Modelling the Pass-Through of Airline Operating Costs on Average Fares in the Global Aviation Market

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Introduction

Background:

- A growing concern: contribution of aviation emissions to climate change
  - ☐ **Aviation emissions:** projected to increase from **2 – 3%**[1] total energy-related emissions to **up to 22% by 2050**[2], driven by strong growth in demand

- Increasing costs for airlines to emit:
  - ☐ EU Emissions Trading Scheme since 2012
  - ☐ ICAO's market-based carbon offsetting program CORSIA in 2021
  - ☐ Airport emissions-related charges

  - ☐ Costs of introducing advanced technologies in mitigating aircraft CO_2 emissions

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1. Schäfer, et al. (2016), Schäfer and Waitz (2014)

2. European Parliament (2015)

Introduction

Questions to be addressed in this research:

- What are the potential pricing responses of airlines to increased operating costs?
- To what extent would the increased costs be passed onto passengers through airfares?
- How does the airline cost pass-through behavior vary across different world regions?

Existing Research Gaps

- Airline pricing literature:
    - Biased focus on the **U.S. domestic market**
    - Regions where aviation emissions to grow most rapidly have rarely been studied, such as the Asia-Pacific market
- Airline operating costs have not been explicitly captured in any of the previous research
    - **Proxy variables** are commonly used: distance, fuel price, and aircraft size, etc.
- Little empirical evidence on airline cost pass-through under competition:
    - Heavily rely on **scenario-based, pre-specified** cost pass-through rates (Lu, 2009; Hofer, et al, 2010; Meleo, 2014; Meleo, et al., 2016)
    - Cost pass-through has not been assessed with rigorous measurement to market competition (PWC, 2005; Koopmans and Lieshout, 2016)

AIM2015 Airfare Model

- A regression-based airfare model that
  - Explicitly captures **itinerary-specific airline operating cost**
  - Includes **demand-, competition-**, and **route-specific features**
  - Estimated for a number of world regions
  - Allows comparison of airline cost pass-through rates within and across different airline markets

- A core component of an open source aviation systems model: **Aviation Integrated Model 2015** (Dray, et al., 2017, this conference)

- **Rich datasets** supported, with a **global coverage**:
  - Sabre: airfares, passenger flows, schedules, itinerary-specific features
  - FlightGlobal: fleet data, aircraft types
  - RDC database: airport landing charges, en-route charges
  - Segment costs input from AIM2015 Direct Operating Cost Model (Al Zayat, et al. 2017, this conference)

Empirical Model

- Model Overview Formulation

$$(Fare)_{mkn} = f(Cost_{mkn}, Demand_{mkn}, Competition_{mkn}, CountryFE_{OD})$$

☐ *m, n, k* denote origin airport, destination airport, and connecting airport(s), respectively; *O* and *D* denote origin country and destination country, respectively.

