
Demand for Air travel

Nathalie Lenoir
Christophe Bontemps

Outline of presentation

- ➔ I- Introduction : demand and transport demand
- ➔ II- How to measure demand?
- ➔ III- Demand Analysis
- ➔ IV- Demand models
- ➔ V- Air transport demand today

1- Why do we care about demand ?

- For the **airlines** : network optimization, revenue management and marketing
- For the **airports** : revenue optimization and infrastructures,
- For the **cities** : local economy related to transport
- For the **authorities** : infrastructure planning
- For all : to forecast traffic, one needs to understand demand

3



Nathalie LENOIR, September 2011



What is demand 1?

- Demand is computed for a specific good on a specific market as the number of goods sold.
- Individual demand is the number (quantity) of goods purchased by a consumer (traveler)
- Aggregate demand is the sum of individual demands

4



Nathalie LENOIR, September 2011



What is demand 2?

- Problem of definition of relevant market: what is the “good”
 - Market for soft drinks, or market for colas ?
 - Are they perfect substitutes ? Where do you draw the line ?
- How do you measure the quantity ?
 - Easier for a good than for a service
 - Choices made at individual level but most data at aggregate level (Question of aggregation)
- Q1 : What is a market in air transport, and how do we measure demand?

5



Nathalie LENOIR, September 2011



Where does it come from?

- Individual i maximizes its utility U_i .
- Imagine there is only 2 goods in the economy ($j=1,2$)
- Each good is characterized by z_j and is sold at price p_j so that i is facing the maximization problem :

$$\text{Max}_{q_j} U_i(q_1, q_2, z_1, z_2, \xi_1, \xi_2)$$

$$p_1 q_1 + p_2 q_2 \leq C_i$$

- Where C_i is the budget of individual i

6



Nathalie LENOIR, September 2011



Utility and individual demand

- The maximization leads to an individual demand depending on the characteristics of goods, the prices of goods (and unobserved “other things”),
- Demand for good 1 for individual i is :

$$q_{i1}(z_1, z_2, p_1, p_2, \xi_1, \xi_2)$$

and depends on many things...

- Q2: what are the main factors influencing individual demand in air transport?

7



Nathalie LENOIR, September 2011



Demand

- Demand for a good is the sum of individual demands from differing consumers

$$Q_1(z_1, z_2, p_1, p_2, \xi_1, \xi_2, \chi_i) \\ = \sum q_{i1}(z_1, z_2, p_1, p_2, \xi_1, \xi_2)$$

Summed over n individuals

- Q3: At a global level, what are the main factors influencing demand in air transport?

8



Nathalie LENOIR, September 2011



Transport Demand

- Transport is not demanded “per se” but complementary of other services or goods
 - Few people travel for the pleasure of taking a plane...
- It is a “derived demand”
 - Part of a broader demand
 - “trip” demand: (air) travel only part of “trip”
 - Results from **spatial localization** of consumers and firms



Factors explaining transport demand

- Demand depends on many factors
 - Supply characteristics (Price, service, network, travel time)
 - Individual characteristics (income, age, sex...)
 - Trip purpose
 - Characteristics of other sectors linked to trip purpose (ex: hotel prices)
- Travel demand is a function of many factors inside and outside of the transport sector
- **Q4: How does one take that into account?**



Outline of presentation

- I- Introduction : demand and transport demand
- II- How to measure demand?
- III- Demand Analysis
- IV- Demand models
- V- Air transport demand today



II- How to measure demand?

- Example of the air traffic between Toulouse and Paris
- 2 949 910 passengers in 2010
- Has all demand been satisfied ?
- What market does it measure ?
- What markets does it measure?
 - 756 794 passengers to CDG
 - 2 193 116 passengers to Orly
- What is the origin and destination of those passengers?



How to measure transport demand ?

- Several quantities may be collected on **satisfied demand**
 - Demand can remain non satisfied because of capacity constraints
 - Non satisfied demand is nearly impossible to know about

Fundamental issue 1: It is difficult to measure real demand (= satisfied + non-satisfied)



How to measure demand ?

- At the individual level, the individual wants to travel from O to D
- Markets in air transport are Origin-Destinations (O-D)
 - Toulouse to New York
- But data easy to observe is on routes
 - Toulouse to Paris and Paris to New York

Fundamental issue 2 : the demand is for an O-D and we only observe demand on routes (i.e. segments)



Collecting data in Air Transport

→ Data collected by authorities

- Firms divulge as little as possible (owning data is strategic)
- They do it only if they are obliged : balance sheet, data on routes (airport fees), global figures
- In the US, data on O-D are collected and made public. Not elsewhere

→ Data collected by surveys

- Latest DGAC survey: 46 000 pax surveyed.
- Costly but can be precious (data at individual level)



Some measures of demand

→ Some typical measures:

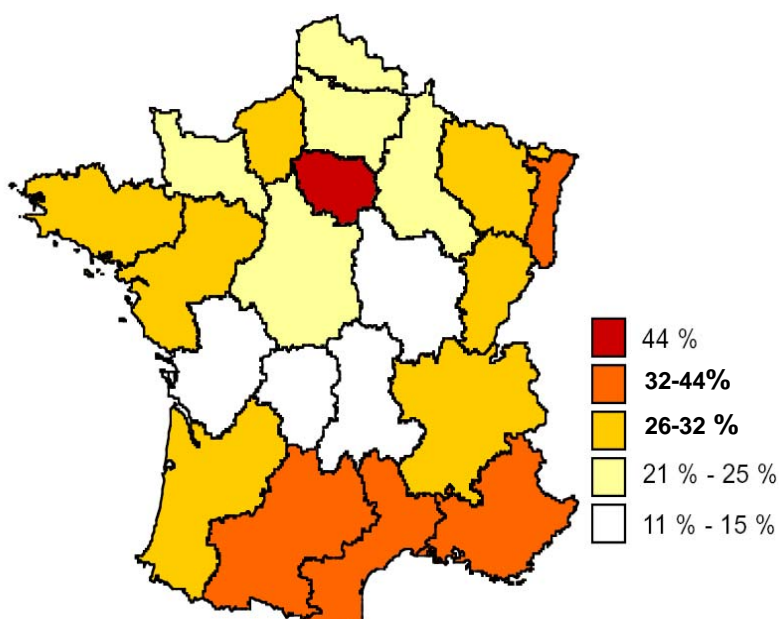
- Number of passengers,
- Tons of freight,
- RPKs,
- RTKs

→ Some more “exotic” measures

- Penetration rate: % of the population who has traveled by plane during the last 12 month.
- Travel propensity: Average number of travels per capita per year



