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Air traffic and economic growth: the case of developing countries

François Bourguignon and Pierre-Emmanuel Darpeix

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Introduction

Air transportation is both a factor and an indicator of development. On the one hand, it is a factor of progress as it facilitates transportation within extended countries or countries without good land transportation infrastructure and it connects the country with the rest of the world. On the other hand, it is an indicator of development as its volume clearly depends on the level of economic activity as well as on the affluence of the population. Additionally, it may also be an indicator of the structure of economic development as a more outward oriented economy may be associated, other things equal, with more intense passenger or freight air traffic.

As often in economics, it is difficult to disentangle these two roles of air transportation – i.e. a development adjuvant or a service whose demand increases with development – as they most likely are both intimately linked (development and air transportation are clearly endogenous magnitudes). Yet, the observation of the way the volume of air transportation changes with the level and, possibly, the structure of the economic activity might give some useful information on its role in development.

This paper is a simple exploration of the relationship between the development of air transportation and economic growth across different regions and countries in the world. It aims at determining whether developing regions share common patterns despite their different degree of economic development. The methodology thus essentially builds on a systematic comparison of the relationship between air transportation, GDP and some other variables in different parts of the world, both at the region and at the country levels.

The paper relies on two sets of data. The first source is the International Civil Aviation Organization (ICAO) database, which reports annual data on passenger and freight traffic on domestically registered airlines at the country level. The second source is the Airport Council International (ACI) database (proprietary), which reports, over a shorter period, passenger and freight traffic for a number of airports in the world. Those databases and their reliability are discussed in the first section of the paper.

The rest of the paper is organized as follows. The second section focuses on the relationship between GDP and air transportation at the aggregate regional level with the two databases. It investigates in particular the homogeneity of that relationship over time and across regions. In the third section, the analysis is conducted at the country level based on the ACI data. This data source has been preferred to the ICAO database because air traffic is defined there in a less restrictive way, even though it covers less countries and for a shorter period. The estimation of the GDP/air transportation relationship is made under the assumption of the same GDP-elasticity of air traffic across countries within a given region, but possibly some heterogeneity across regions. Robust estimates are obtained using panel co-integration techniques including an error correction specification that allows distinguishing between short-run and long-run effects of GDP growth. A complementary analysis in terms of GDP per capita is conducted to address the development aspect of the issue. The general lessons to be drawn from this exploratory statistical analysis are summarized in a concluding section.

Oddly enough, the literature on air transportation and development is rather limited. Possibly because of market size and data availability, existing economic studies on air transportation tend to concentrate on developed countries, see for instance Smyth and Pearce (2008). Relatively little work seems to have been devoted to developing and emerging countries, and these analyses tend to consider either the industrial organization of the sector, as Goldstein (2001) in the African context, or the business multiplier effects of air transport in the domestic economies – see for instance ATAG (2003). A substantial amount of work has been done to estimate demand models – see in particular the meta-analysis in InterVistas (2007) – but this is generally done at a micro level, i.e. route by route. Ishutkina and Hansman (2009) use the ICAO data to analyze the co-evolution of the total number of air passengers by country and developing region but they stop short of producing GDP elasticities.

Estimates of the aggregate relationship between total air transportation and GDP are generally done on the basis of the ratio between the growth rates of the two magnitudes. This elasticity is generally found to be rather high, typically greater than unity. For instance, Fu et al. (2010) survey the literature and come up with the following key benchmark estimates: 1.75 in the US, according to the US Department of Transport, 1.5 in the UK, and a median elasticity of 1.4 in a set of 12 studies bearing mostly on developed countries, reviewed by Gillen et al. (2008). At the world and regional levels, Swan (2008) reports that per-GDP air travel, which corresponds to the ratio of the volume of air traveling measured in passenger-kilometer divided by the GDP, has increased by 42 per cent[1] in the world between 1990 and 2014. This suggests an elasticity of 1.8, an order of magnitude in line with what the dominant view seems to be among operators. Indeed an IATA economic briefing issued in December 2008, which tried to forecast what could be the impact of the crisis upon air traffic worldwide, stated that *"One enduring industry 'fact' (their emphasis) is that traffic grows twice as fast as GDP"*.[2] How to interpret this 'fact' is unclear, however. As a GDP-elasticity, it is tempting to interpret it as a 1% increase in GDP causes a 2% increase in air transport. But it may also simply convey the view that the autonomous trends of air transport and GDP happen to be in ratio 2:1. This paper intends to distinguish these two points of view and calls for taking this 2:1 ratio with extreme care.

