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航空機 需要豫測方法에 대한 實證的 硏究

An Empirical Study on Methodology for Aircraft Demand Forecasting

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Ⅰ. Introduction

1. Background and Purpose

In a aircraft industry, it is well known that capital expenditure needed to develop often act on its manufacturer as a fatal risk. Moreover, it is actually impossible to offset initial enormous expense by gains within a short period.

On the other hand, demands for aircraft is periodical and the range of its fluctuation is wide according to economic phrase. In an initial step of development, it is very difficult to forecast the market aspects of delivering time. Furthermore, the possibility that manufacturer couldn't develop a product in spite of the enormous investment, which is equipped with a promised price, safety, capability, and flying range, should be considered including structural change of the market.

Therefore accurate forecasting the market demand of new aircraft model is an essential factor which affects success or failure of the business. Economies of scale and that of range is accepted as important economic principles in most of industries, but it is especially important to civil aircraft industry.

Accurate long and short term forecasting demand for aircraft could be important subject which we should precede for stepping up of aircraft(A/C) development business which would have strong influence upon national A/C industry.

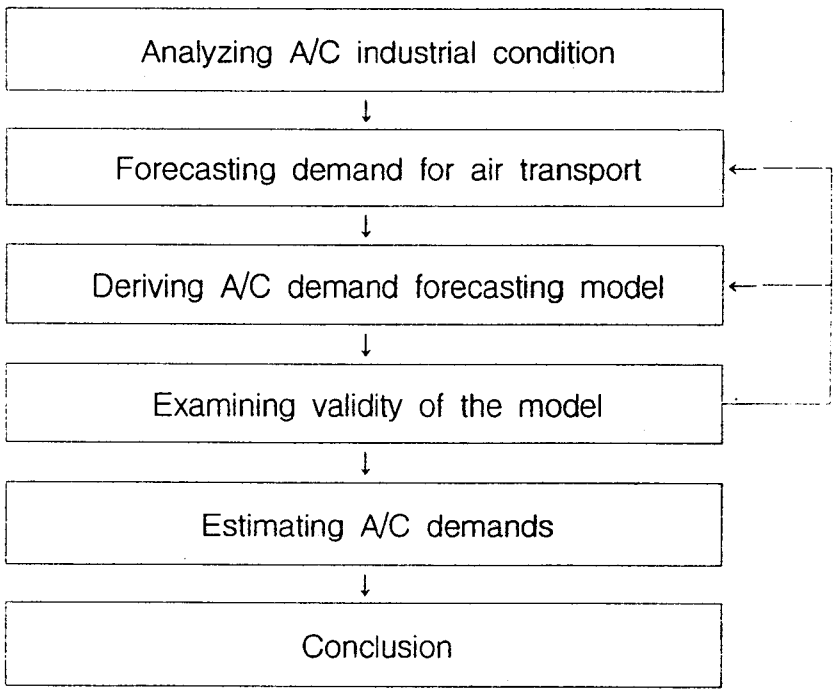
The purpose of this study is to forecast the domestic market demand for 100-passenger class A/C which Korean industry are now driving to develop in the near future. With assumption of economic validity of 100-passenger class A/C, this analysis could be meaningful as a transcendental empirical study which is how many A/C will be necessary in a sample period

2. Methodology

This paper develops somewhat new approaches for forecasting A/C demands. The methodology of this study can be summarized as follows.

- ○ Examining international / domestic A/C industry environment
- ○ Estimating demand for periodic air transport
- ○ Deriving A/C demand forecasting model and testing its validity
- ○ Estimating the A/C demand for sample period(1995-2014)