Penetration rate in France in 2001



Source :DTA SDEEP, Note de synthèse et d'actualité, N° 14, Juillet 2003

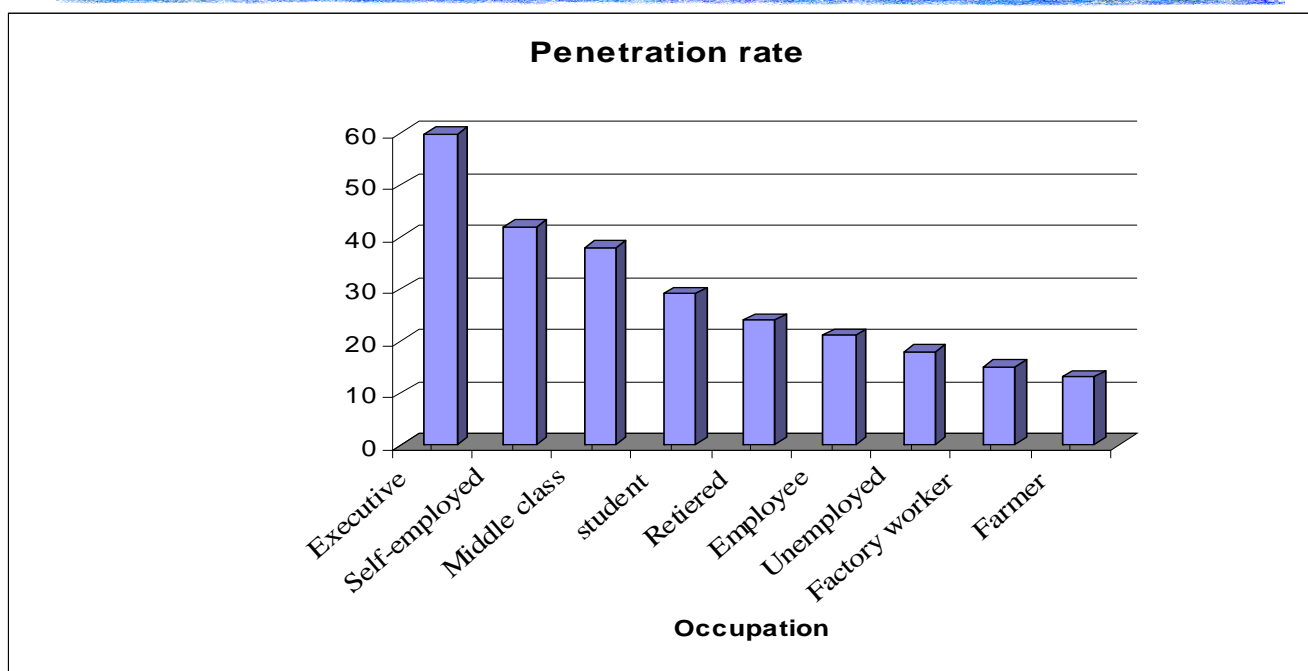
17



Nathalie LENOIR, September 2011



Penetration rate in France in 2001



Source :DTA SDEEP, Note de synthèse et d'actualité, N° 14, Juillet 2003

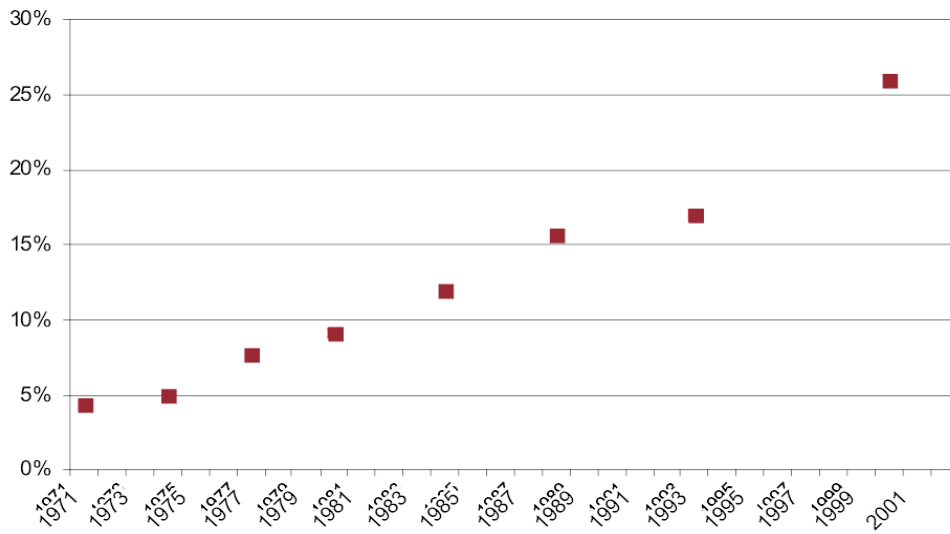
18



Nathalie LENOIR, September 2011



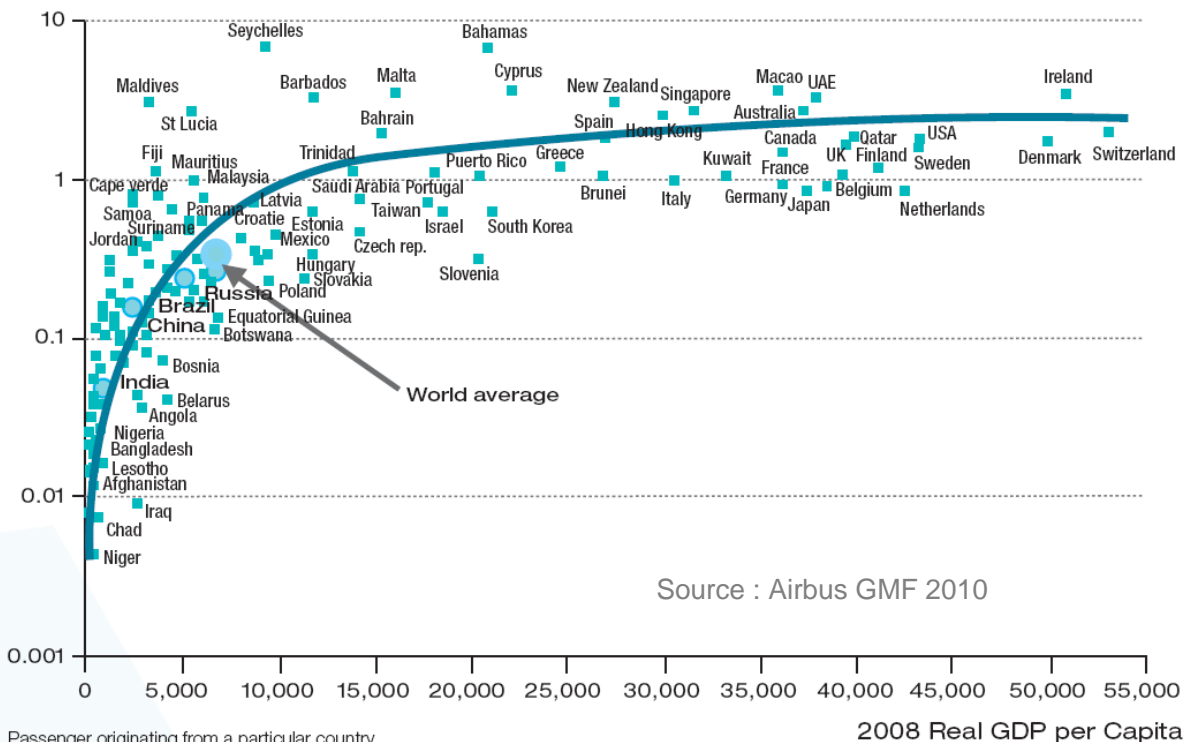
Penetration rate evolution in France



Source :DTA SDEEP, Note de synthèse et d'actualité, N° 14, Juillet 2003



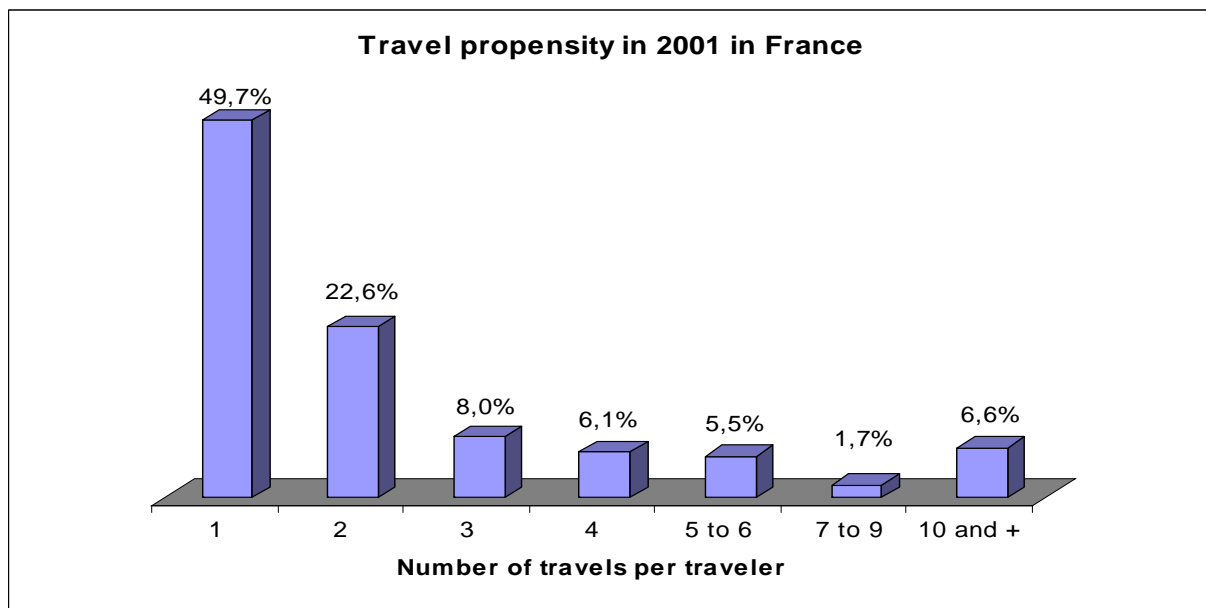
Propensity to Travel in the world



Passenger originating from a particular country
 Note: GDP in 2005 US\$
 Source: IATA PaxIS, Global Insight, Airbus



Propensity to travel in France in 2001



Source :DTA SDEEP, Note de synthèse et d'actualité, N° 14, Juillet 2003

21



Nathalie LENOIR, September 2011



Outlook on French passengers (2007 DGAC survey)

- About half of traffic is business passengers
- 18 % of the population flies at least once a year (17% in 1993)
 - 18% for leisure and other personal motives, 1.6 travels on average,
 - 3% for business , 5.3 travels on average
 - This rate is much higher for higher incomes : 58 % for incomes higher than 5 300 euros per month
 - ...and much lower for lower incomes : 12 % for incomes lower than 1 200 euros
- About 50% of the population never flies

22



Nathalie LENOIR, September 2011



Outline of presentation

- I- Introduction : demand and transport demand
- II- How to measure demand?
- **III- Demand Analysis**
- IV- Demand models
- V- Air transport demand today



III- Demand analysis

- Many dimensions
 - From global demand to individual purposes
 - Many factors of influence
- Many scales
 - Ways of aggregating (means of means are not means!)
 - Dispersion is important (variance)
- Time varying



III- Demand analysis

→ Global demand

- Travel demand and the economy
- Modal split

→ Individual demand

- Travel purpose
- Income
- The price/time trade-off



Transport and the Economy

Strong links exist between economic activities and transport

- All economies are based on exchanges and exchanges need (more or less) transport
- Double sided link between economic growth and transport development



The economy as a factor of transport development

Transport demand evolution is well explained by the evolution of economic factors :

- The economic activity (measured by GDP or GNP for example)
- Transport Prices
- And also ... Technological progress and infrastructures improvements
 - Reduction of transport duration
 - Cost reduction and therefore price reduction

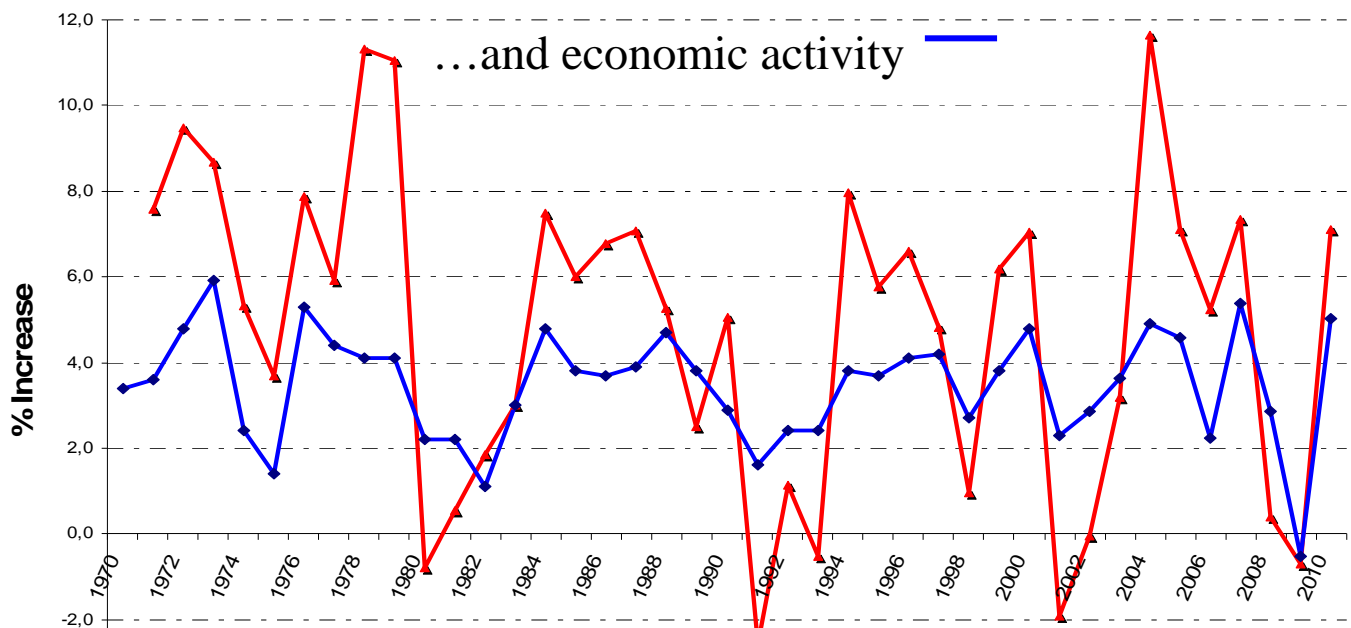
27



Nathalie LENOIR, September 2011



Traffic growth (1970-2010)



