Impact of innovation on air transport organization

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Context

- Launching on the market aircraft with innovative technologies is a challenge for aircraft manufacturers, especially if it is operated differently

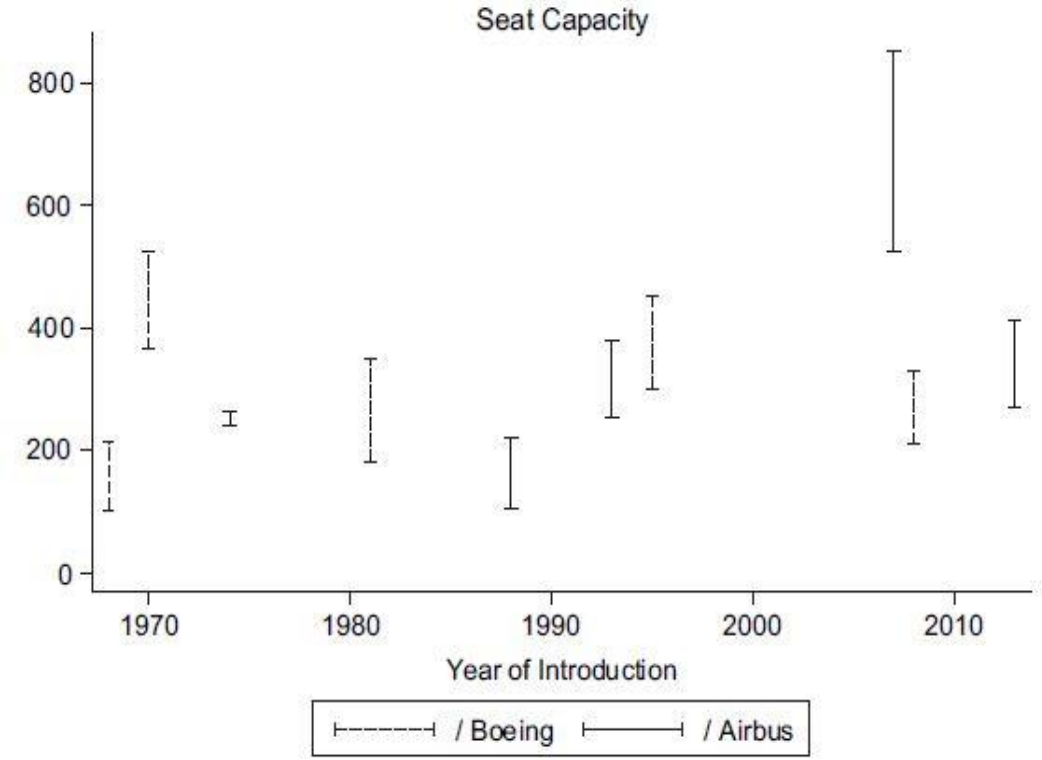
- Some airlines decide to operate first this aircraft because of an expected competitive advantage on the market
- But what about other airlines? What are the impacts on their strategies? Do they change their behaviour?

Innovation and disruptive innovation

- Gault (2018)
  - Innovation: implementation of a new or significantly improved product or process, a new marketing method, a new organizational method in business practices, workplace organization or external relations
- Franke (2007)
  - Innovation must create a competitive advantage
- Christensen et al. (2004)
  - Innovation is disruptive when it creates a commercial disruption

A380: innovation in the air transport system

- A relevant illustration of disruptive innovation in air transport is the introduction of the aircraft A380
- Disruptive innovation linked to its significant larger size



Source Boeing

Innovation and competition

- Concept of competitive tension - Chen et al. (2007):
  - Importance of considering the firm's subjective perceptions of rivals
  - Strain between two rivals firms resulting in a firm taking actions against its rivals

- Factors impacting strategic innovation under competitive tension - Gündüz (2013):
  - relative scale
  - rival's attack
  - rival's capability to contest the innovation

Questions

- Does the use of the A380 by an airline on a particular route give incentives to competitors to introduce as well this type of aircraft on the same route?

- Does the introduction of the A380 on the market change airlines' behaviour in terms of flight frequency?

