

MODELLING AIRLINE COST PASS-THROUGH WITHIN REGIONAL AVIATION MARKETS

Bojun Wang, Aidan O'Sullivan, Lynnette Dray, Andreas Schäfer

Air Transportation Systems Laboratory, UCL Energy Institute,
University College London

97st TRB Annual Meeting
Washington DC., 7-11 Jan 2018

EPSRC

Engineering and Physical Sciences
Research Council



**Dr. Andreas W.
Schäfer**

Professor of Energy
and Transport



**Dr. Aidan
O'Sullivan**

Lecturer in Statistics



Dr. Lynnette Dray

Senior Research
Associate



**Dr. Maria
Kamargianni**

Lecturer in Transport
and Energy & Head,



**Dr. Anna
Mavrogianni**



Dr. Khan Doyme

Research Associate



Bojun Wang

Doctoral Researcher



Kinan Zayat

Doctoral Researcher

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 ETS since 2012



ICAO CORSIA in 2021



Airport emissions charges



Costs of advanced tech

+



Fuel & Oil costs

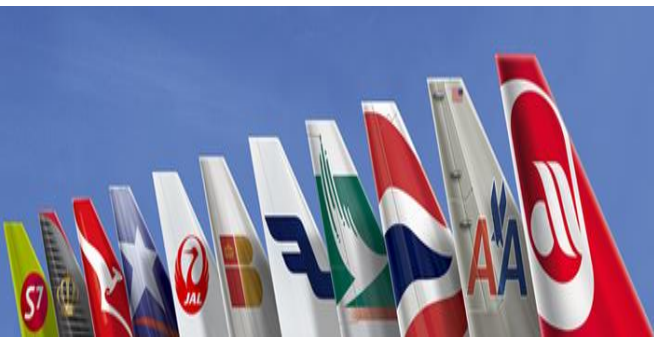


Crew costs

...

Questions to be addressed in this research:

- 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?
- What are the potential pricing responses of airlines to increased fuel costs due to market-based emissions reduction policies?

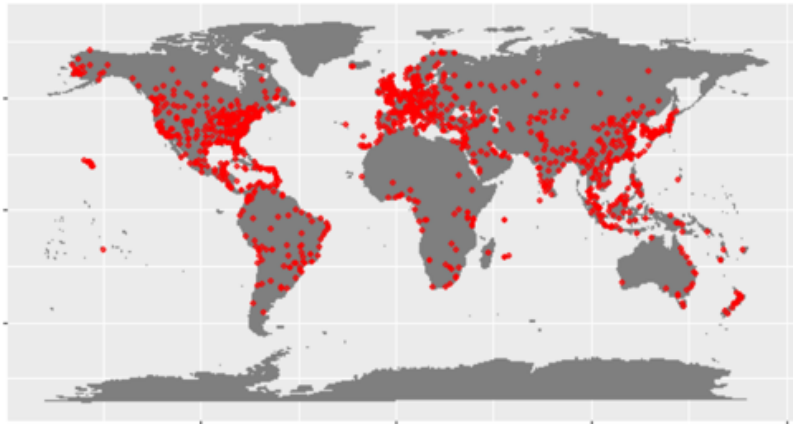


- 1) **Airline pricing** literature:
 - Biased focus on the U.S. domestic market
 - Regions where aviation emissions to grow most rapidly have rarely been studied, such as the Asia-Pacific market
- 2) **Airline operating costs** not explicitly captured in existing fare models
 - Proxy variables** are commonly used: distance, fuel price, and aircraft size, etc.
- 3) 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:

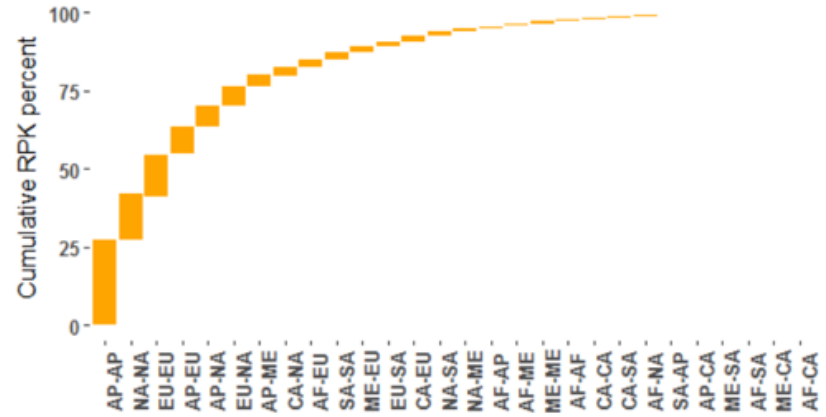
- ❑ Explicitly captures **itinerary-specific airline operating costs** that allows the estimation of airline cost pass-through
- ❑ Includes **demand-, competition-, and route-specific features**
- ❑ Estimated for a number of world regions
- ❑ Allows comparison of airline cost pass-through within and across different airline markets
- ❑ Allows estimation of potential pricing responses of airlines to market-based emissions reduction policies such as CORSIA.
- ❑ A core component of an open source aviation systems model: **Aviation Integrated Model 2015** (Dray, L., 2017, this conference)