The problem with estimates based on the ratio of growth rates is that they implicitly assume that GDP is the sole determinant of the growth of air traffic. However, one may think of many other determinants, including airfares, the market regulation or the construction of new airports. A methodology that would be more elaborate than taking growth rate ratios or merely regressing the log of air traffic on the log of GDP is clearly called for. For lack of data, the present paper stops short of such an objective. Instead, it relies on a more elaborate specification of the possible

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[1] Calculation based on *Table 2* in that paper.

[2] See also O'Conell (2012). Both the IATA document and O'Conell also suggest that the elasticity is higher in times of recession.

relationship between air transportation and GDP, that tries to disentangle that relationship from autonomous time trend.

1. Air traffic data

This paper uses two databases on air traffic. The first source is the International Civil Aviation Organization (ICAO)[3] as reported in the free access World Development Indicators database on the World Bank site[4]. A big advantage of this source is the period it covers: 1970-2014. Apparently, no other data source covers such a long period in a homogeneous way. Yet this advantage comes with some major restrictions. The most severe one is that only the total (international and domestic) scheduled traffic by the air carriers registered in a given country is reported. In other words, the database only accounts for the traffic handled by 'national' air carriers (or possibly 'domestically' registered subsidiaries of foreign companies), whatever the destination-origin pair serviced by those carriers. For instance, Uganda traffic statistics include Air Uganda passengers, the only airline licensed by the Ugandan Civil Aviation Authority (it ceased operations in 2014). However, it would not include passengers boarding a British Airways flight from Kampala, Uganda to London, UK. On the other hand, it would have included passengers boarding an Air Uganda flight in Bujumbura, Burundi to fly to Nairobi, Kenya, if there had been such a route.

The condition that the air carrier must be registered in a country is important. It means that ICAO statistics on passengers and flights are practically restricted to national companies (or again possibly foreign companies if they have a subsidiary registered in the country). This is not necessarily a problem for countries large enough for at least one national company to be operating at all times, provided it is safe to assume that the market share of national companies in international traffic is approximately constant. This is more of a problem for smaller countries with few air carriers or even only one. There, the addition or discontinuation of a home-based air carrier may cause significant changes in reported air traffic.

In the case of small developing countries, the latter issue is clearly problematic. For instance, Air Uganda was created in 2007 as a substitute to Uganda Airlines, a public company that went bankrupt in 2000. Such events necessarily have a strong impact on the passenger traffic data collected by ICAO: indeed, the reported number of passengers carried for Uganda went down from 179,400 in 1999 to 39,379 in 2000.[5] The 2002 failure of the regional company Air Afrique in West Africa is another example of the imperfect coverage of ICAO data. There clearly is no reason to expect that the traffic would become null because of these companies leaving the market. Their market share simply went to foreign companies.

A second restriction of ICAO data is that the public data set only provides the total number of passengers on any flight operated by any airline registered in the country, even though data are probably available by routes and by stages. This simply means that it will only be possible to conduct an analysis on the aggregate traffic (merging together the traffic between a country and

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[3] Civil Aviation Statistics of the World and ICAO staff estimates.

[4] http://databank.worldbank.org/data/reports.aspx?source=World-Development-Indicators

[5] In July 2014 Air Uganda suspended operations indefinitely. Indeed, the issuer of its license, the Uganda Civil Aviation Authority (CAA), ran into problems after failing a safety audit by the International Civil Aviation Organization. Air Uganda was the only domestic airline licensed by the CAA. Yet, oddly enough, and unlike in 2000, the ICAO database shows only a slight decrease of traffic in 2014.

the rest of the world and the domestic traffic within the country). This is a big difference with other data sources. IATA[6] data, for instance, comes by airlines and routes. Yet, those alternative sources also have limitations. IATA data only partially cover low-cost and charter companies. Additionally they are not freely accessible.

