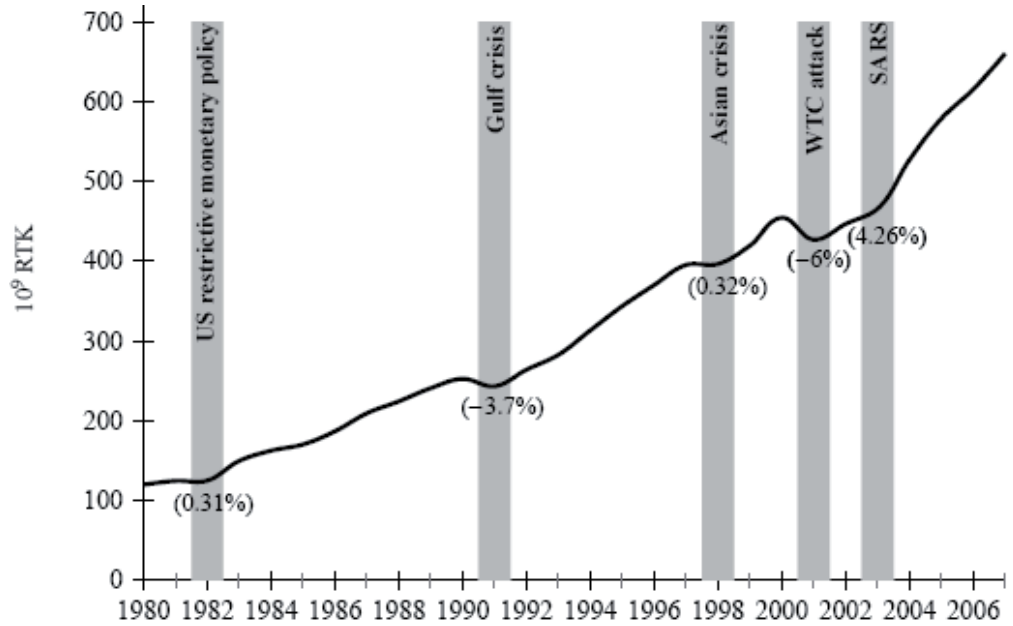
Forecasting Air Traffic CO_2 Emissions Until 2025

B. Chèze (IFP)
J. Chevallier (Univ. Dauphine-Paris)
P. Gastineau (INRETS)

ENVECON2010
London - March 2010



- Air Traffic growth
- Climate change
- Scarce energy resources context
- Integration of the aviation sector in the EU-ETS in January 2012

Forecasting and modelling demand: a central issue for public policy

Air Traffic $\Rightarrow$ Jet-Fuel demand $\Rightarrow$ CO_2 emissions

- data: ICAO, IEA
- Eight regions: *Central and North America, Europe, Latin America, Russia and CIS, Africa, The Middle East, Asian countries and Oceania, China*
- 1983-2006 (two sub-periods: 1983-1996 , 1997-2006)
- international *vs* domestic
- freight *vs* passengers

- RTK: *Revenue Ton Kilometer* → one ton of load (passenger or cargo) transported one kilometer
- ATK: *Available Ton Kilometer* → measure of the capacity of an aircraft/airline
- WLF: *Weight Load Factor* → percentage of an aircraft's available ton effectively occupied during a flight
- ATM: *Air traffic management* → air traffic control and traffic flow management
- Fuel Efficiency → ability of petroleum engines to maximize the transformed chemical energy of the fuel
- CO_2 = Jet Fuel (Mt) x 3.156 → a carbon-based fuel will emit 3.15 times its own weight in CO_2 when burnt.