Dataset

- OAG dataset (Scheduled flights all over the world)
  - Available over 10 years at the monthly level
  - Selection of routes where the A380 has been in use
  - Period of observation: 2007-2016
    - 119 routes
    - 122 carriers, among them 13 carriers use the A380
    - available seats and available freight by aircraft type per airline-route-month
    - total payload by aircraft type per airline-route-month
- Airline website: date of acquisition of their first A380
- ENAC database on passenger flows: measure of airport congestion
- Worldbank statistics: GDP and population
- Index Mundi: Fuel price in USD per gallon

Questions

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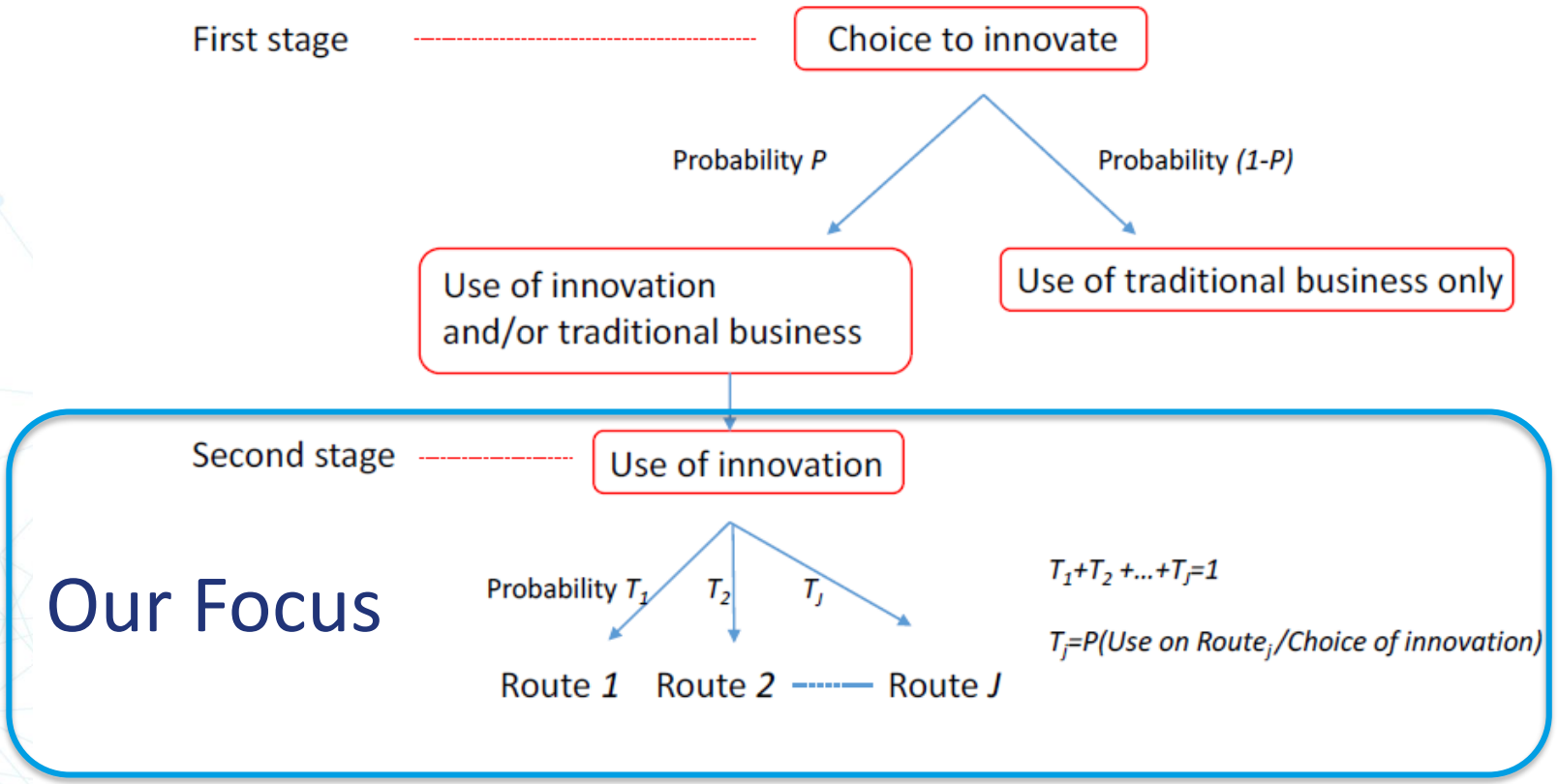
Incentive to innovate: the model

