Modeling Airline Competition in Markets with Legacy Regulation

- The case of the Chinese domestic markets

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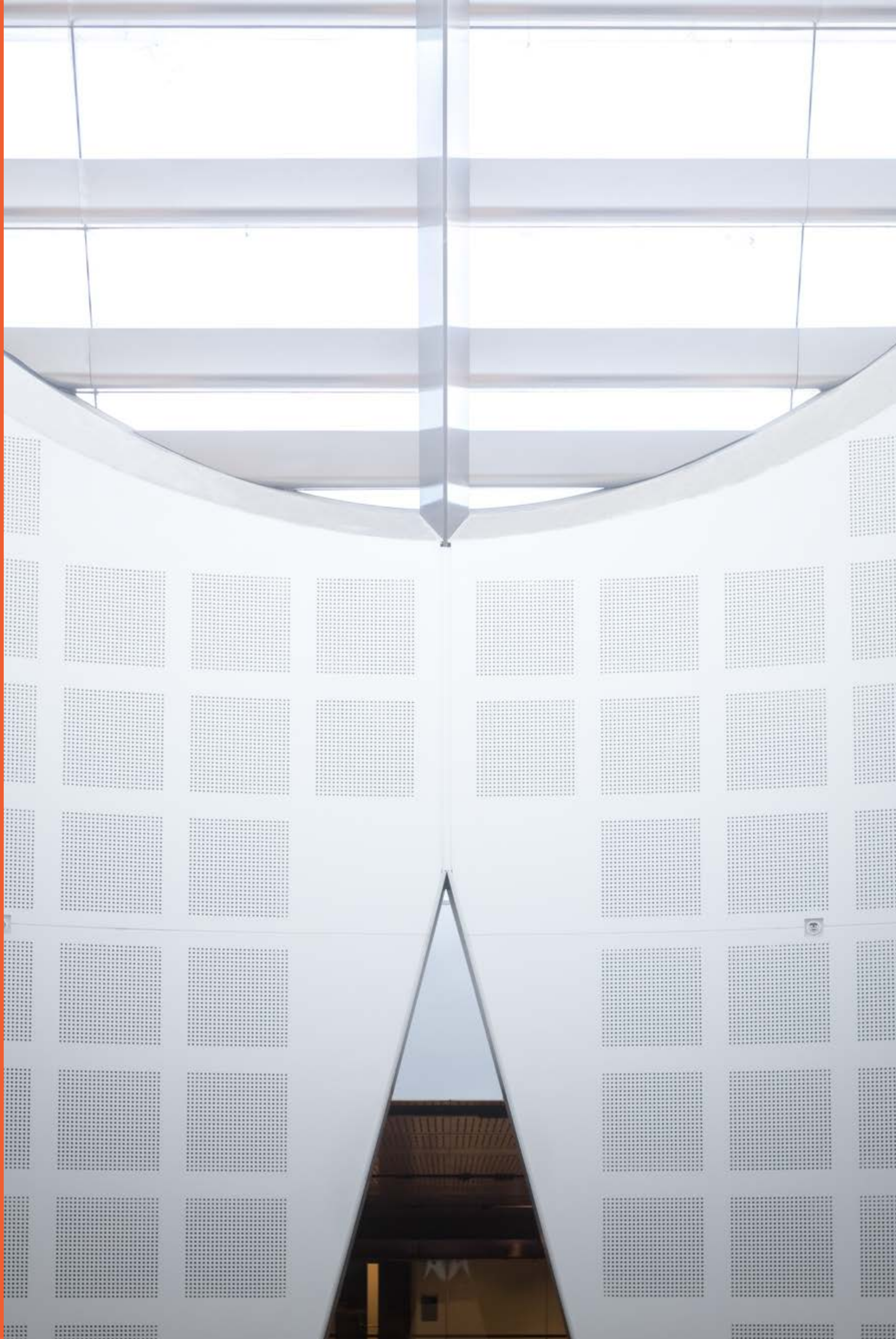


Introduction

- How do airlines compete?
  - *Cournot (Quantity), Bertrand (Price) or Collusive???*

- **Brander and Zhang (1990-RAND, 1993):**Seminal papers to find **Cournot behavior** on Chicago-based **duopoly** market by assuming **product homogeneity**.

- **BSC (2006), Berry and Jia (2010-AEJ)** model and estimate **price competition (Bertrand)** with **product differentiation** for the US aviation markets.

