of any Government (whether civil military or de facto) or public or local authority.

(*g*) Hijacking or any unlawful seizure or wrongful exercise of control of the Aircraft or crew in flight (including any attempt at such seizure or control) made by any person or persons on board the aircraft acting without the consent of the Insured.

Furthermore this policy does not cover claims arising whilst the Aircraft is outside the control of the Insured by reason of any of the above perils.

The Aircraft shall be deemed to have been restored to the control of the Insured on the safe return of the Aircraft to the Insured at an airfield not excluded by the geographical limits of this Policy, and entirely suitable for the operation of the Aircraft (such safe return shall require that the Aircraft be parked with engines shut down and under no duress).

(B) GENERAL CONDITIONS APPLICABLE TO ALL SECTIONS

1. The due observance and fulfilment of the terms conditions and endorsements of this policy shall be a condition precedent to any liability of the Underwriters to make any payment under this policy.

Due Diligence

2. The Insured shall at all times use due diligence and do and concur in doing everything reasonably practicable to avoid or diminish any loss hereon.

Compliance with Air Navigation Orders, etc.

3. The Insured shall comply with all air navigation and airworthiness orders and requirements issued by any competent authority affecting the safe operation of the Aircraft and shall ensure that

(*a*) the aircraft is airworthy at the commencement of each flight

(*b*) all Log Books and other records in connection with the Aircraft which are required by any official regulations in force from time to time shall be kept up to date and shall be produced to the Underwriters or their Agents on request

(*c*) the employees and agents of the Insured comply with such orders and requirements.

Claims Procedure

4. Immediate notice of any event likely to give rise to a claim under this Policy shall be given as stated in Part 8 of the Schedule. In all cases the Insured shall

(*a*) furnish full particulars in writing of such event and forward immediately notice of any claim (by a Third Party or Passenger) with any letters or documents relating thereto

(*b*) give notice of any impending prosecution

(*c*) render such further information and assistance as the Underwriters may reasonably require

(*d*) not act in any way to the detriment or prejudice of the interest of the Underwriters.

The Insured shall not make any admission of liability or payment or offer or promise of payment without the written consent of the Underwriters.

5. The Underwriters shall be entitled (if they so elect) at any time and for so long as they desire to take absolute control of all negotiations and proceedings and in the name of the Insured to settle, defend or pursue any claim.

Subrogation

6. Upon an indemnity being given or a payment being made by the Underwriters under this Policy, they shall be subrogated to the rights and remedies of the Insured who shall co-operate with and do all things necessary to assist the Underwriters to exercise such rights and remedies.

Variation in Risk

7. Should there be any change in the circumstances or nature of the risks which are the basis of this contract the Insured shall give immediate notice thereof to the Underwriters and no claim arising subsequent to such change shall be recoverable hereunder unless such change has been accepted by the Underwriters.

Cancellation

8. This Policy may be cancelled by either the Underwriters or the Insured giving 10 days notice in writing of such cancellation. If cancelled by the Underwriters, they will return a pro rata portion of the premium in respect of the unexpired period of the Policy. If cancelled by the Insured a return of premium shall be at the discretion of the Underwriters. There will be no return of premium in respect of any Aircraft on which a loss is paid or is payable under this Policy.

Assignment 9. This Policy shall not be assigned in whole or in part except with the consent of the Underwriters verified by endorsement hereon.

Not Marine Insurance 10. This Policy is not and the parties hereto expressly agree that it shall not be construed as a Policy of marine insurance.

Arbitration 11. This Policy shall be construed in accordance with English Law and any dispute or difference between the Insured and the Underwriters shall be submitted to arbitration in London in accordance with the Statutory provision for arbitration for the time being in force.

Two or More Aircraft 12. When two or more aircraft are insured hereunder the terms of this policy apply separately to each.

Limits of Indemnity 13. Notwithstanding the inclusion herein of more than one Insured, whether by endorsement or otherwise, the total liability of the Underwriters in respect of any or all Insureds shall not exceed the limit(s) of indemnity stated in this Policy.