<Figure 1> Flow of the study



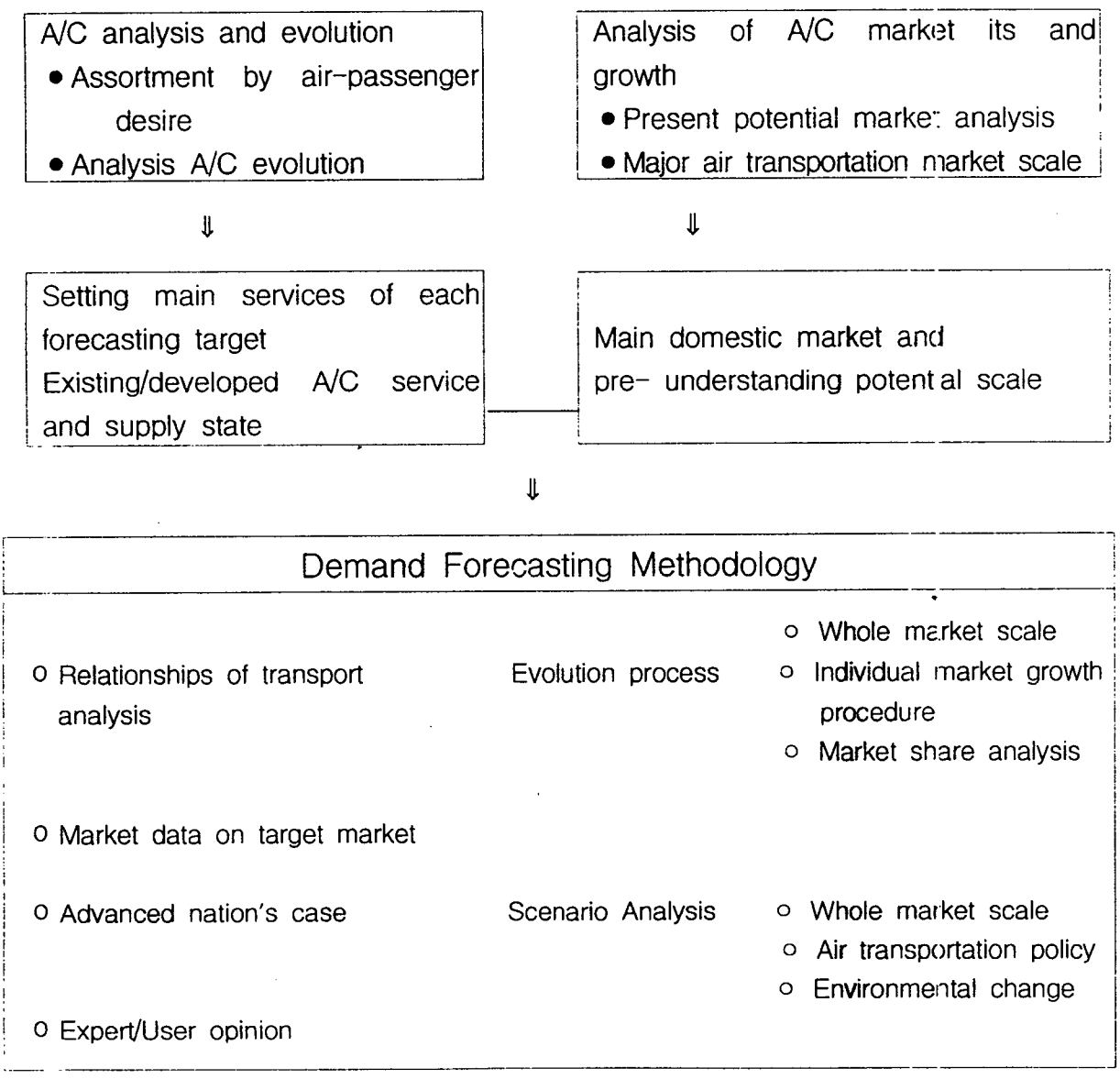
II. Demand for Air Transport

1. Framework of demand forecasting

(1) Procedures for Demand Forecasting

- Forecasting domestic air transport demand is completed by setting up main services and means, then use proper demand forecasting methodology as follows.

<Figure 2> Demand forecasting procedure



(2) Examination on Determinants of Air Transport

- General factors which affect to air transport demand are usually referred to be population, economy growth rate as socio-economic factor, regulation as a government policy, fare as a cost factor, airport capacities, as a infrastructure punctuality, service level, competitive conditions and marketing strategies of airlines as market condition.

<Table 1> Factors affect to air transport demand

Factors	Variables	Remarks
Socio-economic factors	1. Population(age, sex, occupation, etc.)	Social index
	2. GNP and disposable income	Economic index
	3. Income structure	Distribution of NI
	4. Propensity for consumption	Savings ratio
	5. Expenditure on leisure activities	Holidays with payment
	6. Life style	Annual holidays
	7. Preference to air travel	Preference of each social level
Government policies	1. Liberalization of tourism	Scale of foreign currency Holdings
	2. Deregulation	Impacts on travel desires
Cost factors	1. Air fare	Price index
	2. Time value	Labor productivity
	3. Expenditure propensity	Expenses on leisure travel
Airport accessibility	1. Easiness to access airport	Time ratio (ground movement /air travel)
Punctuality and Service level	1. Maintence of frequency	Airline company's image
	2. Diversity and popularity	Market occupation ratio
	3. Service quality	Compare with other service
Competitive Conditions	1. comfortablity	Economy of travel time
	2. Fare	Comparative fare economy
	3. Frequence	Conveniency of air travel
	4. preference for air travel	Preference to air travel
	5. Network of alternatives	Rails, Roads, etc.
Marketing	1. Marketing concept	
	2. Marketing structure and strategy	Marketing Mix strategy

(3) Setting up Forecasting Model of Air Transport Demand

◦ In this data analysis method, air-passenger demands are estimated by applying econometrics model with time series analysis with total volumes. And high resemblant forecasting results are used as basic data for forecasting A/C demand with comparing individual estimated results of existing empirical studies.