The Airport Council International (ACI) source is comparatively less problematic. The data is collected by ACI member airports and gives the count of enplaning and deplaning passengers (with connecting passengers being collected only once). It is possible to distinguish between domestic and international traffic, yet, the data purchased from ACI only corresponds to the total number of passengers and therefore to a very direct measure of air passenger traffic. The difficulty of that database is that the sample of reporting airports varies over time, as more and more airports join the ACI, and new airports are built. Others cease operations or are converted into military airports and are therefore dropped from the sample at some point. Another restriction is that the data covers a much shorter period than ICAO data. To illustrate those two limitations, note that for the period between 1994 and 2013, there are 517 airports with a complete series (spread over 93 countries), while if one restricts the period of observation to 2000-2013, the complete series amounts to 757 airports in 124 countries (see *Table 1* below).

Table 1: Description of the three databases provided by the ACI

	Full Database 1994-2013	Balanced Panel 1994-2013	Balanced Panel 2000-2013
Number of years	**20**	**20**	**14**
Number of datapoints (airport x year)	**22 702**	**10 340**	**10 598**
Number of airports in the database	**2 190**	**517**	**757**
of which in Africa (AFR)	*241*	*37*	*72*
of which in W.Asia-Pacific (ASP)	*581*	*47*	*95*
of which in Europe (EUR)	*697*	*243*	*291*
of which in Latin America (LAC)	*315*	*45*	*105*
of which in Middle East/ E.Asia (MEA)	*113*	*13*	*39*
of which in North America (NAM)	*243*	*132*	*155*
Average number of observation per airport	**10.4**	**20.0**	**14.0**
Number of countries in the database	**186**	**93**	**124**
of which in Africa (AFR)	*50*	*20*	*32*
of which in W.Asia-Pacific (ASP)	*40*	*16*	*21*
of which in Europe (EUR)	*46*	*35*	*39*
of which in Latin America (LAC)	*36*	*12*	*22*
of which in Middle East/ E.Asia (MEA)	*12*	*8*	*8*
of which in North America (NAM)	*2*	*2*	*2*

Assuming that for all countries, reporting airports are the most important ones, the ACI statistics should be better at characterizing the actual evolution of national traffic than the ICAO data for small countries where national companies have been operating irregularly. The problem is the representativeness of the sample of airports in the database, especially the sample that corresponds to the 1994-2013 period. For bigger countries, and under the assumption of a somewhat constant market share for domestic airlines, the two databases should show a comparable evolution of traffic. This is less likely to be the case for developing countries.

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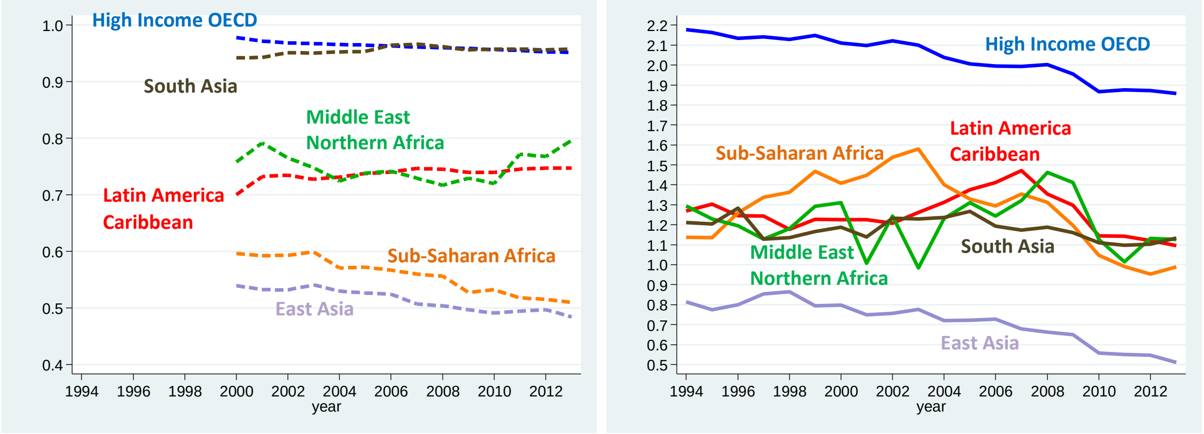
[6] IATA is the International Air Transport Association, i.e. the industry's professional association.