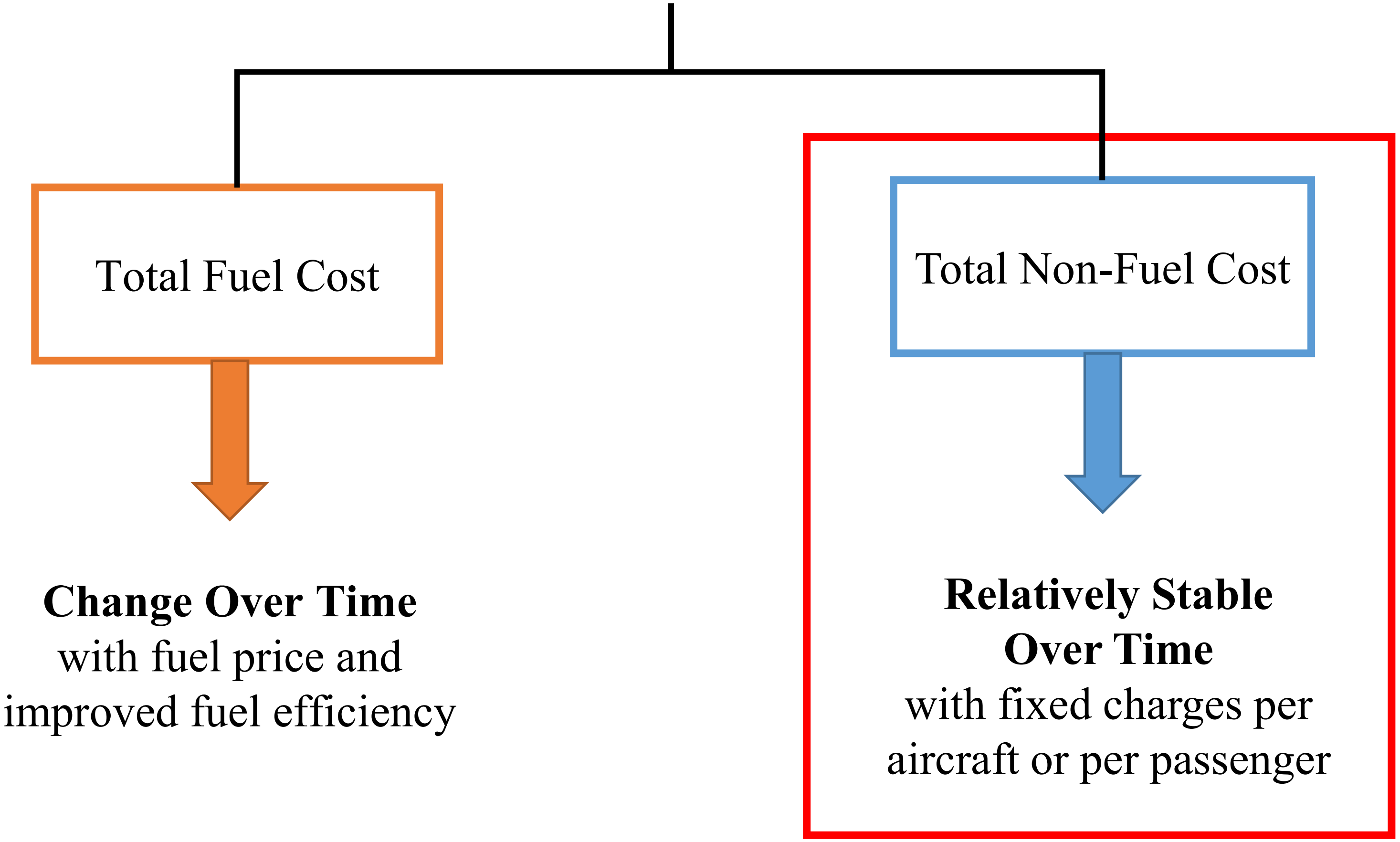
- Model Specification

$$\begin{aligned}\ln(Fare)_{mn} = \beta_0 &+ \beta_1 \ln(FuelCostPerPax)_{mn} + \beta_2 \ln(NonFuelCostPerPax)_{mn} \\ &+ \beta_3 \ln(NonFuelCostPerFlt)_{mn} + \beta_4 \ln(LegMeanHHI)_{mn} + \beta_5 \ln(AirportMeanHHI)_{mn} \\ &+ \beta_6 \ln(CUIMean)_{mn} + \beta_7 \ln(Freq)_{mn} + \beta_8 \ln(Pax)_{mn} + \beta_9 \ln(LoadFactor)_{mn} \\ &+ \beta_{10}(RouteShare)_{mn} + \beta_{11}(Nlegs)_{mn} + \beta_{12}(HubsPass)_{m,n,k} + \beta_{13}(OriginCountry) \\ &+ \beta_{14}(DestCountry) + \varepsilon_{mn}\end{aligned}$$

☐ *m, n, k* denote origin airport, destination airport, and connecting airport(s), respectively.