2. Forecasting Air Transport Demand

(1) Survey on Existing Estimated Results

◦ There are two approaches ways in estimating air transport demand. One is a method which estimate step by step with applying proportion of air traffic after estimating total transportation volume. The other is a method directly measure the past records of air transportation volume, and above mentioned model which I applied could be included in this approach.

◦ Korean Ministry of Transportation(1994) once total-volumely forecasted air transport demand by regression analysis.

<Table 2> Example of Air transport demand forecasting

(Departure + Arrival)

Section		(1990)	(1992)	1995	2000	2001	2005	2010
Passenger (thousand)	Total	31,754	40,522	57,082	86,144	81,488	102,287	133,696
	International	9,626	11,413	15,780	24,378	25,799	32,360	45,588
	Domestic	22,128	29,109	41,302	61,766	55,689	69,927	88,108
Freight (thousand tons)	Total	1,142	1,327	1,969	3,079	3,115	3,928	5,548
	Domestic	777	844	1,235	1,978	2,097	2,648	3,912
	International	365	483	734	1,101	1,018	1,280	1,636
No.Flights (thousand times)	Total	228	291	405	597	585	712	913
	International	56	68	97	160	168	216	314
	Domestic	172	223	308	437	417	496	599

Notes : Under the assumption that new High-Speed Railway(SEL-PSN) open in 2001

Source : Korean Ministry of Transportation (1994. 4)

(2) Forecasting Method and Its Results

◦ Forecasting was performed as follows, I tried to minimize estimation - error method · between existing results and forecasting results of this study. I applied Logistic function with time series analysis, and compared its results with existing estimated results.

Applying Logistic functional equation with past-transported passengers.

