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Abstract

This article investigates the influence of fuel costs on airfares and the existence of an asymmetric fuel cost transmission in the Brazilian airline industry. Prior researches of the airline field haven't focused on the fuel costs or in its asymmetric transmission. We conducted an empirical analysis using panel data for the Brazilian domestic airline industry and the results shows us that the fuel costs influence the fares, and that there is an asymmetric transmission of the fuel costs to the airfares, this meaning that the airfare responds faster to an oil price increase than to an oil price decrease, specially when there is no low cost carrier (LCC) in the route analyzed. The presence of a LCC can null the asymmetric transmission because they are presented as competitors in the market, and the asymmetry can be explained by market power. Another reason for the asymmetry existence is the practice of fuel hedge, the will of maximizing profits, the desire to improve service quality, etc. We also find that in Brazil, if a firm suffers from financial distress, then it can make the prices get lower, as it happens in the US industry argued by Hofer et al. (2009).

Keywords: airline pricing, fuel costs, asymmetric transmission, airfare, Brazilian airline industry.

Introduction

In the global airline industry, according to IATA (2010), the fuel costs represented about 35% of the operational costs in 2008; in 2001 those costs represented about 15%, but due to many reasons, including the oil price increase in the decade, those costs rose up to 40% in some places. As stated in IATA (2011), fuel costs accounted for about 37% of the operational costs for Brazilian airlines, while it globally represented 29%. It has been noted that during fuel crisis the airlines weren't lowering their airfares at the same rate that the oil lowered its prices, and this could be due to a global economic crisis, practice of hedge, desire to improve service quality, increase profits, etc[3]. But once a raising oil price is imposed, the carriers usually increase their fares sharply; even low cost carriers (LCC) join it[4]. What happens is that the airfare rises more rapidly in response to an increase in the oil price than it declines in response to a decrease in oil price.

It has been well established that airline pricing depends on various factors, and one of them is operational cost[5], so an asymmetric transmission in costs would affect the airfares. As reported by Hofer and Eroglu (2010), the operational costs affect the firm strategy because it limits the airline pricing. Some general variables showed by many authors[6] included demand, concentration, market share, type of airline (low cost carrier, legacy, etc.), etc.

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[4] Mouawad, J. Airfares are chasing oil prices higher. The New York Times. February 23rd 2011.
Maynard, M. High fuel costs are squeezing low air fares. June 20th 2008.
[5] See Borenstein (1989), Hofer et al. (2008), Hofer et al. (2009), Hofer and Eroglu (2010).
[6] Idem.

As stated by Peltzman (2000), “output prices tend to respond faster to input increase than to decreases” (p.466). Kaufmann and Laskowski (2005) studied the asymmetrically response of the home heating oil price to changes in the crude oil price and they noted that it exists and that it is “generated by contractual arrangements between retailers and consumers” (p.1595). So both authors noted that the prices of the product studied responded faster to costs increase then to costs decrease, which means that there was an asymmetric transmission in their studied products.

In this paper we aim to evaluate the asymmetric fuel cost transmission in the Brazilian domestic airline industry. This research discriminates fuel costs from other costs because IATA (2010) shows that the fuel costs has the biggest share of airline operating costs, and it will help clarify how much the costs influence the airfares. And the main result and contribution of this article is that a fuel cost asymmetry transmission exists in the Brazilian domestic airfares, especially when the presence of a LCC is not noted in the route.

The remainder of this article is structured as follows: the first section will present the theoretical framework were we bring the literature review and the conceptual model. The empirical model development is brought in section 2. Section 3 is responsible for presenting the results for the econometric analysis. The robustness checks and limitations are summarized in Section 4. After those sections we present the conclusions of this paper.

1. Theoretical framework

The research questions (RQ) are a form to show the goal of this paper, which is to understand the relationship between fuel costs and airfares and its asymmetric transmission. We want to answer the following RQ, is there an asymmetric fuel cost transmission to the airfares? In other words, if we compare the airfare during costs increase and during costs decrease, will they be asymmetrically transmitted?

It is expected that the airfare rise more rapidly in response to an increase in the oil price than it decline in response to a decrease in oil price. And that’s because the carriers usually want to increase their profitability; improve the service quality offering more comfortable seats, a better waiting room on the airport, etc.; they hedge the fuel; etc.

The remainder of this section is divided in literature review and conceptual model.

1.1. Literature review

As pointed out earlier, the airline pricing depends on various factors, including operational costs, airline type, competition, market share, etc. Borenstein (1989) studied the importance of the route and airport market share for airline pricing. Evans and Kessides (1993) say in their work that an airport dominance by a specific carrier, measured by its total airport market share, confers a pricing power, while the route dominance doesn’t confers so. According to Hofer et al. (2008) the presence or the potential competition of a LCC can cause the prices to fall. And as Hofer et al. (2009) article shows, a firm suffering financial distress tends to drop their prices.

Regarding the operational costs, an increase could happen due to many reasons, including (i) currency depreciation and (ii) increase in oil price, regardless of how it happens a decrease in the demand is expected owing to an increase in the (i) airfare and/or (ii) costs of living. The Brazilian currency is real (R$) and according to Morrel and Swan (2006) many of the operational costs are paid in US dollar. Once oil price is globally given in US dollar, in Brazil its prices also changes with the exchange rate, so if a currency depreciation occurs, the Brazilian's market will suffer with an operational costs increase.

The asymmetric transmission is not suggested by economic theory, but previously works have shown that it happens in many cases (Peltzman, 2000). Borenstein et al. (1997) confirmed the asymmetric effect between gasoline and crude oil prices. While Kaufmann and Laskowski (2005) found the asymmetric relation between home heating oil and crude oil price, in their work they say that efficient markets can generate the asymmetry.