Global coverage of the datasets



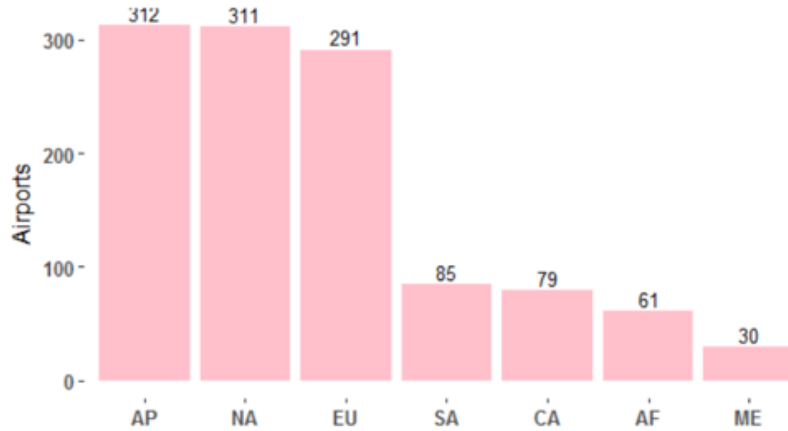
(a)

Global RPK percentage by regional markets



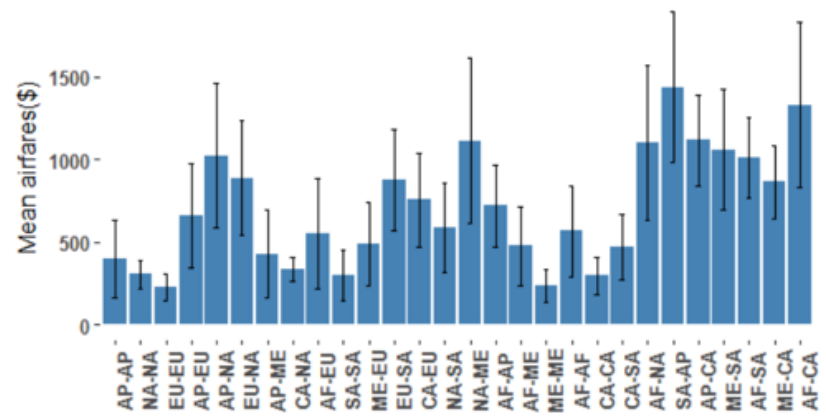
(b)

Number of airports by region



(c)

Mean airfare with standard deviation by regional markets



(d)

NOTE: NA=North America, CA=Central America, SA=South America, EU=Europe, ME=Middle East, AF=Africa, AP=Asia and Pacific

