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Innovation in air transport market: impact on competitors strategies

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ABSTRACT

The objective of this empirical paper is to analyze the impact of an innovation in air transport system on airlines competitive behavior. We consider as innovation, the use of an aircraft with a significant higher capacity: the Airbus 380. Does the use of the A380 by an airline on a particular route give incentives to competitors to introduce as well this type on aircraft on the same route? To answer this question we use some econometric methods to estimate the impact of the introduction of the A380 by an airline, on the probability that airline's competitors will follow up the innovation. Controlling for others factors which might impact the choice of innovation, we show that the use of the A380 by an airline on a route gives incentives to competitors to introduce it as well.

INTRODUCTION

Launching on the market some aircraft with innovative technologies is always a challenge for aircraft manufacturers since this new product has to appeal to airlines. The challenge is all the more important that the innovative aircraft involves differences in the operating process. This is in particular the case for the Airbus 380 whose dimension is bigger than anything previously

produced for a civil aircraft and for which new transportation methods were needed.

The decision to operate an innovative and different aircraft is driven by the competitive advantage that airlines might identify once the innovation has been adopted. But what are its impacts on competitors' strategies?

The objective of this empirical paper is to provide answers to this question. We consider as innovation the introduction of an aircraft with a significant higher capacity: the Airbus 380. We tend to answer the question: 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?

We use some econometric methods to estimate the impact of the introduction of the A380 by an airline, on the probability that airline's competitor will follow up the innovation.

We implement the analysis on an oligopoly market, Frankfurt – New York JFK route, for the period of time January 1st 2006 to December 31th 2015. We estimate the model using the adapted econometric model: a Conditional Fixed Effects Logistic model.

In the following second part we summarize the economic literature related to aircraft capacity on the air transport market. Then, we describe the

market we focus on. In the fourth part we explain the econometric model and the variables of interest. In the last part we present the results of our analysis.

2. RELEVANT LITERATURE

Among all the aircraft characteristics, aircraft size may be the one which has the biggest impact on the whole aviation industry. Airlines choose the size of the aircraft in their fleet in order to provide the most adapted air transport capacity to fulfill demand while facing competition. Airport planners need to know the size of the aircraft they receive from both technical (runways, gates etc.) and practical (congestion) points of view. Policy makers use the predicted aircraft size for planning expensive infrastructure investments and future traffic control regulation.

In order to accommodate their air transport capacity to existent and future demand, airlines may use two levers: aircraft size and service frequency. Both variables play a central role in their profitability (by the load factor) and strategic (competition) decisions.

Keeping high load factors while offering high frequency service, moves airlines towards the use of smaller aircraft. In 2006, according to Givoni and Rietvel (2009), "at many of the world's largest airports there were fewer than 100 passengers per air transport movement despite growing congestion and delays". Givoni and Rietveld (2009) investigate and explain this phenomenon. They associate this choice with the benefits of high frequency service, the competitive environment in which airlines operate and the way airport capacity is allocated and priced. By a regression analysis of over 500 routes in the US, Europe and Asia they provide empirical evidence that the choice of aircraft size is mainly influenced by route and airport characteristics. They estimate that the aircraft size depends on market size with an elasticity of 0.35, indicating that carriers give priority to increases in frequency.

From the supply point of view it is important to know how the total cost (capital cost & operating cost) is affected by the aircraft size. Wei and

Hansen (2003) have estimated a trans-log cost function for aircraft operating costs and confirmed the existence of economies of size and stage length. They found a positive relationship between the aircraft optimal size and the stage length. They also find that the scale properties of the cost function are changed considerably if pilot unit cost is treated as endogenous, since it is positively correlated with aircraft size. Consequently, pilot wage structure is particularly responsible for airlines choice of smaller jets on short-haul markets.

Wei and Hansen (2005) have also investigated how size together with service frequency affects the total demand and the market share in a non-stop duopoly market. Using a nested logit model they confirmed previous findings of an S-curve effect - an increase in service frequency over a certain level translates in a more than proportional increase in market share. Increasing service frequency give higher returns in market share than increasing aircraft size. Therefore they argued that airlines have an economic incentive to use smaller than optimal aircrafts, since for the same capacity provided in the market, an increase in frequency can attract more passengers. Another important result is that they don't observe from their data a passenger preference for larger aircraft which can be inferred from such reasons as aircraft amenity, comfort and safety, by contrast. Only the number of available seats matters.

The size of aircraft is determined by a number of factors, among them the route characteristics and the market size. On the markets they operate, airlines face a trade-off between size of aircraft and frequency of the operations. The factors which impact the choice of aircraft impact as well the frequency of flights. As a result it is difficult to split the direct effect of frequency on aircraft choice and the indirect effect through other factors.