Introduction

- Both **Cournot** competition with **product homogeneity** and **Bertrand competition** with **product differentiation** are all for **deregulated aviation markets, like US.**

- **Directly applying the same assumption** in the **regulated aviation markets** to analyze airline competition can result in **biased** and **inconsistent estimations** !!!

- How to model and estimate airline competition in **regulated but fast growing aviation markets**, for example **China** ???

- **Innovative modeling** and **estimation method** should be proposed to analyze Chinese airlines competition behaviors.

Introduction

- Despite phenomenal growth, the Chinese market is still subject to **several restrictions.**

- Airlines were allowed to **freely set price** since year 2005, but **several restrictions** are still present **for route entry, capacity expansion, pilot recruitment *etc*, especially on major trunk markets.**

- **Regulation Rationale: to protect state-owned airlines and avoid price-wars (fierce competition).**

- **Regulations are mainly put on densest routes which are lucrative.**

Introduction

- We develop an **advanced BLP** (Berry, Levinsohn and Pakes, 1995, Econometrica) style structure model to incorporate the impact of government regulation on airline competition.
- We find the model considering **potential regulation effect on airline competition** produces **better competition estimation** for Chinese airline market.
- **Specifically, we have the following findings:**

  (1). There is strong evidence of **Collusive Pricing** among Chinese carriers on **densest airline markets**, which is subject to regulation of **route entry, capacity expansion and airport slot control**;

  (2). For the **other less important routes**, airlines compete **Freely in Price**.

Model Set Up

-Demand Side

The **demand model** is discrete choice model developed and adopted by BLP (1995-Econometrica), Berry and Jia (2010-AEJ), Yan and Winston (2014-AEJ)

$$u_{ijt} = x_{jt}\beta - \alpha p_{jt} + \xi_{jt} + \nu_{it}(\lambda) + \lambda\epsilon_{ijt}$$

Where

x_{jt} is a vector of observable product characters including route distance, airline brand, tourism destination, etc.

β is a vector of sensitivity of characters of the air passengers

α is the marginal disutility of a price increase for passenger

ξ_{jt} is the product characters which are unobservable for us researcher

λ is the nested logit parameter which is between 0 and 1, and ν_{jt} is nested logit error

Model Set Up

-Demand Side

We can derive the market share of product j in market t as follows,

$$s_{jt}(x_t, p_t, \xi_t, \theta_d) = \frac{e^{\frac{x_{jt}\beta - \alpha p_{jt} + \xi_{jt}}{\lambda}}}{D_t} \times \frac{D_t^{\lambda}}{1 + D_t^{\lambda}}$$

Inverting above function we can get the expression of ξ,

$$\xi_{jt} = s^{-1}(x_t, p_t, s_t, \theta_d).$$

$$\xi_{jt}^{M} = \xi_{jt}^{M-1} + \lambda\left[\ln s_{jt} - \ln s_{jt}(x_t, p_t, \xi_t, \theta_d)\right]$$

Model Set Up
-Demand Side

Then **GMM estimation approach** can be used by using the **Instrument variables** (IVs) satisfying the following mean-independence moment condition

$$E\left(h(z_t)\xi(x_t, p_t, s_t, \theta_d)\right) = 0$$

Where $h(z_t)$ is the function of IVs.

It should be noted the **Demand Side Moment Conditions** have already allowed us to consistently estimate the demand parameters β, regardless the **airline Competition Types** !!

Model Set Up

-Airline Competition

Bertrand Competition- **free price competition with product differentiation**: BCS (2006); Berry and Jia (2010)

$$\Pi_{ft} = \sum_{j=1}^{J_{ft}} (p_{jt} - mc_{jt}) M_t s_{jt}(p_t, x_t, \xi_t; \theta_d) - FC_{ft}$$

Airline's decision variable is the ticket price p_{jt}, we get the FOC as

$$s_{jt}(p_t, x_t, \xi_t; \theta_d) + \sum_{r \in J_{ft}} (p_{rt} - mc_{rt}) \frac{\partial s_{rt}(p_t, x_t, \xi_t; \theta_d)}{\partial p_{jt}} = 0$$

$$s_t(p_t) - \Omega_t(p_t - mc_t) = 0,$$

$$mc_t = w_t \psi + \omega_t$$

$$\omega_t = p_t - \Omega_t^{-1} s_t(p_t) - w_t \psi$$

$$E\left(g(z_t)\omega_t\left(x_t, p_t, s_t; \theta_{d,} \psi\right)\right) = 0$$

Model Set Up

-Airline Competition

Cournot Competition- free quantity competition with product differentiation **(no research done)**

$$p_{jt} = \frac{1}{\alpha}\left[x_{jt}\beta + \xi_{jt} + (\lambda - 1)\log\left(\frac{s_t}{s_0}\right) - \lambda\log(s_{jt}) + \lambda log(s_0)\right]$$

