Is Environmental Innovation Worth It? The Case of the Civil Aviation Industry of Emerging Markets

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Abstract. This paper analyses the case of emerging markets by studying the impacts of the airline companies' environmental innovations on airlines' financial results and customers' willingness to pay. Environmental innovations have been classified into technology based and market based innovations. It has been found that both types of innovations are proven to be positively related to airlines' financial performance although the interaction between the two does not show significant causal relationship. As to customers' willingness to pay, none of the two types of innovations not their interaction has been tested with significant causal relationship. As one of the first studies on this field of emerging markets, this paper fills the academic void, and its results and conclusions can provide some guidelines for airline companies operating within and beyond emerging markets.

Keywords: innovation, environment, emerging markets, civil aviation

1. Introduction

The civil aviation industry plays an increasingly important role in promoting the world economic growth. Air transport has gained unprecedented growth in the last few decades, and has become the only rapid long-distance network making worldwide economic and cultural communications possible. The aviation industry currently produces around 2% of the world's manmade emissions of carbon dioxide. As the industry grows, it is forecasted that its share on global emission will increase to around 3% by 2050 (IATA 2010). It is of particular importance to study airlines from emerging markets. Emerging markets are playing a prominent role in global economic and political issues, and along with the rapid growth, their environmental responsibilities are growing as well (Nayyar, 2011) .

This paper assesses the issue through environment related innovations, adopted by airlines from emerging markets. In this study, we have classified the environmental innovations into two types: technology based innovations, and market based innovations. For technology based innovations, we have built our own index taking the following three variables: use of biofuels, use of winglets, and use of continuous descent approach. For market based innovations, another three variables are taken to build the index: CO2 offset program, online check-in, and charge for checked-in luggage. Both types of innovations are treated as independent variables to analyze their effects on the airlines' financial results—

measured by total revenues, and customers' willingness to pay—measured by aircraft occupation rate. Meanwhile, the interaction between the two types of innovations is also taken into account and is treated as another independent variable. It is found that both types of innovations are proven to be positively related to airlines' financial performance. However, for customers' willingness to pay and the interaction between the two types of innovations, no significant relationship is found.

The rest of the paper is organized as follows. Part 2 to 4 respectively draw on the literature of civil aviation, drivers of airlines innovations and the two types of innovations. Part 5 proposes the hypotheses. Part 6 explains the data and methodology used in this study. Part 7 presents the results. Lastly, Part 8 concludes.

2. Civil Aviation Industry

The commercial aviation industry plays an important role in promoting the global economic development. Air transport moves over 2.2 billion passengers annually. The air transport industry generates a total of 32 million jobs globally. Aviation's global economic impact, both direct and indirect, is estimated at USD 3,560 billion, equivalent to 7.5% of the world gross domestic product (ICAO 2010).

Airlines across the globe are gaining increasing social impacts and responsibility. Among all responsibilities, the environmental issue is of alerting importance (ATAG, 2011). Air travel is the most energy-intensive form of transport, followed by road, rail and sea. The greenhouse gas emissions from airplanes and their implication for climate change have been a growing concern for the industry.

It is of particular interest to study the case of emerging markets, as these markets, to some extent, mean the future for the global civil aviation industry (Table 1). Growing market implies growing responsibility, airlines of emerging markets are ever alarmed about the negative environmental impacts they leave, and are taking various measures to demonstrate their environmental awareness.

Table 1: Fleet size of some airlines from developed and emerging markets

Airlines (DM)	Fleet Size	Airlines (EM)	Fleet Size
Airlines 1D	721 (+206 orders)	Airlines 1E	399 (+139 orders)
Airlines 2D	256 (+60 orders)	Airlines 2E	308 (+250 orders)
Airlines 3D	183 (+70 orders)	Airlines 3E	291 (+110 orders)
Airlines 4D	147 (+24 orders)	Airlines 4E	193 (+220 orders)

DM: Developed Markets EM: Emerging Markets

3. Drivers of Airlines Innovations

Driver 1: Fuel costs. With the global economic downturn and an increased focus on environmental concerns, airlines are scrutinizing every step of their operations for new ways to gain efficiencies and cut their fuel bills. Fuel is their single biggest expense. In 2003, 15% of airfare went to pay for jet fuel; in 2013, it is 40 %, according to the IATA. Aiming for further improvement, airlines have pledged to

increase fuel efficiency by another 25 percent by the year 2020 (Honeywell, 2011).