False and Fraudulent Claims 14. If the Insured shall make any claim knowing the same to be false or fraudulent as regards amount or otherwise this Policy shall become void and all claims hereunder shall be forfeited.

(C) DEFINITIONS

(*a*) "ACCIDENT" means any one accident or series of accidents arising out of one event.

(*b*) "UNIT" means a part or an assembly of parts (including any sub-assemblies) of the Aircraft which has been assigned an Overhaul Life as a part or an assembly. Nevertheless, an engine complete with all parts normally attached when removed for the purpose of overhaul or replacement, shall together constitute a single Unit.

(*c*) "OVERHAUL LIFE" means the amount of use, or operational and/or calendar time which, according to the Airworthiness Authority, determines when overhaul or replacement of a Unit is required.

(*d*) "OVERHAUL COST" means the costs of labour and materials which are or would be incurred in overhaul or replacement (whichever is necessary) at the end of the Overhaul Life of the damaged or a similar Unit.

(*e*) "PRIVATE PLEASURE" means use for private and pleasure purposes but NOT use for any business or profession nor for hire or reward.

(*f*) "BUSINESS" means the uses stated in Private Pleasure and use for the purpose of the Insured's business or profession but NOT use for hire or reward.

(*g*) "COMMERCIAL" means the uses stated in Private Pleasure and Business and use for the carriage by the Insured of passengers, baggage accompanying passengers and cargo for hire or reward.

(*h*) "RENTAL" means rental, lease, charter or hire by the Insured to any person, company or organisation for Private Pleasure and Business uses only, where the operation of the Aircraft is not under the control of the Insured. Rental for any other purpose is NOT insured under this Policy unless specifically declared to Underwriters under SPECIAL RENTAL USES in the Schedule.

Definitions (*e*), (*f*), (*g*) and (*h*) constitute Standard Uses and **do not include** Instruction, Acrobatics, Hunting, Patrol, Fire-fighting, the intentional dropping, spraying or release of anything, any form of experimental or competitive flying, and any other use involving abnormal hazard, but when cover is provided details of such use(s) are stated in the Schedule under SPECIAL USES.

(*j*) "FLIGHT" means from the time the Aircraft moves forward in taking off or attempting to take off, whilst in the air, and until the aircraft completes its landing run.

(*k*) "TAXYING" means movement of the aircraft under its own power other than in flight as defined. Taxying shall not be deemed to cease merely by reason of a temporary halting of the aircraft.

(*l*) "MOORED" means, in the case of aircraft designed to land on water, whilst the aircraft is afloat and is not in flight or taxying as defined, and includes the risks of launching and hauling up.

(*m*) "GROUND" means while the aircraft is not in flight or taxying or moored as defined.

SCHEDULE

PART 1	Policy No.	Proposal dated
	Name of Insured Address	
	Period of Insurance From To both days inclusive	

PART 2 Particulars of Aircraft

(1) Make & Type (Insert "Land","Sea" or "Amphibian" as applicable)	(2) Year of Manufacture	(3) Registration Marks	(4) Declared Max. No. of Passengers at any one time	(5) Amount Insured	(6) Risks covered (Insert "Flight", "Taxying", "Moored", "Ground" as applicable)

PART 3 Purposes of Use

Standard Uses (Insert "Private Pleasure", "Business", "Commercial", "Rental for Private Pleasure and Business only" as applicable)	*Special Uses*	*Special Rental Uses*

PART 4 Pilots

PART 5 Geographical Limits

AVN 1A

APPENDIX (3)

Examples of the 70/30 or 80/20 formula

Theoretically, the insurance premium rate is calculated to cover two different kinds of losses, total loss and partial loss.

In some cases, the insured asks to change the sum insured during the year, due to buying, selling, leasing aircraft or readjusting the estimated aircraft values to match market prices.

In such cases if an aircraft insured with a sum inured of $5,000,000 faces a total loss accident, this sum insured will be paid. But if the accident leads to partial loss for say $100,00, the underwriter will pay the claim $100,000 whether the sum insured is $5000,000 or was reduced to 3,500,000.