↓

$$\Pi_{ft} = \sum_{j=1}^{J_{ft}}\left(p_{jt}(s_t, x_t, \xi_t; \theta_d) - mc_{jt}\right)M_t s_{jt} - FC_{ft}$$

Airline's decision variable is the market share s_{it}

$$mc_t = w_t\psi + \omega_t$$

$$\omega_t = p_t - \Omega_t^{-1}s_t(p_t) - w_t\psi$$

$$E\left(g(z_t)\omega_t\left(x_t, p_t, s_t; \theta_{d,}\psi\right)\right) = 0$$

Model Set Up

-Airline Competition

Weighted-Profit Model

$$\underset{p_{jt}}{\text{Max}} \ \Pi_{ft} = \sum_{j=1}^{J_{ft}} (p_{jt} - mc_{jt}) M_t s_{jt}(p_t, x_t, \xi_t; \theta_d) - FC_{ft}$$

$$\text{s.t.} \quad Q_{f^-t}(p_t - mc_t) - F_{f^-t} \geq \underline{\Pi}_{f^-t},$$

Airline's decision variable is the ticket price p_{it}, but under the constraint

$$\underset{p_{jt}, \Phi}{\text{Max}} \ \Pi_{ft} = \sum_{j=1}^{J_{ft}} (p_{jt} - mc_{jt}) M_t s_{jt}(p_t, x_t, \xi_t; \theta_d) - FC_{ft}$$

$$+ \left\{ Q_{f^-t}(p_t - mc_t) - F_{f^-t} - \underline{\Pi}_{f^-t} \right\}' \Phi$$

$$= \sum_{j=1}^{J_{ft}} (p_{jt} - mc_{jt}) M_t s_{jt}(p_t, x_t, \xi_t; \theta_d) - FC_{ft}$$

$$+ \sum_{g \neq f} \left\{ \phi_g \left[\sum_{i=1}^{J_{gt}} (p_{it} - mc_{it}) M_t s_{it}(p_t, x_t, \xi_t; \theta_d) - FC_{gt} \right] \right\}$$

- $\boldsymbol{\phi_1}$ **- top 25% densest markets**
- $\boldsymbol{\phi_2}$ **- top 25-50% densest markets**
- $\boldsymbol{\phi_3}$ **- top 50-75% densest markets**
- $\boldsymbol{\phi_4}$ **- other markets**

Joint Estimation (Both Demand and Airline Competition moments)

Table 4. BLP Joint Estimation of Demand and Marginal Cost Functions

Demand Variables	Bertrand Model	Cournot Model	Weighted Profit Model
Fare	-1.2605***	-1.4533***	-0.9232***
	(0.0545)	(0.0554)	(0.0560)
Connection	-1.3205***	-1.34715***	-1.3331***
	(0.0175)	(0.01675)	(0.01705)
Constant	-10.8620***	-10.7260***	-10.8290***
	(0.1113)	(0.1099)	(0.1078)
No. Destination	0.1548***	0.2060***	0.1081***
	(0.0443)	(0.0431)	(0.0436)
No. Departure	0.0275***	0.0269***	0.0286***
	(0.0012)	(0.0012)	(0.0012)
Distance	1.9977***	2.1280***	1.7554***
	(0.1000)	(0.1011)	(0.0992)
Distance_squared	-0.4189***	-0.4230***	-0.4065***
	(0.0306)	(0.0309)	(0.0300)
Tour	0.9326***	0.8264***	0.8811***
	(0.0503)	(0.0499)	(0.0501)
Slot_control	-0.5181***	-0.5004***	-0.5183***
	(0.0358)	(0.0356)	(0.0350)
Income	0.0549***	0.0508***	0.0527***
	(0.0019)	(0.0018)	(0.0019)