Figure 1 graphically compares the results obtained when computing regional aggregates from each of the three balanced dataset (*"ACI_2000"*, the ACI base of 757 airports over 2000-2013; *"ACI_1994"*, the ACI base of 517 airports over 1994-2013; and *"ICAO_1994"*, a balanced version of the ICAO base over 1994-2013[7]).

The graph on the left *(a)* plots the ratio of the regional aggregates between the two ACI sets (*ACI_1994* divided by *ACI_2000*). The right graph *(b)* plots the ratio of the aggregates obtained with *ACI_1994* divided by those from *ICAO_1994*.

The groupings that are displayed in *Figure 1* follow the World Bank definitions.

Figure 1: Comparison of the regional traffic estimates between the three balanced datasets



(a) Regional aggregates: Comparison between the 1994-2013 balanced ACI set of 517 airports and the 2000-2013 balanced ACI set of 757 airports

(b) Regional aggregates: Comparison between the 1994-2013 balanced ACI set of 517 airports and the balanced ICAO set of countries.

Figure 1 (a) shows that the relationship between the two ACI sets is rather stable. As more airports are included in ACI_2000 than in ACI_1994, it is not surprising that the ratio be lower than one. Only for Middle-East/Northern Africa do we find a pretty erratic behavior over the period. The slightly declining trend that is observed for East Asia and for Sub-Saharan Africa indicates that some airports which reported over a shorter period did have a stronger growth than others.

Figure 1 (b) compares ACI and ICAO aggregates over 1994-2013. It can be seen that the traffic estimates from the two sources are more or less proportional. *Figure 1 (b)* is consistent with the difference of definitions between the two data bases. Because the ICAO data refers to domestically registered airlines, the corresponding volume of traffic in a country is expected to be lower than the traffic reported by the main airports of the country, at least if the coverage of airports is comprehensive enough. This turns out to generally be the case (with the noticeable exception of East Asia). Also the fact that the lines are generally downward sloping would mean that the market share of domestically registered companies tends to increase over time, which seems to make sense. Another explanation could be that the traffic of large newly built airports is not accounted for in the ACI balanced panel data.

Another subset of the ACI data will be used in the section of this paper dealing with panels of countries. It consists of the main airports of a country – most often the capital and/or the largest

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[7] The only country that is added with a balanced version of the ICAO base over 2000-2013 is Armenia, which does not enter in the composition of the country-groupings under scrutiny. This therefore explains why we only refer to the ICAO set when balanced over 1994-2013.

cities' airport. The difference with the data sets reported in *Figure 1* is that the resulting panel is unbalanced. A detailed presentation of the construction of this set can be found in *Appendix 1*, but the main idea is to pick for each country an airport (or a group of airports) with the longest possible time depth and being as representative (in terms of size) as possible. If one is to select one representative airport by country, this selection must be handled with much care as some cities have multiple airports, the traffic of which need to be added to account for the capacity limits. For example, if one focuses on the United Kingdom, the larger traffic is observed in London Heathrow, but other airports help support the traffic growth for the city (Luton, Gatwick, London City Airport…). Secondary airports (which later become primary) are often created to cope with the traffic limitations of the main airport (see for instance the case of Paris: in 1994, both Charles-de-Gaulle and Orly airports were fairly close in terms of traffic – respectively 28.7 and 26.6 million passengers. Yet in 2013, Charles-de-Gaulle represented more than twice the traffic reported by Orly – 62.1 vs. 28.3 million passengers). Additionally with the development of the low-cost industry, some peripheral airports contributed actively to the growth of air traffic.