Accordingly, whenever the aircraft value changes the premium rate should change with the rate (%), increasing when the sum insured increases and the rate decreasing when the sum insured increases. The standard formula often used to calculate this change is "K/100-K" where K is a percentage to be chosen by the underwriter. This formula is applied as follow:

First, the leading underwriter uses his experience to examine the size of this change, and airline record within the last few years to decide the percentage to be used. This percentage could be 70/30 or 80/20.

Secondly the chosen percentage is applied as follows,

Suppose the aircraft's existing value is $250,000 and the existing premium rate is 1.75%. The airline asks to reduce the existing value to $200,000. The leading underwriter decides to use the percentage 70/30

The existing premium is $ 250,000 . 1.75%	=	$ 4,375
The difference will be $50,000 . (70%.1.75)	=	$ 612.5
The premium required therefore is	=	$ 3762.5
and the premium rate will be $\frac{\$3762.5}{\$20,000}$	=	$ 1.88%

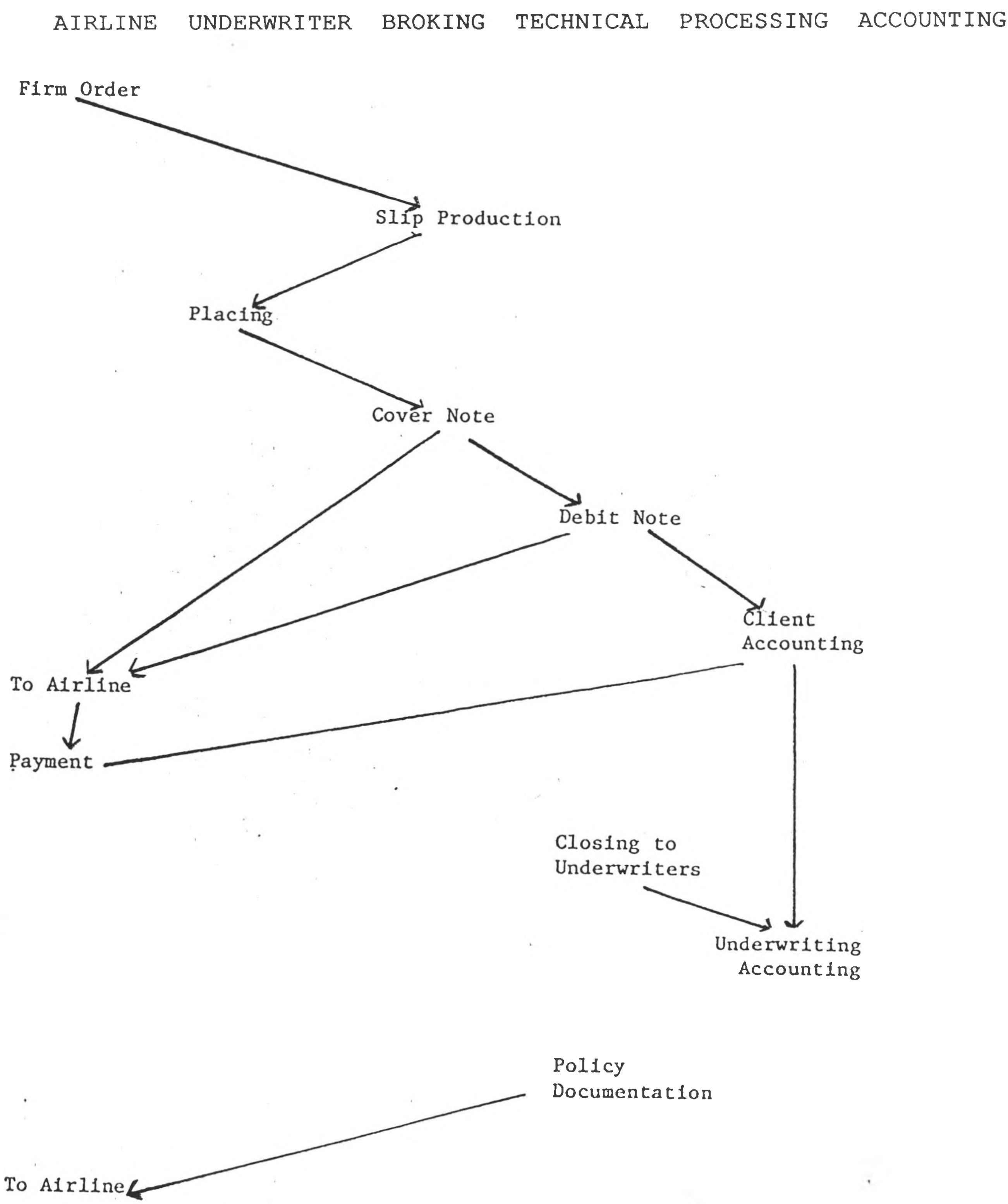
The same method will be used if the airline increases the sum insured. Suppose the existing value is $ 150,000 with a premium rate of 2.5%. the airline asks to increase this value up to $ 190,000 and the leading underwriter decides to use the " 80/20" formula,