- A two stages model



The model

- Decision ex-ante to acquire the innovation
- The choice for airline *i* to use the A380 on the route *j* during the monthly period *t* is described by a dichotomous variable

$$A380_{ijt} = \begin{cases} 1 & \text{if the airline } i \text{ uses the A380 on} \\ & \text{the route } j \text{ at time } t \\ 0 & \text{otherwise} \end{cases}$$

- The probability p_{ijt} for airline *i* to choose the innovation on route *j* during period *t* is:

$$p_{ijt} = P(A380^{*}_{ijt} > 0) = \Lambda(\alpha_{ij} + Y_{ijt}\beta + Z_{jt}\gamma + W_t\delta)$$

The model

- Matrix Y_{ijt} is of particular interest for the measure of incentives to follow competitors' innovation
- At the route level, 3 scenarii for competitors:
  - 1 Airline *i* owns the A380 and uses it; 20% route-month
  - 2 Airline *i* owns the A380 and does not use it: threat of innovation; 57% route-month
  - 3 Airline *i* does not own the A380: no threat of innovation; 23% route-month
- Aggregation of all competitors to a representative competitor
- Measure of use: ratio of A380 use by all competitors on the route, in terms of total payload ; ranges between 0.2% and 100%
- Concept of competitive tension is addressed in our model: market share as a measure of relative scale; intensity of innovation use as a measure of rival's attack

Results - Regression

Regression: probability of innovation	Model 1 Fixed effect	Model 2 Random effect	Model 3 Mixed effect[i]
No threat of innovation	0.170	-0.024	-0.031
	(0.37)	(1.72)	(0.36)
Threat of innovation	0.709***	0.616	0.608**
	(0.27)	(1.44)	(0.26)
Intensity of innovation use	2.697***	2.256	2.259***
	(0.50)	(2.10)	(0.47)
Random effect			
lnsig2u		2.917***	
		(0.27)	
sigma_u		4.298***	
		(0.58)	
rho		0.849***	
ID: Identity			
sd			4.236***
			(0.30)
N	10119	12567	12567
Wald chi2	3206.68	87.2	1420.91
Prob>chi2	0.000	0.000	0.000
Log likelihood	-3422.282		-4097.333
Log pseudo likelihood		-4096.47	

* p<0.05, ** p<0.01, *** p<0.001
(i) LR test vs. logistic model: chibar2(01) = 6685.84 Prob >= chibar2 = 0.0000

Significant role of the fear of rivals' attacks

Incentive to follow the innovation:

1- Threat of innovation increases the incentive to innovate

2- Intensity of use by competitors increases the incentive to innovate

3- When no threat of innovation, no effect on the incentive to innovate

Results - Regression

Regression: probability of innovation	Model 1 Fixed effect	Model 2 Random effect	Model 3 Mixed effect[i]
Monopoly	-1.697***	-1.796*	-1.790***
	(0.27)	(1.00)	(0.27)
Competitor's market share	-0.077***	-0.080***	-0.079***
	(0.01)	(0.02)	(0.01)
Congestion in one airport	2.072***	2.016***	2.014***
	(0.15)	(0.69)	(0.15)
Congestion in the two airports	3.556***	3.467***	3.464***
	(0.20)	(0.82)	(0.20)
Average GDP on the route	5.783***	4.613**	4.575***
	(0.61)	(1.91)	(0.53)
Six months lagged jet fuel price	-0.706***	-0.685***	-0.684***
	(0.05)	(0.16)	(0.05)
Financial crisis fixed effect 2008	-5.901***	-5.915***	-5.909***
	(0.37)	(1.05)	(0.36)
Financial crisis fixed effect 2009	-3.388***	-3.565***	-3.568***
	(0.25)	(0.77)	(0.23)
Financial crisis fixed effect 2010	-1.804***	-1.938***	-1.940***
	(0.16)	(0.51)	(0.15)
constant		-45.765**	-45.336***
		(20.60)	(5.51)