Cost Variables			
Constant_short	-0.7253***	-0.9119***	-1.0354***
	(0.0463)	(0.0510)	(0.0734)
Distance_short	0.6685***	0.6689***	0.6637***
	(0.0075)	(0.0075)	(0.0076)
Connection_short	-0.0504***	-0.0346***	-0.0500***
	(0.0043)	(0.0044)	(0.0053)
Constant_long	0.1959	0.0832	-0.0380
	(0.1565)	(0.1618)	(0.1781)
Distance_long	0.2392***	0.2097***	0.2233***
	(0.0538)	(0.0546)	(0.0570)
Connection_long	-0.0269	-0.0096	-0.0530***
	(0.0229)	(0.0233)	(0.0252)
Hub	-0.0704***	-0.1316***	-0.0574***
	(0.0163)	(0.0163)	(0.0180)
Slot_control	0.0048	0.0129*	-0.0021
	(0.0088)	(0.0088)	(0.0096)
ϕ_1			0.4489***
			(0.2127)
ϕ_2			0.0487
			(0.3450)
ϕ_3			0.3497
			(0.4409)
ϕ_4			0.4592
			(0.4292)

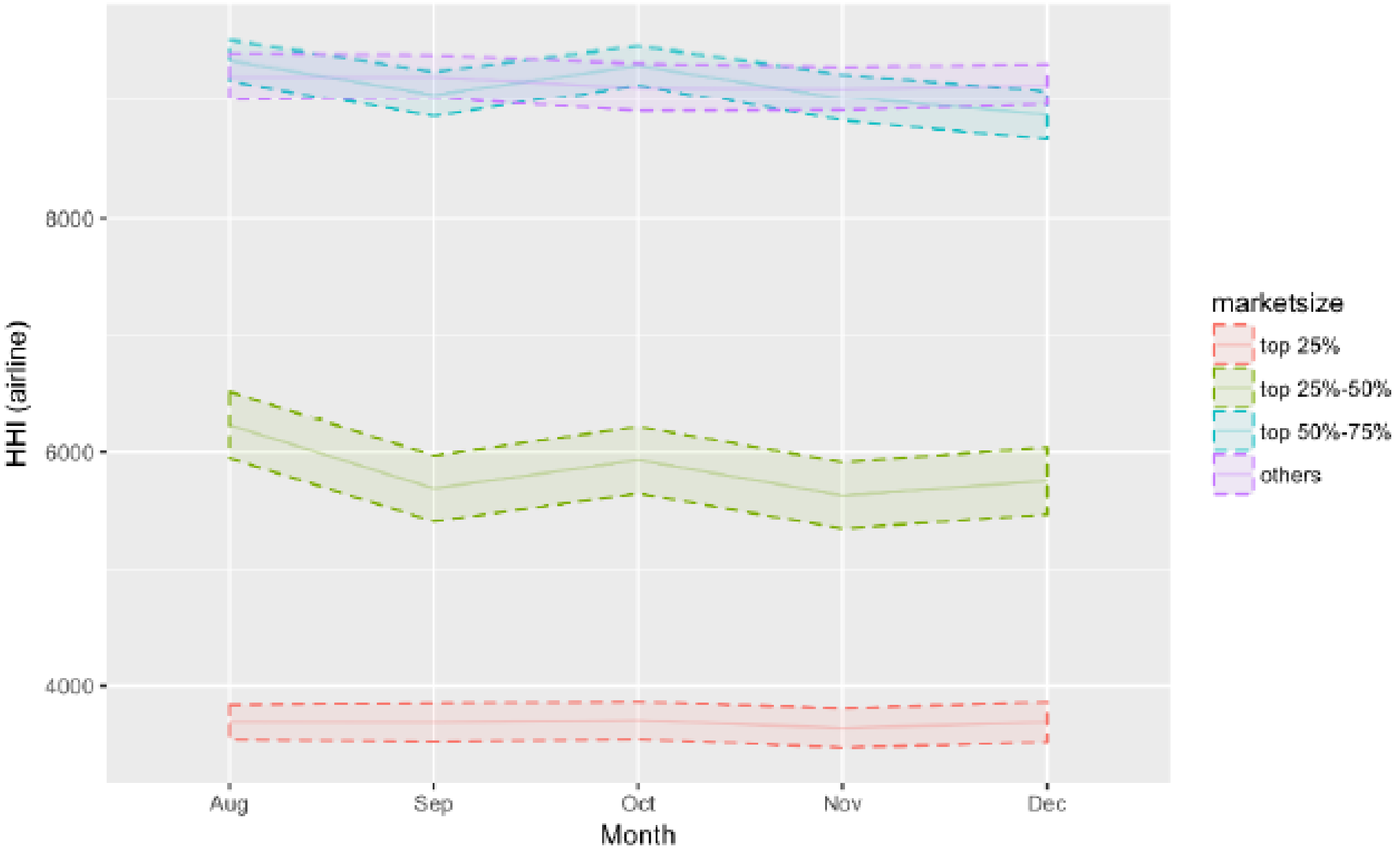


Figure 3. Average route-level airline HHI for different density markets from August to December of 2010