◦ Analysis period : 1970 - 1994

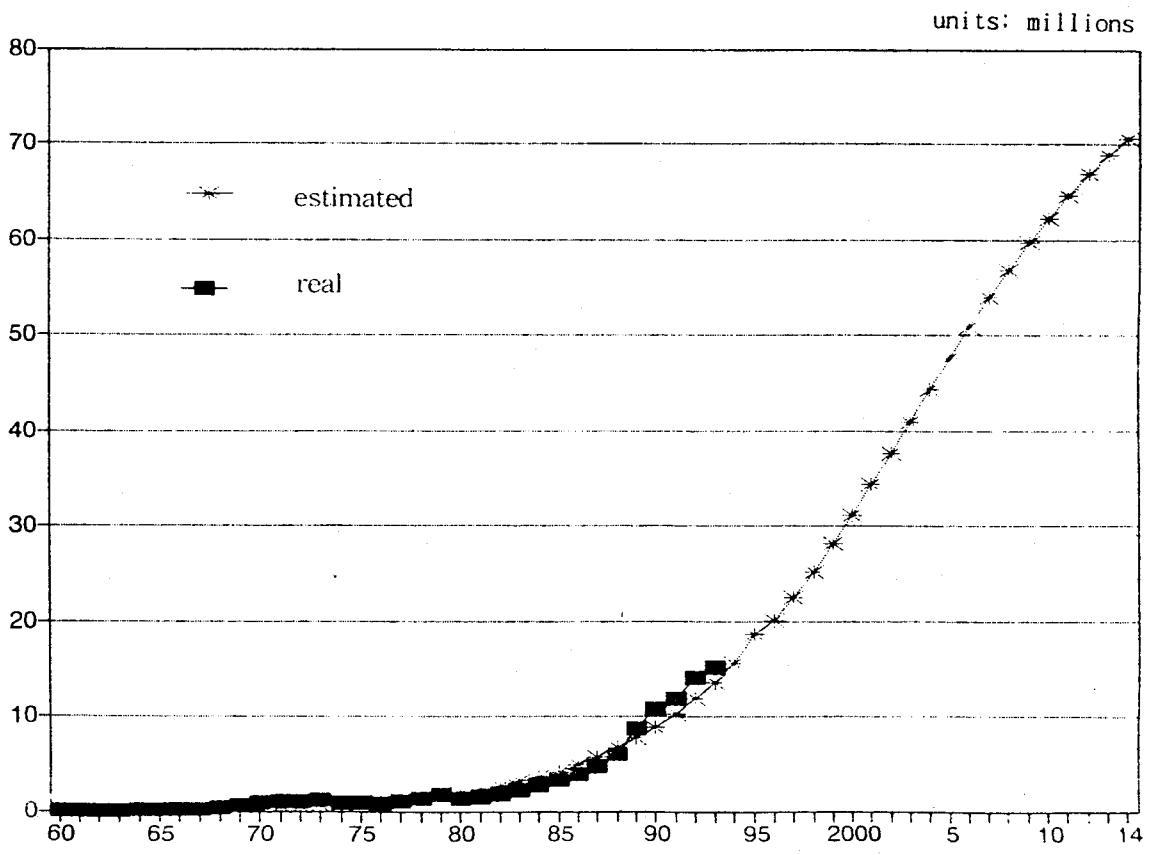
◦ Forecasting period : 1995 - 2014

Estimating equation : $$Y = \frac{K}{1 + \exp(a+bT)}$$

Y : passengers, K : constants of mature stage, T : year,

a, b : estimated coefficient

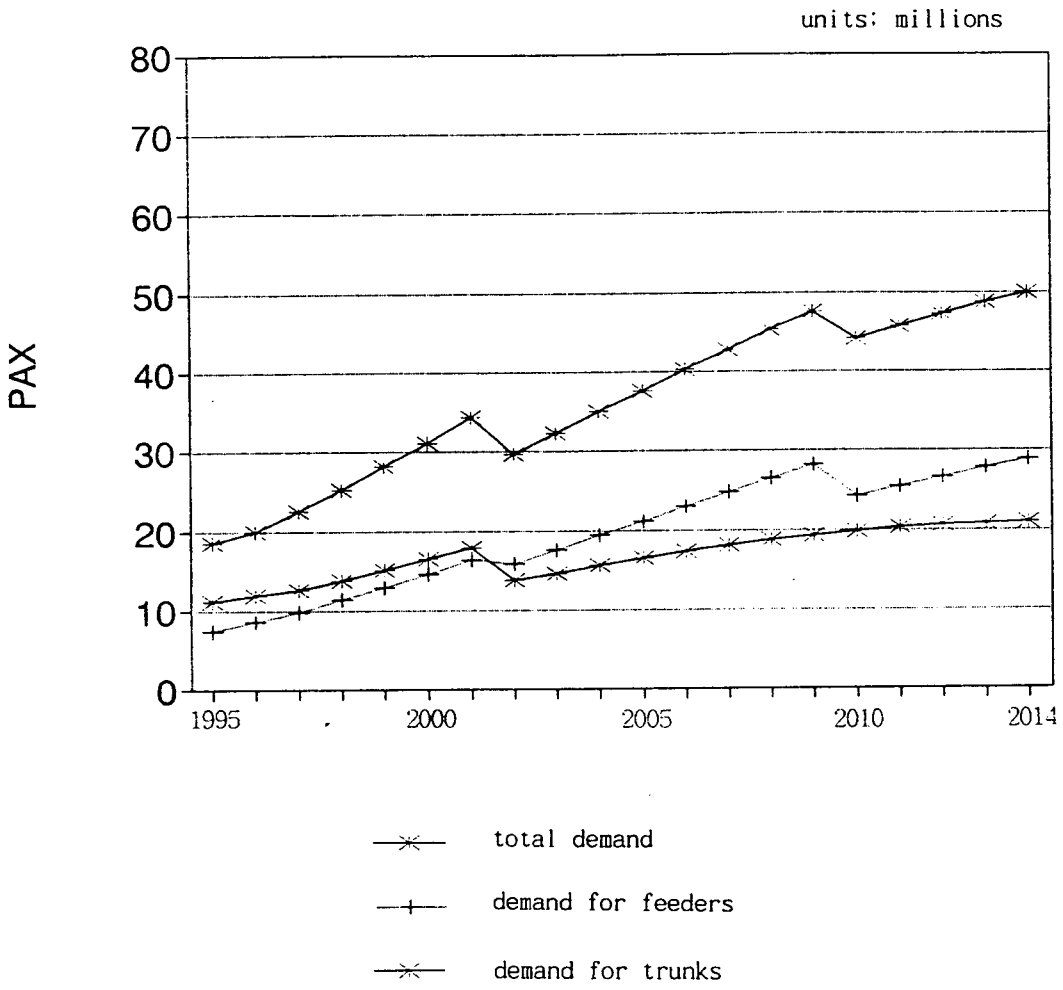
<Figure 3> Estimated results fit with Logistic functions



notes : Not considered new High-Speed Railway(SEL-PSN : 2001)

◦ Forecasted demand was modified applying the effect of new alternatives, High-Speed Railway between Seoul and Pusan, which are expected to substantially decrease demand of air transport.