The existing premium is $ 150,000 . 2.55%	=	$ 3750
The difference will be $40,000 . (20%. 2.5)	=	$ 200
The premium required therefore is	=	$ 3950.5
and the premium rate will be $\frac{\$3950}{\$190,000}$	=	$ 2.08%

(APPENDIX 4)

Figure 1

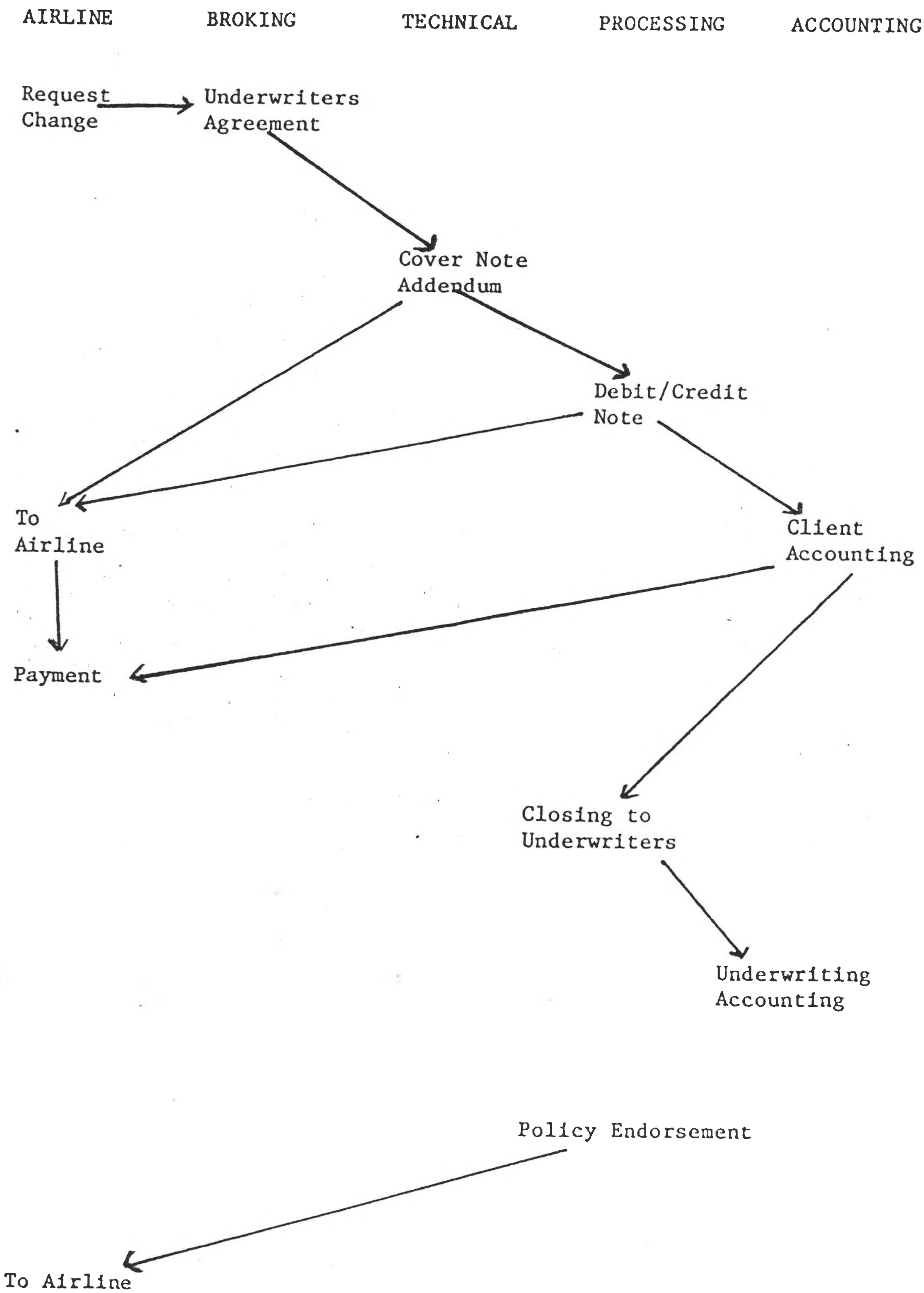
PLACEMENT OF RISK



Source of data: Brokerage insurance company.