We decide to simplify the analysis focusing on the choice of aircraft with frequency remaining constant. Our objective is to determine the direct effect of several factors, such as the size of the market, the characteristics of route..., on the probability to choice a particular aircraft size. We

select a route where the frequencies remain constant while the size of the aircraft evolves during the period of observation. A higher aircraft size corresponds to the choice of the A380. We interpret this choice as an innovative technological choice. Then, to answer the question of incentives to follow one's innovation, the behavior of competitors in terms of innovation is introduced as a factor which impacts the choice of using the innovative technology.

3. THE FRAPORT - JOHN F. KENNEDY MARKET

We focus on the Fraport-John F. Kennedy market. The FRA-JFK route is an oligopoly market with three competitors: Lufthansa, Singapore Airlines and Delta Airline. Lufthansa and Singapore Airlines have introduced recently the A380 for their operations. The introduction of A380 is observed at different period of time. This route is a good candidate for the analysis of the impact between competitors of the use of A380. Moreover the frequency supplied by the different airlines on the route remain constant, whatever the choice of aircraft.

The main source of our data is the OAG database. The OAG schedule analyzer is a product from the Official Airline Guide – a British business company providing aviation information and analytical services. It contains worldwide data on capacity reports from 693 active carriers and 3413 active airports. We access data on the time period 2005 to 2015. We supplement the information on capacities with socio-economic data from World Bank, IMF, U.S. Energy Information Administration websites, air transport data from ENAC Air Transport Database, and ENAC BADA Eurocontrol calculation model for the aircraft fuel consumption data.

We observe monthly capacities supplied by the three airlines from January 1st 2005 to January 1st 2015. This corresponds to 109 monthly observations for each company, and there are no missing values in the data set.

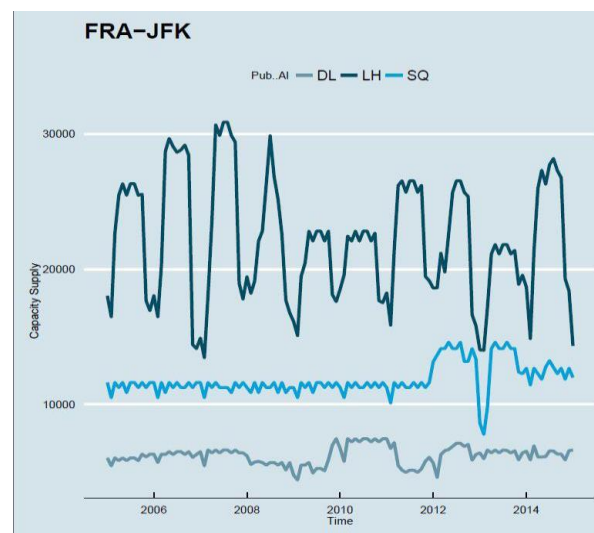
The demand on the route is increasing as stressed by 0. The evolution of air traffic demand on the route is consistent with the worldwide evolution of air traffic: +5% yearly on average

according to several sources in particular IATA¹. Moreover, the evolution of the number of passengers exhibits a positive trend in each airport during the period of analysis. The regional GDP, traditionally considered as a driver of local demand, also increases in departure and arrival airports.



Source : ENAC Air Transport Database

Figure 1. Evolution in number of passengers on the route



Source : OAG database

Figure 2. Supplied capacity on the Fraport - J.F. Kennedy market

¹ Source : IATA, World Air Transport Statistics 2015

The evolution of capacities during the period of observation is presented in Figure 2.

In terms of total capacities supplied, Lufthansa dominates the market during the full period 2005-2015, with an average of 22150 monthly seats when Singapore and Delta airlines supply respectively on average 11820 and 6218 monthly seats. Lufthansa introduces first the A380 on February 2011, but the A380 use is not regular. The A380 has been used from February to October in 2011, from May to October in 2012 and from April to October in 2014. The strategy implemented by Singapore Airline is different: once the A380 is introduced on the route, on January 2012, it remains in use, except during the short period January to March 2013. Note that, Delta never uses A380 on this route.

Finally, the evolution of market shares in terms of seats on the route seems disconnected to the intensity of use of the A380 (see Figure 3). When an airline introduces the A380 or when it intensifies its use, this doesn't lead to an increase on its market share in terms of posted capacity on the route.