<Figure 4> Modified Result of air transport demand



<Table 3> Forecasted air transport demand

(units : thousand)

Year	Trunk	Feeder	Total	Year	Trunk	Feeder	Total
1995	11,174	7,433	18,608	2005	15,510	21,164	37,674
1996	11,827	8,613	20,040	2006	17,328	22,959	40,287
1997	12,551	9,925	22,476	2007	18,076	24,741	42,817
1998	13,836	11,369	25,205	2008	18,745	26,492	45,237
1999	15,171	12,941	28,112	2009	19,332	28,197	47,529
2000	16,538	14,635	31,173	2010	19,833	24,195	44,028
2001	17,919	16,439	34,358	2011	20,248	25,472	45,720
2002	13,743	15,903	29,646	2012	20,581	26,686	47,267
2003	14,704	17,615	32,319	2013	20,834	27,835	48,669
2004	15,631	19,376	35,007	2014	21,014	28,915	49,929

◦ Yearly increasing rate of total forecasted transportation demand

- period(1995-1999) : 12.47%
- period(2000-2004) : 9.32%
- period(2005-2009) : 6.14%
- period(2010-2014) : 3.43%

III. Demand for Aircraft(A/C)

1. Basic Assumptions

(1) Deregulation of existing airports and airspace

(2) Modernization of existing weak airport and construction of new airports

(3) Economy of middle-size aircraft

(4) Others

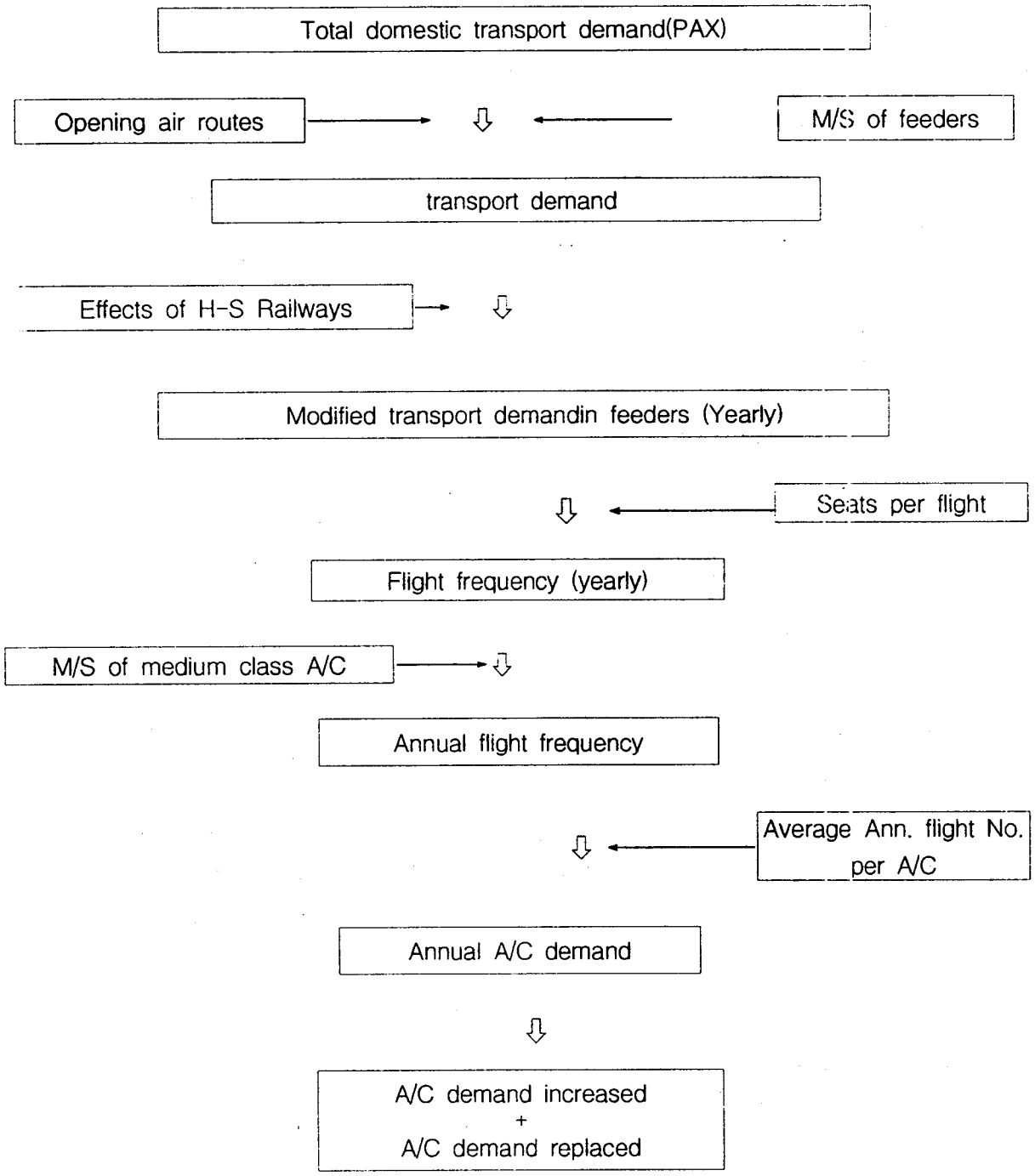
- o assuming stable demand and supply of relavant man powers
- o all other conditions, such as non-scheduled · commuter services, being unchanged.