More expensive databases might give better information on aggregate air traffic than the two just described. As mentioned above, the IATA database is constructed from airline information so that national and regional traffic data is that reported by the companies registered in the country or the region, which may be very different from the actual traffic.[8] Other databases collect detailed information on origin-destination flows but they also are incomplete – e.g. low-cost carriers are not recorded – and/or cover only a few recent years, and/or are not freely accessible.[9]

2. Air transportation and GDP: an analysis by region

This section analyzes the regional aggregates obtained from the three balanced databases. Given the differences in the evolution of the estimates of total regional traffic seen in *Figure 1*, we expect that the ACI and ICAO databases might lead to different conclusions, but the magnitude of the difference still needs to be assessed.

We start with the ICAO database, which offers the advantage of covering a longer time period. *Figure 2* shows the evolution of passenger traffic since 1970 by developing region and for developed countries as a whole. The ordinate scale is set in natural logarithms so that the slope of the various curves corresponds to the growth rate of passenger air traffic in the various groups of countries. Three distinct patterns are readily observable. First, the traffic in developed countries is much larger than in any other region – almost three times the traffic in East Asia by 2013 – but its rate of growth is smaller and declining. Second, East Asia appears as the most dynamic region of the world with a practically constant growth rate close to 10% per annum. The evolution of air transportation in the other three regions is similar: a fast increase in the 1970s, followed by a long slowing down – even a stagnation in Sub-Saharan Africa – during the following two decades, and a new acceleration over the past 10 years or so.

Air traffic in a region logically depends on the degree of economic affluence and on the economic activity of that particular region. Quite remarkably, very much of the heterogeneity in

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[8] See http://www.iata.org/publications/Documents/monthly-traffic-statistics-specs.pdf

[9] This is the case of the MIDT (Market Information Data Transfer) database which records all fares going through travel agencies, including airlines' agencies with proprietary data available since 2001. For a list of available data sources and a short critical review of them see Devriendt, L, B. Derudder and F. Witlox, Introducing a New and Exciting Global Airline Database: 'MIDT', Aerlines, e-zine, issue 32, (2013).

the previous figure mimics differences in the time profile of economic growth rates over the last 40 years across regions. In particular, the slowing down of growth in the developing world (leave aside East Asia) during the 1980s and part of the 1990s seems to have directly affected the evolution of passenger air traffic.

Figure 2 : Air traffic evolution by regional aggregate (1970-2013)
ICAO database (balanced for the "passenger" variable over 1970-2013),
Natural logarithm of the annual number of passengers