Operating Cost Variables

Total Operating Cost by Segment



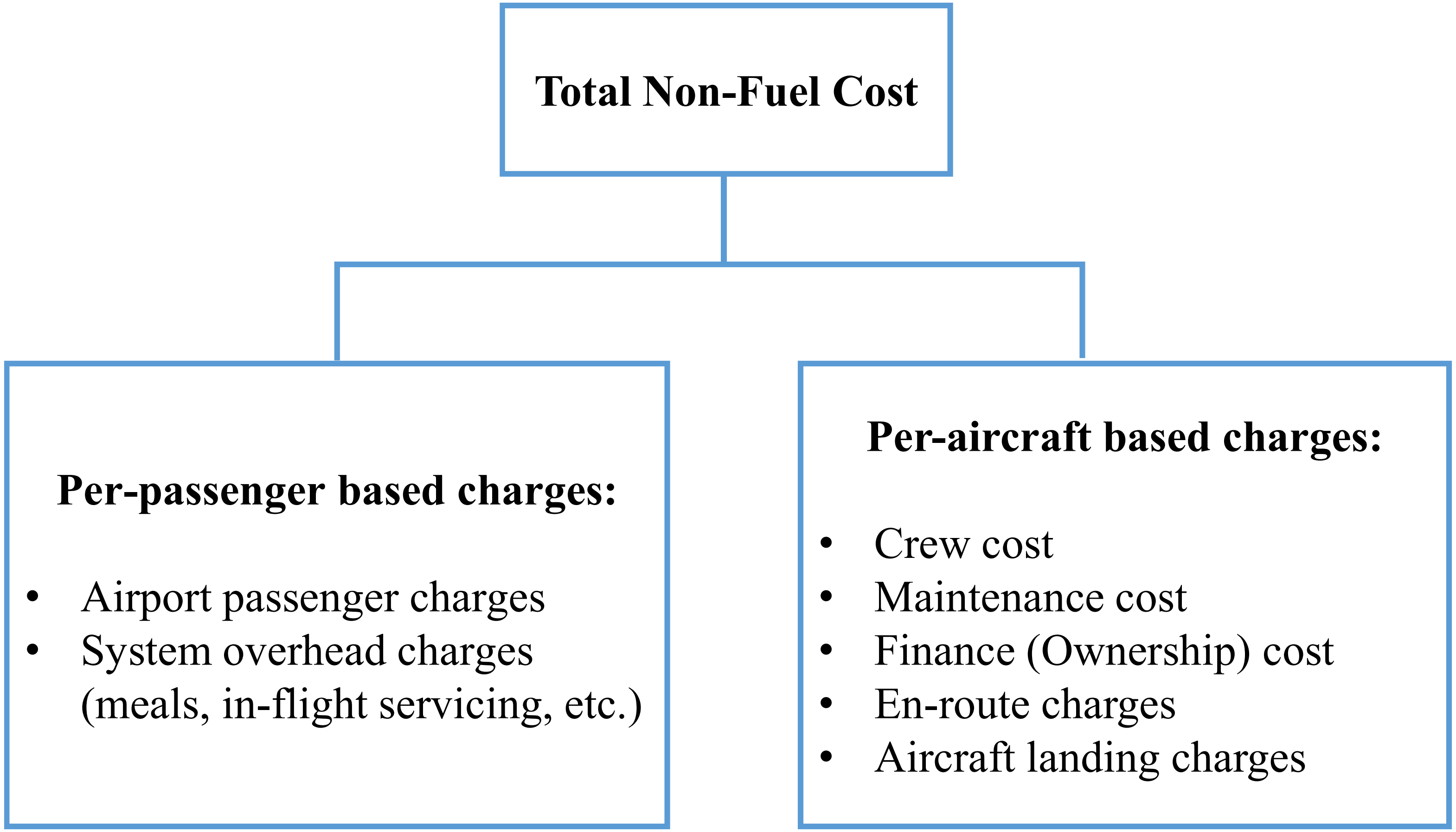
Total Fuel Cost

Change Over Time
with fuel price and
improved fuel efficiency

Total Non-Fuel Cost

Relatively Stable
Over Time
with fixed charges per
aircraft or per passenger

Operating Cost Variables



Total Non-Fuel Cost

Per-passenger based charges:

- Airport passenger charges
- System overhead charges (meals, in-flight servicing, etc.)

Per-aircraft based charges:

- Crew cost
- Maintenance cost
- Finance (Ownership) cost
- En-route charges
- Aircraft landing charges