Significant role of the airline relative scale

Impact of competition:
1- Being a monopoly on a route reduces the incentive to innovate
2- Reduced market power reduces the incentive to innovate

Route characteristics:
1- Congestion gives incentive to innovate in bigger aircraft
2- Increase in demand gives incentive to innovate

Impact of macroeconomic fators:
1- Negative impact of the financial crisis
2- Negative impact of the fuel price

Questions

- Does the use of the A380 by an airline on a particular route give incentives to competitors to introduce as well this type of aircraft on the same route?
- Yes:
  - When competitors already use the innovation
  - When there is a threat of innovation from competitors
- We show the existence of a relationship between innovation and competition
- Results tend to confirm that factors used to represent the competitive tension on the route (fear of rivals' attacks, relative scale of the airline) influence airline's strategical decisions in terms of innovation use

Questions

- Does the use of the A380 by an airline on a particular route give incentives to competitors to introduce as well this type of aircraft on the same route?

- Does the introduction of the A380 on the market change airlines' behaviour in terms of flight frequency?

Main variables of the model

Variables of interest

Variable code	Variable description	Role
FREQ	**Frequency of flights supplied by airline *j* on route *i* per month**	**Variable to be explained**
NUMBCOMP	Number of airlines operating on route *i* at period *t*	Used to represent the intensity of competition on the market
RATIO380	Lagged Ratio of maximum total weight (cargo and seats converted to kg) transported by A380 aircraft	Reflects the own intensity of utilization of A380 on the route Expressed in classes
COMPRATIO380	Lagged Competitors' ratio of total weight (cargo and seats converted to kg) transported by A380 on the route	Reflects the intensity of utilization of A380 by competitors on the route
LOGPOP	Logarithm of the lagged population at departure airport of route *i* per year	Used to measure the traffic demand evolution
LOGTRAF	Logarithm of the lagged two-way annual traffic on the route	

Estimated model

$$FREQ_{ijt} = \beta_0 + \beta_1 NUMBCOMP_{it} + \beta_2 LOGPOP_{it} \text{ (or } \beta_2 LOGTRAF_{it}) + \beta_3 RATIO380_{ijt} + \beta_4 COMPRATIO380_{ijt} + \beta_5 DUMMY2008_{ijt} + \beta_6 DUMMY2009_{ijt} + \beta_7 DUMMY2010_{ijt} + \beta_8 FEB_{ijt} + \beta_9 MAR_{ijt} + \beta_{10} APR_{ijt} + \beta_{11} MAY_{ijt} + \beta_{12} JUN_{ijt} + \beta_{13} JUL_{ijt} + \beta_{14} AUG_{ijt} + \beta_{15} SEP_{ijt} + \beta_{16} OCT_{ijt} + \beta_{17} NOV_{ijt} + \beta_{18} DEC_{ijt} + \alpha_i + \epsilon_{ijt}$$

- Variable RATIO380 expressed in classes
  - Ratio380=0
  - Ratio380>0 and Ratio380<100%
  - Ratio380=100%
- Estimation by First Difference to correct for serial correlation

Main results: main interesting effect

Exogenous variables	Model A.1	Model A.2
Number of competitors	0.321**	0.318**
	(0.135)	(0.135)
Ratio competitors'use of A380	1.096*	1.124**
	(0.620)	(0.621)
Positive Ratio own use of A380	-0.481	-0,461
	(0.506)	(0.505)
Ratio own use of A380 of 100%	-1.492** *	-1.468***
	(0.538)	(0.537)

Positive sign: Airline increases its flight frequency when the number of competitors increases (general result)

Positive sign: Airline increases its flight frequency when the competitor increases its use of A380

Negative sign: Airline decreases its flight frequency when using exclusively A380 on the route

Note: Robust Std.Err. in parenthesis; *** 1% significance; ** 5% significance; * 10% significance

Questions

- Does the introduction of the A380 on the market change airlines' behaviour in terms of flight frequency?

YES
Expected decrease if 100% use of A380

Expected increase if competitors increase their use of A380

Next steps

- Two stages model:
  - Consider the dynamic of the model: allows strategic games between competitors and interactions over time
  - Include the choice to innovate in the model: first stage in the airline decision process