Driver 2: The current movement on global climate change and sustainability. As demand for passenger and cargo air transportation continues to rise, the reduction of aviation's environmental footprint becomes even more critical (Bows et al., 2009). Commercial aviation is increasingly being targeted by legislators such as the EU Emission Trading Scheme for mandatory carbon-trading schemes and limits on aircraft emissions. Some important consequences of air transportation are related to noise, decreased air quality, roadway congestion, and local water quality.

Driver 3: Social Demand. Technological innovation is not only driven from innovators but also influenced by society. Currently, the general public is not well aware of the effects of aviation emissions on the global climate (Becken, 2007; Thomas, 2002). Green innovation in aviation is neither a fashion nor an end in itself. It is rather a means to the overarching goal of growth (Lykotrafiti, 2012).

4. Technology Based and Market Based Innovations

Recent studies further differentiate two types of breakthrough or radical innovations based on their advances of existing technology and departure from the existing market segment (Benner and Tushman 2003). The first type, which is defined as technology based innovations in this study, adopts new and advanced technologies and improves the services or products compared with existing ones. The second type, defined as market based innovations here, departs from serving existing mainstream markets by new and different technologies with the goal of creating a set of fringe, and usually new, customer values (Benner and Tushman 2003; Christensen and Bower 1996).

In this study, we have classified the environmental innovation adopted by airlines into the above explained two types: technology based innovations and market based innovations. For the former, three most commonly adopted innovations have been included: use of biofuels, installation of winglets, and adoption of continuous descent approach. *Biofuels*: this type of fuels is produced from renewable biological resources such as plant or animal material rather than traditional fossil fuels like coal, oil and natural gas. *Winglets*: these are the angled extension to the end of some aircraft wings which help with fuel efficiency by reducing the drag caused by airflow patterns over the wingtip. *Continuous descent approach*: this is a new technology that creates a much smoother descent from the cruising level to the ground, cutting fuel use and noise at the same time (ATAG 2012).

For market based innovations, another three common practices are included in our study: CO2 offset program, online check-in, and charge for checked-in luggage. *CO2 offset programs*: these programs are offered by airlines to let their passengers calculate the CO2 emissions they would leave by taking their flight and encourage them to compensate the environmental impact. *Online check-in*: it is a facility offered by most airlines nowadays to allow passengers confirm their presence on a flight via the internet and typically print their own boarding passes be-

fore getting to the airport. *Charge for checked-in luggage*: this is a charge imposed by a growing number of airlines for checked-in luggage. This policy, though understandably negative from passengers' perspective, can save airlines a considerable amount of fuels and thus reduce the environmental impact (IATA 2012).

5. Research Hypotheses

As Baylis et al. (1998) argued, environmental activities go along with a higher amount of financial and human resources, that is why larger firms tend to have better capabilities and more resources to reduce environmental impacts. Several empirical studies show that, in general, firm size has a positive influence on environmental innovation (e.g., Rehfeld et al., 2006; Arimura et al., 2007). Airline companies included in this study are major airlines of emerging markets, and should therefore have more resources and capabilities to adopt environmental innovations and later on benefit from them through economy of scale.

Hypothesis 1: Technology based environmental innovations are positively related to the financial results of airline companies in the emerging markets.

Similarly, for market based innovations, as stated by Johnson et al. (2009), innovation is the response of market based companies to profit potential and other market based incentives. Through the above mentioned market based innovations, airline companies are expected to directly save money by, for instance, using less paper from check-in and burning less fuels thanks to less checked-in luggage.