Operating Cost Variables

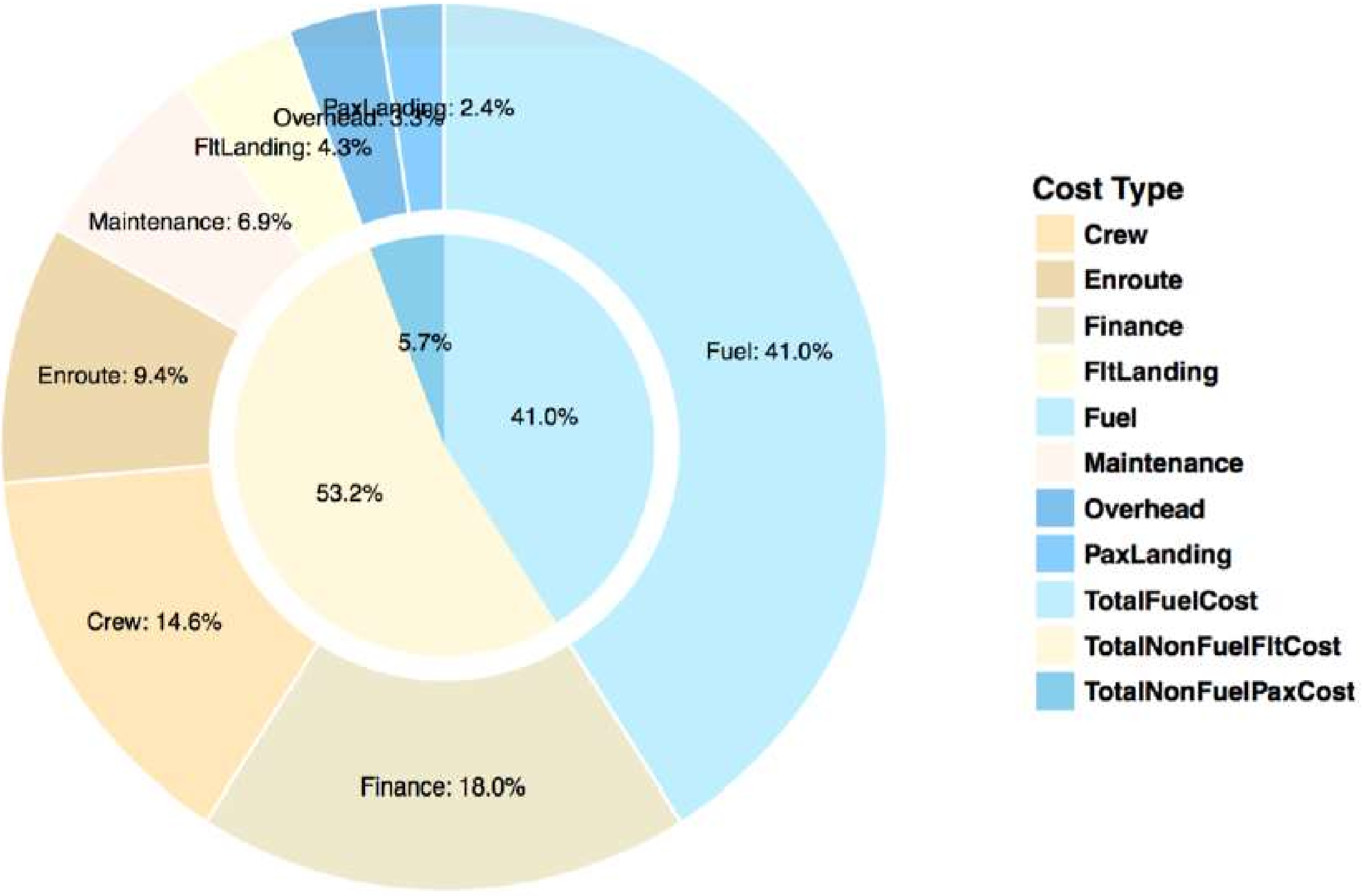
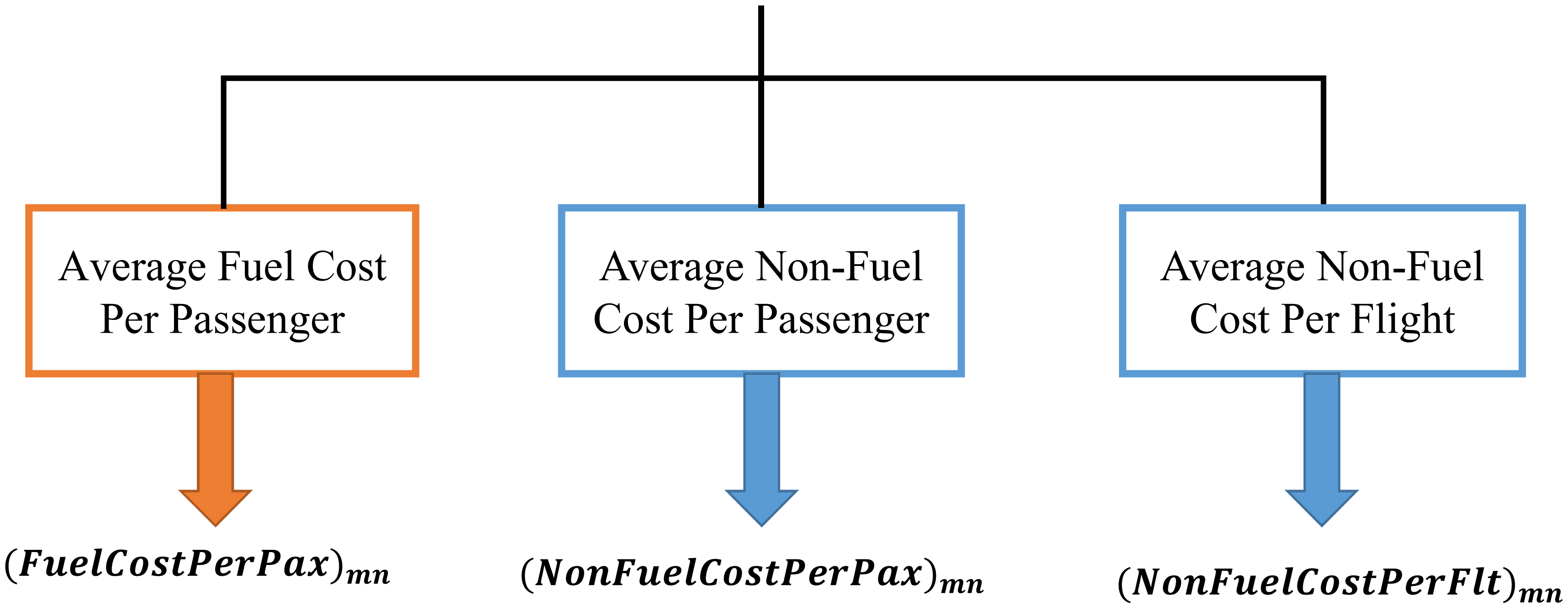