The literature also brings alternatives to control fuel price, some of them are fuel hedge practice, change airplane type and frequency of flights, company mergers, etc. Ryerson and Kim (2013) cover mergers in their article, and they say that when there is a merger, then the companies can increase their fuel efficiency, decrease flight frequency, increase airfares, etc., so it is expected a depreciation on the operational costs, but according to Lim and Hong (2013) if the merger is inefficient, then the costs can increase. Morrel and Swan (2006) define fuel hedge as locking the fuel costs for future purchases, which can decrease the operational costs when well applied. Sometimes upgauging (replace smaller airplanes with larger ones) allows a decrease in the frequency of flights, which can decrease the fuel consume for the airline (Ryerson and Hansen, 2011). And according to Hsu and Eie (2013) one of the main solutions to control losses and costs is to resize the flight frequency and the airline fleet.

The competition among the companies can happen in two levels (i) airport and (ii) route, and it can be noticed by concentration in the market (HHI) or dominance in the market (market share). The more dominant the company is, the more they're able to maximize its profit, regardless if they're concentrated or not in the market, Hofer et al. (2008). Many authors including Hofer et al. (2008) noticed that the presence of a low cost carrier (LCC) in the market influences the price behavior and the demand. When a LCC enters the market it can be expected an airfare drop or not. Sometimes just the fact that a LCC could enter the market or enter in an alternative market (potential competition) could drop the prices, and sometimes it can maintain the prices just like they were, because some customers are willing to pay more for a better service quality.

Hofer et al. (2009) shows in its article that an airline financial distress impacted in the airline pricing negatively, which means that a firm suffering from financial distress would charge less in its airfare in the US market. Their work also indicates that a greater operational costs results in a smaller decrease in price, and the same happens with market share, while with firm size and level of market concentration the opposite happens, the greater the firm size or market concentration, the more the price tends to drop in a financial distress case.

When it comes to fuel price, Morrel and Swan (2006) discuss three strategies for dealing with it (i) increase the airplane fuel efficiency, (ii) pass on costs increase to the customers and (iii) fuel hedging practice. The first alternative is limited due to technology existence, the second alternative is what we study in this article, and sometimes the competition limits it, and the third alternative can either decrease or increase volatility and cannot be the best option when it comes to fuel price drop. They also say that in theory, "the fuel hedge reduce the major source of swings in profits, and gain higher prices for the airline's stock" (p. 714).

The literature has focused the attention on factors that influence airline and oil pricing. According to Morrel and Swan (2006) hedging protects profits, and this can explain a few things noticed in some variables in the airline pricing, as the asymmetric transmission. Hofer et al. (2008) concludes that price premium tend to be lower when there are low cost carriers competing in the market, which makes the presence of LCC's be negatively correlated to the airline pricing. And Hofer et al. (2009) shows that a firm financial distress affects negatively the airline pricing.

In summary, the literature reveals mostly that the operational costs limits the airline pricing, but little is known about the fuel costs impact in the airfare. It is expected an asymmetric transmission, which means that the airfare rises more rapidly in response to an increase in the oil price than it declines in response to a decrease in oil price. If this is true, then part of the airline profit can be explained, and also the airfare variation can be understandable for some periods.

1.2. Conceptual model

The literature brings the idea of operating costs influencing the airline pricing[7]. Once we want to analyze the impact of oil price on airfare we divide operating costs in two, being fuel costs and other costs, which include labor, maintenance, etc. According to Hofer et al. (2009), the airline operating cost impact their strategy, for that reason we consider analyzing the operating costs something important.

There are three forms for raising fuel costs (i) increase in fuel consumption, (ii) the oil prices increase and (iii) currency depreciation. Assuming that a specific route consumes a constant quantity of fuel, and there is only an increase in the oil price, *ceteris paribus*, the operational costs will also increase. And as stated earlier in this work, the fuel cost represent an important part of the airline operating cost, and for that reason it is expected a positive correlation between fuel cost and airfare. We assume that the same thing will happen to the other costs, which means that we expect a positive effect of other costs on airfare.

IATA (2010) shows that the fuel costs has the biggest share of airline operating costs, for that reason this variable was divided into two (i) fuel costs up and (ii) fuel costs down. Those variables represent the asymmetric costs transmission to the airfare. As stated by Peltzman (2000), "output prices tend to respond faster to input increase than to decreases" (p.466). In accordance to Hofer et al. (2009) a lower operating cost imply in higher profit, and this is one of the reasons why a cost decrease doesn't respond as fast as an increase. Another reason is that the air carriers usually practice fuel hedge, this means that despite an oil price drop the jet fuel price may not have been dropped to the carrier. An example of what we expect to happen is: from month 1 to month 2 the costs and the airfares increased in x% (fuel costs up), and from month 3 to month 4 the costs decreased in x%, but the airfares decreased in y% (fuel costs down), if there is an asymmetric transmission, then y is smaller than x.

Therefore, our hypothesis is as follows:

Hypothesis 1. There is an asymmetric costs transmission to the airfares.

Hypothesis 2. The asymmetry makes the airfare respond faster to an oil price increase than to an oil price decrease.

The basis for our model is that airfares are set due to a number of factors, including costs, market share, etc. To represent our model Figure 1 is shown.

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[7] See Borenstein (1989), Hofer et al. (2008), Hofer et al. (2009), Hofer and Eroglu (2010).

Following Hofer et al. (2009), the operational costs of an airline affect its strategy, and it can affect the airfares. As discussed above, we expect an asymmetric transmission between costs, which means that we expect different behaviors between fuel costs and other costs (H1). And we also expect that an increase in fuel costs results in a more severe effect on airfares than costs drop would (H2).

In addition to operational costs there are other factors that impact airfares, and those are presented in the literature review. Figure 1 shows the variables considered to influence airfare in the Brazilian airline industry in our model, which includes market share and HHI, those are presented with a double ended arrow representing that they are endogenous variables in our model, as stated in Borenstein (1989). The demand (number of passengers) also leads to different airfares and is considered endogenous to the price in Hofer et al. (2008) article. And the exogenous variables included in the model are aircraft size and proportion of transfer passengers.

