EI @ Haas WP 216

Would Pricing Aviation GHGs Really Lower Efficiency or Profitability?: A Comment on Winchester et al, 'The Impact of Climate Policy on U.S. Aviation'

Severin Borenstein
June 2011

Would Pricing Aviation GHGs Really Lower Efficiency or Profitability?: A Comment on Winchester et al, “The Impact of Climate Policy on U.S. Aviation”

(M.I.T. Working Paper, PARTNER-COE-2011-01)

Severin Borenstein[1]

June 2011

Abstract: In a recent working paper, Winchester et al (2011) used computable general equilbrium models to evaluate the impact on U.S. airlines of pricing greenhouse gases through a cap-and-trade program. In this comment, I raise two issues about the analysis itself, suggesting that the Winchester et al conclusions about fuel price changes and load factor changes are inconsistent with the basic economics of the industry. More importantly, I argue that the paper's analytical conclusions do not suggest that including avation in GHGs would be harmful to the efficiency or profitability of the industry.

---

[1] E.T. Grether Professor of Business Economics and Public Policy, Haas School of Business, University of California, Berkeley, CA 94720-1900 (faculty.haas.berkeley.edu/borenste); Co-Director of the Energy Institute at Haas (ei.haas.berkeley.edu); Director of the University of California Energy Institute (www.ucei.berkeley.edu); Research Associate of the National Bureau of Economic Research (www.nber.org). Email: borenste@haas.berkeley.edu.

I. Introduction

"The Impact of Climate Policy on U.S. Aviation" by Niven Winchester, Christoph Wollersheim, Regina Clewlow, Nicolas C. Jost, Sergey Paltsev, John M. Reilly, and Ian A. Waitz was recently released as M.I.T. Working Paper, PARTNER-COE-2011-01.[2] The research is joint work between the The Partnership for AiR Transportation Noise and Emissions Reduction and the MIT Joint Program on the Science and Policy of Global Change. The paper uses a computable general equilibrium model of emissions – Emissions Prediction and Policy Analysis (EPPA) – and a more detailed model of the aviation industry – Aviation Environmental Portfolio Management Tool for Economics (AMPT-E) – to analyze the impact of a cap-and-trade program on U.S. aviation.

The paper concludes that pricing of greenhouse gas (GHG) emissions (through a cap-and-trade program) would result in emissions from the aviation industry that in 2050 would be 3.5% to 14.5% lower than under a reference case with no cost to airlines of GHG emissions.[3] They also find that under their preferred specification, pricing GHGs would reduce average fleet efficiency compared to the reference case. The paper defines average fleet efficiency as available ton-kilometers per ton of CO_2e emitted, but it also reports revenue ton-kilometers per ton of CO_2e.[4] Finally, the paper reports proportional changes in airline profits compared to the reference case in 2050 that range from a 5% decline to a 17% decline.

The study has already been noted by the airline industry and some transportation policy makers.[5] It is also likely to be presented as evidence in future policy debates.

For these reasons, I feel compelled to raise some concerns I have with the paper, to some extent with the analysis, but to a much greater extent with the way the primary conclusions are presented, which I think could easily lead to misinterpretation. In particular, I am concerned that policy makers might infer from the paper that that pricing airline GHG emissions would be counter-productive. The conclusions of the paper do not support such an inference at all.

I divide my comments into four topics: fuel costs, load factors, fleet efficiency, and profits. The first two are concerns about data and analytical issues that feed into the analysis of

---

[2] The paper is available at http://web.mit.edu/aeroastro/partner/reports/proj31/proj31-captraderpt.pdf

[3] The paper is not explicit on whether other sectors must pay for GHG emissions under the reference case, but in personal communications with the authors, I was told that there is no climate policy imposed in the reference case.

[4] Changes in the two measures differ if average load factor changes.

[5] See James Ott, "MIT Studies Airline Response to Cap-And-Trade Proposal," *Aviation Week*, May 24, 2011. Links to the paper have also been posted on the websites of the Transportation Research Board and Salon.com.