Source : ENAC Air Transport Data

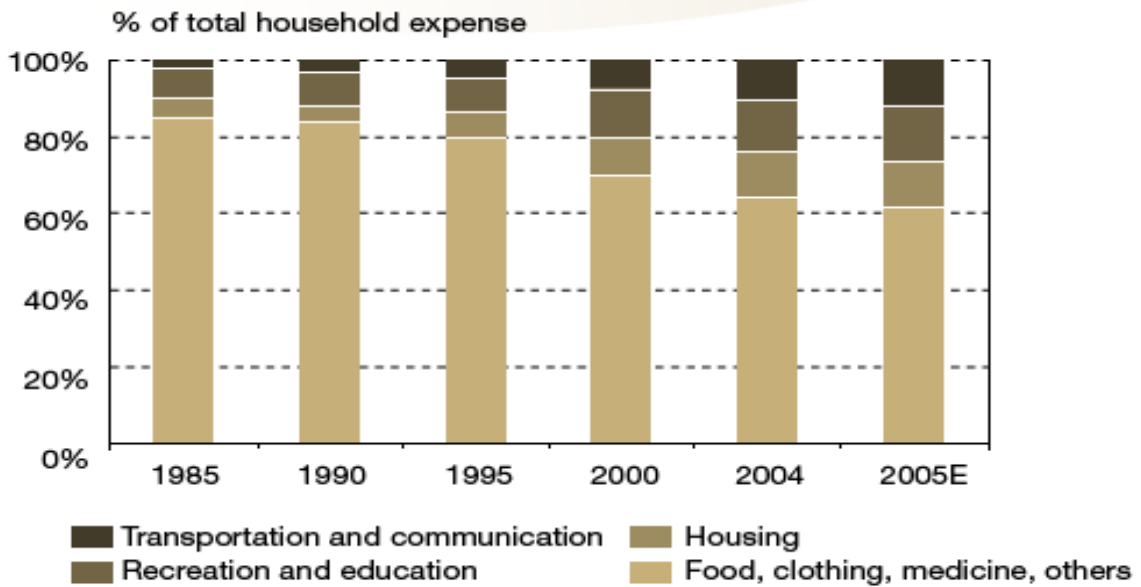
28



Nathalie LENOIR, September 2011



The economy as a factor of transport development



Source : China National bureau of statistics & Airbus GMF 2007



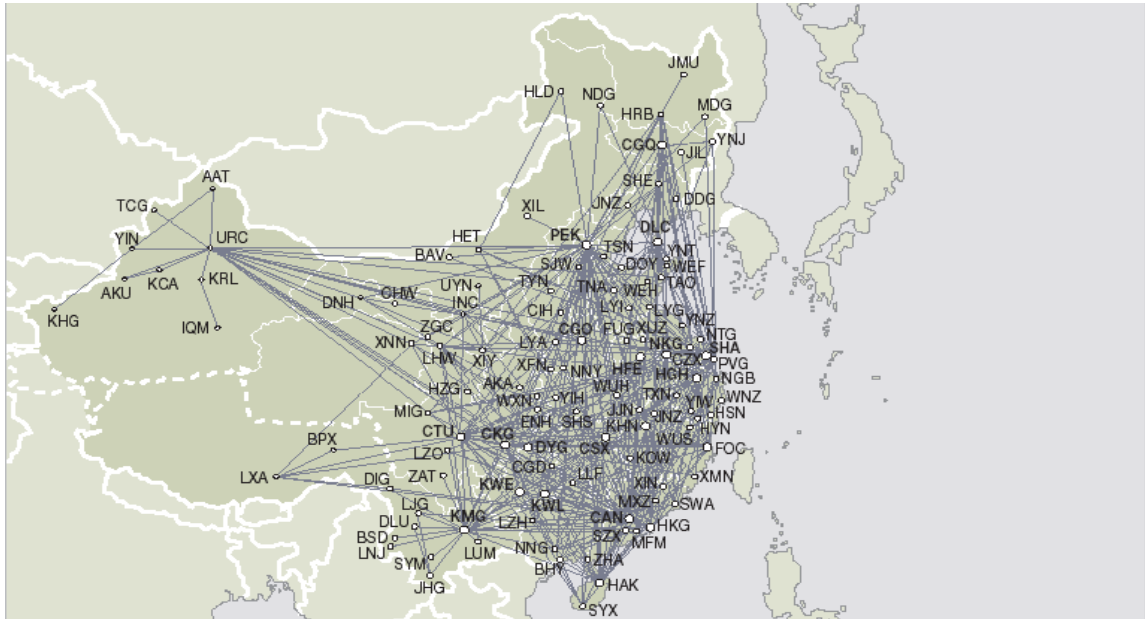
The economy as a factor of transport development



The Chinese route network (1985)



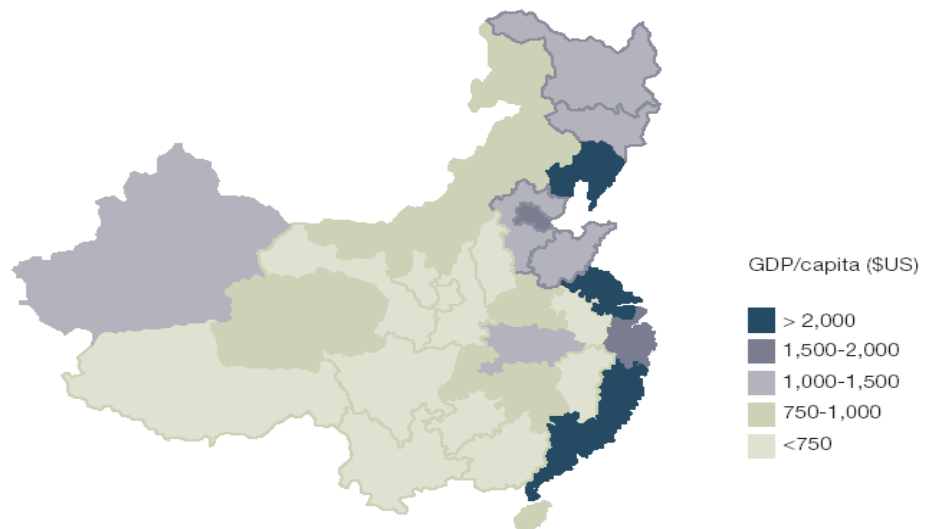
The economy as a factor of transport development



The Chinese route network (2004)



The economy as a factor of transport development

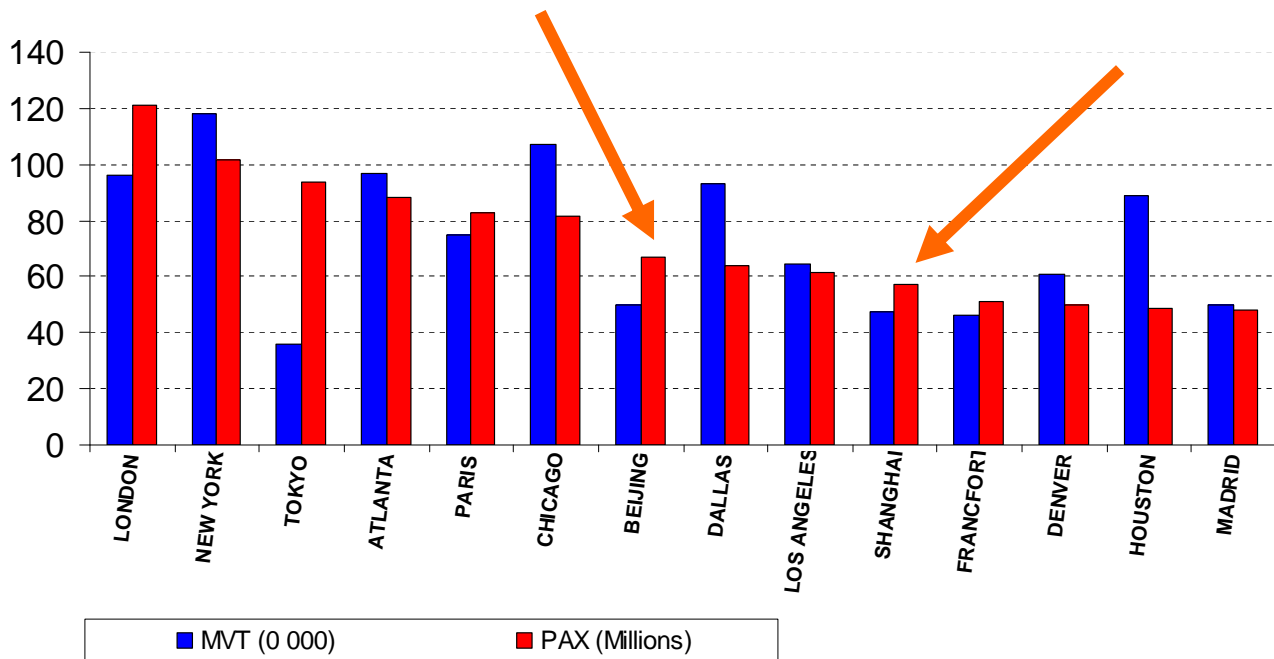


Source: China Statistical Year Book 2003.