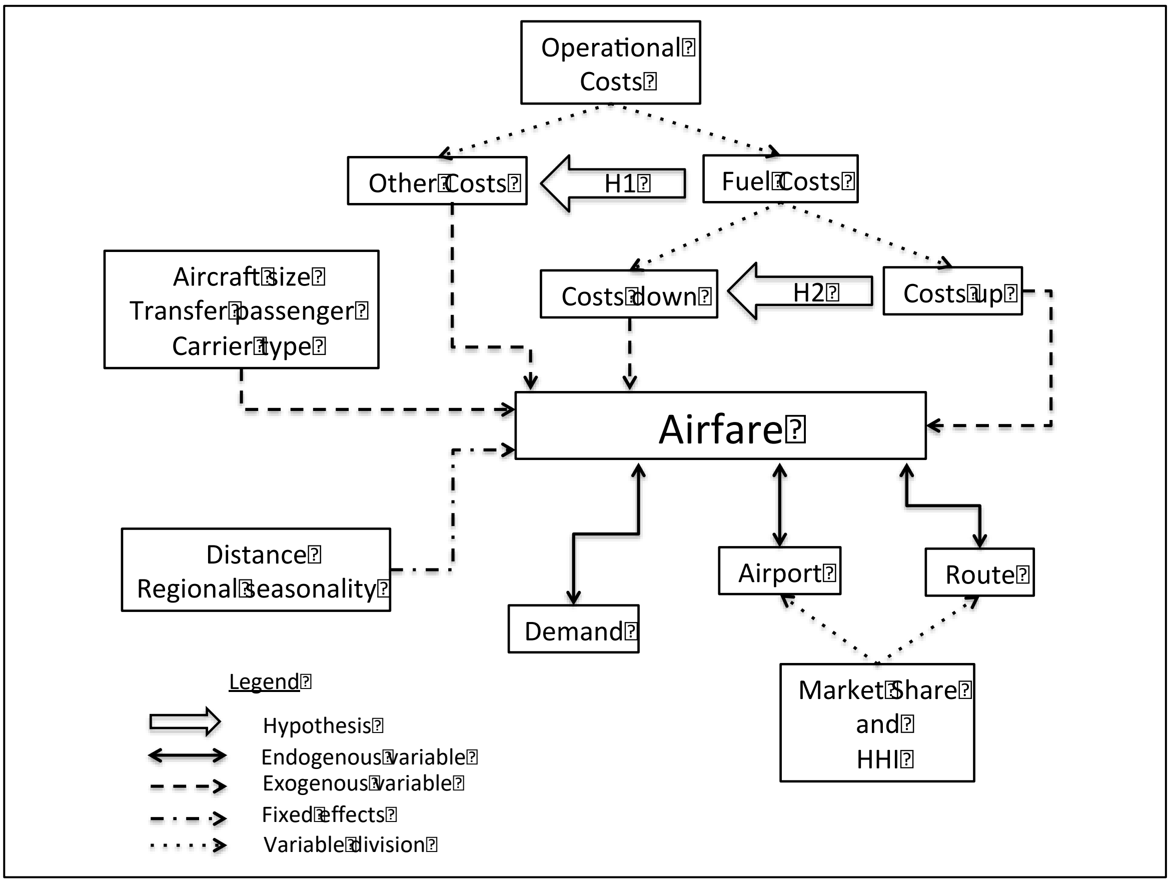

Figure 1 – Airfare influences

Finally we include a series of airline dummy variables to control the presence of different carrier types, as full service carrier (FSC), legacy, LCC, and firms suffering from financial distress (bankruptcy).

2. Empirical model development

2.1. Application

The proposed model was applied to the Brazilian domestic airline industry, and it is known that omitted variables bias the results, while too many variables could only present zero elasticity. In our model we considered the variables presented in the Figure 1 as important variables to represent airline pricing.

We consider fuel costs as the most important variable for this article, and that's because we aim to study the impact of it on airfares and the asymmetrically transmission of it. This is considered important to study because this is a manner to show to the air companies that maybe looking for cheaper alternatives for fuel costs could increase their demand and their profits, and would also be good to the customers once that they would be able to travel more for less.

2.2. Data

The database consists of a data panel in which the data came from several sources, including ANAC, HOTRAN, INFRAERO, etc. and it covers the period from January 2002 to June 2009. During this period Brazil had a company that suffered from bankruptcy (Varig in 2006), and in late 2002 the country suffered a financial crisis where the exchange rate reached almost 4:1 to US dollar[8]. As stated in the beginning of this work, the exchange rate could be one of the reasons for fuel costs increase.

2.3. Empirical model

The empirical model used here is presented in the equation 1 bellow.

$$\begin{aligned} ln\, fare_{kt} = {} & \beta_0 + \beta_1\, ln\ jfuel\ costs_{kt} + \beta_2\, ln\, costs\ excl\ jfuel_{kt} \\ & + \beta_3\, ln\, av\ aircraft\ size_{kt} + \beta_4\, ln\, pdew_{kt} + \beta_5\, ln\, maxprconn_{kt} \\ & + \beta_6\, ln\, routehhi_{kt} + \beta_7\, ln\, max\ cityhhi_{kt} + \beta_8\, ln\, max\ routeshare_{kt} \\ & + \beta_9\, ln\, max\ cityshare_{kt} + \delta_{10}\, pres\ legacy_{kt} \\ & + \delta_{11}\, pres\ legacy\ bankr_{kt} + \delta_{12}\, pres\ FSC_{kt} + \delta_{13}\, pres\ LCC_{kt} \\ & + regional\ seasonality_{kt} + distance_{kt} + \varepsilon_{kt} \end{aligned} \tag{1}$$

Where all variables are analyzed at route k and month t, and k varied from 1 to 86 and t varies from 1 to 90, this meaning that the data contains 86 city pair routes and 90 months (7.5 years). And β is the elasticity for each variable.