Hypothesis 2: Market based environmental innovations are positively related to the financial results of airline companies in the emerging markets.

Additionally, we have looked at the interaction between technology based and market based innovations. No previous literature has been found concerning the effect of this interaction on airlines' financial results. However, since the both types of innovations are proposed to have a positive effect on financial results, it follows that their interaction should all be positively related to the financial results:

Hypothesis 3: The interaction between technology based and market based environmental innovations is positively related to the financial results of airline companies in the emerging markets.

For customers' willingness to pay, we have proposed similar hypotheses. Note that we did not propose the hypothesis concerning the relationship between technology based innovations and customers' willingness to pay, as most customers are not aware of the technology innovations that airlines are adopting.

Hypothesis 4: Market based environmental innovations are positively related to customers' willingness to pay of airline companies in the emerging markets.

Hypothesis 5: The interaction between technology based and market based environmental innovations is positively related to customers' willingness to pay of airline companies in the emerging markets.

6. Data and Methodology

Data are collected from 40 major airlines of emerging markets. Airlines were selected mainly by their fleet size. And only medium-large sized airlines of their respective country or region were included in our sample. Geographic coverage of the airlines is fairly complete. Airlines' data were of the year 2011. All data were manually collected from various sources such as annual reports, corporate social responsibility reports, International Air Transport Association (IATA), International Civil Aviation Organization (ICAO), and Air Transport Action Group (ATAG).

The dependent variables of this study are airline companies' financial results and customers' willingness to pay as explained earlier. These two variables are measured respectively by airlines' total revenue, and aircraft's occupation rate. The independent variables are both technology based innovations and market based innovations. Due to the lack of existing environmental indexes for the aviation sector in emerging markets, we have constructed our own indexes using a series of key indicators for both types of innovations. For technology based environmental innovations, we have taken the average of the three indicators to generate the combined index. Likewise, the average of the three market based innovations is taken to generate the index for market based environmental innovations. As to the interaction between the innovations, we have multiplied the above mentioned two indexes to create the variable. Each of these six innovations and their measurement are displayed in the following tables (Table 2 and 3):

Table 2: Airlines' technology based innovations and measurement

Technology based innovations	Measurement
Use of biofuels	Percentage of flights using biofuels
Use of winglets	Percentage of aircraft with winglets
Continuous descent approach	Percentage of flights using this approach

Table 3: Airline's market based innovations and measurement

Market based innovations	Measurement
CO2 offset program	dummy variable (1 or 0)
Online check-in	dummy variable (1 or 0)
Charge for checked-in luggage	dummy variable (1 or 0)

We have also included two control variables in our study: fleet age and market conditions. Fleet age is included due to the fact that fuel consumption of an aircraft is directly related to the age of the aircraft and the model of the engine. It is measured by the average age of an airline's entire operating fleet. Market condition is included in order to control for any common economic or political circumstances that benefit or deteriorate the entire market of a specific country or region. It is measured by the local stock exchange index by the end of the year 2011.

7. Results and Analyses

In order to test the hypotheses we have proposed, multiple regressions by Stata

have been conducted. We took the natural log of the revenue since total revenue is considerably large compared with all other variables. Below are the two tables with the results of the regressions. They are taking log of the total revenue and aircraft occupation rate respectively as the dependent variables.

Table 4: Regressions of Log of Revenue (t-statistics in parentheses)

Technology based innovations	1.562** (2.17)
Market based innovations	1.172*** (2.76)
Interaction	-0.706 (-1.78)

** Significant at the 5% level, *** Significant at the 1% level

Table 5: Regressions of Aircraft Occupation Rate (t-statistics in parentheses)

Market based innovations	0.005 (0.17)
Interaction	0.014 (0.50)

As can be seen from Table 4, both innovations are tested to be positively related to airline companies' financial performance, and both of them have statistical significance. Thus, Hypothesis 1 and 2 are supported. However, the interaction between the two types of innovations is tested to be negatively related to the financial results, though not significantly so. Thus, Hypothesis 3 cannot be supported. Table 5 gives the results for airline customers' willingness to pay. None of the two variables, the market based innovations and the interaction, are gaining statistical significance, which disapproves both Hypothesis 4 and 5.