	CO2e price ($/t CO2-e)			Fuel Price Change (%)			Implied Reference Fuel Price ($/gallon)			Fuel Price Annual Growth Rate	
	2015	2030	2050	2015	2030	2050	2015	2030	2050	2010-30	2010-50
F1	$7.27	$13.09	$28.69	5.83%	4.60%	4.74%	$1.19	$2.72	$5.79	5.65%	5.16%
F2	$7.79	$14.03	$30.74	12.50%	9.20%	18.10%	$1.19	$2.92	$3.25	6.15%	0.72%
M1	$21.31	$38.39	$84.07	17.50%	17.82%	26.72%	$1.17	$2.06	$3.01	3.88%	2.56%
M2	$22.25	$40.07	$87.08	36.67%	41.38%	65.09%	$1.16	$1.85	$2.56	3.17%	2.18%

Table A: Reference Fuel Prices Implied by Winchester et al

the fleet efficiency and profits.[6] The last two are areas of overarching conclusions of the study that may be misinterpreted.

II. Fuel Costs

The paper does not specify the reference fuel costs that were assumed, but it appears they can be inferred from Table 1 of Winchester et al. Table A, above, reproduces the CO_2e price and percentage fuel price change from Table 1 of Winchester et al. These two sets of data, along with the fact that jet fuel contains 9.57kg CO2/gallon[7] and the paper's assumption about permit requirements for non-CO2 greenhouse gases under each scenario (see top of page 6) allow one to calculate the implied price of jet fuel under the reference case.[8]

The reference case prices inferred in this way raise two concerns. First, the implied reference price of jet fuel varies for different scenarios in a given year, substantially so for 2050. One possible partial explanation for the inconsistent fuel prices is that inferring the reference case fuel price in this way assumes 100% passthrough, *i.e.,* that the price of fuel changes by exactly 100% of the cost of the associated GHG permits. Some of the incidence of the GHG cost could fall on the oil producers and refiners. The EPPA model that the paper uses allows supply-side price adjustments when GHGs are priced, so that the

---

[6] These are outputs of the EPPA and AMPT-E models that the authors run in order to simulate outcomes under different GHG scenarios. The models are not part of this research. The concerns I raise may be with the models themselves, not just this paper's implementation, but without attempting to replicate the entire research, I cannot discern the source of the output that raises concerns.

[7] See http://www.eia.doe.gov/oiaf/1605/coefficients.html .

[8] To be precise, the implied price of jet fuel in the reference case is $P_f = 0.00957 \cdot P_{CO_2e} \cdot r/chg_f$, where P_f is the reference price of jet fuel, P_{CO_2e} is the assumed permit price for 1 ton of CO_2e, r is the ratio of permit liability to CO2 emissions from an aircraft (set to either 1 or 2 in the scenarios presented by Winchester et al) and chg_f is the proportional change in fuel price under each scenario.

percentage price change reflects only part of the GHG price.[9] However, unless the EPPA model concludes that suppliers would bear less than 0% of GHG costs in some scenarios and/or more than 100% of the GHG costs in other scenarios, the fuel price differential across scenarios for a given year should not vary by more than the GHG liability associated with a gallon of refined petroleum products,[10] which is less than \$0.20 in all scenarios modeled. So, incomplete passthrough does not seem to explain the large discrepancies in the implied reference fuel costs across scenarios.

The second concern is the implied *level* of fuel prices. For 2015, the implied jet fuel price is between \$1.16 and \$1.19.[11] These numbers are substantially below current wholesale fuel prices, jet fuel prices at any point since 2005,[12] or the fuel prices implied by the current futures prices for crude oil deliveries in 2015.[13] In fact they are less than half of the current wholesale price of jet fuel or the wholesale price implied by futures markets.[14] Also, the implied prices for 2030 would imply real annual growth rates in fuel prices that vary from 3.2% to 6.1%, a very wide range and above nearly all forecasts of real fuel price growth rates. The 2050 prices imply an even wider range of fuel price growth rates, from 0.7% to 5.2%.

III. Load Factors

The Winchester et al conclusions about load factors seems to be at odds with the economics of the airline industry. Based on the EPPA and AMPT-E models, the paper concludes that pricing GHGs would *lower* industry load factors in the short run and in the long run.