- Fare is the average price[9] of an air ticket for a city pair route;
- Jfuel costs is the cost of jet fuel per available seat kilometer (ask) for a city pair route;
- Costs excl jfuel is all the other costs, excluded jet fuel, for a city pair route;
- Av aircraft size is the average seat numbers in the aircraft used for a city pair route;

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[8] See in Brazilian Real from Trading economics.
[9] It is important to note that the costs and prices are given in the Brazilian currency (real).

- Pdew is the number of passengers daily each way;
- Maxprconn is the maximum proportion of transfer passengers between origin and destination;
- RouteHHI is the route concentration;
- Max cityHHI is the maximum concentration between origin and destination;
- Max routeshare is the maximum share of the route;
- Max cityshare is the maximum share between origin and destination;
- Pres legacy is a dummy variable that indicates the presence of a legacy company;
- Pres legacy bankr is a dummy variable that indicates the presence of a legacy company suffering from financial distress;
- Pres FSC is a dummy variable that indicates the presence of a full service carrier;
- Pres LCC is a dummy variable that indicates the presence of a LCC;
- Regional seasonality and distance are treated as fixed effects for each route k at month t;

ε is the error that includes the unobserved components.

Table 1 presents the descriptive statistics for the variables presented on equation 1.

Table 1 - Descriptive statistics of continuous variables

Variable	Unity	Mean	Std. Dev.	Min	Max
JFuel Costs	Cost/ask	0.107	0.042	0.001	0.455
Costs Excl JFuel	Cost/ask	0.176	0.071	0.024	0.859
JFuel Costs - Up	Cost/ask	0.107	0.042	0.001	0.455
JFuel Costs - Down	Cost/ask	0.107	0.042	0.001	0.455
Av aircraft size	# Seats	146.820	20.825	79.347	285.000
Pdew	Pax/day	926.688	1095.948	30.000	7597.097
Max pr conn	%/100	0.203	0.118	0.002	0.569
Pres legacy	index [0,1]	0.582	0.493	0.000	1.000
Pres legacy bankr	index [0,1]	0.067	0.250	0.000	1.000
Pres LCC	index [0,1]	0.975	0.157	0.000	1.000
Pres LCC – young	index [0,1]	0.390	0.488	0.000	1.000
Pres LCC – mature	index [0,1]	0.596	0.491	0.000	1.000
Route HHI	%/100	0.453	0.129	0.205	1.000
Max city HHI	%/100	0.389	0.067	0.229	0.756
Max route share	%/100	0.527	0.153	0.000	1.000
Max city share	%/100	0.451	0.092	0.002	0.865

We performed the results in four different models, the first one is the one presented in the equation 1, the second is a variation of the first model, where the presence of LCC is divided into presence of LCC young and mature. The third model is the second one, but jfuel costs was divided into jfuel costs up and down. And the forth and last model interacts the presence of LCC with jfuel costs up for the third model.

The hypothesis are included in the model in a few variables, H1 can be analyzed testing the equality of the variables jfuel costs and costs excl jfuel, in other words, β_1 and β_2 should be different. H2 is testable because we can break the variable jfuel costs into jfuel costs up and jfuel costs down, and we can also interact the jfuel cost up with the presence of LCC, and test the equality of those variables. The interaction is made because the asymmetric transmission, as stated in Borenstein et al. (1997) and Peltzman (2000), only makes sense when there is a market power, and the presence of a LCC can affect this market power.

2.4. Estimation strategy

When it comes to econometrics a few tests have to be done to check the validity of the model and check if any adjustment has to be done. The tests are stationarity and cointegration, multicolinearity, heteroskedasticity and autocorrelation. After doing the needed arrangement, as we have endogenous variables, we need to find instruments for them, and then calculate the regression to be able to analyze the variables.

This section was subdivided to present in each of the subsections the analysis of the tests performed.

2.4.1. Stationarity and cointegration

The first test to be performed checks the presence of unit root for some variables in the model, it was tested the unit root for ln routeHHI, ln max cityHHI, ln jfuel costs, ln costs excl jfuel and ln av aircraft size. To accomplish that, we used the Augmented Dickey-Fuller test (ADF), Phillips-Perron test and Im-Pesaran-Shin test. The calculated ADF statistics only exceeded the critical value at the 5% level significance for max cityHHI, with unit root not rejected and therefore meaning that the series is nonstationary. It is possible to have a combination of nonstationary series that is stationary, when this happens the variables are cointegrated. The cointegration is important to analyze the long run relationship. A formal test for cointegration was therefore performed, using Pedroni/ PDOLS (panel dynamic OLS) method. We implemented the Pedroni/ PDOLS procedure with and without a trend variable included, and in both procedures the group statistics were greater than 2, so we rejected the null hypothesis of no cointegration, and we can say that there is a long run interpretation to the model.

2.4.2. Multicolinearity, heteroskedasticity, autocorrelation

For each model we performed the tests of multicolinearity, heteroskedasticity and autocorrelation. And when it was necessary, the arrangements were made to treat the model.

We calculate the variance inflation factor (VIF) to measure the degree to which the variance of estimates was inflated by multicolinearity. For the first model ln pdew and ln maxprconn had calculated VIF figures greater than 10, and this is an indicative of multicolinearity, the mean VIF was 5.13. The multicolinearity can present the risk of false negative in the model, which means that it can inflate the estimation of standard errors of some of these estimates, so the statistical insignificance results must be interpreted with caution. For model 2 ln pdew, ln maxprconn and pres LCC – mature had calculated VIF figures greater than 10, and the mean VIF was 4.96. Model 3 had ln pdew, ln jfuel costs – do, ln jfuel costs – up, pres LCC – mature and ln maxprconn with VIF grater than 10, and mean VIF of 4.17. And for model 4 ln jfuel costs – up, ln jfuel costs x LCC, ln jfuel costs – do, ln pdew, pres LCC – young, pres LCC – mature and ln maxprconn had its calculated VIF greater than 10, and the mean VIF was 4.95.