China: Wealth by region



The economy as a factor of transport development (air traffic 2009)



Source : ENAC Air Transport Data

Nathalie LENOIR, September 2011

33



Transport as a factor of economic development

- ➔ **Infrastructures** : Effect on the economy of infrastructure development (not to be over-evaluated)
- ➔ Reduction of **transport costs**, and therefore production costs implying reduction of individuals transport costs
- ➔ **External effects** : Communication improvements, access to broader, further markets (fundamentals effects even if difficult to measure..)
- ➔ **Long term effects** on the economic and social organization (effects very difficult to measure)

34



Nathalie LENOIR, September 2011



Other "global" factors: modal split

- We are interested in how demand is split between modes at a global level
 - Modal split : observed distribution of usage of different transport modes: Kms, nb of trips in each mode...
- Traffic intensity and modal split between two cities are linked to distance :
 - Ceteris paribus (all things being equal), transport demand decreases when distance increases
 - Travelers are attracted by fastest transport solutions
 - Modal split is linked to global travel duration more than to distance (but distance is easier to measure).

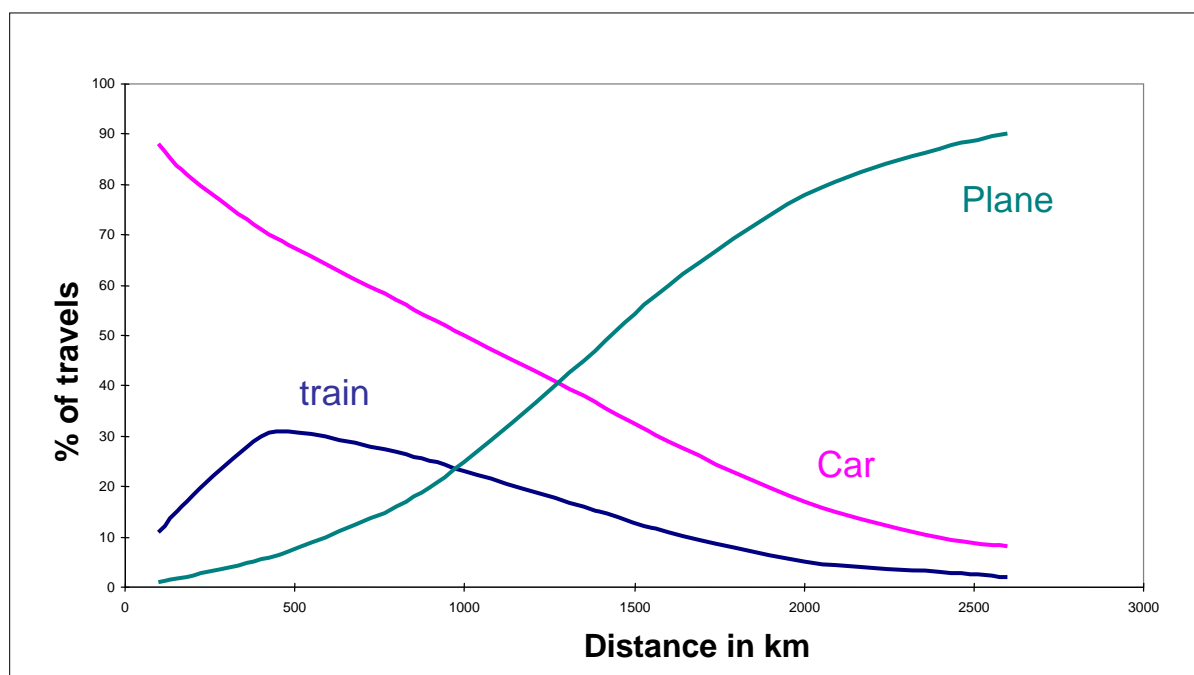
35



Nathalie LENOIR, September 2011



Example: Impact of distance on modal split



36



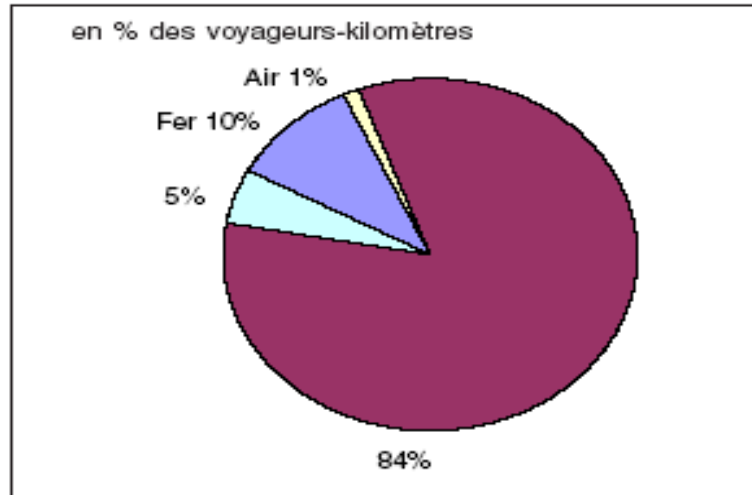
Nathalie LENOIR, September 2011



Modal split in France (Passenger-km)