2. Estimation Method

(1) Procedures

- o Estimating yearly demand for air transport in feeder lines based on changes of estimated domestic demand for total passenger.
- o Estimating demand for modified feeder transportation considering passenger-decreasing effects of new High-Speed Railways.
  - KyungBu High-Speed Railway (2002)
  - Honam, DongSeo High-Speed Railway (2010)
- o Forecasting yearly demand by applying middle size A/C market share after estimating the yearly number of flight based on feeder transportation demand.
- o Estimating final A/C demands for A/C including those replaced and newly procured.

<Figure 5> Forecasting demand procedure



① Market share rate of the feeder lines : M/S of passenger transport except the three main trunk lines which are regarded as the market of A/C considered.

② Effect of High-Speed railway : annual influential rate (applying demand decreasing rate) during sample period(2002-2014)

③ The number of passengers in single transport : ASK × Load Factor

④ The transport market share of medium-sized A/C : the transport percentage of medium-sized A/C in the existing feeder

⑤ The average flight frequencies of airline service : utilization hours / block time

⑥ New A/C demand : Xt+1 - Xt

(2) Data required

① Market share of feeder line

- M/S rate of passenger transport has increased about 1.7%(annual average) in the last 10 years, except three trunk line
- The annual passengers on local lines are 6,570,000 at the end of 1993. It covers about 42.27% of total air passengers
- It is assumed that past market share of feeder lines is continuously increasing due to deregulation trend of the local military air-service and the establishment of new routes. The trend of M/S of feeder lines was estimated as follow.

<Table 4> Estimated M/S of feeders

(unit : %)

Criteria	1993	1995	1999	2004	2009	2014
M/S of feeder lines	42.22	46.03	46.03	50.45	54.51	58.23

② Decreasing rate of passenger demand with the effects of opening High-Speed Railways

- After opening High-Speed railways that is under constructed now, railway service will be getting much improved. Therefore it would considerably affect the demand for airline service. The decreasing rate of air transport demand, due to opening HSR, was adjusted to be the modified rate after investigating the results of existing researches
- The case of HSR in Japan seems reliable about prospective results by Logit model. It is, however, impossible to exactly predict the change of the amount of existing transport only using the Logit analysis method. That is because 'what is chosen as the means of transportation' is affected by not only time table and fare but also by other exogeneous elements. Moreover, the results from existing assumptions depend on newly opened routes, the construction of new airports, and expansion of existing airports etc.
- In this analysis, I used the existing presumptive findings but the decreasing rate of demand for some routes was adjusted as follows.

<Table 5> adjusted decreasing rate of demand

(unit : %)

Routes	Case of Japan	KOTI (1994)	KMOT (1994)	Remark	Adjusted decreasing rate
SEL-PSN	72.9	70	22.2 - 45.6	· comparatively high transit passengers ratio	70
SEL-TKU	79.5	85	30.9 - 65.3	-	75
SEL-KWJ	82.4	80	27.0 - 54.3	-	70
SEL-YOS	32.8	10	0	· Indirect effect of HSR	5
SEL-USN	53.3	40	6.6 - 15.9	· Inconvenience of HSR passengers	20
SEL-POH	60.2	40	6.6 - 15.9	〃	20
SEL-KNG	91.0	95	26.0 - 57.9	· stable demand considered	60
SEL-SKC	87.3	95	1.5 - 12.9	〃	60
SEL-MOK	-	-	6.6 - 15.9		10

③ The amount of passengers in a single transport

- Define the seat category of 80- to 120-seat A/C as 100seats, and then calculate the amount of passengers in a transport.

  PAX per A/C = ASK × LF(load factor)

- Domestic airlines are expected to develop more efficient seat management. And the deregulation measures in air transport industry can be assumed to be continuonsly extended in the near future. Therefore LF of A/C is assumed to be 65%, 70%, 75% respectively.

④ The M/S of medium-sized A/C transport

- It is assumed that the kinds of 100-seat A/C, in the feeder lines, amounted to approximatedly 30 per cent of all air transport as of 1994.
- However, domestic airlines predict that transportation in medium-sized A/C would be increased by actualizing potential latent demand, improving customer satisfaction, and the transport of catered A/C on some international routes. Hence They presume that medium-sized A/C will take 40 per cent of market share in domestic transport market from the year 2000 on.

⑤ The frequency of annual average transport per A/C is calculated as follows.

It should be standardized as the utilization hours of 100-seat domestic A/C under operations

- Divide utilization hours by block time

  annual flights per A/C = utilization / block time

- utilization hours : UH

  UH = daily utilization(6.5hrs) × 365(days)

  = 2372.5(hrs)

- block time(BT)

It should be standardized as the average section distance of 100-seat domestic A/C under operations.

- section distance 162NM(300KM)
- velocity 600KM/M

⑥ Demand for A/C

· The total annual demand for A/C is calculated as follows.

demand for A/C = total block time / utilization hours

= 2BT×[No. of PAX/(ASK×LF)×2] / UT

· LF is applied with 65%, 70%, and 75% respectively.