We tested for heteroskedasticity and autocorrelation. First, we implemented the White/Koenker and Breusch-Pagan/Godfrey/Cook-Weisberg heteroskedasticity tests and all the models rejected the null hypothesis at the level of 5%, which says that the models are heteroskedastic, and this can present a risk of false positive due to a decrease in the estimation of standard errors, to correct that we employed the Huber-White-Sandwich procedure to adjust the models. After the heteroskedastic adjustment, a Cumby-Huizinga test of autocorrelation was performed for each model, and at the level of 5% this test suggested the presence of autocorrelation of order 8 for all models. The autocorrelation also present the risk of false positive, so we employed the Newey-West estimator to adjust the standard error.

2.4.3. Endogeneity and instrumental variables

According to the literature in the airline pricing equation some variable are endogenous, and this means that the variable is potentially correlated with unobserved components, in other words, it is correlated to the error term ε in the equation 1. The presence of endogenous variables biases the OLS estimation of the coefficients. Hofer et al. (2008) presents demand as endogenous to the price and Borenstein (1989) presents market share and HHI as endogenous to the price. Knowing this, in equation 1 we have cov(routeHHI, ε) $\neq 0$, cov(max cityHHI, ε) $\neq 0$, cov(max routeShare, ε) $\neq 0$, cov(max cityShare, ε) $\neq 0$, and cov(pdew, ε) $\neq 0$; and this is what biases the OLS estimation. The presence of endogenous variables biases the estimation of other regressors as well because they depend on the correct estimation of the effect of other variables, so we must employ instrumental variables estimators to treat the endogeneity of the model.

Our identification strategy used key exogenous demand shifters as instrumental variables. In particular, we used as instrument a variation of the endogenous variable. The endogenous variable was accounted for route k and month t. We chose as instrument the same variable for a different route q at month t, each route had a weight that is inversely proportional do the distance from route q to route k. We tested 20 instruments of this type and we chose the ones that better suited the model. Income and gross domestic product were also used as instruments.

For endogenous model it is necessary to examine the quality of the instrumented model by analyzing the validity and relevance of the instruments and for that some tests were performed. The underidentification tests check the relevance of the proposed instruments, while the over identification tests check the validity of the instruments, those tests were respectively Kleibergen-Paap rk LM statistic (KP) and the Hansen J statistics. To treat endogeneity the number of instruments must be equal or greater than the number of endogenous variables, this is verified by the Hansen J test; and the instruments must be relevant, which means that they need to be correlated with the endogenous regressors, tested by the KP statistic. On table 2 we can see those tests results for the entire instrumented model. The KP test should reject the null hypothesis, and we’re able to see in the results that the null hypothesis was rejected at 5% level (KP_PValue < 0.05), that meaning that the model is not underidentified. While the J test should not reject the null hypothesis, otherwise the instruments would not satisfy the orthogonality conditions and one reason for that is that the instrument is not truly exogenous. The J test did not rejected the null hypothesis at 25% level (J_PValue > 0.25), this validate the instruments.

2.4.4. Estimator

We employed the two-step feasible efficient generalized method of moments (2SGMM) with adjusted heteroskedasticity and autocorrelation. The bandwidth used in the estimation with a Newey-West (Bartlett) kernel was set equal to 9.

3. Results

Table 2 presents the estimation results of the empirical model 1, 2, 3 and 4 of the airline pricing in the Brazilian airline industry.

Table 2 - Estimation results (2SGMM)[10]

	(1) M1 2SGMM	(2) M2 2SGMM	(3) M3 2SGMM	(4) M4 2SGMM
ln routehhi	0.7186***	0.6362***	0.6352***	0.6595***
	[0.219]	[0.217]	[0.217]	[0.217]
ln max cityhhi	-0.5487*	-0.3556	-0.3492	-0.3783
	[0.331]	[0.311]	[0.311]	[0.311]
ln max routeshare	-0.5227***	-0.3965**	-0.3987**	-0.4171***
	[0.178]	[0.158]	[0.158]	[0.158]
ln max cityshare	0.3230*	0.3705**	0.3694**	0.3614*
	[0.188]	[0.188]	[0.188]	[0.188]
ln av aircraft size	0.3157***	0.3032***	0.3030***	0.3032***
	[0.096]	[0.092]	[0.092]	[0.092]
ln pdew	0.0192	-0.0526	-0.0564	-0.0645
	[0.104]	[0.138]	[0.137]	[0.138]
ln max pr connects	0.0333	0.0474	0.0473	0.0485
	[0.030]	[0.031]	[0.031]	[0.031]
pres legacy	0.3565***	0.3987***	0.3992***	0.3943***
	[0.052]	[0.045]	[0.045]	[0.045]
pres legacy bankr	-0.2399***	-0.2667***	-0.2664***	-0.2651***
	[0.044]	[0.042]	[0.042]	[0.042]
pres FSC	0.0512	0.0819	0.0814	0.0841
	[0.057]	[0.053]	[0.053]	[0.054]
pres LCC	-0.0782			
	[0.056]			
pres LCC - young		-0.0965***	-0.0958***	-0.1421***
		[0.034]	[0.034]	[0.033]
pres LCC - mature		-0.0793*	-0.0791*	-0.1226***
		[0.043]	[0.043]	[0.037]
ln costs excl jfuel	0.0964**	0.0860**	0.0862**	0.0910**
	[0.041]	[0.043]	[0.043]	[0.043]
ln jfuel costs	0.1085***	0.1093***		
	[0.034]	[0.033]		
ln jfuel costs - up			0.1139***	0.1741***
			[0.035]	[0.042]
ln jfuel costs - do			0.1111***	0.1083***
			[0.034]	[0.034]
ln jfuel costs x LCC				-0.0645**
				[0.028]
Adj_R2	0.6726	0.7038	0.7038	0.7019
RMSE	0.2775	0.2640	0.2640	0.2649
F	54.095	54.870	54.493	54.578
KP	34.9120	30.9947	30.4606	29.8653
KP_PValue	0.0000	0.0001	0.0002	0.0002
J	4.0752	5.5610	5.4587	5.1062
J_PValue	0.7711	0.5918	0.6042	0.6470
Weak_CD	5.6067	5.8435	5.9005	5.9037
Weak_KP	3.1900	3.0227	2.9671	2.9098
N_Obs	6476	6476	6476	6476

[10] Results produced by the two-step feasible efficient generalized method of moments estimator (2SGMM); statistics robust and efficient to arbitrary heteroskedasticity and autocorrelation; figures are representative of the estimated elasticities calculated at the sample mean; P-value representations: ***p<0.01, ** p<0.05, * p<0.10; results generated by alternative estimators presented in the Appendix.