Figure 1
Flight Segment Total Operating Cost Structure Example: LHR-PEK

Operating Cost Variables

Average Operating Cost by Itinerary

(sum of each cost type over all segments on the itinerary)



Average Fuel Cost Per Passenger

Average Non-Fuel Cost Per Passenger

Average Non-Fuel Cost Per Flight

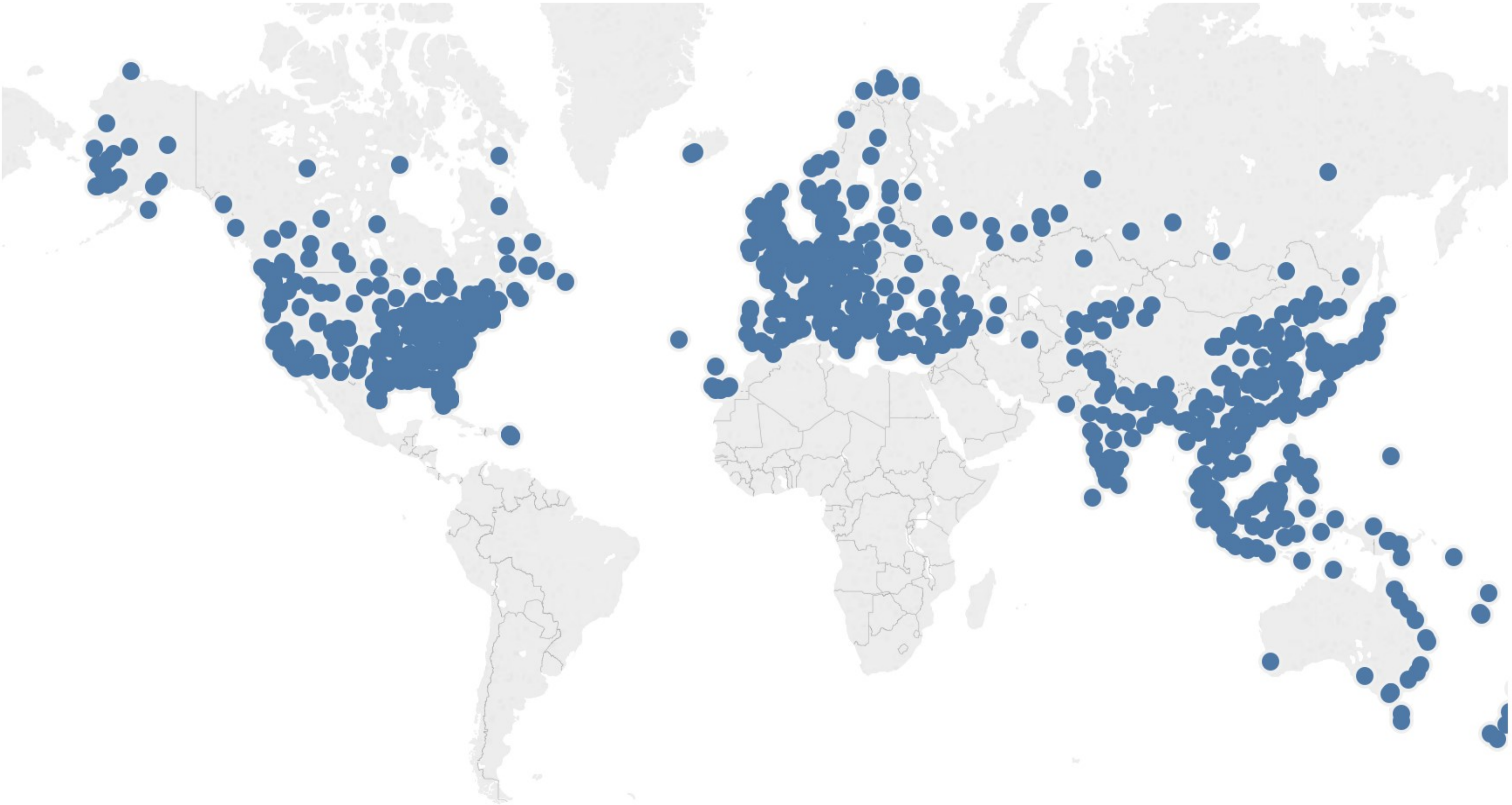