□ Model Overview Formulation

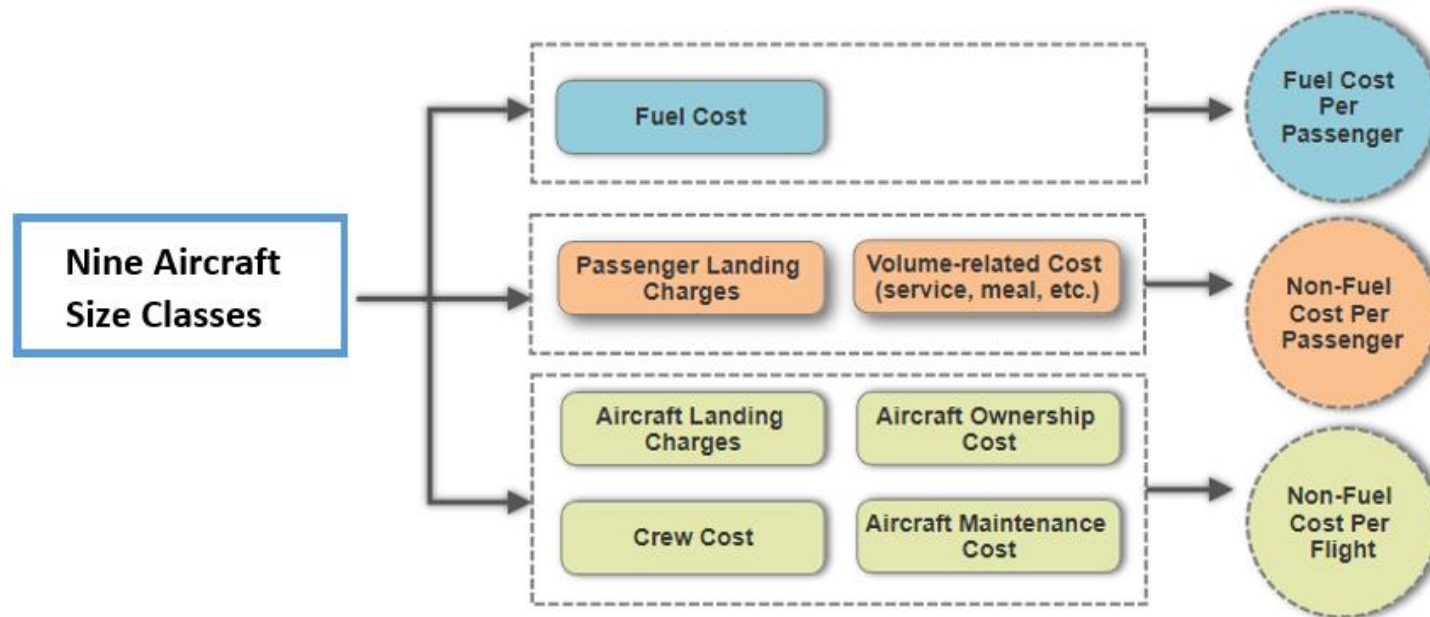
$$(Fare)_{mkn} = f(Cost_{mkn}, Demand_{mkn}, Competition_{mkn}, CountryFE_{OD})$$

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

$$\begin{aligned} \ln(Fare)_{mkn} = & \beta_0 + \beta_1 \ln(FuelCostPerPax)_{mkn} + \beta_2 \ln(NonFuelCostPerPax)_{mkn} \\ & + \beta_3 \ln(NonFuelCostPerFlt)_{mkn} + \beta_4 \ln(Freq)_{mkn} + \beta_5 \ln(Pax)_{mkn} \\ & + \beta_6 \ln(RouteShare)_{mkn} + \beta_7 \ln(CUIMean)_{mkn} + \beta_8 \ln(LegMeanHHI)_{mkn} \\ & + \beta_9 \ln(AirportMeanHHI)_{mkn} + \beta_{10} (Nlegs)_{mkn} + \beta_{11} (HubsPass)_{mkn} \\ & + \sum_{O=2,3,4\dots} \delta_O OriginCountry_O + \sum_{D=2,3,4\dots} \theta_D DestCountry_D + \varepsilon_{mkn} \end{aligned}$$

m, n, k denote origin airport, destination airport, and connecting airport(s), respectively,
and ε is the random error.



□ Itinerary-specific costs computation:

$$(FuelCostPerPax)_{mkn} = \sum_{l \in Legs} \frac{\sum_{f,l} FuelC_{f,l} Freq_{f,l}}{Pax_l} \quad \forall Legs \in mkn$$

$$(NonFuelCostPerPax)_{mkn} = \sum_{l \in Legs} \frac{\sum_{f,l} (PaxLndC + VolC)_{f,l} Pax_{f,l}}{Pax_l} \quad \forall Legs \in mkn$$

$$(NonFuelCostPerFlt)_{mkn} = \sum_{l \in Legs} \frac{\sum_{f,l} (FltLndC + CrewC + MtnC + OwnC)_{f,l} Freq_{f,l}}{Freq_l} \quad \forall Legs \in mkn$$

Overall Model Performance Statistics:

	AP-AP	NA-NA	EU-EU	SA-SA	ME-ME
Obs.	29,830	70,429	43,263	3,519	626
<i>Adj. R²</i>	0.854	0.574	0.532	0.859	0.864
	AF-AF	CA-CA	AP-EU	AP-NA	EU-NA
Obs.	2,802	2,190	12,313	6,302	11,193
<i>Adj. R²</i>	0.838	0.838	0.798	0.567	0.52
	AP-ME	NA-CA	EU-AF	EU-ME	EU-SA
Obs.	3,579	8,487	4,496	3,286	2,623
<i>Adj. R²</i>	0.865	0.534	0.877	0.775	0.662
	EU-CA	NA-SA	NA-ME	AP-AF	AF-ME
Obs.	1,754	2,366	1,399	1,910	1,093
<i>Adj. R²</i>	0.654	0.7	0.651	0.866	0.938

- ❑ Adjusted R-squared statistics range from 0.520 to 0.938.
- ❑ 50 airline costs coefficient estimates out of 60 across the 20 markets are significant.