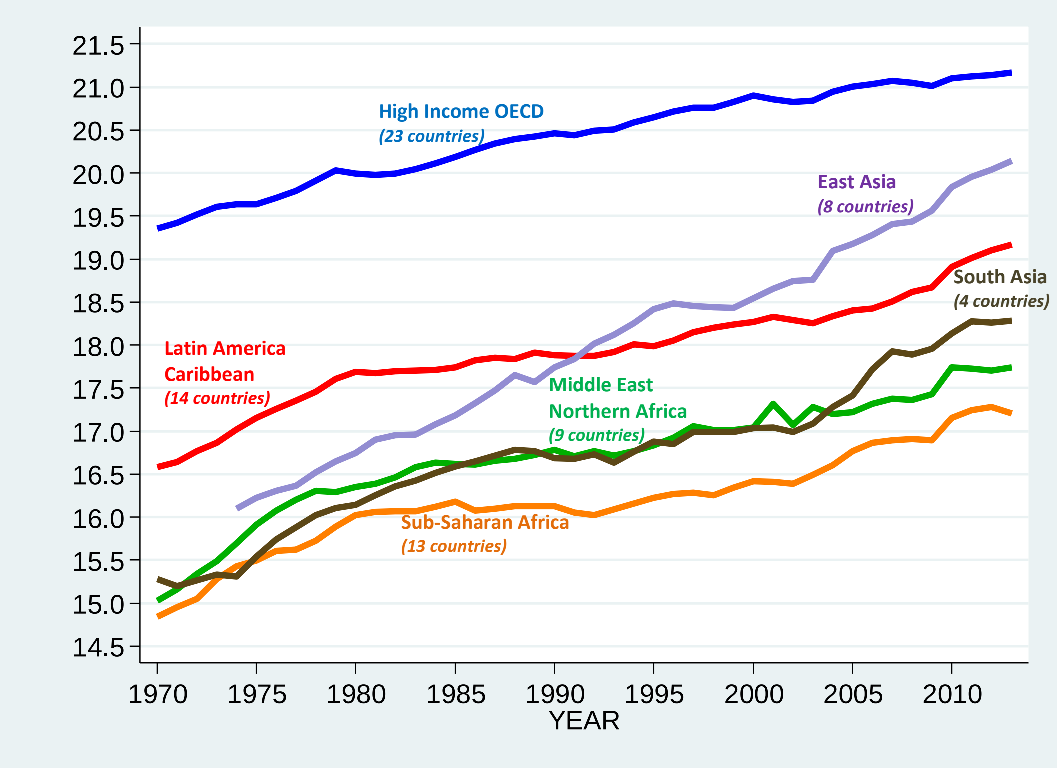
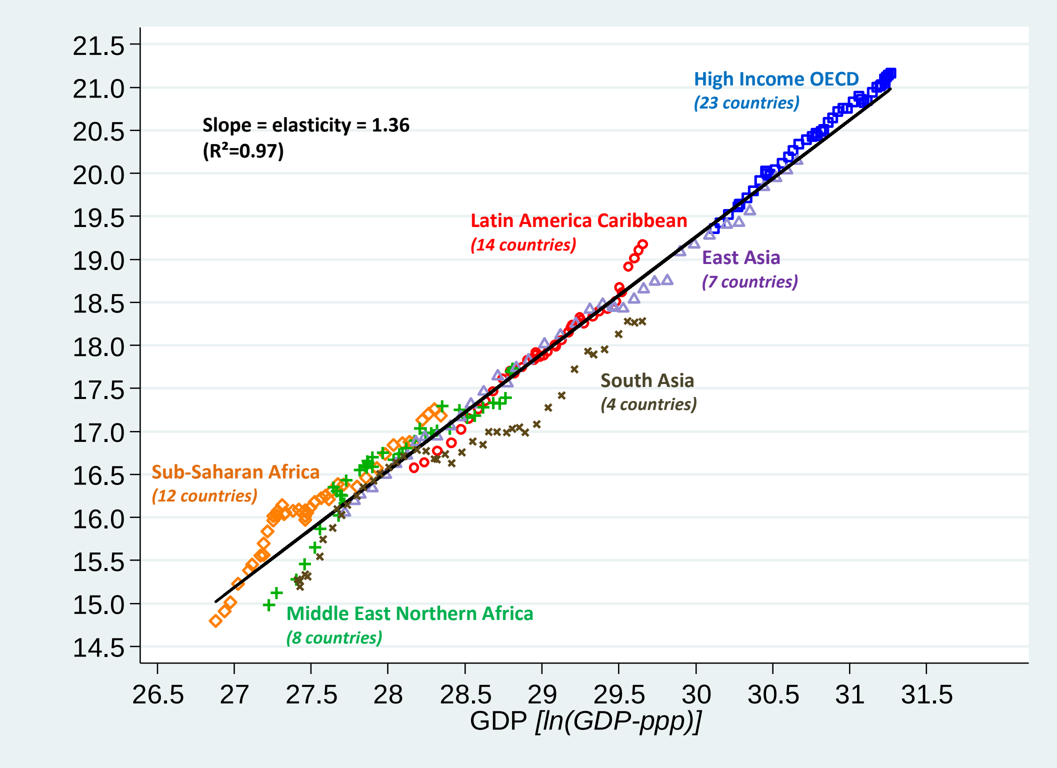