$(\boldsymbol{FuelCostPerPax})_{mn}$

$(\boldsymbol{NonFuelCostPerPax})_{mn}$

$(\boldsymbol{NonFuelCostPerFlt})_{mn}$

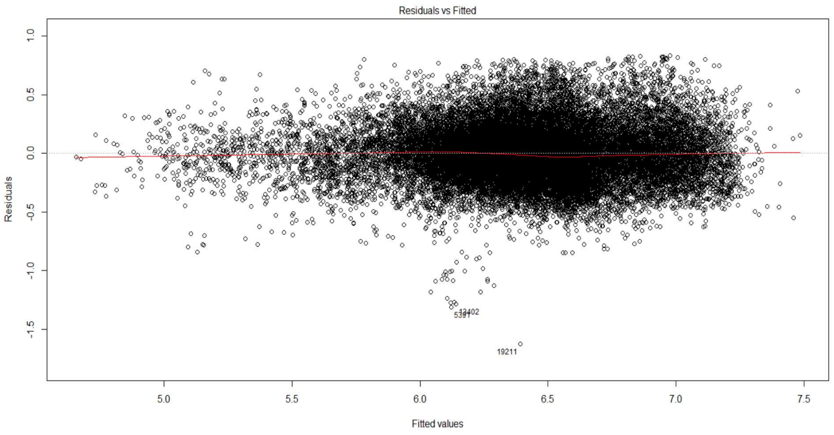
Model Estimation

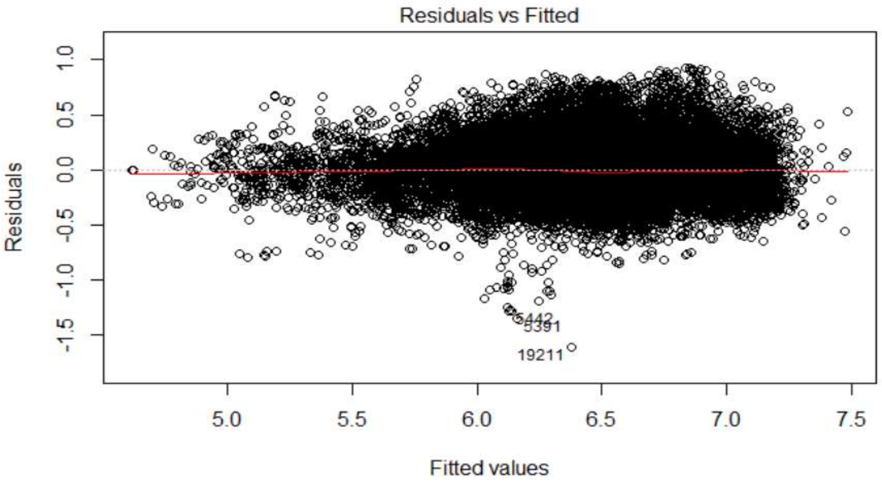
- Estimated for **four regional markets** with the largest RPK: **NA-NA, EU-EU, AP-AP, AP-EU**, accounting for **62.7% of global RPK** in 2015.