	Intra-regional	Inter-regional
Costs Elastic (<i>elasticity</i> ≥ 0.25)	AP-AP (0.29-0.31) SA-SA (0.20-0.28) EU-EU (0.23-0.25)	AP-EU (0.31-0.37) EU-SA (0.25-0.39) CA-NA (0.21-0.25) EU-NA (0.18-0.25)
Costs Less Elastic (<i>elasticity</i> < 0.25 <i>but significant</i>)	AF-AF (0.19-0.23) NA-NA (0.19-0.21) CA-CA (0.14-0.20)	NA-SA (0.12-0.24) AP-NA (0.11-0.21) AF-EU (0.11-0.19) CA-EU (0.08-0.20) EU-ME (0.07-0.17) AF-AP (0.01-0.10)
Costs Inelastic (<i>not significant</i>)	ME-ME (Not significant)	AP-ME (Not significant) NA-ME (Not significant) AF-ME (Not significant)

- ❑ AP-AP and AP-EU are the most responsive markets to fuel costs changes.
- ❑ Impacts of fuel costs to fares are relatively close among all markets, expect the ME-related ones.
- ❑ Increases in fuel costs do not have an airfare impacts in the majority ME-related markets, due to cheaper fuel costs for the Gulf flag carriers (O'Connell, 2011).

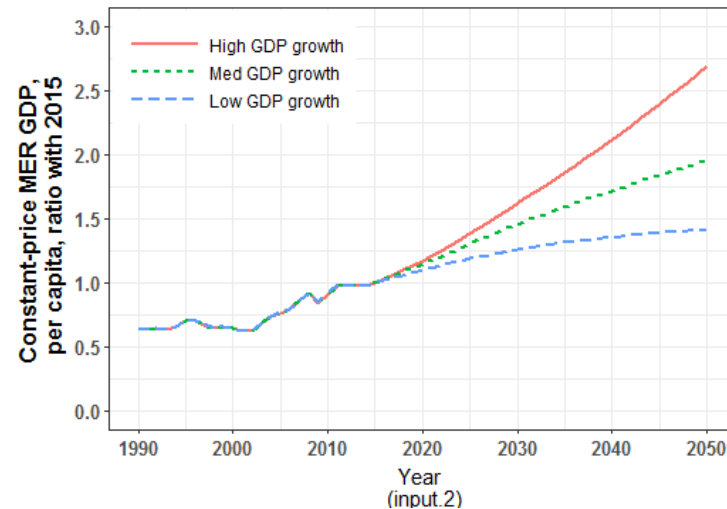
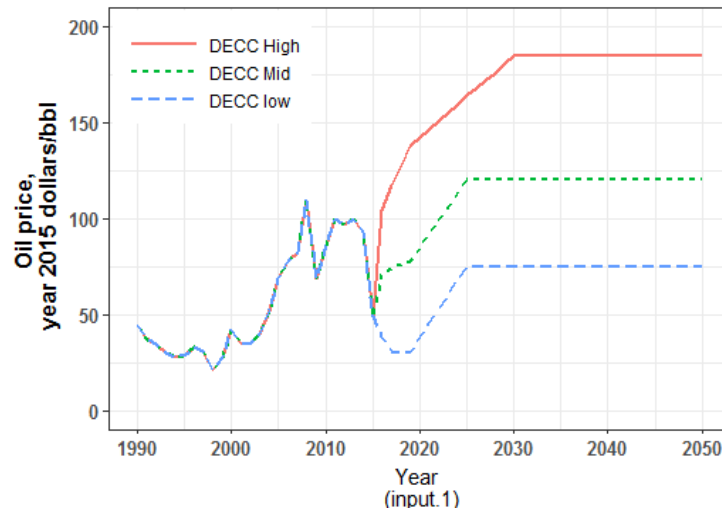
	Intra-regional	Inter-regional
<i>Costs Elastic</i> (<i>elasticity</i> ≥ 0.25)	ME-ME (0.55-0.77)	AF-ME (0.36-0.45)
	SA-SA (0.32-0.40)	AF-AP (0.33-0.41)
	AF-AF (0.24-0.30)	EU-ME (0.29-0.38)
	AP-AP (0.20-0.25)	NA-ME (0.20-0.45)
		CA-EU (0.12-0.24)
		NA-SA (0.22-0.34)
		AP-NA (0.22-0.33)
		AP-ME (0.24-0.30)
		AF-EU (0.22-0.29)
		EU-SA (0.15-0.30)
<i>Costs Less Elastic</i> (<i>elasticity</i> < 0.25 <i>but significant</i>)	CA-CA (0.14-0.19)	EU-NA (0.13-0.21)
	NA-NA (0.15-0.16)	AP-EU (0.08-0.14)
	EU-EU (0.15-0.16)	CA-NA (0.06-0.09)
<i>Costs Inelastic</i>	None	None