Most important travel modes

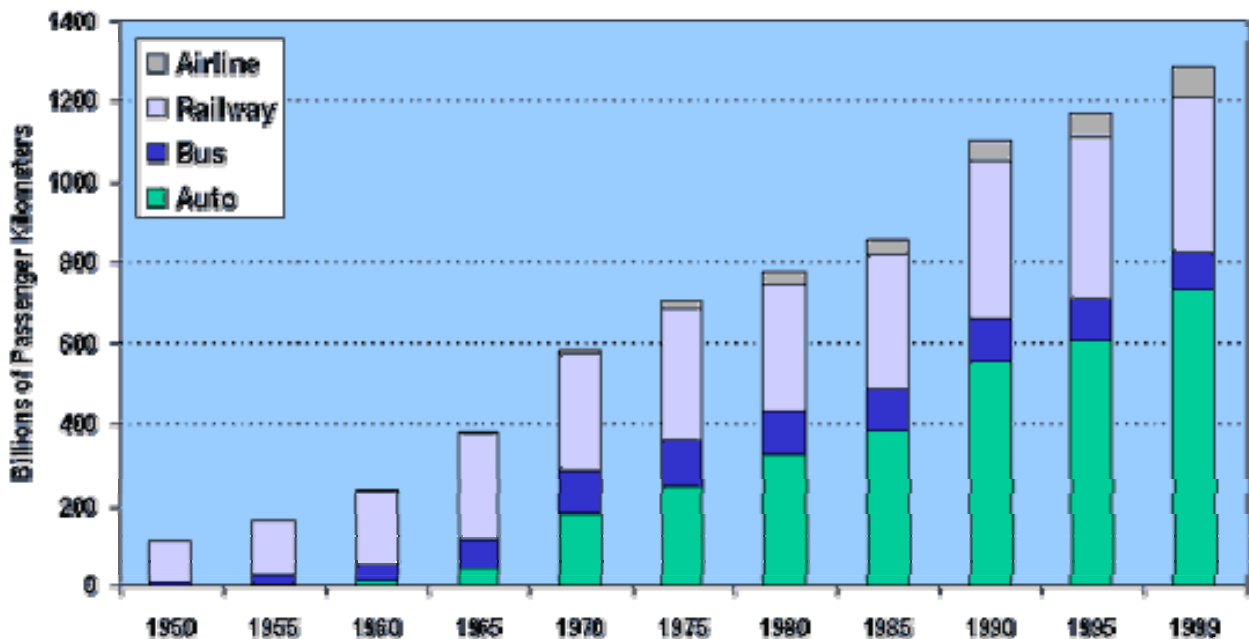
- Car
- Train
- Bus & coach
- Plane



Sources : SNCF, RATP, UTP, DGAC, DAEI-SESP



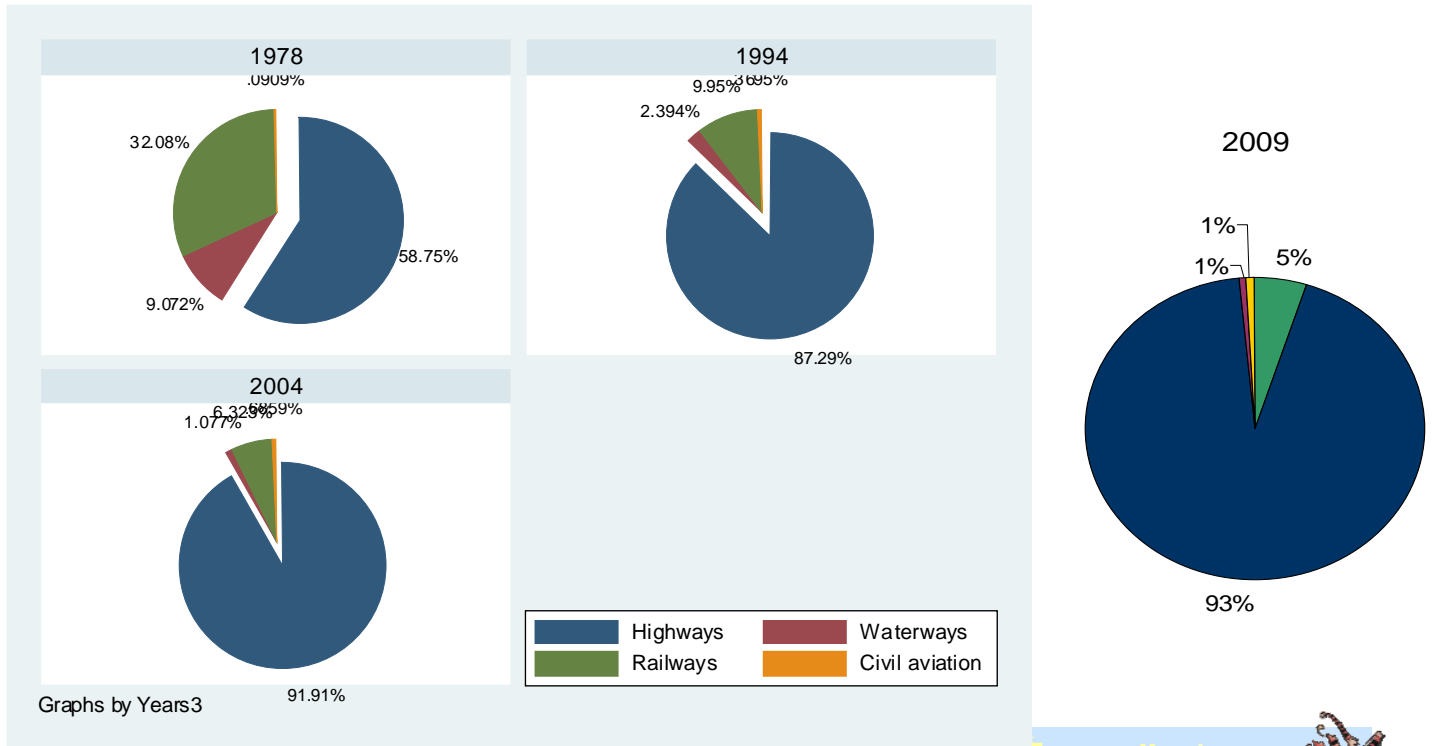
Modal split in Japan



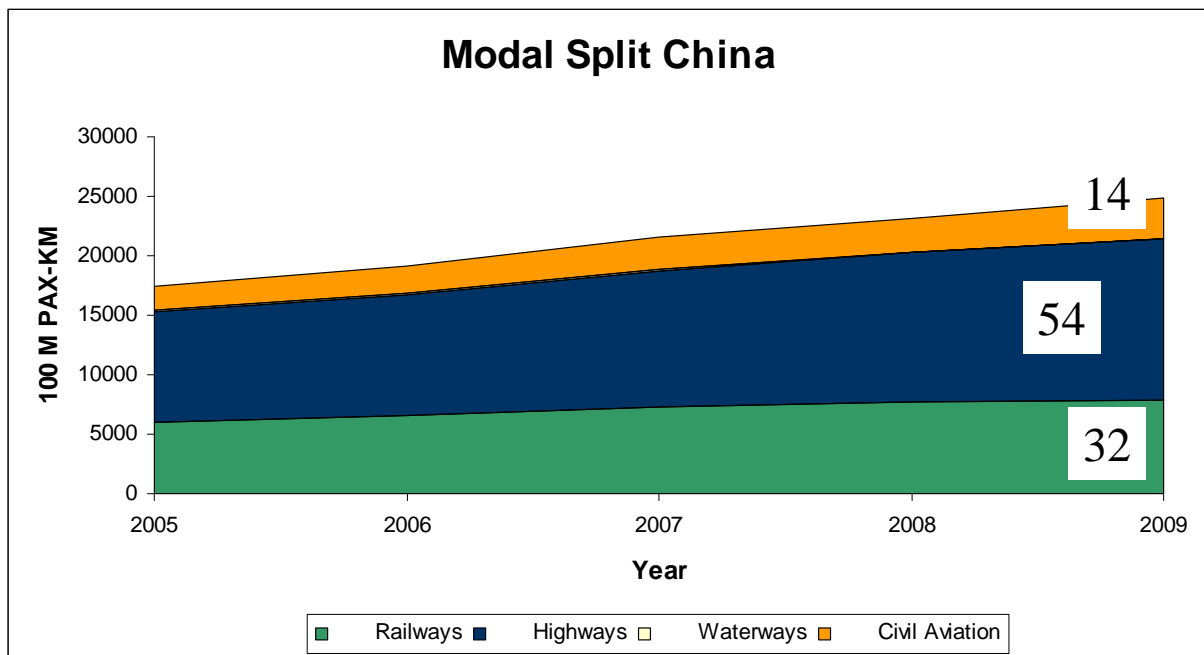
Source: Japan Ministry of Transport.



Modal split in China (Passengers)



Modal split in China (Passenger-km)



III- Demand analysis

- Global demand
 - Travel demand and the economy
 - Modal split
- Individual demand
 - Travel purpose
 - Income
 - The price/time trade-off



Global factors are driven by Individual demand

- Global demand (country global demand, world traffic, etc...) is the addition of all the individuals demands
- Two main kind of demands at the individual level
 - Travels for **personal purpose** : tourism, Visiting Friends and Relatives (VFR)...
 - Travels for **business** : meetings, ...



Individual demand factors : Travel purpose

- ➔ A client traveling for personal reasons is making a choice :
 - He decides to travel and chooses his transport mode as a function of his personal characteristics (**he maximizes his utility**)
- ➔ A business traveler travels for the needs of his firm
 - The travel decision is made by the firm, with a **profit maximization goal**.

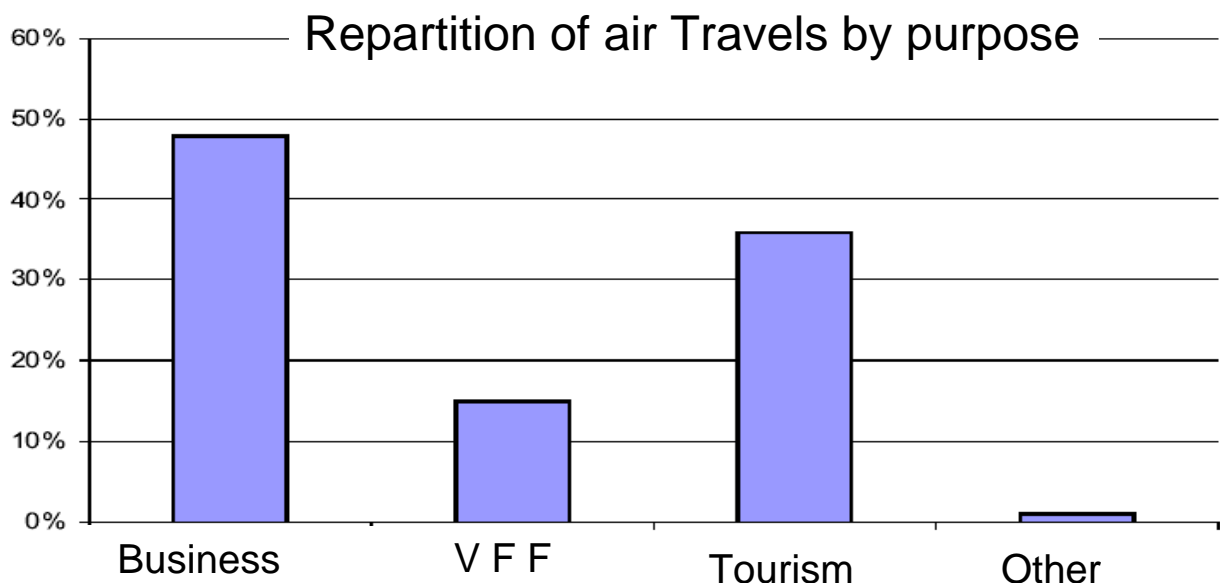
43



Nathalie LENOIR, September 2011



Travel purpose



Source :DTA SDEEP, Note de synthèse et d'actualité, N° 14, Juillet 2003

44



Nathalie LENOIR, September 2011



Business travelers

- At the origin of air travel
- Still an important part of domestic traffic
 - 48% of the French traffic in 2001
- **One third** of the scheduled international traffic
- Not very sensitive to prices, but choice criteria are : schedules, frequencies, flexibility, comfort...

45

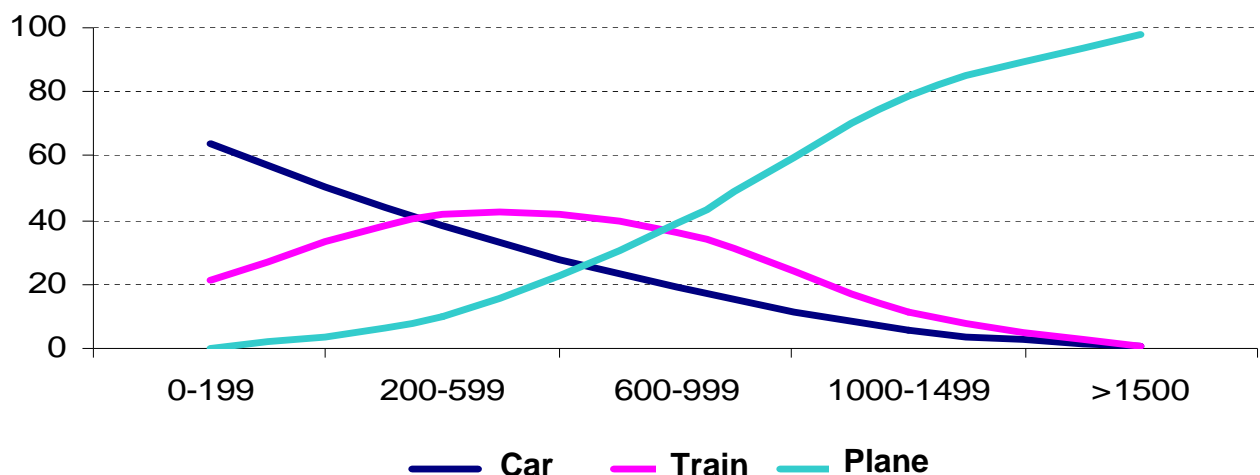


Nathalie LENOIR, September 2011



Modal split by travel purpose :

Business travelers



Source : Survey (S D T, 2002)