Table 5. Estimated Airline Profit Margin and Demand Elasticity of the Three Competition Conducts

Profit Margin	**Bertrand Model**	**Cournot Model**	**Weighted Profit Model**	**Berry and Jia (2010)**
Overall	0.484	0.621	0.660	0.60
Direct Flight	0.531	0.677	0.712	0.66
Connecting Flight	0.377	0.503	0.561	0.56
CA	0.405	0.547	0.592	
MU	0.462	0.599	0.648	
CZ	0.487	0.612	0.650	
HU	0.497	0.634	0.687	
FM	0.461	0.61	0.674	
ZH	0.473	0.632	0.666	
MF	0.509	0.664	0.697	
SC	0.523	0.677	0.712	
Top 25% market			0.684	
25%-50% market			0.644	
50%-75% market			0.628	
other market			0.661	
Price Elasticity	**Bertrand Model**	**Cournot Model**	**Weighted Profit Model**	**Demand Side (BLP)**
Market Aggregate	-1.5113	-1.7405	-1.1092	-1.022

Counterfactual

What will be the price if the price collusion on the **top 25%** routes is removed? Free price competition in the densest routes?

Bertrand competition equilibrium FOC,

$$(p_t - mc_t) = \Omega_t^{-1} s_t(p_t).$$

⇓

$$p_t = \Omega_t^{-1}(p_t) s_t(p_t; x_t, \xi_t, \theta_d) + mc_t(\omega_t, w_t, \psi).$$

⇓

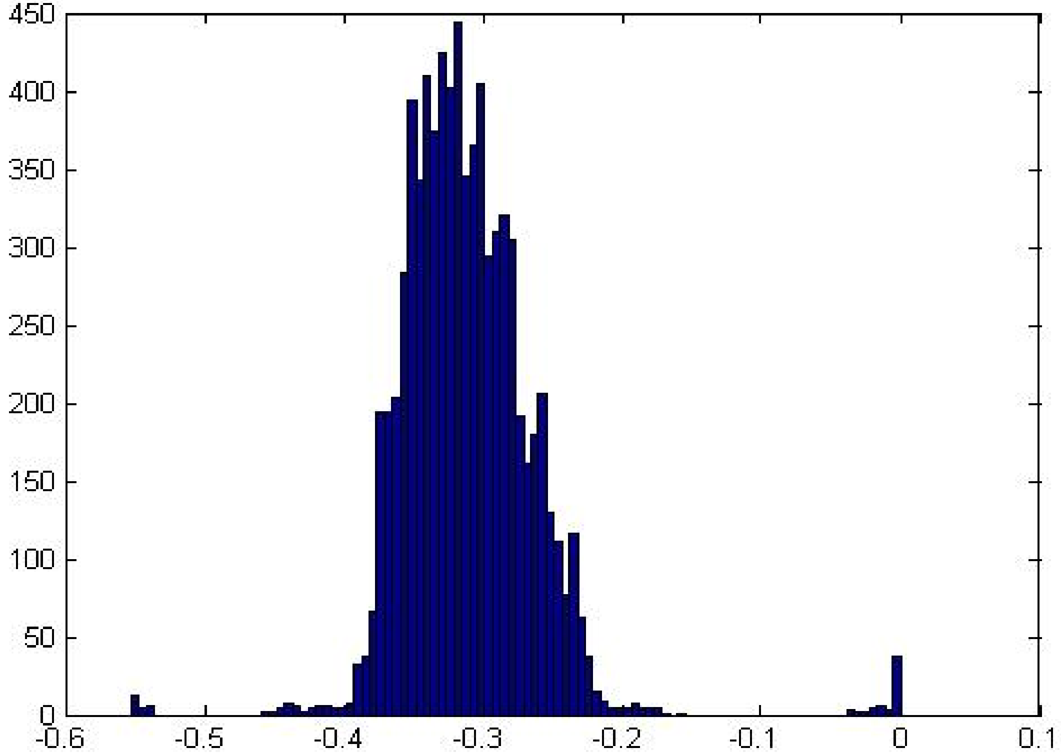
$$p_t^M = \Omega_t^{-1}(p_t^{M-1}) s_t(p_t^{M-1}; x_t, \xi_t, \theta_d) + mc_t(\omega_t, w_t, \psi)$$