- ❑ Sharply contrasting with the result in fuel costs, ME-related markets top the cost-elastic markets to non-fuel flight costs changes.
- ❑ Policy interventions in increasing non-fuel flight costs will impact all markets.
- ❑ Elasticities of NA-NA and EU-EU are not statistically significantly different.

	Intra-regional	Inter-regional
<i>Costs Elastic</i> <i>(elasticity ≥ 0.25)</i>	SA-SA (0.48-0.68) AF-AF (0.20-0.36)	AP-NA (0.23-0.28)
<i>Costs Less Elastic</i> <i>(elasticity < 0.25 but significant)</i>	AP-AP (0.13-0.18) NA-NA (0.14-0.17) EU-EU (0.06-0.08)	AP-EU (0.16-0.21) AF-EU (0.12-0.21) EU-ME (0.29-0.38) EU-SA (0.10-0.20) EU-ME (0.07-0.18) NA-ME (0.04-0.19) AP-AF (0.03-0.19) NA-EU (0.05-0.11) CA-NA (0.04-0.11)
<i>Costs Inelastic</i> <i>(not significant)</i>	ME-ME (Not significant) CA-CA (Not significant)	AP-ME (Not significant) CA-EU (Not significant) NA-SA (Not significant) AF-ME (Not significant)

- ❑ Passenger costs have the smaller impacts than the other two costs types, and with 6 out of 10 total insignificant estimates.
- ❑ Potentially because: a) passenger costs have the smallest weights in airline total costs; b) firm-level costs are less passed onto passengers (RBB, 2014).

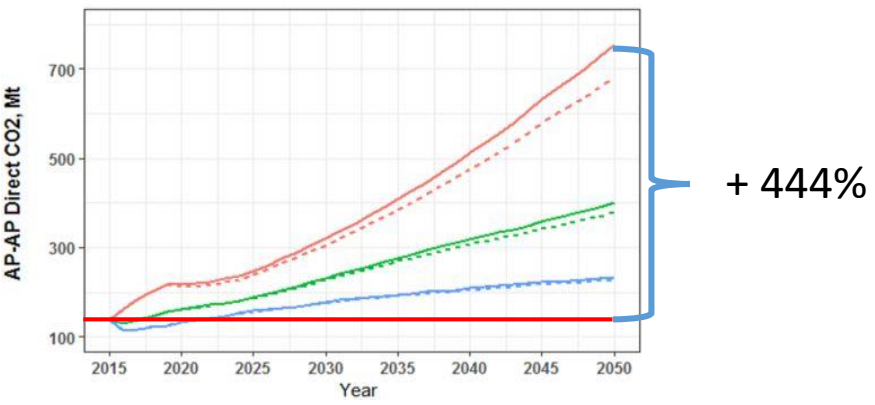
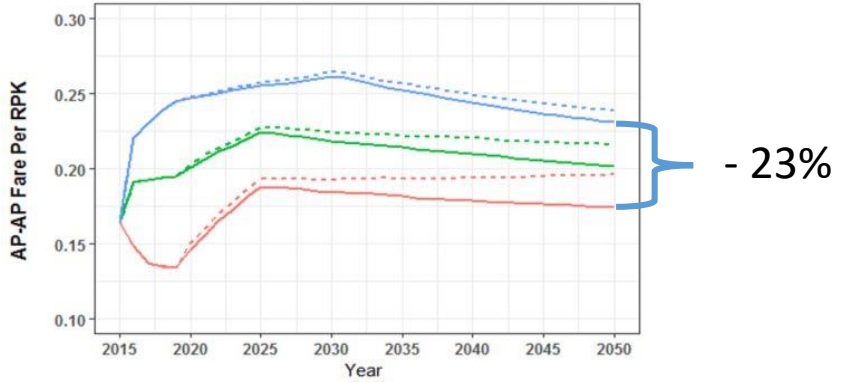
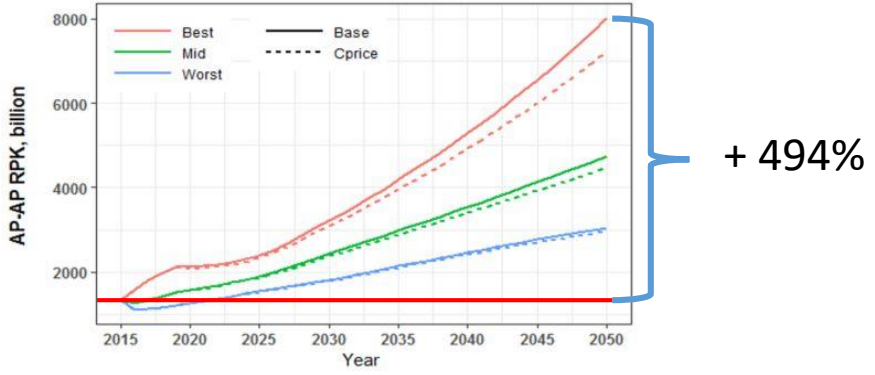
- Using AIM2015, we assessed the potential impacts of a carbon tax policy on demand, airfares, and CO₂, based on the estimated cost pass-through elasticities.