Between 85% and 90% of a commercial jet aircraft's weight at takeoff is unrelated to the number of passengers carried, so for a given flight schedule, fuel is effectively a fixed cost for the firm. Profit maximization implies that changes in a fixed cost would not affect

---

[9] I was told this by the authors in personal communication.

[10] In a competitive model, the passthrough of such a cost shift due to GHG pricing is bounded between 0% and 100%. In some circumstances with imperfect competition, the passthrough can lie outside this range, but those would be specific parameter scenarios that are seldom, if ever, included in CGE models.

[11] In personal communications with the authors, I was told that the changes reported are for refinery gate prices, which are essentially wholesale fuel prices, not retail.

[12] See http://www.eia.doe.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EER_EPJK_PF4_RGC_DPG&f=A

[13] Futures prices for 2015 crude are about the same as current spot crude oil prices, about \$100 per barrel.

[14] To the extent that suppliers bear some of the incidence of the GHG price, it would imply that the assumed baseline gasoline prices are lower than those shown in Table A. Less than full passthrough of the permit price would imply $P_f \cdot chg_f < 0.00957 \cdot P_{CO_2e} \cdot r \iff P_f < 0.00957 \cdot P_{CO_2e} \cdot r / chg_f$. The 2015 prices would be even less plausible.

prices until fixed inputs changes, in this case until flight schedules changed. Therefore fuel price changes due to GHG pricing would not affect load factors until flight schedules changed.[15] So, in the very short run, load factors would be unaffected.

In the long run, a competitive airline would aim to at least break even on each flight. When the fixed cost of each flight rises, the airline must charge a higher fare to the same number of passengers and/or put more passengers on the plane. It is possible, if customers have extremely inelastic demand for comfort in flight – "elbow room", the inverse of load factor – that the new equilibrium will have higher prices and almost no increase in load factor. But it is hard to see how higher fixed costs per flight would lead to *lower* load factors in long-run equilibrium.[16] Elbow room is more expensive at higher fuel prices (or any other increase in fixed cost per flight) and customers will almost surely prefer to buy less of it.

In the medium run, an increase in fuel prices will cause airlines to reduce flights and raise prices. The same argument applies as in the long run except the shadow value of aircraft (and possibly other semi-fixed costs such as labor) declines, as the short-run shadow price of these inputs could fall below their long-run competitive price (or cost). Still, the qualitative argument for the long run would also apply to this medium run so long as the cost of other fixed flight costs don't fall by more than the price of fuel per flight rises, so that the overall economic fixed cost per flight does not fall. Put differently, equilibrium load factors are likely to fall in the medium run only if the break-even net revenue (*i.e.,* after costs that are incremental per customer) falls as a result of a fuel price increase. It seems difficult to come up with a plausible scenario where that would be the case.

Finally, the claim that the very modest fuel price increases envisioned here will lead to substantially lower load factors in the short run is at odds with the empirical history of load factors in the U.S. airline industry. Borenstein & Rose (2008) show that load factors display no empirically detectable response to much greater short-run fuel price fluctuations than could plausibly result from a permit price of \$7 to \$21 per ton of CO_2e.

From the numerical results and the discussion in Winchester et al, it appears that the AMPT-E model may assume that airlines don't adjust aircraft utilization over the short

---

[15] This is true in any non-cooperative economic model of airline competition. If the airlines use fuel prices as a coordination device in colluding on airfares, then a change in fuel prices could trigger fare changes and affect load factors even before a schedule change, but even then the Winchester et al assumption that fuel prices are fully passed through while capacity is unchanged seems hard to credit.

[16] Such a result is theoretically possible if the remaining customers have a stronger than average taste for in-flight comfort – creating a selection effect that changes equilibrium average demand for elbow room – but that effect would have to outweigh the strong incentive to increase load factors along with raising fares. It would also be very surprising if such a nuanced analysis of customer preferences is included in the AMPT-E model.

to medium run, so available ton-kilometers only changes as airlines change their fleet size. Such an assumption – along with the complete and immediate passthrough of fuel price changes that Winchester et al assume – could result in the load factor changes shown in their table 2. The assumption, however, would be very much in conflict with the data from demand and fuel price fluctuations of the last decade. Demand drops and fuel price spikes have triggered widespread groundings of the existing fleet within 1 to 2 quarters.