46



Nathalie LENOIR, September 2011



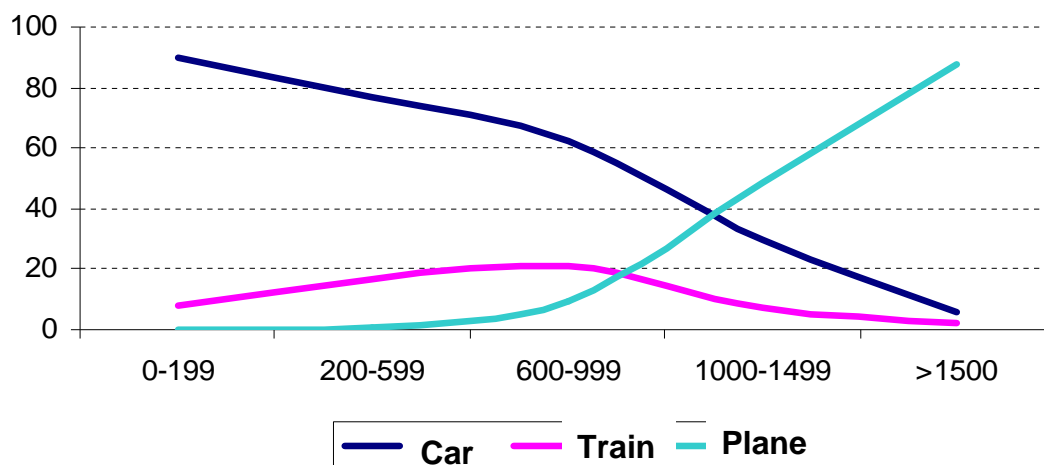
"Leisure" travelers

- Travel for personal reasons ("leisure" clients) has grown with the decrease of fares
- Leisure passengers represent 100% of the international non-scheduled regular flights, and 2/3 of scheduled international flights.
- Very sensitive to prices
- Divided into several types of clients
 - Airlines propose different fares as a response



Modal split by travel purpose :

Leisure travelers



Source : Survey (S D T, 2002)



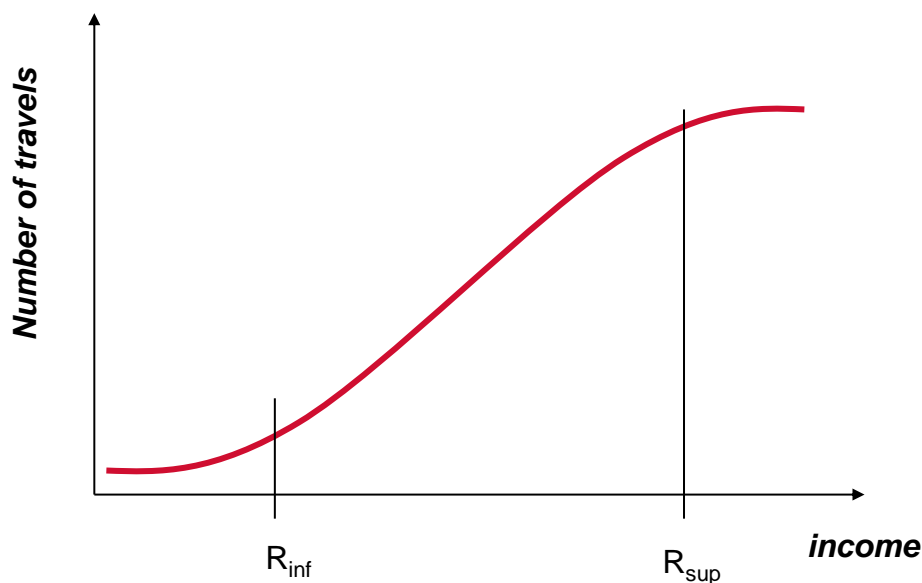
Impact of income

The income constraint influences more the “leisure” clients than the business travelers

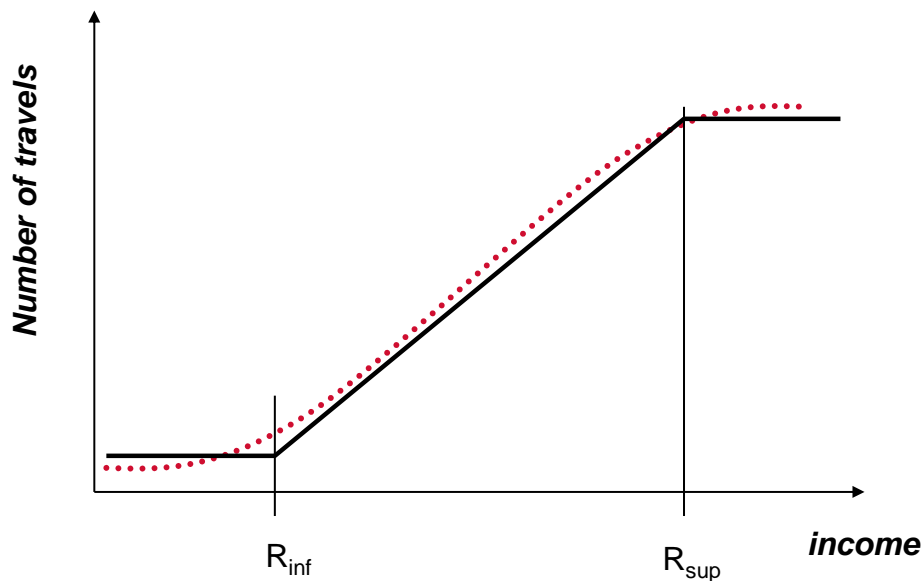
- Still, there is a correlation between salary and number of business travels.
- Propensity to travel increases with the income, but within a non-linear relationship
- Less sensitive for high and low incomes
- Within a population, the air traveler has an average income higher than the average.



Propensity to travel and income



Propensity to travel and income: modeling



51



Nathalie LENOIR, September 2011



The trade-off between Price and Time : Modal choice

- Every traveler seeks the best way to reach his destination, for the best price, and as fast as possible:
 - For an equal price, he always chooses the fastest transport mode
 - Very often, there is a trade-off between price and time
 - A fast but expensive mode
 - A slower but cheaper mode

52



Nathalie LENOIR, September 2011



Time (duration) : an essential factor

- ➔ The global journey duration is important :
 - Transport duration in vehicle (time spent in plane)
 - Access time (home to airport + boarding time)
 - Difference between preferred arrival time and real arrival time (importance of frequencies)
- ➔ Each stage has its own value of time and a different cost for the traveler.

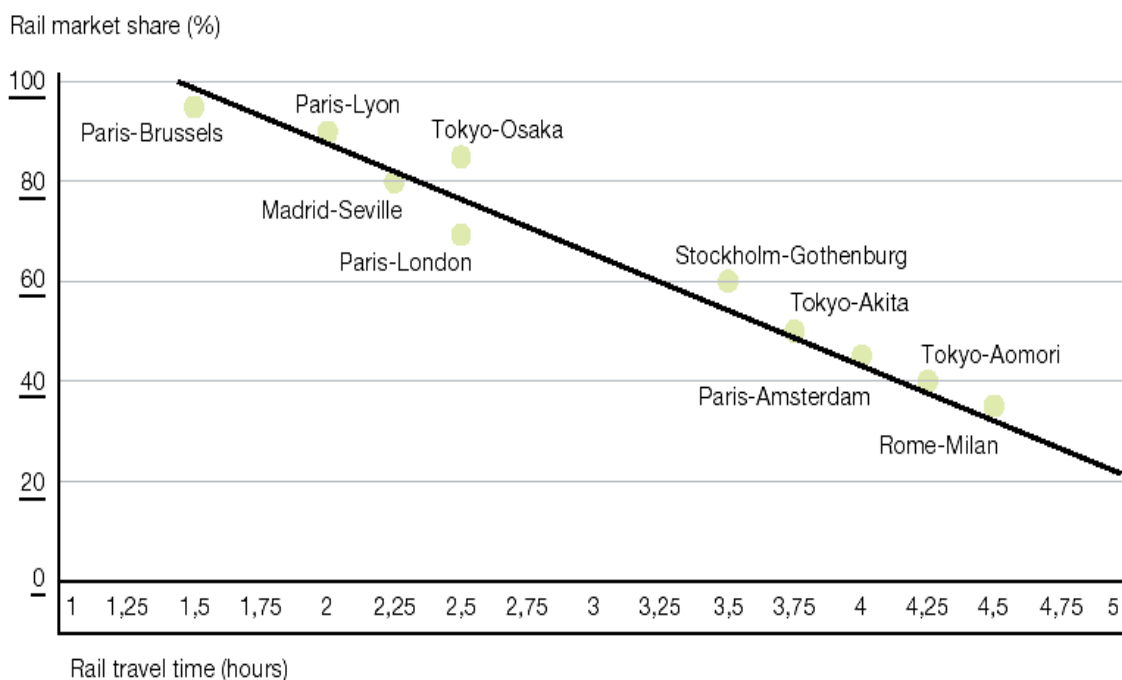
53



Nathalie LENOIR, September 2011



Time and modal split



54



Nathalie LENOIR, September 2011



The value of time : "time is money"

- Each traveler has its own valuation (cost) of the time spent in transport
- This cost is evaluated as the traveler's value of time : It is the cost of spending (wasting) one hour for the traveler
- *Ex: If my value of time is 50\$, my willingness to pay for a "one hour shorter" journey is 50\$*
- This value is usually estimated by surveys or statistical methods.



Examples of values of time

- Here are some values estimated by INRETS* in 1988, for France
 - Business travelers : 61.4 €
 - Leisure travelers : 28.7€
 - All : 42.1 €
- Other values exist, but not detailed by type of travelers (Quinet, 1998)
 - Air : 45.7 €
 - Train first class : 32.3 €
 - Train second class : 12.3 €

*Institut National de Recherche sur les Transports et leur Sécurité.