Figure 2

CHANGES OF RISK

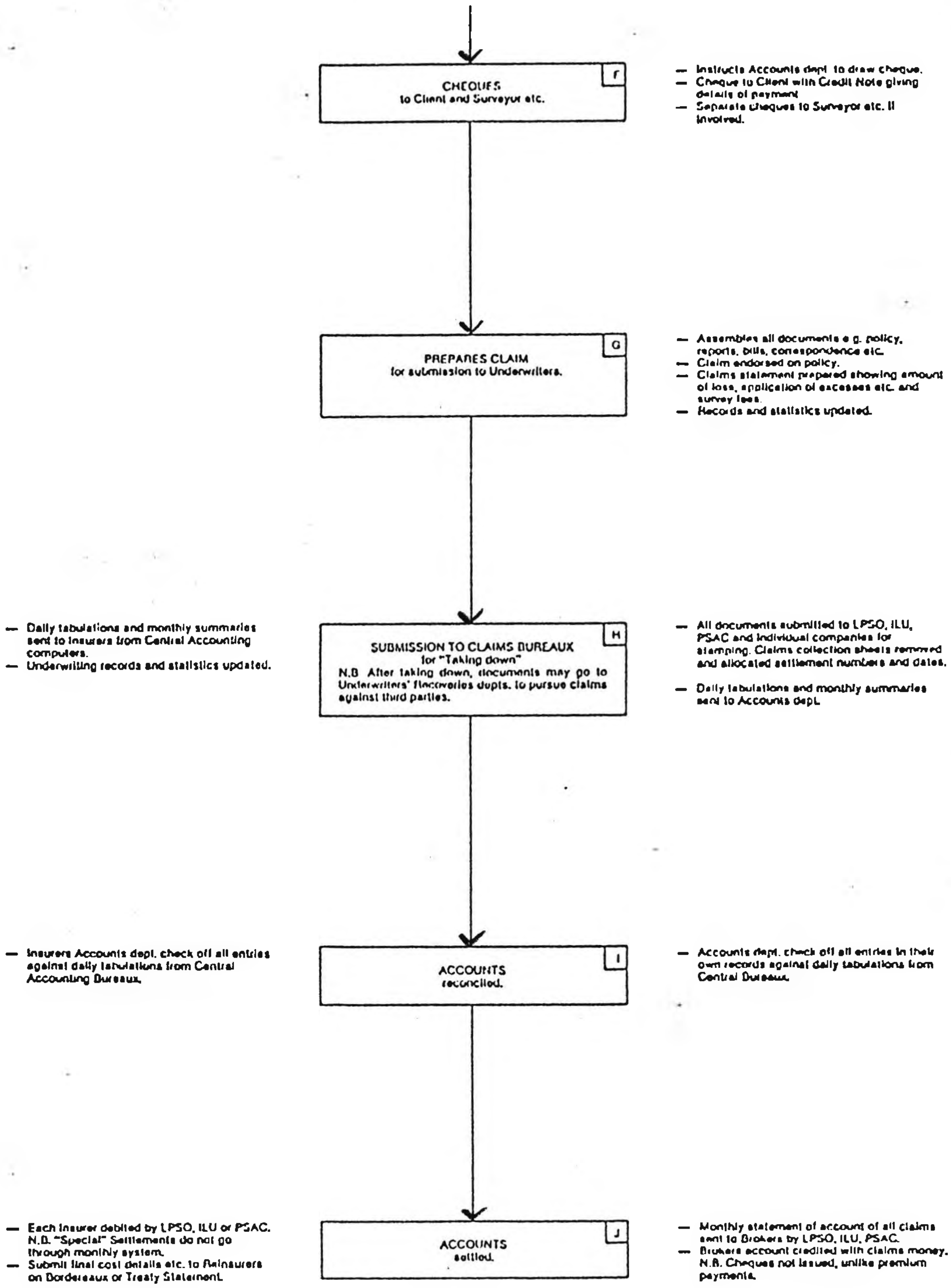


Source of data: Brokerage insurance company.

(APPENDIX 5b)

CLAIMS FLOW CHART

LONDON MARKET INSURER	CLAIMS FLOW CHART	BROKING HOUSE
	A LOSS SITUATION Notified by Telex, Telephone, Letter etc. N.B. Client must comply with policy conditions regarding claims notification.	— Opens Claims file — Collects details of loss e.g. type of loss/damage, when, where and how it occurred, estimate of cost if known. — Claims form only used for personal claims e.g. Motor, contents, jewellery etc. — Check loss falls within policy details (date, location etc.)
— May appoint Surveyor etc. if loss likely to be substantial. — May appoint Lawyer if third party involved. — Brief details entered in records. — Advises Reinsurers if necessary, of brief details.	**B** ADVICE TO INSURERS	— Discuss with Leading, or all, Underwriters on slip. — If straightforward claim, may settle to client at this stage. — May advise Underwriters claims offices a) L.U.C.O. Lloyd's Underwriters' Claims Office (Marine) b) L.U.N.C.O. Lloyd's Underwriters' Non-Marine Claims Office (Non-marine) c) L.A.C.C. Lloyd's Aviation Claims Centre (Aviation)