IV. Fleet Efficiency

One of the primary conclusions of the paper is that pricing GHGs would lead to lower average fleet efficiency, as measured by available ton-kilometers (ATK) per ton of CO_2e emissions. The result sounds both counter-intuitive and worrisome. Upon closer inspection, it is neither.

The AMPT-E model used in the paper estimates an aircraft retirement rate – driven by the age of aircraft and their relative fuel inefficiency – and a fleet expansion rate – driven by demand growth and load factors. Higher fuel costs lead to somewhat faster retirement of older, less fuel efficient aircraft than would occur in the reference case. But high fuel costs also raise airfares and reduce quantity demanded, thus lowering the purchase of new aircraft. The paper concludes that the net effect would be to reduce the share of newer aircraft in the fleet.

Winchester et al argue that net aircraft fleet change under GHG pricing would lower ATK/CO_2e relative to the reference case. The driver of this result is the fact that quantity of travel demanded doesn't expand as quickly when GHG emissions are priced into airfares, so fewer new planes are purchased. This does not suggest that a given set of aircraft become less efficient.[17] Rather, it simply argues that fewer new planes will enter the fleet and therefore will not pull up the *average* efficiency of the fleet as much as they would in the reference case. The efficiency of both new aircraft and older aircraft will almost certainly rise as GHG prices rise, but because there would be less expansion of the fleet, the *average* efficiency of the fleet will be more weighted towards older aircraft. This is not a sign of an ineffective policy at all, but rather reflects the conclusion that a primary way in which GHG prices will reduce emissions from the airline industry is through reducing the total number of airline trips.[18]

---

[17] Actually the opposite would occur with flight speed reductions and other adjustments to existing aircraft.

[18] Analogously, if GHG pricing raises gasoline prices, we could possibly see a greater reduction in freeway trips than in short in-town trips, which could lead to a reduction in the *average* fuel efficiency of driving. But it would still lead to fewer GHG emissions and more fuel-efficient driving habits and capital investments. And by using a market mechanism it would likely reduce GHGs much more economically than through command and control regulation.

The paper also finds that revenue ton-kilometers per unit of CO_2e (RTK/CO_2e) would fall very substantially in the short run and significantly in the long run. This is driven primarily by the conclusion that there would be quite substantial declines in load factor in the short run and smaller, but still significant declines in the long run. As I've discussed above, I think this conclusion about the change in load factors is not well founded.

V. Profits

The paper is quite up front in saying that the authors assume all cost increases are passed through to consumers, "so cost increases only influence profits via their impact on demand" (page 10). Put differently, the paper makes no prediction about a change in the profit *rate* of the industry, nor does it contribute to the debate about the industry's long-run viability. It simply points out that pricing GHGs will raise airfares and reduce the quantity of trips taken compared to the reference case. By assumption, the profit *rate* is held constant in the long run, so a reduction in the quantity of travel reduces the total profits of the industry compared to the reference case.

In both the reference and all comparison cases, the total profits of the industry grow over the forecast period. In no way do the results suggest that pricing GHGs would adversely affect the profitability of the industry (by the common use of the term "profitability", meaning the rate of return on investment) or threaten the viability of the industry. Thus, it is unfortunate that the paper introduces the issue of profits with "To examine changes in financial viability of the aviation sector....". Nonetheless, nothing in the modeling or results reflects at all on the financial viability of the aviation sector. The paper simply concludes the industry will earn the same rate of return on a somewhat smaller business volume and, thus, smaller capital investment. This is consistent with the broad recognition that pricing GHGs will lead to slower growth of more-GHG-intensive sectors of the economy relative to less-GHG-intensive sectors.

REFERENCES

Borenstein, Severin and Rose, Nancy L. "How Airline Markets Work...Or Do They? Regulatory Reform in the Airline Industry," National Bureau of Economic Research (Cambridge, MA) working paper #13452, 2008.

Winchester, Niven, Christoph Wollersheim, Regina Clewlow, Nicolas C. Jost, Sergey Paltsev, John M. Reilly, and Ian A. Waitz, "The Impact of Climate Policy on U.S. Aviation," M.I.T. Working Paper, PARTNER-COE-2011-01, The Partnership for AiR Transportation Noise and Emissions Reduction, May 2011.