Traffic Efficiency

'An increase of 6%/yr of air traffic does not mean a strictly corresponding increase of 6%/yr in Jet-Fuel demand'

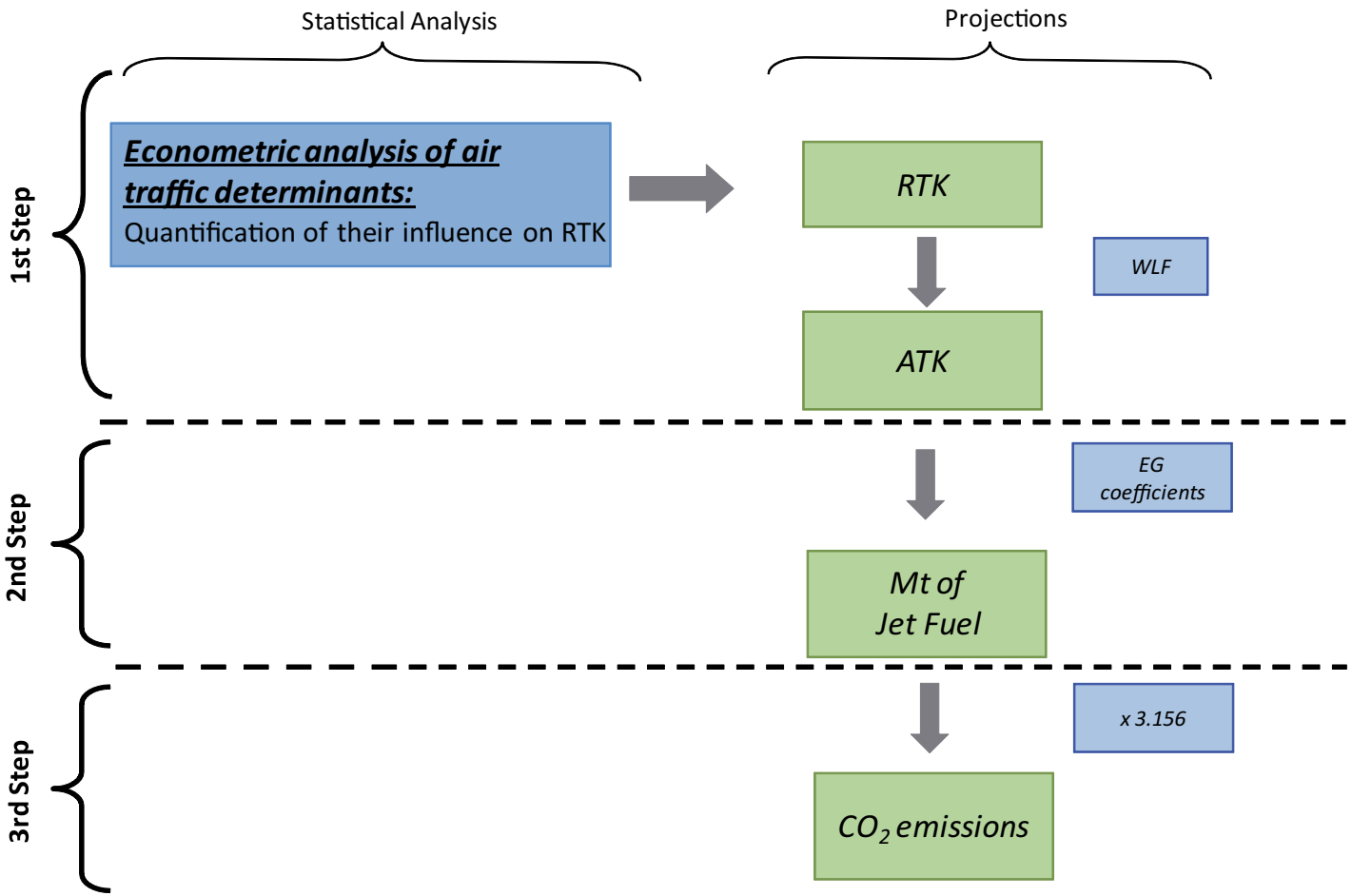
- Load Factor

$$RTK_{it} = WLF_{it}.ATK_{it}$$

Energy gains:

- Air Traffic management
- Fuel Efficiency

$$ATK_{it}.EG_{it} = T_{JET_{it}}$$


Statistical Analysis
Projections
1st Step
Econometric analysis of air traffic determinants:
Quantification of their influence on RTK
RTK
WLF
ATK
2nd Step
EG coefficients
Mt of Jet Fuel
3rd Step
x 3.156
CO_2 emissions

Main drivers:

- GDP (+)
- Jet fuel price (used as a proxy of ticket prices) (- *above a given price threshold*)
- Some external shocks (-)

The magnitude of the influence of these air traffic determinants depends on market maturity