Additionally to the testing of the five hypotheses, we have also conducted a more detailed analysis measuring each of the six practices by looking at their impact on airline companies' total revenue and aircraft occupation rate. The procedure and methodology remain the same. The results are as follows:

Table 6: Regressions of Log of Revenue (t-statistics in parentheses)

Use of Biofuels	5.578 (1.33)
Use of Winglets	-0.486 (-0.64)
Continuous Descent Approach	0.779** (2.59)
CO2 offset program	0.630** (2.32)

Online Check-in	1.062** (2.26)
Charge for Checked-in Luggage	0.107 (0.13)

** Significant at the 5% level

Table 7: Regressions of Aircraft Occupation Rate (t-statistics in parentheses)

CO2 offset program	0.053** (2.52)
Online Check-in	0.032 (0.88)
Charge for Checked-in Luggage	0.052 (0.84)

** Significant at the 5% level

As can be seen in Tables 6 and 7, among the three technology based innovations, use of biofuels and continuous descent approach are both showing positive coefficients with the financial results of the airlines, and the use of winglets is tested to be negatively related to the financial results, though not significantly so.

For the relationship between market based innovations and airlines' financial results, it can be seen in Table 6 that the first two innovations are proven to be positively related to the airlines' financial results and both of them are statistically significant, while the last one also shows positive relationship though without statistical significance. Thus we can conclude that CO2 offset program and online check-in can positively contribute to airlines' financial performance. As to customers' willingness to pay, we can see from Table 7 that all of them are showing positive relationship, but only CO2 offset program gains statistical significance. Therefore, we can draw the conclusion here that CO2 offset program as a market based innovation is positively related to customers' purchase willingness.

8. Conclusions

This paper assesses the issue of environmental innovations with the focus on airlines from emerging markets. Innovations are treated in two groups depending on whether they are technology based or market based. For each group, three commonly adopted innovations among airlines are used to analyze their effect on the airlines' financial performance and customers' willingness to pay, measured by airlines' total revenue and aircraft occupation rate respectively.

Both types of innovations are found to be positively related to airlines' financial performance. However, it is worth noting that the interaction of technology based and market based innovations does not seem to do contributions to airlines' financial performance. Therefore, it is important to know which innovations are key contributors. As our additional testing suggests, Continuous Descent Approach, CO2 offset program, and online check-in are showing significant contributions to airlines' financial performance. Therefore, airline companies could be advised to give more weight to the above mentioned three key practices.

For the other three practices which are not proved to be positively related to

airlines' financial performance, it implies that, on the one hand, for environmental innovations heavy in investment, airlines may not see immediate rewards as the initial investment on those innovations can counterbalance possible benefits in the short run; on the other hand, airlines adopting those innovations are often under pressures from their competitors which somehow impede them from fully assessing the necessity of adopting certain innovation before making the decision.

As to customers' willingness to pay, however, no significant findings are obtained; neither technology based nor market based innovations play an important role in customers' purchase decision-making. This implies that for airlines of emerging markets there is still a lot to do to enhance their customers' environmental consciousness and provide them with the type of products and services that are both ecological and good value for money.

These results, though preliminary, can shed some light on environmental innovations for the airlines industry. As probably the first study dealing with this issue in emerging markets, this paper fills the academic void by raising the issue and giving grounded analyses. It also provides some managerial implications with the most updated cases and results for airlines in and beyond emerging markets.

Among future research avenues we might cite to focus on how to manage emerging airline pilots, -as in Harvey, Williams, and Probert (2013)-, who have unparalleled opportunities to affect green performance through their control of the machines that directly impact the industry's carbon footprint.

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