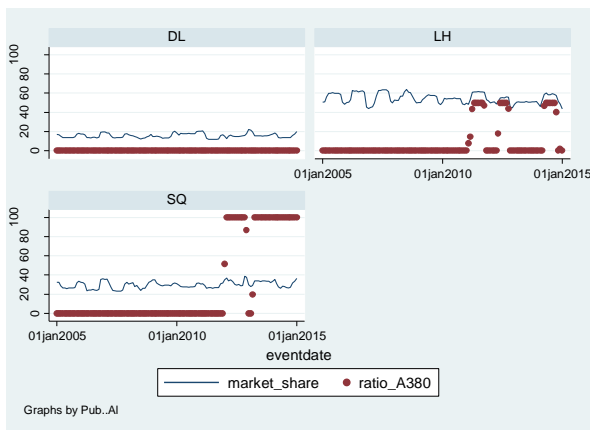


Figure 3. Market share and ratio of A380 use

4. MODEL

To test the likelihood that competitors on a route follow the innovation adopted by one another, we use a condition fixed effect logistic regression model. This model is consistent with panel data as

the ones we have. In particular the endogenous variable, *i.e.* the use of A380, is observed several times for two among the three airlines and the control variables, *i.e.* the factors which might impact the use of A380, change across time.

The data are monthly observed. The endogenous variable of the model is a dummy variable which takes value 1 if the airline uses the A380 during a month of the period of analysis, and 0 otherwise.

The logit model will estimate the probability for an airline to use an A380, given that she was using it the month before, and given that competitors use it or not. Among all others factors which influence the probability to innovate the competitor's use of innovation is of the main interest.

The own use of A380 is included as the lagged ratio of A380 use: number of seats supplied with the A380 with respect to the total number of seats during the month before the current period. We expect a positive relation between the use of the innovation during the current period of time and its use during the previous period.

The impact of competitors' use of innovation is also measured through the ratio of A380 use. The effect is the main effect that we want to estimate. A positive sign would correspond to positive incentives of following the innovation; a negative sign to negative incentives; finally a non-significance of the impact could be interpreted as an absence of relationship between the use of innovation by the competitors on the route.

Additional factors which might impact the probability to use the innovation are included into the regression. These factors are related to the market power of the firm on the route, the evolution of demand, as well as some cost factors.

Regarding the market power on the route, we have tested the usual index of concentration, HHI, as well as the market share, expressed in available seats, of the main competitor. Due to lack of variability in the HHI, we kept the market share of the main competitor has the indicator of market power.

There are several ways to measure the evolution of demand on the market. Population and GDP are traditionally considered as the main drivers of the air transport demand. We observe the regional GDP on a yearly basis for the two regions of Frankfurt and New-York and we will test this impact on the model. We expect a positive impact of the level of GDP on the probability to use the A380.

The observed demand on the route is the perfect candidate to measure the impact of the traffic evolution on the probability to use the innovation. We use the lagged traffic as we suspect that airlines react with a time gap to a potential traffic increase. As for GDP we suspect the impact of the lagged-traffic to be positive on the probability to use the innovation.

We don't have any a priori argument in favor of one or the other control for demand and we propose two different specifications of the model with one or the other variable.

Finally we introduce into the model the price of fuel, assuming that it impacts the probability to use the A380. Because of its large size, the A380 is designed to minimize seat costs in both fuel and CO₂.² The share of fuel cost in cost of operations keeps increasing and as reached the level of 29% on average in 2014.³ This is due to the constant increase in fuel price. As a consequence the increase in price of fuel might be an additional incentive to use greener aircraft such as the A380. We introduce in our model the price of fuel, in 2015 constant prices, and expect a positive relationship with the probability to use the A380.

The variables used into the model are described in Table 1.

Variable code	Variable description
A380	Dummy variable: indicator for the use of A380 aircraft

² Source : Airbus Global Market Forecast, 2012-2031, Navigating the Future

³ Source : IATA – World Air Transport Statistics 2015

Competitor A380-ratio	Competitor monthly seats supplied with A380, as percentage of its total seats
Own lagged A380-ratio	Own monthly seats supplied with A380, as percentage of its total seats
Competitor Market Share	Competitor market share in terms of capacity supplied
Fuel Price	Fuel price in constant \$2015
Lagged route traffic	One year lagged annual traffic on FRA-JFK route
Departure GDP	GDP of departure country in 2015

Table 1. Variables of the model

Because Delta doesn't use the A380 during the period of observation, it is automatically excluded from the analyses and the two remaining groups correspond to Lufthansa and Singapore Airline.

The estimation is implemented on the monthly observation of the two airlines from January 2005 up to December 2014. This leads to a 218 sample size.

5. MAIN RESULTS

We built two specifications in order to test the different proxies for the demand. Moreover we implement two versions by specification using or not the variable *Own-lagged-A380-ratio*.

The robustness of the model is confirmed by the similarity of the results obtained with the two specifications (see Table 2 and Table 3).

We find a positive and statistically significant impact for the variable *Own-lagged-A380-ratio* (model 1.2 and 2.2). When an airline already uses the A380 during the previous period, this increases its probability to use it at the current period. As expected the impact of using the innovation during the previous period increases the probability to keep on using it during the current period.

Whatever the specification, there is a positive and statistically significant relationship between the

intensity of use of the A380 by a competitor and the probability to use the innovation. This is the main result of our model: it is likely that competitors on a route follow the innovation adopted by one of them.