Fixed Point Iteration

New Market Equilibrium

Counterfactual

Price reduces by **30 USD** by removing the Price Collusion on the top 25% routes (Average price in these market is 130 USD)



Take-Aways

(1). There is strong evidence of **Collusive Pricing** among Chinese carriers on **densest airline markets**, which is subject to effective **regulation of route entry, capacity expansion and airport slot control;**

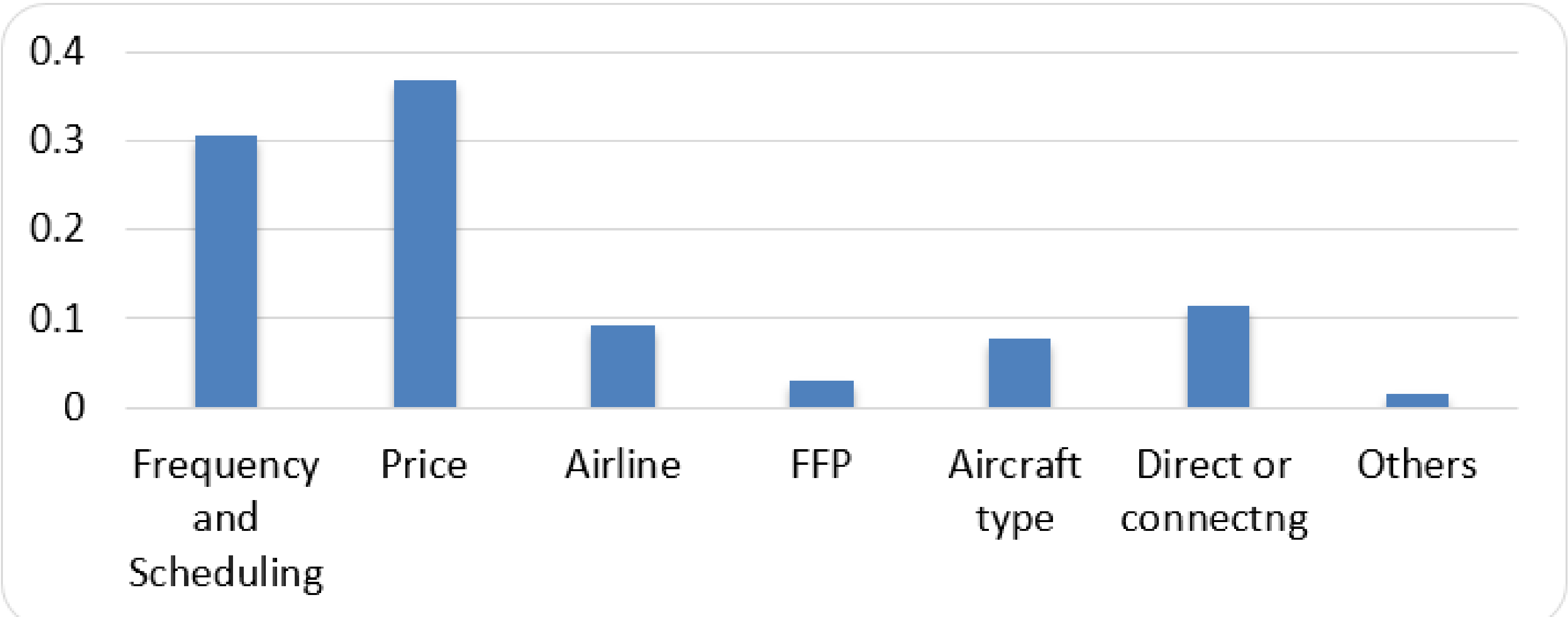
(2). On the **less dense markets**, airlines compete **Freely in Price**

Thank you for listening.

Questions?