Examples of values of time

Table 3.4-7: Recommended Values of Travel Time Saved

User Group	Business Trips	% of All Business Trips	Non-business Trips	% of all Non-business Trips	Average for all Trips	% of all Trips
Air Carrier - Domestic	\$25.00	70.8%	\$26.97	78.5%	\$26.20	75.4%
Air Carrier - International	37.22	1.1%	55.83	7.7%	\$50.34	4.8%
Commuter	25.00	4.8%	26.97	5.3%	26.20	5.1%
GA Piston	38.00	11.8%	57.00	8.4%	47.52	9.6%
GA Turbine	140.47	7.6%	210.71	0.03%	140.96	3.2%
Rotorcraft	75.00	2.4%	112.50	0.1%	78.34	1.1%
Air Taxi	52.65	1.5%	0.00	0.0%	52.65	0.6%
Government	25.00	0.0%	0.00	0.0%	25.00	0.0%
Military	20.00	0.0%	0.00	0.0%	20.00	0.0%
Weighted Average	37.06	100.0%	31.86	100.0%	33.85	100.0%

source: FAA 1989 p. 11

57



INQUIRIE LENOIR, SEPTEMBRE 2011



Frequency effect

There is a relation between traffic on a route and the number of flights (frequency) on this route

- Increasing the frequency of departures on a route results in traffic increases
- If flights are not frequent on a route, the time between the desired schedule and the available one is considered as an addition to the journey duration.
- The passenger may not travel or change his transport mode

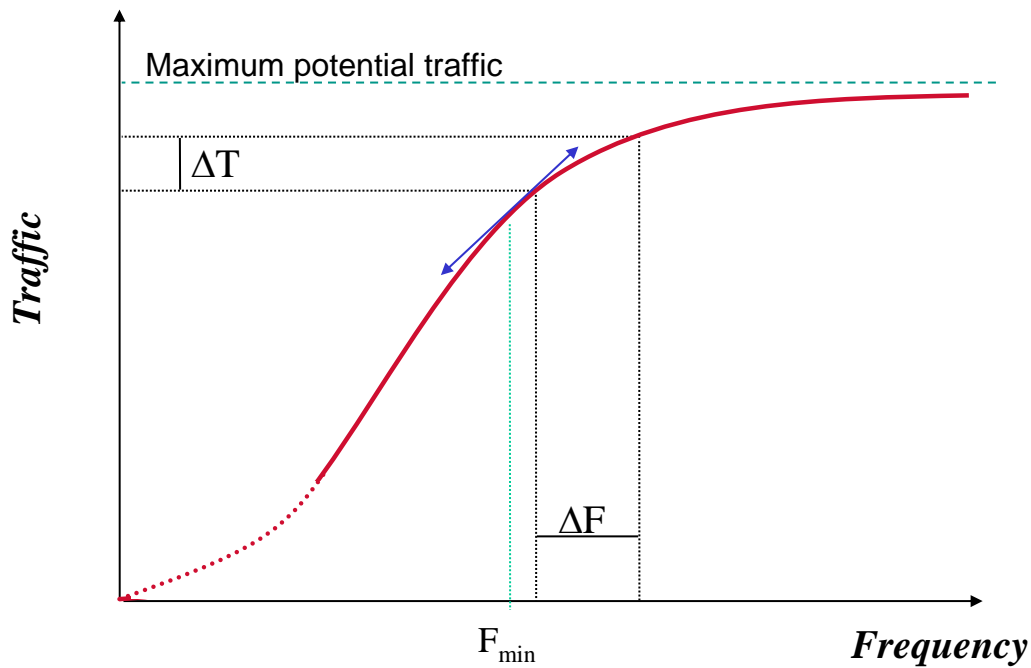
58



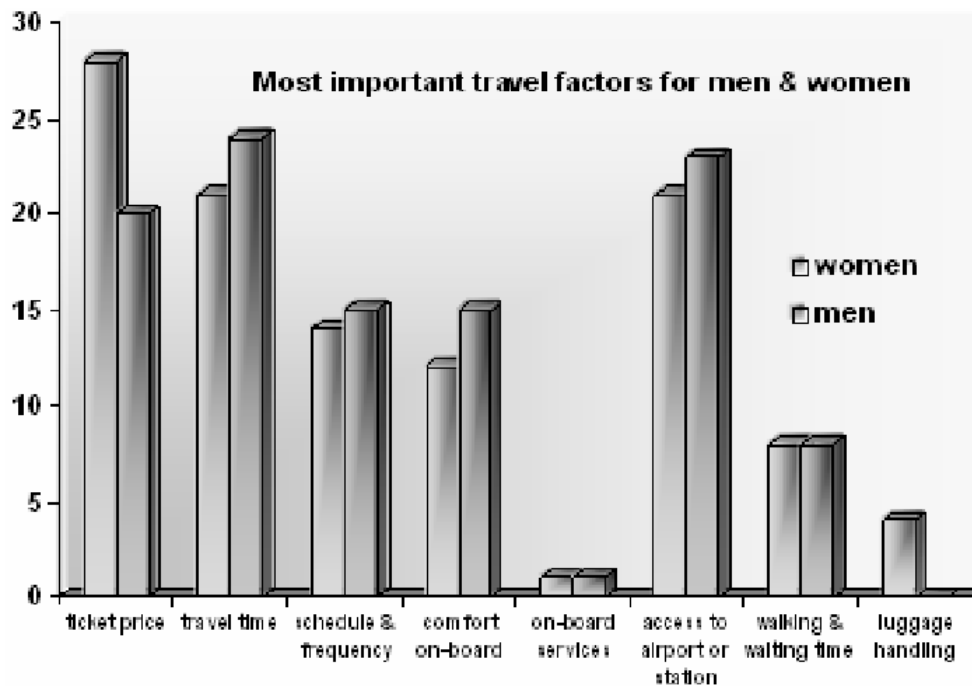
Nathalie LENOIR, September 2011



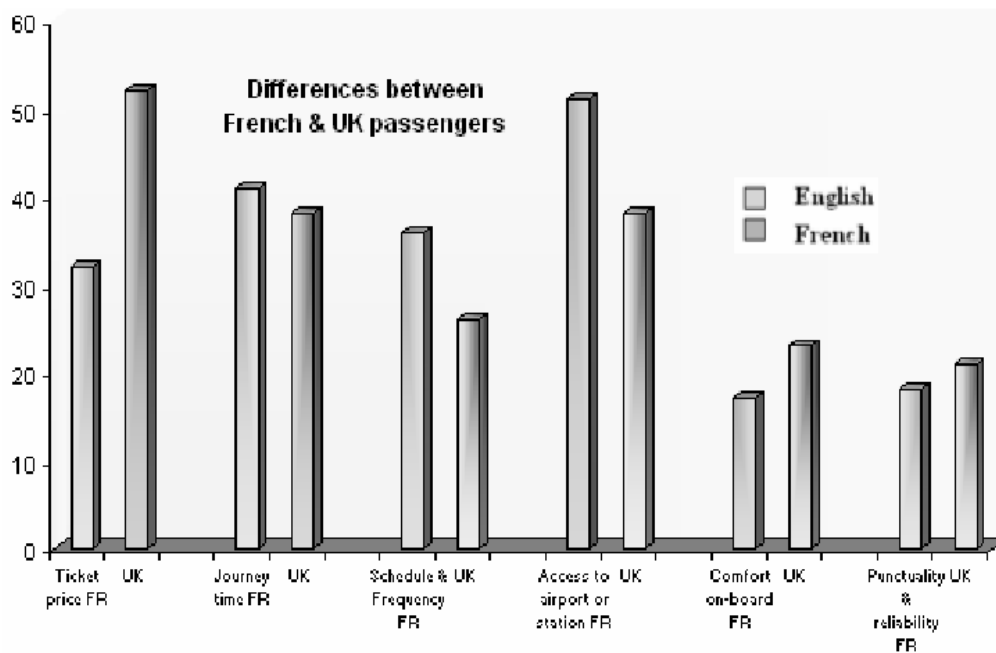
Frequency effect



Other factors



Other factors



Summary : factors affecting individual demand

- Purpose of the trip
 - Income,
 - *Price*
 - *Global transport duration*
 - *Quantitative factors*
 - *Characteristics of transport mode*
 - *Quality, flexibility, availability, frequencies*
(Factors difficult to evaluate)
- } Depends on Traveller's characteristics
- } Depends on each transport mode !



Outline of presentation

- I- Introduction : demand and transport demand
- II- How to measure demand?
- III- Demand Analysis
- **IV- Demand models**
- V- Air transport demand today



IV- Demand models:

- Why do we need to model demand?
- What do we need to model demand?
- Models
- Elasticities



Why ?

- Need to understand passengers' behaviour in a quantitative way
 - Decisions today taken depending on assumptions about demand behaviour (ex: pricing, scheduling, new routes...)
- Need to forecast demand in the future
 - Decisions today taken depending on forecast about future demand (demand in 2, 5, 10 years)

Need for FIGURES



What do we need ?

- Models
 - Relationships between demand and the main factors
 - What relation should we use ?
 - How to summarize those complex mechanisms/relationships ?
- Data
 - We know the main factors:
 - Income, purpose of trip, individual transport price
 - What do we observe ?
 - Global level: GDP, average prices...



What is a model ?

- Simplification of a complex mechanism (based on **hypotheses**)
 - Therefore “All models are wrong” ... but useful !
- Used for
 - detecting **dominant effects**
 - **ranking** the main variables underlying this complex mechanism
 - Giving direction and order of magnitude of effects
- A model needs **data** to be estimated
- and “thinking” is not forbidden!!



Example

$$Y_t = f(Z_t) + \varepsilon_t$$

- One wishes to analyze how a variation in some explanatory variable **Z** on the right hand side affects the variable of interest **Y** on the left hand side.
- Remarks :
 - There may be (are) many Z!
 - There are hypothesis (type of function)
 - There are errors !



A useful concept: elasticity !

One measures the reaction of a variable (*demand*) to a change in another variable (*income, price*) through an economic indicator: the elasticity

Income elasticity = % change in demand / % change in **income**

Price elasticity = % change in demand / % change in **price**

Exemple

- If a 3% increase in personal income results in a 6% growth in demand, the income elasticity equals 2.



Question !

➤ What is the income elasticity of air traffic in Portugal ?

➤ What is the (average) price elasticity in Sweden?