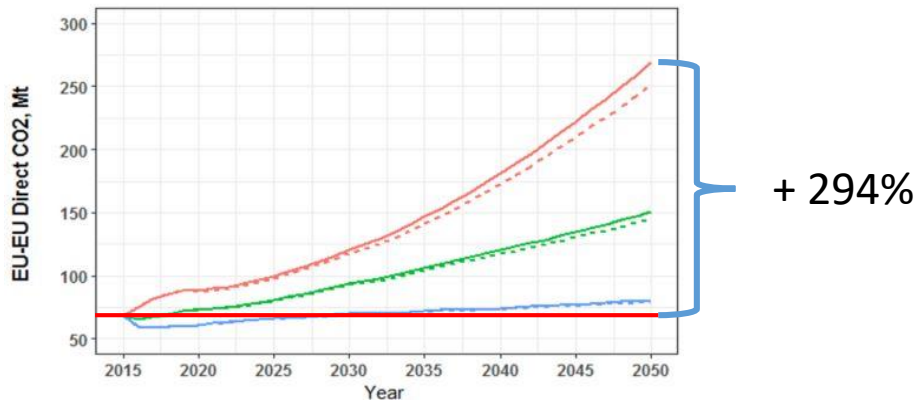
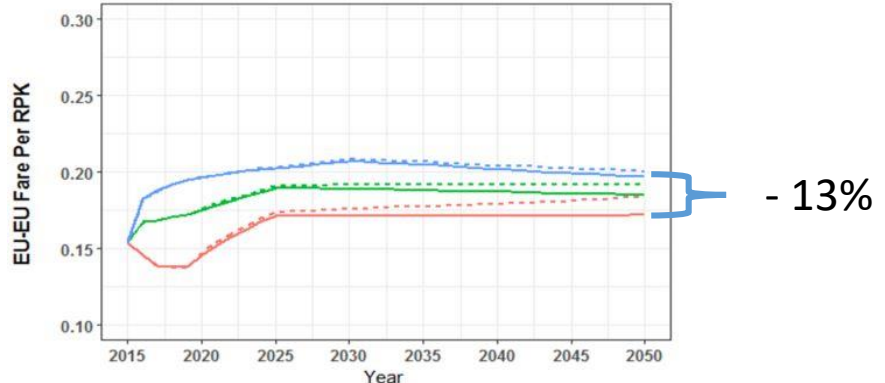
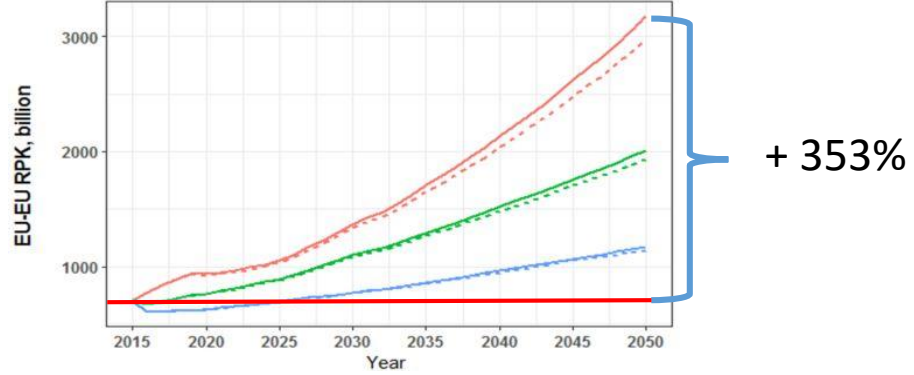
Three baseline scenarios for different futures:

- The worst-case scenario:** low GDP growth to 2050, high oil prices, and pessimistic technology adoption (late availability date, high cost, low benefit).
- The mid-case scenario:** mid GDP growth to 2050, central oil prices, and mid-range technology adoption.
- The best-case scenario:** high GDP growth to 2050, low oil prices, and optimistic technology adoption (early availability date, low cost, high benefit).

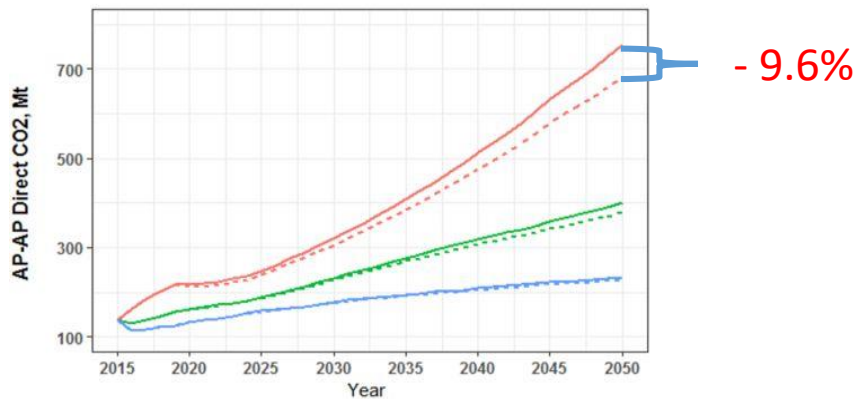
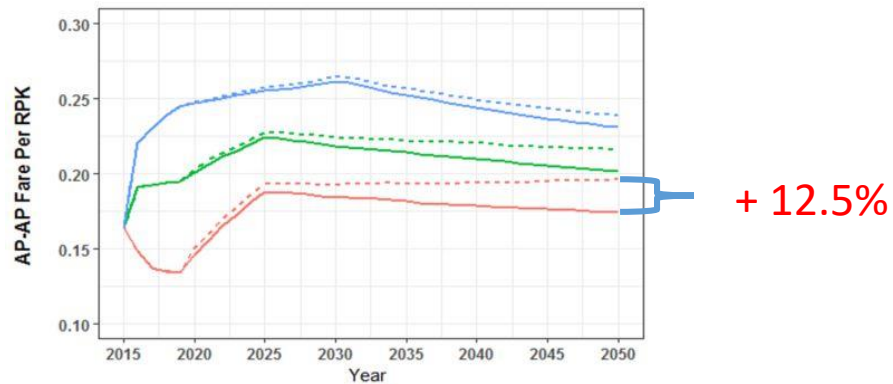
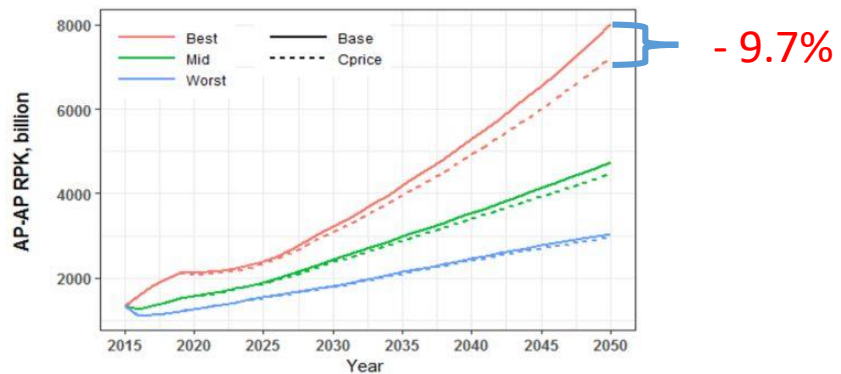
AP-AP Simulation