Data

- **IATA PaxIS (Global Distribution System)**
  - Airline specific and route level: Ticket price, traffic volume
- **OAG (Official Airline Guide)**
  - Airline flight frequency data
- **Data Period: Aug 2010-Dec 2010**
- **Chinese domestic routes**
- **Total 18,349 observations**
- An observation is defined as a unique combination of **directional city pair**, **airline, and directional/connecting flight**



Source: CAMIC report 2010.

Note: the percent represents the frequency of the factor is expressed as the most important factor when the surveyed

Table 6. Yield comparison between Chinese and US airlines from accounting data

(a) Average yield for different categorized Chinese domestic routes (USD/Kilometer)

Route Category	2008-Q4	2009-Q1	2009-Q2	2009-Q3	2009-Q4	2010-Q1	2010-Q2
Top 1- Top 50	0.096	0.101	0.101	0.118	0.111	0.109	0.122
Top 51- Top 150	0.098	0.105	0.104	0.117	0.110	0.110	0.117
others	0.117	0.119	0.119	0.130	0.124	0.124	0.130
All	0.114	0.117	0.116	0.128	0.122	0.122	0.128

Note: The yield is calculated by dividing ticket price by flying distance. The fare data is from PaxIS; Flying distance is from OAG. The data are for Air China, China Eastern and China Southern airlines only.

(b) Average yield for US Carriers (USD/kilometer)

Airline Group	2008-Q4	2009-Q1	2009-Q2	2009-Q3	2009-Q4
Regional	0.121	0.117	0.103	0.098	0.104
Low-Cost	0.084	0.075	0.071	0.071	0.078
Network	0.083	0.075	0.068	0.070	0.075
21-Carrier Total	0.085	0.077	0.071	0.071	0.078

Source: Wang *et al* (2014)

Demand Estimation (only demand moments)

Table 2. Demand Function Estimation and Robust Test with IV and OLS Demand Estimation

Demand Variables	BLP	IV Logit	OLS Logit
Fare	-0.8501***	-0.7555***	0.0559**
	(0.0808)	(0.0591)	(0.0222)
Connection	-1.2957***	-1.4284***	-1.3315***
	(0.0187)	(0.0114)	(0.0104)
Constant	-11.0717***	-9.1751***	-9.541***
	(0.1141)	(0.0573)	(0.0526)
No. Destination	0.1223***	0.2921***	0.2846***
	(0.0494)	(0.0467)	(0.0433)
No. Departure	0.0281***	0.0267***	0.0387***
	(0.0014)	(0.0016)	(0.0014)
Distance	1.7262***	0.8753***	0.1326***
	(0.1192)	(0.072)	(0.0512)
Distance_squared	-0.4147***	-0.1444***	-0.0613***
	(0.0332)	(0.0169)	(0.0149)
Tour	0.9873	0.4355***	0.4616***
	(0.0521)	(0.0396)	(0.0368)

Slot_control	-0.5276***	-0.1706***	-0.0371*
	(0.0370)	(0.0231)	(0.0214)
Income	0.0579***	0.0222***	0.0245***
	(0.0020)	(0.0006)	(0.0005)
γ	0.6431	0.748***	0.6215***
	(0.0102)	(0.0525)	(0.0040)
Carrier Dummy			
OT	0.0065		
	(0.0782)		
CA	0.2981***	0.2103***	-0.2143***
	(0.0817)	(0.0492)	(0.0452)
MU	0.3609***	0.2095***	0.0488
	(0.0759)	(0.0410)	(0.0381)
CZ	0.4719***	0.3323***	0.0729*
	(0.0770)	(0.0405)	(0.0374)
HU	0.3082***	0.3443***	0.3362***
	(0.0813)	(0.0487)	(0.0454)
FM	0.2691***	0.2033***	0.0352
	(0.0830)	(0.0517)	(0.0479)
ZH	0.1876***	0.3089***	0.1386***
	(0.0832)	(0.0479)	(0.0444)
MF	0.3556***	0.0951*	-0.0425
	(0.1310)	(0.0494)	(0.0457)
No. of Obs	18,349	18,349	18,349

Table 3. Median Price Elasticity and Willingness to Pay for Product Attributes

	BLP	IV Logit	Berry and Jia (2010)	Yan and Winston (2014)	Brons et al. (2002)
Median price elasticity	-1.022	-0.9083	-1.55	-1.54	-1.146
Willingness to pay (US$)					
Additional weekly flight frequency	3.31	3.53	6.75	2.28	
Additional one destination valuation	0.14	0.38	1.17	0.20	