Example

Country	Price elasticity	Income elasticity
High income countries		
Scandinavia	-0.27	+2.44
France	-0.66	+1.88
Switzerland	-0.52	+1.80
Germany	-0.62	+2.65
Low income Countries		
Portugal	-0.12	+3.02
Turkey	-0.56	+3.23
Ireland	-0.81	+1.17
Greece	-0.33	+2.65

Source Doganis 2002

Price = average yield per passenger on intra-European routes

Income = real Growth Domestic Product of each country



Why is it important ?

- A useful simplification
- Confirms intuitions:
 - Business travelers are less price sensitive than leisure travelers
 - There are policy implication :
 - Impact of a tax on demand ,
 - Forecasts !
- Gives FIGURES
 - Or rather orders of magnitude



Is it satisfactory?

- Underlying hypothesis : elasticity is a constant
 - In reality, it may not be !
 - If prices/income triple, your reaction (elasticity) may change
 - Ex : if your income becomes very large, your demand may be unresponsive to changes in income
- Measuring demand elasticities for small variations of price or income is OK
 - For large variations, elasticity may change
- Long term elasticity may be different from short term elasticity
 - Usually, people are less adaptable/sensitive in the short term (and more adaptable in the long run)
 - Short term elasticities may underestimate effects of price change



How to estimate elasticities ? An Example

- Models in practice!
 - We have the RPK for China over the period (1978-2004)
 - We have the GDP on the same period

A simple model :

$$Y_t = f(Z_t) + \varepsilon_t$$

A simpler linear model :

$$Y_t = \alpha + \beta Z_t + \varepsilon_t$$

- Linear model : valid for small changes...



A simple trick : Use the log

- When estimating a model of demand it is easier to interpret if the variables are in log :
 - The coefficient is the elasticity

$$\ln(Y_t) = \alpha + \beta \ln(Z_t) + \varepsilon_t$$

$$\frac{\partial \ln(Y_t)}{\partial \ln(Z_t)} = \beta$$

$$\frac{\partial \ln(Y_t)}{\partial \ln(Z_t)} = \frac{\frac{Y_t'}{Y_t}}{\frac{Z_t'}{Z_t}} = \frac{\text{variation}(Y_t)}{\text{variation}(Z_t)}$$

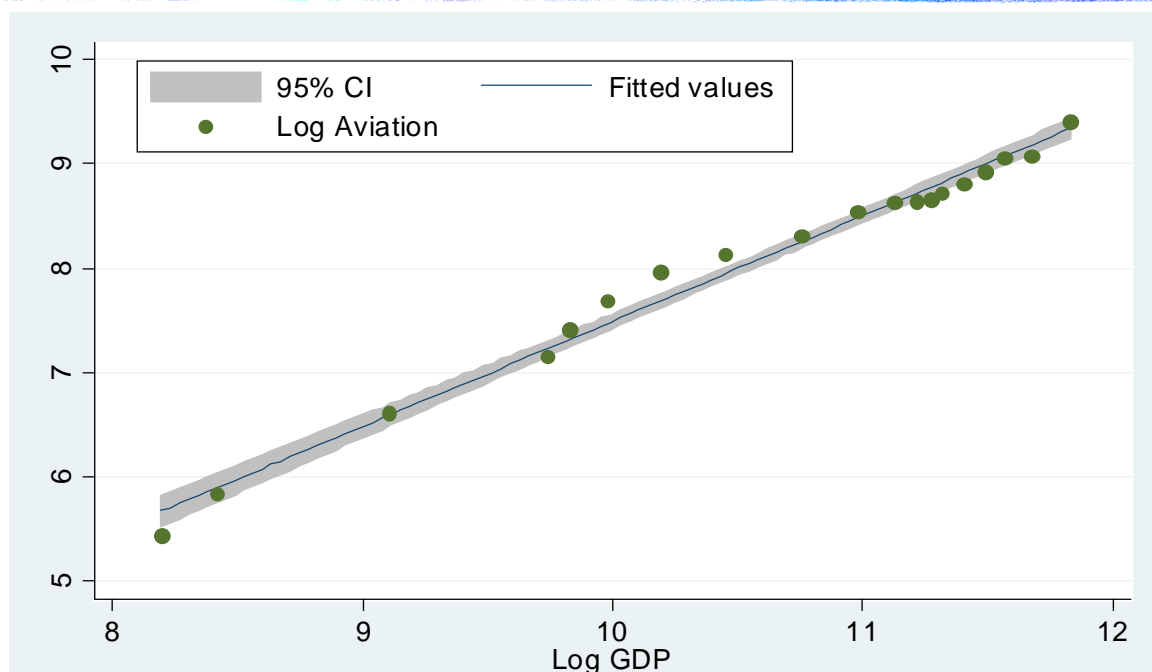
75



Nathalie LENOIR, September 2011



Ex: China GDP and domestic traffic



76

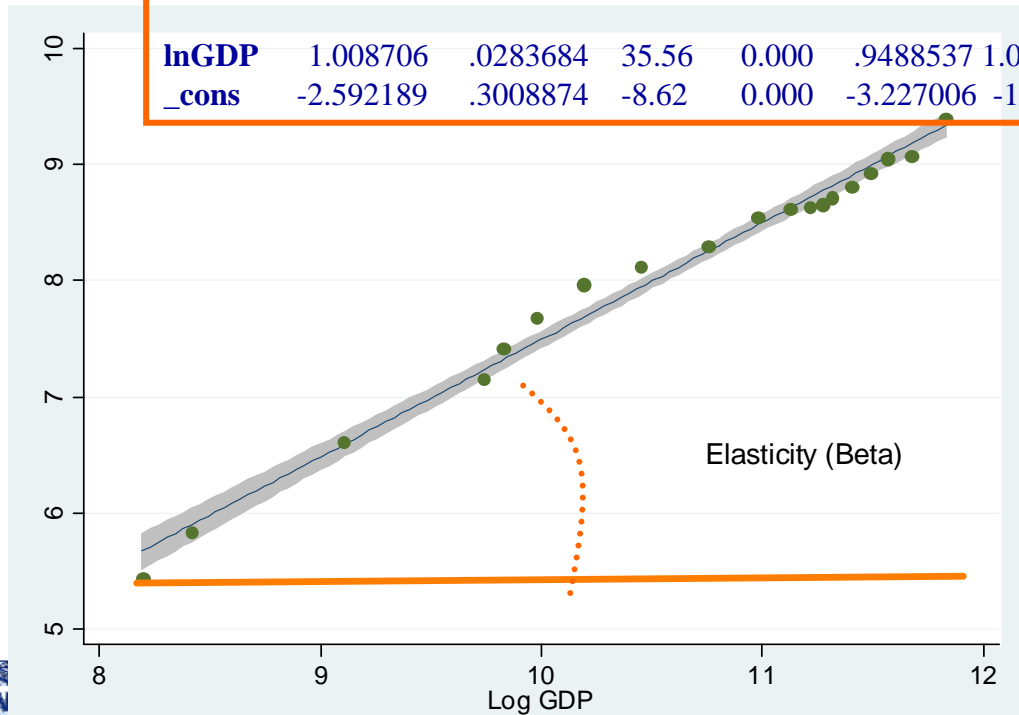


source : Data IMF 2006 and Boeing CMO, 2005



Ex: China GDP and Interior traffic

lnAviation	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]
lnGDP	1.008706	.0283684	35.56	0.000	.9488537 1.068558
_cons	-2.592189	.3008874	-8.62	0.000	-3.227006 -1.9573



Ex: China GDP and domestic traffic Critics !

- Too simple model?
- How to ensure the validity of a model?
 1. Data
 - Data collection: 19 points
 2. Variables
 - Data aggregation: what is “Traffic”
 - Variable chosen: income is not GDP !
 - Other factors may affect traffic !



How to misuse a model !

- Adding variables may be a good or wrong answer !

$$Y_t = \alpha + \beta Z_t + \gamma W_t + \varepsilon_t$$

- Correlated variables as RHS → identification problem

lnAviation	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
lnGNI	11.93619	4.2576	2.80	0.013	2.910477	20.96189
lnGDP	-10.86619	4.235804	-2.57	0.021	-19.84569	-1.886682
_cons	-3.156517	.3240745	-9.74	0.000	-3.843524	-2.46951



Critics ?

- Omitted variables
- Simultaneity Y_t depends directly on X_t
- Linear relation
- What's in ε_t ?
- What are we measuring exactly ?
 - Interior aggregated demand in China.
- How to measure the validity of the variables involved ?
 - Test if β is null or not
- How to measure the validity of the model ?
 - Compare, robustness checks and THINK !



Income elasticity of demand

- ➔ Income elasticity of airline demand in China ranges between 1.5 to 1.8. (*Zhang 1997*)
- ➔ This means that a 10% growth in national income would increase demand travel by 15% to 18%.
 - The annual economic growth rate in China was 8.7 during the 1980-94 period, this would explain a 15% growth rate for airline demand
 - Demand growth during the period was 21% !!
 - There are other factors explaining that growth



Outline of presentation

- ➔ I- Introduction : demand and transport demand
- ➔ II- How to measure demand?
- ➔ III- Demand Analysis
- ➔ IV- Demand models
- ➔ V- Air transport demand today...



Economic situation

- Energy prices way up, compared to before 2000
 - Increase in costs of transport in all modes, for all actors
- Crisis in the USA and elsewhere since the end of 2008
 - Many bankruptcies of financial establishments
 - Cash problems to finance the economy (investments)
- Economic crisis means
 - No increase in salaries or purchasing power
 - Unemployment rising
- Recovery in progress in 2010-2011
 - World GDP growth: +5% in 2010 (- 0,5 in 2009)



Demand today

- In a crisis situation
 - For potential passengers: pressure on purchasing power
 - Less disposable income for travelling
 - High income elasticities of demand: **first order effect**
 - For airlines: pressure on costs
 - Increases in prices
 - lower price elasticities: **second order effect**
- Recovery in progress
 - Air transport: +7.1% passengers in 2010, after two years of stagnation