	Anderson-Hsiao First-Differenced 2SLS estimator	Arellano & Bond First-Differenced GMM estimator	
	Reduced Form	Reduced Form First kind of modeling of Jet-Fuel Price	Reduced Form Second kind of modeling of Jet-Fuel Price
$lrtk_{i,t-1}$	1.019***	0.868***	0.666***
	(0.065)	(0.112)	(0.135)
$lgdp_{i,t}$		0.276**	0.363*
		(0.132)	(0.209)
$ljetp_t$			-
$ljetp_{t-1}$			-
$ljetpup_{t-1}$		-	0.014*
			(0.008)
$ljetpdown_t$		-	-0.015***
			(0.002)
growth shocks		-0.059*	-
		(0.035)	
growth counter-shocks			-
sectorial shocks		-0.116***	-
		(0.030)	
sectorial counter-shocks			-
shocks (growth or sectorial)		-	-0.152***
			(0.039)
counter-shocks (growth or sectorial)		-	
constant	-	-4.518**	-2.162
		(1.979)	(3.392)
Endogeneity Test (P-value)	6.52 (0.03)	-	-
m1 (P-value)	-	-1.8393 (0.06)	-1.8997 (0.05)
m2 (P-value)	-	-0.27987 (0.78)	-0.1219 (0.90)
Sargan Test (P-value)	-	58.68 (0.19)	63.2889 (0.09)
Test for growth shocks coeff. = sectorial shocks coeff. (P-value)	-	14.56 (0.001)	0.68 (0.41)
Test for ljetpup(t-1) coeff. = ljetpdown coeff. (P-value)	-	-	10.34 (0.001)
Instruments	$lrtk_{i,t-2}$	$lrtk_{i,t-2}$, $lrtk_{i,t-3}$	$lrtk_{i,t-2}$, $lrtk_{i,t-3}$

'*Air traffic*' scenarios

- '*IMF hypothesis*': IMF World Economic Outlook (WEO) Database
- '*Low GDP growth rates*' (-10%)
- '*High GDP growth rates*' (+10%)

$$RTK_{it} = WLF_{it}.ATK_{it}$$

Regional WLF $\longrightarrow$ 75%.

Yearly mean growth rate of the period 1996-2006.

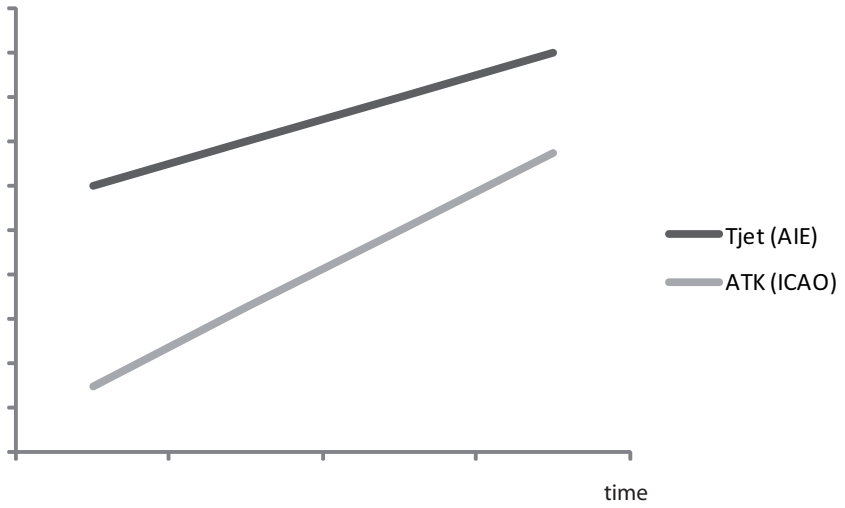
'*Energy gains*' scenarios:

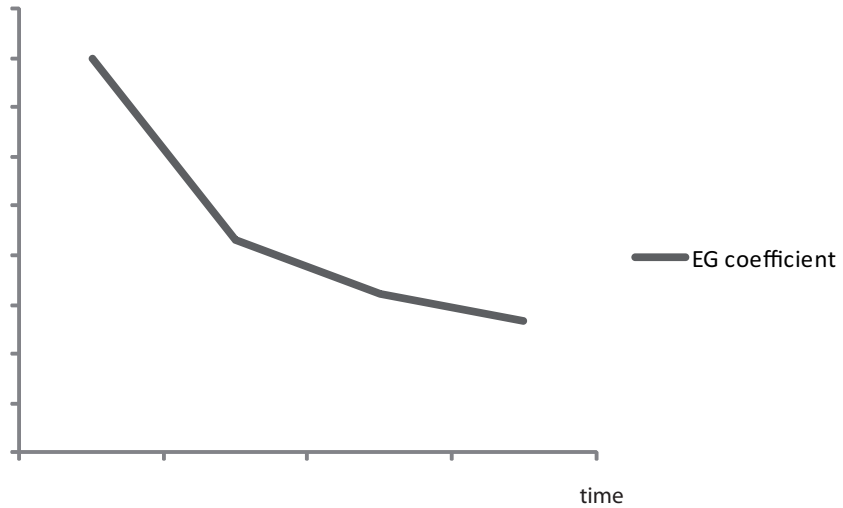
- '*heterogeneous energy gains*': heterogeneity of energy gains among regions. Energy gains recorded during the period 1996-2006 (ex: 1.20 % Europe, 5.79 % Russia).
- '*homogeneous energy gains*': 2.61% (yearly mean growth rate of world energy gains during the period 1996-2006).
- '*green energy gains*': highest energy gains improvements recorded.

'Macro level' approach

$$EG_{it} = \frac{TJET_{it}}{ATK_{it}}$$

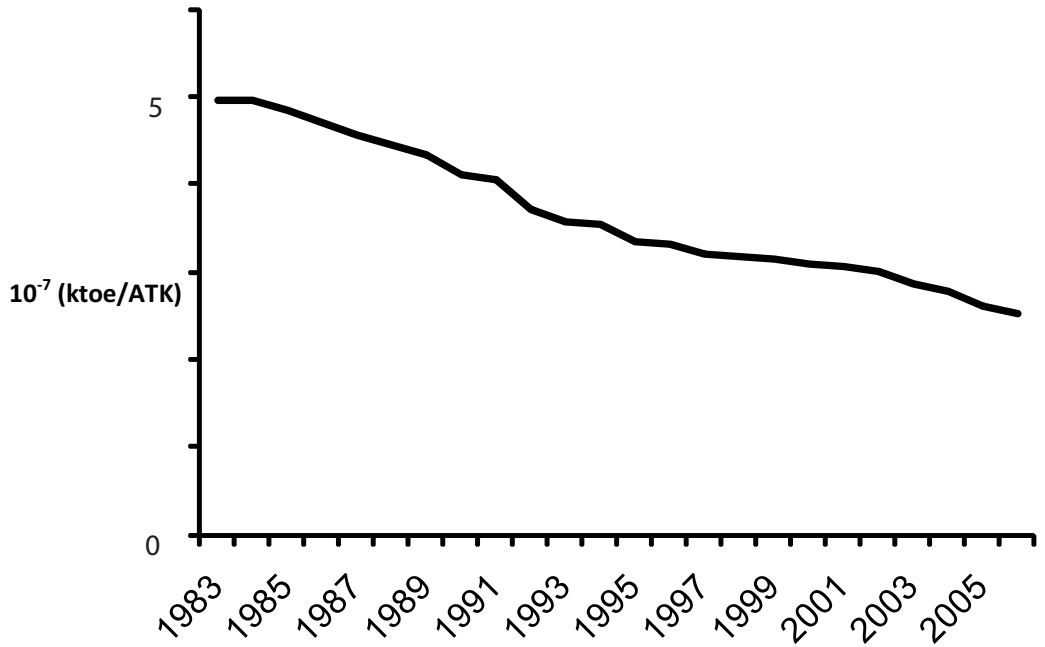
$EG_{it+1} < EG_{it}$ = energy gains





EG = quantity of Jet-Fuel required to power the transportation of one ton over one kilometer