Figure 3 plots the logarithm of air traffic against the logarithm of GDP for the five regional groups of countries considered in the previous figures. The shape of the resulting plots appears much more similar across regions than what could be observed in the preceding chart, even though a clear slowing down of air transportation relative to GDP is still noticeable in the case of South Asia and Sub-Saharan Africa. For the three other groups of countries, *Figure 3* exhibits two remarkable features. First, the three scatter plots are quite clearly linear, with a slope that is comparable across regions. Taken at face value, this would mean that the elasticity of air transportation with respect to GDP has been approximately constant over the last 40 years in these three groups of countries. The elasticity may be a bit higher in the case of high income countries, but, overall it seems to oscillate around a value of 1.35. The second remarkable feature is that the three scatter plots lie approximately on the same line, with clear overlaps between them. In other words, not only does it seem to be the case that the elasticity of air transportation is similar for the East Asian region and high income countries, but the levels of traffic look similar across regions for given levels of GDP. East Asia in 2006 had the same volume of GDP as high income countries in 1970, 36 years earlier, around 12,000 billion ppp-corrected 2011 USD (for roughly 2.5 times more population for East Asia). For this common level of total GDP, air traffic

was the same in 2006 East Asia as in high income countries in 1970, around 270 million passengers. Seven years later, in 2013, East Asia has the same total GDP as high income countries in 1984 and, again, the same volume of passenger air traffic. The same may be observed when comparing Latin America and East Asia. The overlap of the two scatter plots in *Figure 3* is even much longer.

The GDP-air traffic relationship is much less regular for Sub-Saharan Africa and South Asia. Yet, it is remarkable that, in both cases, there seems to be a tendency for the scatter plots not to diverge permanently from the kind of common path that other regions seem to have followed. Sub-Saharan Africa was close to the common path in the 1970s, then diverged for two decades, but seems to be getting close to it again over the recent years. Likewise, South Asia was for some times on the same path as East Asia (with some lag), then diverged, but is eventually getting back to it.

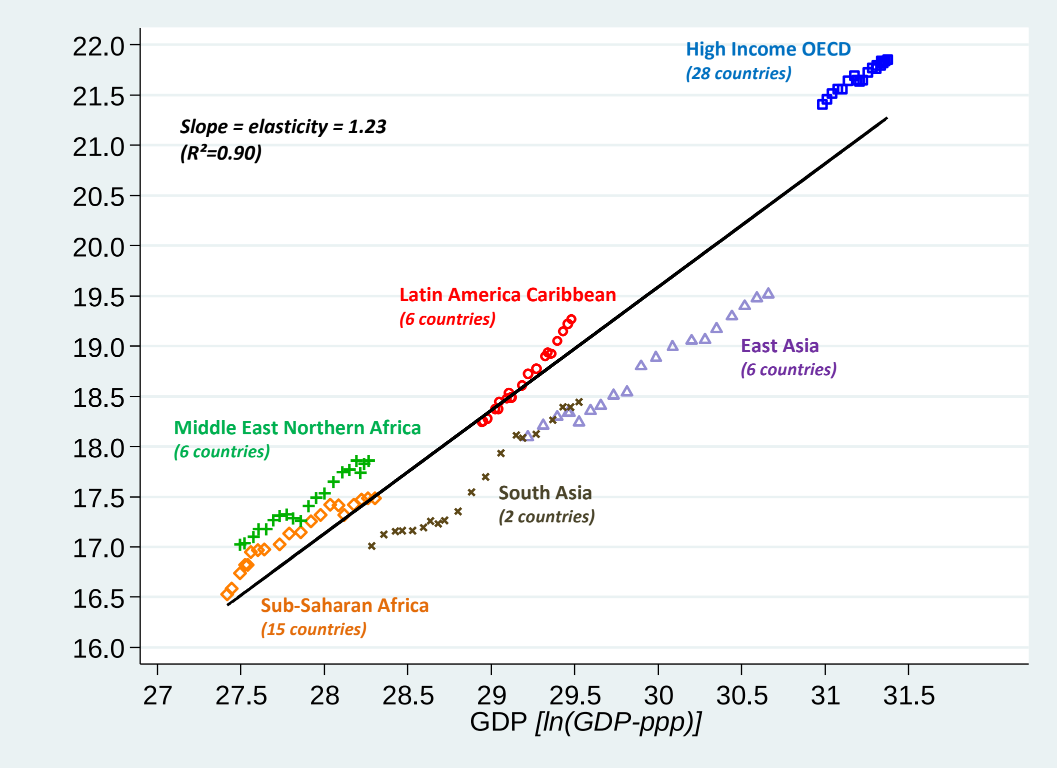
Figure 3: The relationship between passenger air traffic and GDP by region (1970-2013)
ICAO database, (balanced for the "passenger" and "GDP" variables over 1970-2013),
Natural logarithm of the annual number of passengers and of GDP (USD-PPP-2011)