Most of the literature analyzes the U.S airline industry and they present a positive relation between market share and airfare, and HHI and airfare, as stated in Hofer and Eroglu (2010), Borenstein (1989) and Evans and Kessides (1993). But Borenstein and Rose (1991) says that both market share and HHI can be positively or negatively related to prices, this depends on the competition; a monopoly tends to be positively correlated, while competitive markets tend to be negatively correlated.

Analyzing the results of model 4, our preferred model, we can note that route share for the Brazilian market has a negative effect while city share and route concentration has a positive effect; with this we can conclude that the Brazilian market has a concentrated share on airports, which means that the biggest share company in the airport has enough influence to dictate prices, and so the company that is concentrated in a specific route; while analyzing route share we notice a competitive market, meaning that the biggest share company in a route does not have enough power to dictate the prices, once that there is potential competition wanting to enter the route.

Av aircraft size has a positive sign due to the supply curve. It is known that the customer wants to buy more when the prices are lower, and the company wants to sell more when the prices are higher. If there is an increase in the aircraft size, then the firm is able to offer more tickets for the same route, and due to the supply curve they want to sell the tickets with a higher price, so they can increase their profits margin.

It is known that the legacy tickets in the U.S are more expensive than the LCC tickets, and that is because their services is different from other companies; usually the legacy company offer free baggage, miles program, meals, etc., while in the LCC company the customer has to pay more for those services. Some people are willing to pay more for a better service quality, more confortable seats, etc., and that means that the legacy company clients are usually different from the LCC customers. In Brazil this was also noted, and that explains the positive and significant signal for the dummy variable pres legacy.

The dummy variable pres legacy bankr has a statistical significance at a 1% level and has a negative effect, which means that the companies suffering financial distress charge less for their tickets, and this agrees with Hofer et al. (2009) work for the U.S market.

The presence of LCC in the first model didn’t present significance probably because its effect is included in the shares and HHI. But we divided it into two for the other models. In Brazil the most important LCC during the period covered by the data is the company called Gol, this company changed its service after a few years in the market, for that reason we have the LCC – young, which is Gol in the first years of service, and LCC – mature. We noted that the LCC – young has a stronger negative effect to the prices than LCC – mature. After analyze those variables, we noted that young Gol worked more as a LCC to enter the market, but after they got their place and importance in the market, they started to charge more for their tickets, starting to deviate from the LCC service characteristics if compared to the first years of its existence.

The hypotheses were tested comparing the variables of interest. A null test was conducted, and it was performed in a way to see if the variables in study were equal, the results are seen in Table 3. If Prob > F = 1, then the variables compared are equal, and if Prob > F = 0, then they are completely different. Our first hypothesis (H1) says that there is an asymmetric costs transmission to the airfares, so we tested the equality of the variable jfuel costs and costs excl jfuel, in both model where those variable were presented we cannot discard their equality, so we cannot say for sure that the asymmetry exists.

On hypothesis 2 we say that the asymmetry makes the airfare respond faster to an oil price increase than to an oil price decrease, this was tested comparing the variable jfuel costs – up and down, and also jfuel costs – up, down and the interaction with the presence of a LCC. On our preferred model, model 4, we can say that jfuel costs – up and down are different, but in model 3 we cannot say it. So, we conclude that when there is no LCC in the market, then the asymmetric transmission is more prominent, but when there is a LCC, the asymmetry practically disappears. That's because the asymmetry is justified by market power, and the LCC erode the market power once they are a potential competition.

Another thing that we noted analyzing the results is that the jfuel costs – do stays around the mean value of jfuel costs, 0.1083 (model 4) and 0.1111 (model 3) are closer to 0.1093 (model 2) than the elasticities for jfuel costs – up, which are 0.1741 (model 4) and 0.1139 (model 3). So the jfuel costs – up rise more than proportionally to the mean value, especially when we consider that there is no LCC, and this is another way to show the asymmetric transmission of jet fuel costs.

Table 3 – Null test

Prob > F	Model 1	Model 2	Model 3	Model 4
	Jfuel Costs	Jfuel costs - do	Jfuel costs - do	Jfuel costs - do
Costs excl jfuel	0.8565	0.7264	-	-
Jfuel costs - up	-	-	0.3924	0.0183
Jfuel costs - up x LCC	-	-	-	0.7263

4. Robustness checks and limitations

The robustness check was obtained for the models 1, 2, 3 and 4 of this paper by analyzing the results with alternative estimators. The appendix presents tables 4, 5 and 6 containing the results for the empirical model using the estimators OLS, 2SLS and LIML, the estimator 2SGMM is the one used in the body of the article. According to Angrist and Pischke (2008), if we compare the results from 2SLS and LIML and they come out similar, then the instruments used can be accepted, that's because "LIML is less precise than 2SLS but also less biased" (p. 213). In all cases the estimated elasticity did not change significantly. The LIML assumes a strong hypothesis that the empirical model has i.i.d disturbances and the OLS is a biased estimation once that it does not treat endogenous variables, for those reasons we did not chose LIML or OLS estimator. Hahn et al. (2004) suggest that in the presence of weak instruments the LIML perform better than the 2SGMM; with all the tests performed and the results presented we chose the 2SGMM to present in the body of this article.