	C APPOINT REPRESENTATIVE Lloyd's Agent Surveyor Loss Adjuster Lawyer Other Expert e.g. Doctor	— Broker contacts experts as required and gives all known details including copy policy etc.
— Notes expert's comments. — May await further reports/developments. — Recommends course of action regarding repairs/replacements etc. — Makes a "Reserve" i.e. sets aside money, in books, to cover loss amounts for when it is paid.	**D** PRELIMINARY REPORT Contains: Date and place of loss How caused Liabilities involved Method of repair/replacement Costs.	— Discuss with Underwriters. — Show to LUCO, LUNCO, or LACC as appropriate.
— Agree to settle. — Notification to Accounts dept. that debit will occur.	**E** FINAL REPORT Summarises Loss/Damage and gives details of actual repairs etc. and amounts recommended to/agreed with.	— Obtain agreement from all Underwriters to settle.



Source of data: Brokerage insurance company.

(APPENDIX 6)

Number Of Expected Claims Using Different Combinations Of The Range Parameter K And The Probability P.

P \ K	0.3	0.2	0.1	0.05	0.01
0.9	30	68	271	1082	27060
0.95	43	96	384	1537	38416
0.99	74	166	663	2654	66358
0.999	120	271	1083	4331	108274

(After Hossack et al., 1983)

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