Estimation Methodology

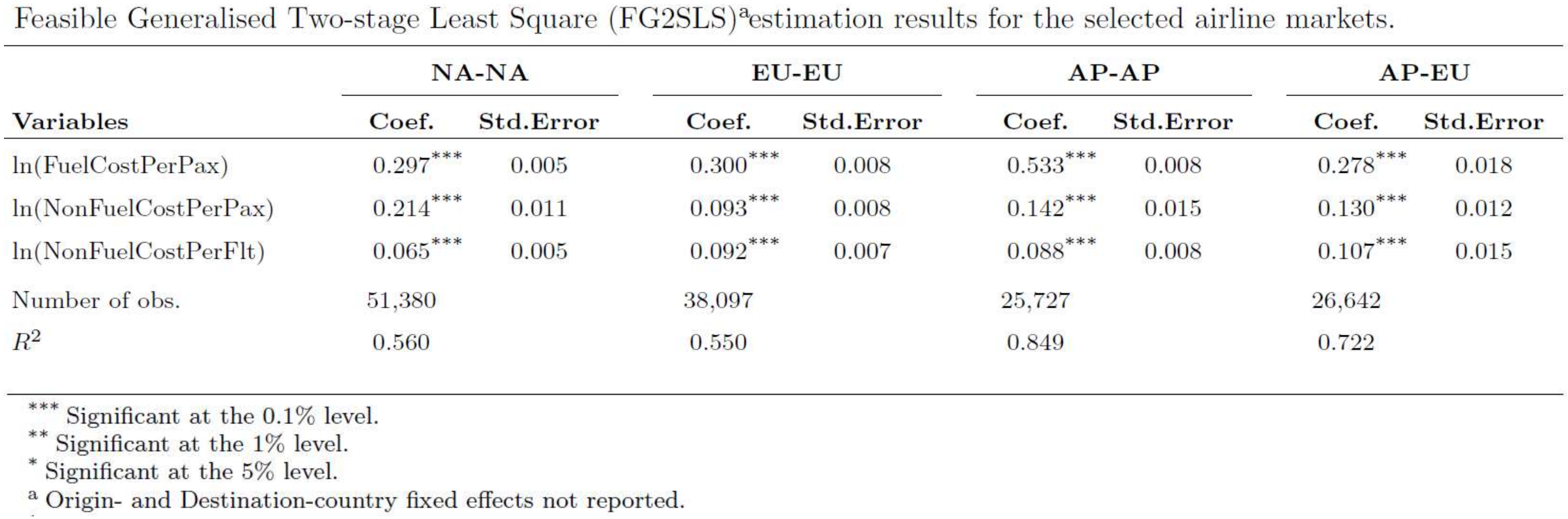
- Endogeneity bias in the model:
  - ❑ Demand-related variables are jointly determined with airfares.
- To address the endogeneity bias, instrumental variables (IVs) are introduced for four endogenous variables:
  - ❑ *Passengers, LegMeanHHI, AirportMeanHHI, RouteShare*
- Heteroscedasticity in the model: if detected, invalid standard errors and *t*-statistics





- The model is estimated using a feasible generalized two-stage least squares (FG2SLS) procedure to correct for the heteroscedastiticy and endogeneity issue.

Estimation Results



Feasible Generalised Two-stage Least Square (FG2SLS)[a]estimation results for the selected airline markets.

	NA-NA		EU-EU		AP-AP		AP-EU	
Variables	Coef.	Std.Error	Coef.	Std.Error	Coef.	Std.Error	Coef.	Std.Error
ln(FuelCostPerPax)	0.297^{***}	0.005	0.300^{***}	0.008	0.533^{***}	0.008	0.278^{***}	0.018
ln(NonFuelCostPerPax)	0.214^{***}	0.011	0.093^{***}	0.008	0.142^{***}	0.015	0.130^{***}	0.012
ln(NonFuelCostPerFlt)	0.065^{***}	0.005	0.092^{***}	0.007	0.088^{***}	0.008	0.107^{***}	0.015
Number of obs.	51,380		38,097		25,727		26,642	
R^2	0.560		0.550		0.849		0.722	

*** Significant at the 0.1% level.
** Significant at the 1% level.
* Significant at the 5% level.
[a] Origin- and Destination-country fixed effects not reported.