⑦ Consideration of securing new A/C and replacing obsolete A/C.

· It is assumed that airlines would secure new A/C at the upper limit of LF 70%.

· It is assumed that airlines would not secure airlines until demand are actually increasing, specially not when the demand for transport is predicted to decrease.

· It is assumed that A/C should be replaced when their life expires, and they go out of commission entirely because of obsolescence when it is 20 years since they start operations.

(3) Classification of estimated A/C demand

The A/C demand was classified with three levels. optimistic level(H), most likely level(M), and pessimistic level(L).

<Table 6> Classification of demand estimated

Classification	LF(%)	Seat Category	UH (hours)
Optimistic(H)	65	80,100,120	2372.5
Most Likely(M)	70	80,100,120	2372.5
Pessimistic(L)	75	80,100,120	2372.5

3. The results

(1) Total demand for A/C

· Total demand of medium sized A/C, estimated annually during the presumed period(1995-2014), is as follows.

<Table 7> Total demand estimated annually

(unit : A/C)

Criteria	Ann. demand(1995-2004)			Criteria	Ann. demand(2005-2014)		
	L	M	H		L	M	H
1995	2	2	2	2005	5	5	5
1996	2	2	3	2006	6	6	6
1997	2	3	3	2007	4	4	5
1998	3	3	3	2008	2	2	2
1999	3	5	4	2009	3	3	3
2000	3	3	3	2010	2	2	2
2001	2	1	3	2011	5	6	6
2002	0	0	0	2012	4	4	5
2003	3	3	4	2013	4	4	5
2004	3	4	4	2014	5	5	5

(2) The A/C demand to be newly secured

① periodic demands

· Total demand for A/C that will be secured during presumed period(1995-2004) : approximately 67 units

· Total demand of A/C etimated annually is as follows

<table 8> A/C demand forecasted annually

(unit : A/C)

Classification	1995-1999	2000-2004	2005-2009	2010-2014	Total
Optimistic(H)	15	14	21	23	73
Most Likely(M)	15	11	20	21	67
Pessimistic(L)	12	11	20	20	63

② Annual A/C demand

<Table 9> Annual A/C demand estimated by most likely level(M)

(unit : A/C)

Year	newly secured	replaced	Total	Year	newly secured	replaced	Total
1995	2	0	2	2005	3	2	5
1996	2	0	2	2006	4	2	6
1997	3	0	3	2007	2	2	4
1998	3	0	3	2008	0	2	2
1999	5	0	5	2009	0	3	3
2000	3	0	3	2010	0	2	2
2001	1	0	1	2011	3	3	6
2002	0	0	0	2012	2	2	4
2003	3	0	3	2013	2	2	4
2004	4	0	4	2014	2	3	5
				Total	44	23	67

<Table 10> Annually A/C demand estimated by optimistic level (H)

(unit : A/C)