When the market share of the competitor on the route increases the model estimates a statistically significant negative impact on the probability to use the innovation. If the market share is interpreted as the market power on the route, the highest market power of the competitors, the lowest incentives to innovate.

If the price of the fuel increases, the model suggests an increase in the probability to use the A380. This is consistent with the characteristic of the A380 to exhibit a lowest cost of fuel per passenger.

Finally the demand is measured by the lagged-traffic on the route (Models 1.1 and 1.2), or by the level of GDP on departure airport (Models 2.1 and 2.2). When the demand increases on the route, the probability to innovate using the A380 increases as well. The impact is statistically significant in the models without the *own-lagged-A380-ratio* and non-significant into the models which include this variable. The use of an A380 during the previous period impacts more the probability to use the A380 during the current period than the increase of demand on the market.

Exogenous variables	Model 1.1	Model 1.2
Competitor A380-ratio	0.030*** (0.008)	0.021* (0.012)
Own lagged A380-ratio		0.106*** (0.024)
Competitor Market Share	-0.394*** (0.077)	-0.219* (0.128)
Fuel Price	0.005*** (0.002)	0.004 (0.003)
Lagged route traffic	0.00004*** (0.00001)	4.22E-06 (0.0000184)
Monthly fixed effect	yes	yes

Airline fixed effect	yes	yes
Statistics of the model		
LR chi2 (dl)	104.6 (15)	183.43 (16)
Prob > chi2	0.000	0.000
Log likelihood	-67.4103	-27.991

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

Table 2. Results of estimation Model 1.1 and 1.2

Exogenous variables	Model 2.1	Model 2.2
Competitor A380-ratio	0.044*** (0.011)	0.023* (0.014)
Own lagged A380-ratio		0.092*** (0.023)
Competitor Market Share	-0.597*** (0.120)	-0.288* (0.178)
Fuel Price	0.006** (0.003)	0.002 (0.005)
Departure GDP	5.27E-06** (2.08E-06)	3.99E-06 (3.29E-06)
Monthly fixed effect	yes	yes
Airline fixed effect	yes	yes
Statistics of the model		
LR chi2 (dl)	91.15 (15)	142.28
Prob > chi2	0.000	0.000
Log likelihood	-47.9789	-22.0371

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

Table 3. Result of estimation Model 2.1 and 2.2

6. CONCLUSION

The objective of this empirical paper is to analyze the impact of an innovation in air transport system on airlines competitive behavior. We consider as innovation, the use of an aircraft with a significant higher capacity: the Airbus 380. Does it give incentives to competitors to introduce as well this type on aircraft on the same route?

To answer these questions we use econometric methods to estimate the impact of the introduction

of the A380 by an airline, on the probability that airline's competitor will follow up the innovation. We implement the analysis for an oligopoly market, Frankfurt – New-York JFK route, for the period of time January 1st 2005 to December 31th 2015. The three competitors on that route are Lufthansa, Delta airlines and Singapore Airlines. Lufthansa introduces first the A380 on that route, but the A380 use is not regular. The strategy implemented by Singapore Airline is different: once the A380 has been introduced on the route, it remains in use, except during a short period of time.

We estimate a Conditional Fixed Effects Logistic model. Two specifications of the model are tested with different control for the demand on the route. The robustness of the model is confirmed by the similarity of the results obtained with the two specifications.

We find that the introduction of the A380 by a company has a positive impact on the probability of its introduction in its rival's operational fleet: the higher is the intensity of the A380 use, the higher is the probability to introduce the A380. We find that the fuel price has a positive effect on the probability to use an A380. This result is consistent with decreasing cost per passenger when the capacity of the aircraft increases. Finally, the higher the level of GDP in the country, the higher the probability to use an A380.

The empirical results show the incentives to innovate given by an innovative airline, when introducing a new aircraft without changing the frequency of operations on its route. An extension of this analysis will be to consider the case where the introduction of the new bigger aircraft leads the innovative airline to reduce its flight frequency level. The model would then have to consider this additional strategic choice linked to the use of the new aircraft when estimating the impact on competitors' strategies.

Such extended model, applied on a panel of routes on which the A380 has been operated, will then help to go further in the analysis and to estimate environmental impacts of this innovative aircraft. More precisely, besides pollution reduction linked to the aircraft technological

performance, environmental benefits can also be obtained by changes in airlines' operations when adopting this new aircraft. The larger size of the A380 associated to a reduction in flight frequencies reduce the fuel consumption per seat-kilometer and by the way the carbon dioxide emissions. The impacts would be all the more important that other airlines in competition on the same long-haul routes could also use larger aircraft and decrease their flight frequencies.

One important result of the extended econometric model would then be to estimate to what extent the introduction of the A380 innovative aircraft can help reducing air transport environmental impacts.

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