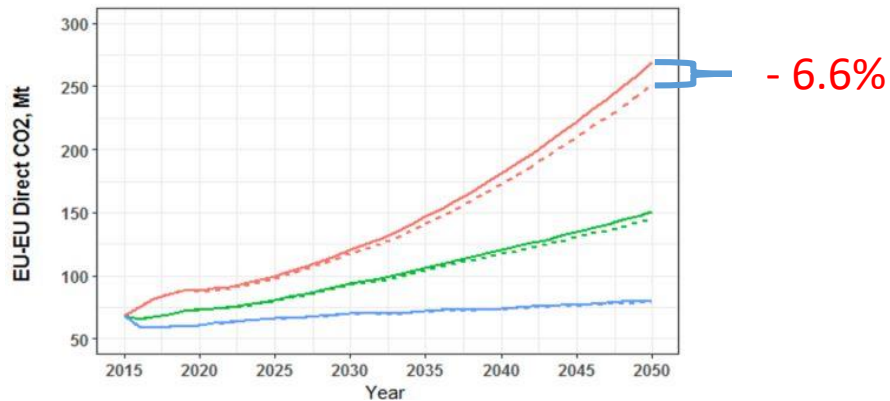
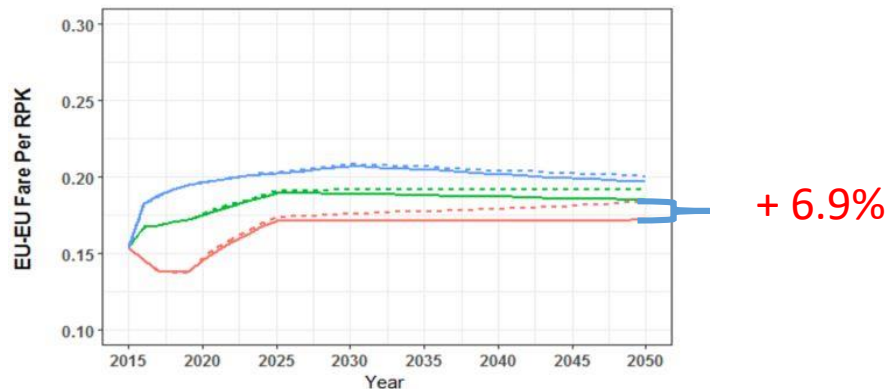
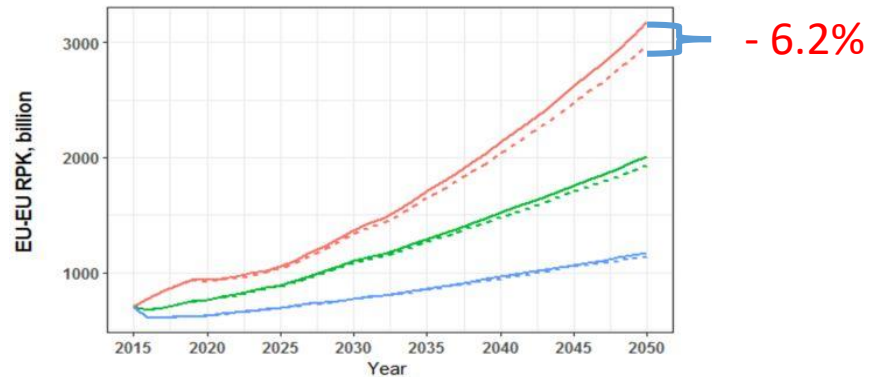
EU-EU Simulation



AP-AP Simulation



EU-EU Simulation



- ❑ Estimating cost pass-through can help researcher to evaluate the economic impacts of introducing market-based policies on reducing aviation emissions.
- ❑ Airlines' pricing behavior differs when facing increases in fuel costs, non-fuel flight costs, and non-fuel passenger costs, and in different regional markets.
- ❑ The Middle-East related markets are not affected by fuel costs changes due to lower fuel costs, whereas very sensitive to changes in other costs types.
- ❑ Based on this study, policies such as carbon taxes would indeed reduce aviation CO₂ emissions by increasing airline airfares, but the impacts are different in magnitude depending on how sensitive the given airline is to the costs changes.
- ❑ Carbon tax is expected to make a difference but will not be a game changer.

SAECA

Thanks! Q&A Time

Systems Aspects of Electric Commercial Aircraft (SAECA)



About Air Transportation Systems Lab