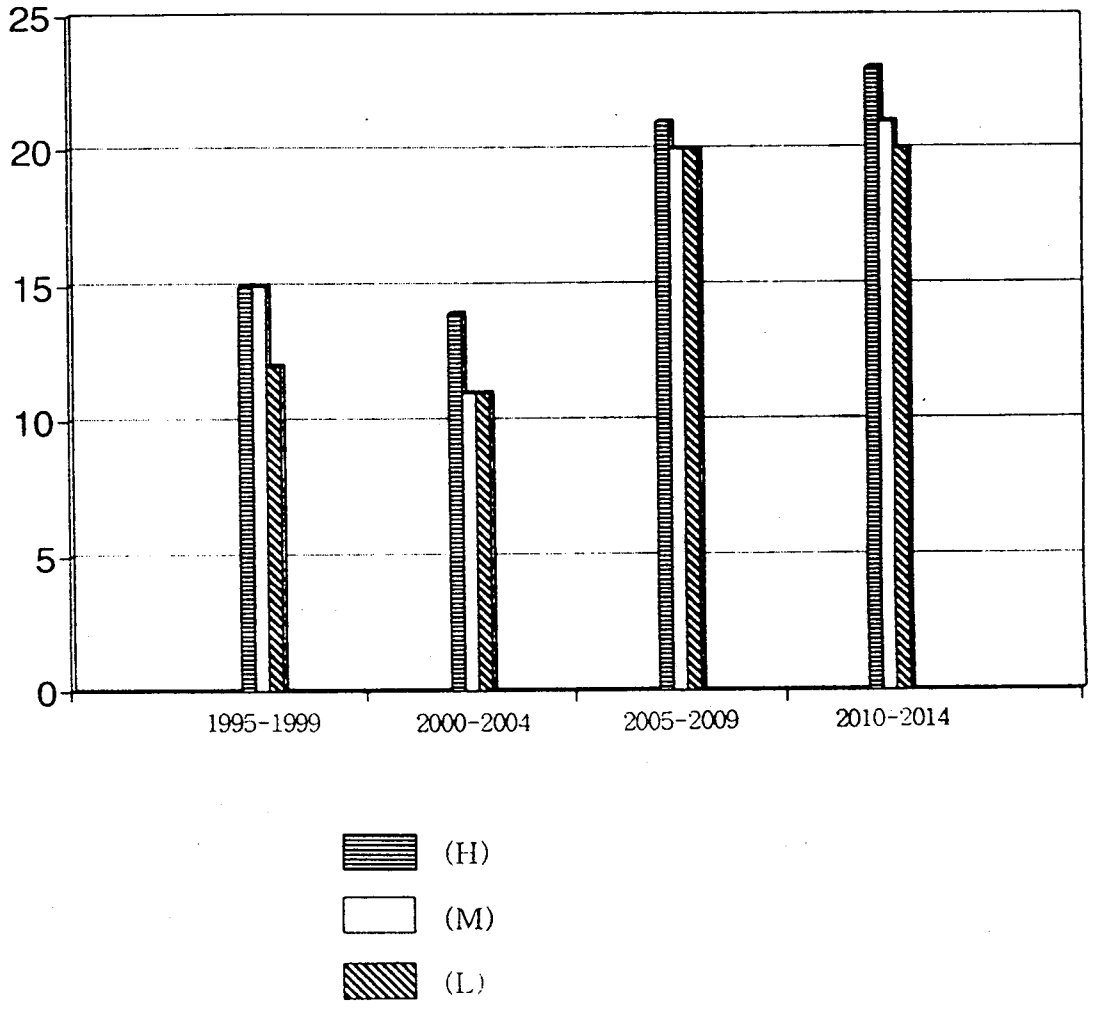
Year	newly secured	replace	Total	Year	newly secured	replaced	Total
1995	2	0	2	2005	3	2	5
1996	3	0	3	2006	4	2	6
1997	3	0	3	2007	3	2	5
1998	3	0	3	2008	0	2	2
1999	4	0	4	2009	0	3	3
2000	3	0	3	2010	0	2	2
2001	3	0	3	2011	3	3	6
2002	0	0	0	2012	3	2	5
2003	4	0	4	2013	2	3	5
2004	4	0	4	2014	2	3	5
				total	49	24	73

<Table 11> Annually A/C demand estimated by pessimistic level (L)

(unit : A/C)

Year	newly secured	replaced	Total	Year	newly secured	replaced	Total
1995	2	0	2	2005	3	2	5
1996	2	0	2	2006	4	2	6
1997	2	0	2	2007	2	2	4
1998	3	0	3	2008	0	2	2
1999	3	0	3	2009	0	3	3
2000	3	0	3	2010	0	2	2
2001	2	0	2	2011	2	3	5
2002	0	0	0	2012	2	2	4
2003	3	0	3	2013	2	2	4
2004	3	0	3	2014	2	3	5
				Total	40	23	63

<Figure 6> Annual A/C demand estimated



Ⅳ. Conclusion

This study has been performed to estimate the domestic demand of 100-seat civil A/C in the 2000's. Most of the demand forecasting for A/C has been performed by companies individually based on historical trends.

This research aims to forecast the demand for newly developing A/C based on long-term prospect of domestic air transport industry. Therefore I estimated the annual demand for A/C using the results of domestic demand of air passengers.

To control uncertainty that could be occurred in industrial situations, this research controlled some relevant variables as follow.

- relaxation of the regulations in the air transport industry
- modernization of weak airports and construction of new local airport
- economic efficiency of developing 100 seats A/C
- other conditions, such as commuter, non-scheduled services, being unchanged.

The demand for A/C is estimated with the procedure belows:

- Using the predictable changes of air transport demand, I could forecast the demand for air transport on feeder lines.
- Air transport demand would be considerably decreased because of the effect of HSRs. Threfore I adjusted its effects with total demand. Then multiplied M/S of 100-seat A/C.
- Calculate the annual frequency of A/C using the demand for transport of medium-sized A/C and estimate the total demand with a derived equations.
- Estimate the newly increased demand and replacement demand by period.

The results of forecasting are summarized as follow.

- estimation period : 1995 - 2104 (for 20 years)
- the subject : 100-seat airplane market in S. Korea.
- total demand (No. of A/C) :
  - optimistic level - 75
  - most likely level - 67
  - pessimistic level - 65

This research was performed using the long-term air-passenger demand and the historical data of air transportation. Also, some variables were conveniently controlled and the situational uncertainties are covered with the scenario analysis. Hence the fitness of assumption should be guaranteed, and it should be noted that the demand forecasting for A/C have some limitation due to limitation of collecting data and high uncertainty existing in this industry.