One of the limitations of this research is the data, once we were only able to get more precise data until June 2009. Another limitation is that we did an alteration in the variable costs and prices once that 1 real in 2002 didn't worth the same in 2009. We didn't analyzed exchange rate because the data was already in real. And the data collected did not informed us when the customer was travelling, so the average airfare included airfares to travel on the day collected or even months after that day.

The dataset does not bring booking and service class information, and according to Hofer et al. (2009) this can be a critical shortfall to the analysis of airfare. Future works could analyze the impact of the exchange rate, which would need a new variable representing that in the model, and could study other costs more deeply.

Conclusion

In summary, we analyzed the results of an empirical model that we proposed and we can conclude that the operational costs of an airline influences the airfares charged by them positively, this meaning that an increase in costs drives to more expensive airfares. And that there is an asymmetric fuel cost transmission.

This study also contributes the literature with: first a theoretical review of the relationship between fuel costs and airline pricing; second the analysis of the results in a supply problem. It also confirm Hofer et al. (2009) conclusion for the Brazilian domestic airline industry that financial distress leads to a price drop. And as stated by Hofer et al. (2008), the presence of low cost carriers in the market also leads to a price drop, and this is also valid in the Brazilian market.

An important result and contribution is related to the asymmetric transmission of jet fuel costs, when there is a fuel cost drop, the airfares will get cheaper, but this being not as expressive as they would with an increase, as stated by Peltzman (2000), "output prices tend to respond faster to input increase than to decreases" (p.466), and this was noted in the Brazilian airline industry. One of the explanations for that is that fuel hedge practice cited by Morrel and Swan (2006), maximization of profits, service quality improvement, etc. holds some of the airline capacity of dropping prices. And the asymmetry is more pronounced when there is no LCC in the route.

In other words, we answer the RQ proposed in the beginning of the paper. Is there an asymmetric fuel cost transmission to the airfares? In other words, if we compare the airfare during costs increase and during costs decrease, will they be asymmetrically transmitted? The answer for this is yes, there is an asymmetric fuel cost transmission to the airfares, the fare rises more rapidly in response to an increase in the oil price than it declines in response to a decrease in oil price.

The lack of booking and service class information on the dataset is a limitation of the model studied as well as the data availability only until June 2009 and the other costs analysis. Future works could improve other costs analysis, the FSC and the demand analysis in a supply problem, as well as the difference between LCC – young and mature.

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Appendix

Table 4 - Estimation results (OLS)[11]

	(1) M1 OLS	(2) M2 OLS	(3) M3 OLS	(4) M4 OLS
ln routehhi	0.0932*** [0.021]	0.0881*** [0.021]	0.0882*** [0.021]	0.0907*** [0.021]
ln max cityhhi	0.0247 [0.035]	0.0134 [0.035]	0.0141 [0.035]	0.0146 [0.035]
ln max routeshare	-0.0609*** [0.010]	-0.0599*** [0.010]	-0.0599*** [0.010]	-0.0593*** [0.010]
ln max cityshare	0.0316** [0.013]	0.0356*** [0.013]	0.0354*** [0.013]	0.0360*** [0.013]
ln av aircraft size	0.4788*** [0.038]	0.4549*** [0.039]	0.4551*** [0.039]	0.4560*** [0.039]
ln pdew	-0.1993*** [0.015]	-0.2130*** [0.015]	-0.2129*** [0.015]	-0.2152*** [0.015]
ln max pr connects	0.0271* [0.014]	0.0348** [0.014]	0.0343** [0.014]	0.0354** [0.014]
pres legacy	0.3281*** [0.011]	0.3473*** [0.012]	0.3482*** [0.012]	0.3518*** [0.012]
pres legacy bankr	-0.2150*** [0.014]	-0.2404*** [0.015]	-0.2402*** [0.015]	-0.2447*** [0.015]
pres FSC	0.0671*** [0.018]	0.0613*** [0.018]	0.0613*** [0.018]	0.0637*** [0.018]
pres LCC	-0.0427* [0.024]			
pres LCC - young		-0.0974*** [0.019]	-0.0968*** [0.019]	-0.1467*** [0.023]
pres LCC - mature		-0.0541*** [0.020]	-0.0540*** [0.020]	-0.1011*** [0.023]
ln costs excl jfuel	0.0818*** [0.016]	0.0789*** [0.016]	0.0797*** [0.016]	0.0813*** [0.016]
ln jfuel costs	0.1347*** [0.010]	0.1342*** [0.010]		
ln jfuel costs - up			0.1375*** [0.011]	0.1965*** [0.019]
ln jfuel costs - do			0.1348*** [0.010]	0.1348*** [0.010]
ln jfuel costs x LCC				-0.0606*** [0.016]
Adj_R2	0.7583	0.7596	0.7596	0.7602
RMSE	0.2381	0.2375	0.2375	0.2373
F	132.087	132.130	131.282	130.821
N_Obs	6594	6594	6594	6594

[11] Results produced by the ordinary least squares estimator (OLS); statistics robust to arbitrary heteroskedasticity and autocorrelation; figures are representative of the estimated elasticities calculated at the sample mean; P-value representations: ***p<0.01, ** p<0.05, * p<0.10.