Taking into account the standard errors, the conditional mean of fare elasticities with respect to each cost type are (with 95% confidence intervals):

	NA-NA	EU-EU	AP-AP	AP-EU
FuelCostPerPax	0.29-0.31	0.28-0.32	0.52-0.55	0.25-0.30
NonFuelCostPerPax	0.19-0.23	0.08-0.11	0.11-0.16	0.11-0.15
NonFuelCostPerFlt	0.06-0.07	0.08-0.11	0.07-0.10	0.08-0.13

Discussion

1) Variance of cost pass-through within each region

	NA-NA	**EU-EU**	**AP-AP**	**AP-EU**
FuelCostPerPax	0.29-0.31	0.28-0.32	0.52-0.55	0.25-0.30
NonFuelCostPerPax	0.19-0.23	0.08-0.11	0.11-0.16	0.11-0.15
NonFuelCostPerFlt	0.06-0.07	0.08-0.11	0.07-0.10	0.08-0.13

Coefficients interpretation:

- ☐ The effect of increasing fuel cost on fares significantly outweigh the effects of increasing nonfuel costs by a same percentage.
- ☐ Airlines are the most responsive to fuel cost changes in all the selected markets.
- ☐ Increases in nonfuel passenger cost have larger impact on airfares than nonfuel flight cost, expect EU-EU.

Discussion

1) Variance of cost pass-through within each region

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FuelCostPerPax	0.29-0.31	0.28-0.32	0.52-0.55	0.25-0.30
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Implications to market-based emissions reduction policies:

- ☐ Emissions reduction policies that can result in fuel cost increase, such as fuel taxes, have the greatest impact on passengers.
- ☐ Such policies may discourage demand the most.
- ☐ A relatively moderate option is to increase airline's nonfuel per flight cost, such as en-route charges and aircraft landing charges, where airlines pass the least cost onto passengers.

Discussion

2) Variance of cost pass-through between different regions

	NA-NA	EU-EU	AP-AP	AP-EU
FuelCostPerPax	0.29-0.31	0.28-0.32	0.52-0.55	0.25-0.30
NonFuelCostPerPax	0.19-0.23	0.08-0.11	0.11-0.16	0.11-0.15
NonFuelCostPerFlt	0.06-0.07	0.08-0.11	0.07-0.10	0.08-0.13

Coefficients interpretation:

- ☐ Airfares in AP-AP are the most elastic to fuel cost changes than the other three regions, while AP-EU shows only about half of this effect. Pass-through rates in NA-NA and EU-EU are not statistically significantly different.
- ☐ Changes in nonfuel per passenger cost in NA-NA have an effect more than twice that of EU-EU, whereas AP-AP and AP-EU have almost statistically identical coefficients for nonfuel per passenger cost.
- ☐ Fare elasticities to nonfuel per flight cost show relatively less variation across different markets.

Discussion

2) Variance of cost pass-through between different regions

	NA-NA	EU-EU	AP-AP	AP-EU
FuelCostPerPax	0.29-0.31	0.28-0.32	0.52-0.55	0.25-0.30
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NonFuelCostPerFlt	0.06-0.07	0.08-0.11	0.07-0.10	0.08-0.13

Implications to market-based emissions reduction policies:

- ☐ Policies like fuel taxes will make passengers in AP-AP face higher fare increases than passengers in any other market under the study.
- ☐ Such policies would be considered a more aggressive option in AP-AP than in other regional markets.
- ☐ The lowest variation of cost pass-through rates in the per-flight cost suggests that MBMs aiming to increase this cost will bring relatively balanced price increases across different regions, and thus is most likely to be accepted by the global aviation community.

Conclusion

- Fills existing gaps in empirical evidence on airline cost pass-through across world regions.
- Evaluates potential impacts of aviation emissions reduction policies on passengers in different markets.
- Key take-aways:
  - ❑ Airlines tend to pass higher proportion of fuel cost burden onto passengers, **especially in AP-AP**, than that of non-fuel per passenger and per flight costs.
  - ❑ Passengers in **AP-AP market** will be affected the most for this study by policies that increase airline fuel cost.
  - ❑ The lowest variation of airline cost pass-through rates in **per flight cost** across different markets suggests a higher feasibility of adopting MBMs that affect flight-based operating costs at a global scale.

Air Transportation Systems Lab: www.ATSlab.org

Thanks!
Q&A Time

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