Evolution of energy gains



Regions (Energy gains hypothesis)	RTK (10^9) (mean growth rate per year)		Corresponding ATK (10^9) (mean growth rate per year)		Jet fuel-Mt/y (consumption of the region-%)		% variation of Jet fuel (2008-2025)	Mean growth rate per year of Jet fuel (2008-2025)
	2008	2025	2008	2025	2008	2025		
Central and North America (-3.18%)	246.2	405.9 (3.0%)	403.9	627.5 (2.6%)	86.96 37.9%	77.98 24.6%	-10%	-0.6%
Europe (-1.20%)	163.5	310.0 (3.9%)	235.2	413.1 (3.5%)	51.61 22.5%	73.83 23.3%	43%	2.2%
Latin America (-1.63%)	28.5	64.7 (5.0%)	47.1	89.3 (3.9%)	17.42 7.6%	24.97 7.9%	43%	2.2%
Russia and CIS (-5.79%)	9.6	21.1 (4.9%)	15.4	28.1 (3.8%)	9.03 3.9%	6.00 1.9%	-34%	-2.2%
Africa (-4.20%)	9.9	30.0 (6.7%)	17.3	47.6 (6.2%)	7.73 3.4%	10.27 3.2%	33%	1.7%
The Middle East (-4.20%)	24.1	48.7 (4.5%)	39.9	74.3 (4.0%)	7.91 3.5%	7.11 2.2%	-10%	-0.3%
Asian countries and Oceania (-1.54%)	98.6	296.4 (6.9%)	158.2	465.2 (6.8%)	33.62 14.7%	75.92 24.0%	126%	5.2%
China (-1.65%)	56.9	215.0 (8.2%)	82.8	296.7 (7.9%)	15.10 6.6%	40.77 12.9%	170%	6.1%
World (-2.22%)*	637.4	1391.8 (4.7%)	999.8	2041.9 (4.3%)	229.37 100%	316.87 100%	38%	1.9%

'Heterogeneous energy gains' / 'IMF hypothesis'

Regions (Energy gains hypothesis)	RTK (10^9) (mean growth rate per year)		Corresponding ATK (10^9) (mean growth rate per year)		Jet fuel-Mt/y (consumption of the region-%)		% variation of Jet fuel (2008-2025)	Mean growth rate per year of Jet fuel (2008-2025)
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China (-2.61%)	56.9	215.0 (8.2%)	82.8	296.7 (7.9%)	14.80 6.5%	33.84 11.5%	129%	5.1%
World (-2.61%)	637.4	1391.8 (4.7%)	999.8	2041.9 (4.3%)	228.71 100%	294.59 100%	29%	1.5%

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'Homogeneous energy gains' / 'IMF hypothesis'

	2008	Hetero EG/ IMF 2025	Hetero EG/ IMF Variation	Homo EG /IMF 2025	Homo EG /IMF Variation	Hetero EG / -10% 2025	Hetero EG / -10% Variation
RTK	637.4	1391.8	118%	1391	118%	1268.9	99.36%
MtCO2/yr	723.89	1000.04	38%	929.73	29%	911.83	26%
% world CO_2 emissions							
IPCC scenario I*	2.7%	3.4%	28.6%	3.2%	20%	3.14%	17.44%
IPCC scenario III**	2.7%	3.1%	16.6%	2.9%	9%	2.85%	6.43%
IPCC scenario IV***	2.7%	2.7%	0.8%	2.5%	-6%	2.46%	-7.95%

*IPCC scenario I (350-400ppm CO2, $i.e. 2 - 2.4C$)
**IPCC scenario III (440-485ppm CO2, $i.e. 2.8 - 3.2C$)
*** IPCC scenario IV (485-570ppm CO2, $i.e. 3.2 - 4C$)

2008	2025	Variation
27000	29000	7.41%
27000	32000	18.52%
27000	37000	37.04%

CO_2 emissions = TJet $\times$ 3.156

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27000	37000	37.04%

CO_2 emissions = TJet $\times$ 3.156

Contributions

- **Disparities among regions**
  - Energy gains
  - Air traffic and Jet-Fuel demand growth
- **World** (heterogenous EG / IMF)
  - Air Traffic (RTK) : + 120 %
  - CO_2 emissions : + 40 %
- **Lessons for policy makers**
  - Technological progress: an important way of mitigating the environmental impact of the rise of air traffic...
  - ...but not sufficient to annihilate its impact on climate change.