Table 5 - Estimation results (2SLS)[12]

	(1) M1 2SLS	(2) M2 2SLS	(3) M3 2SLS	(4) M4 2SLS
ln routehhi	0.6912***	0.6430***	0.6432***	0.6598***
	[0.232]	[0.231]	[0.231]	[0.231]
ln max cityhhi	-0.4997	-0.3394	-0.3346	-0.3536
	[0.349]	[0.328]	[0.328]	[0.327]
ln max routeshare	-0.4962***	-0.4238**	-0.4250**	-0.4401***
	[0.192]	[0.165]	[0.166]	[0.166]
ln max cityshare	0.3735*	0.3883*	0.3881*	0.3908*
	[0.201]	[0.202]	[0.202]	[0.203]
ln av aircraft size	0.3225***	0.3123***	0.3121***	0.3148***
	[0.100]	[0.096]	[0.096]	[0.097]
ln pdew	0.0073	-0.0593	-0.0612	-0.0674
	[0.110]	[0.144]	[0.144]	[0.145]
ln max pr connects	0.0392	0.0545*	0.0545*	0.0550*
	[0.031]	[0.032]	[0.032]	[0.032]
pres legacy	0.3701***	0.4003***	0.4013***	0.4002***
	[0.055]	[0.048]	[0.048]	[0.048]
pres legacy bankr	-0.2471***	-0.2692***	-0.2693***	-0.2711***
	[0.046]	[0.045]	[0.045]	[0.045]
pres FSC	0.0571	0.0762	0.0760	0.0780
	[0.059]	[0.055]	[0.055]	[0.055]
pres LCC	-0.0766			
	[0.059]			
pres LCC - young		-0.0969***	-0.0966***	-0.1435***
		[0.036]	[0.036]	[0.035]
pres LCC - mature		-0.0808*	-0.0808*	-0.1251***
		[0.045]	[0.045]	[0.038]
ln costs excl jfuel	0.0984**	0.0883**	0.0889**	0.0920**
	[0.042]	[0.044]	[0.044]	[0.044]
ln jfuel costs	0.0969***	0.0989***		
	[0.036]	[0.035]		
ln jfuel costs - up			0.1016***	0.1626***
			[0.037]	[0.044]
ln jfuel costs - do			0.0994***	0.0986***
			[0.036]	[0.035]
ln jfuel costs x LCC				-0.0634**
				[0.029]
Adj_R2	0.6792	0.6985	0.6984	0.6960
RMSE	0.2747	0.2663	0.2664	0.2675
F	53.322	53.413	53.111	53.065
KP	34.9120	30.9947	30.4606	29.8653
KP_PValue	0.0000	0.0001	0.0002	0.0002
J	4.0752	5.5610	5.4587	5.1062
J_PValue	0.7711	0.5918	0.6042	0.6470
Weak_CD	5.6067	5.8435	5.9005	5.9037
Weak_KP	3.1900	3.0227	2.9671	2.9098
N_Obs	6476	6476	6476	6476

[12] Results produced by the two-stage least squares estimator (2SLS); statistics robust to arbitrary heteroskedasticity and autocorrelation; figures are representative of the estimated elasticities calculated at the sample mean; P-value representations: ***p<0.01, ** p<0.05, * p<0.10.

Table 6 - Estimation results (LIML)[13]

	(1) M1 LIML	(2) M2 LIML	(3) M3 LIML	(4) M4 LIML
ln routehhi	0.7303***	0.6790***	0.6788***	0.6946***
	[0.259]	[0.262]	[0.261]	[0.260]
ln max cityhhi	-0.5674	-0.3900	-0.3850	-0.4026
	[0.384]	[0.359]	[0.358]	[0.355]
ln max routeshare	-0.5526**	-0.4777**	-0.4778**	-0.4912**
	[0.225]	[0.195]	[0.194]	[0.193]
ln max cityshare	0.4195*	0.4453*	0.4439*	0.4443*
	[0.231]	[0.240]	[0.240]	[0.239]
ln av aircraft size	0.3243***	0.3124***	0.3121***	0.3146***
	[0.103]	[0.101]	[0.100]	[0.101]
ln pdew	0.0177	-0.0489	-0.0505	-0.0571
	[0.116]	[0.155]	[0.155]	[0.155]
ln max pr connects	0.0384	0.0545*	0.0544*	0.0549*
	[0.032]	[0.033]	[0.033]	[0.033]
pres legacy	0.3648***	0.3997***	0.4006***	0.3994***
	[0.061]	[0.053]	[0.053]	[0.052]
pres legacy bankr	-0.2466***	-0.2715***	-0.2715***	-0.2731***
	[0.050]	[0.050]	[0.050]	[0.050]
pres FSC	0.0497	0.0693	0.0693	0.0715
	[0.063]	[0.059]	[0.058]	[0.059]
pres LCC	-0.0850			
	[0.062]			
pres LCC - young		-0.0996***	-0.0993***	-0.1448***
		[0.037]	[0.037]	[0.037]
pres LCC - mature		-0.0850*	-0.0850*	-0.1279***
		[0.047]	[0.047]	[0.040]
ln costs excl jfuel	0.0980**	0.0862*	0.0869*	0.0900*
	[0.045]	[0.049]	[0.049]	[0.048]
ln jfuel costs	0.0948***	0.0969***		
	[0.036]	[0.036]		
ln jfuel costs - up			0.0993***	0.1586***
			[0.038]	[0.046]
ln jfuel costs - do			0.0974***	0.0966***
			[0.036]	[0.036]
ln jfuel costs x LCC				-0.0616**
				[0.029]
Adj_R2	0.6597	0.6815	0.6818	0.6795
RMSE	0.2829	0.2737	0.2736	0.2746
F	52.131	52.213	51.941	51.997
KP	34.9120	30.9947	30.4606	29.8653
KP_PValue	0.0000	0.0001	0.0002	0.0002
J	3.9697	5.4364	5.3390	5.0015
J_PValue	0.7833	0.6069	0.6187	0.6598
Weak_CD	5.6067	5.8435	5.9005	5.9037
Weak_KP	3.1900	3.0227	2.9671	2.9098
N_Obs	6476	6476	6476	6476

[13] Results produced by the limited-information maximum likelihood estimator (LIML); statistics robust to arbitrary heteroskedasticity and autocorrelation; figures are representative of the estimated elasticities calculated at the sample mean; P-value representations: ***p<0.01, ** p<0.05, * p<0.10.