Given what has been said above about the quality of the ICAO data, the idea that all regions follow more or less the same path in terms of the relationship between GDP and air traffic is to be taken with extreme care. On the one hand, it was seen that ICAO data were weak, or at least strongly divergent from ACI data for a region like Sub-Saharan Africa. On the other hand the apparent strong common correlation between passenger air traffic and GDP in *Figure 3* may be very much affected by the strong autonomous time trends behind the evolution of both variables. Yet, the idea of a common path across regions remains an interesting hypothesis that will be formally tested below. It must also be emphasized that what might be true at the regional level might prove wrong at the level of sub-regions and, a fortiori, for individual countries within regions.

A proof that the apparent similarity across regions in *Figure 3* may be due to the data, the length of the period and the country composition of regions is provided by *Figure 4* which shows the same relationship on the basis of the ACI database (balanced set of 517 airports) on a shorter period and for a different set of countries for each region. Regions appear more heterogeneous in this figure than in the previous one.

Figure 4: The relationship between passenger air traffic and GDP by region (1994-2013)
ACI database (balanced for the "passenger" and "GDP" variables over 1994-2013),
Natural logarithm of the annual number of passengers and of GDP (USD-PPP-2011)



The top of *Table 2* reports the GDP elasticity of air transportation in the various regions obtained from a linear regression in growth rates when using the complete ICAO database. Such a specification is preferable to a regression in level or in logarithms because of the spurious correlation that may come from the increasing time profile of the two series, even though the consequence is a somewhat imprecise estimation of the GDP elasticity. The average elasticity across regions is around 1.4, roughly the estimate reported in *Figure 3*. In agreement with the comments made on that figure, and quite remarkably, the GDP elasticity of passenger air traffic does not appear to be significantly different across regions. This can be easily guessed from the wide overlap of the 95% confidence intervals that can be computed from the standard errors of estimates reported in *Table 2* and this is confirmed by a standard Chow test (not reported here). On average, the confidence interval of the elasticity estimate extends from around .5 to 2.3, which includes the 'enduring industry fact' recalled above of an elasticity equal to 2. A second remarkable result in the top of *Table 2* is that the autonomous time trend of regional air traffic –

i.e. the constant of a regression specified in time variation – is not significantly different from zero. Here, too, however, the interval of confidence of the estimate is quite broad. If it cannot be excluded that the annual trend is zero, it cannot be excluded that it is above 1 percent or even more.

The very bottom of *Table 2* is based on the ACI data, the traffic in each country being approximated by the traffic in those airports with complete series over 1994-2013. Because of a shorter time period, and possibly a different data source, the precision of the elasticity estimates is much lower than in the preceding case. Orders of magnitude are generally comparable, but estimates are not significant for Sub-Saharan Africa and the Middle East/North Africa region. The estimated GDP elasticity for South Asia is abnormally high and is compensated for by an abnormally high and quite suspicious negative time trend.

Table 2: Econometric estimates of regional GDP-elasticities and autonomous trend for passenger air traffic in the ICAO and the ACI databases. a), b)

ICAO Balanced panel of countries over 1970-2013 - Regional aggregates

Δ(ln.Passenger)	World	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East North Africa	East Asia	South Asia
	(78 countries)	*(23 countries)*	*(14 countries)*	*(12 countries)*	*(8 countries)*	*(7 countries)*	*(4 countries)*
Δ(ln.GDP)	1.915***	1.928***	1.440***	1.369**	0.769***	1.549***	1.483**
(i.e. GDP-elasticity)	*(0.420)*	*(0.266)*	*(0.285)*	*(0.575)*	*(0.245)*	*(0.424)*	*(0.636)*
Constant	-0.020	-0.009	0.011	0.009	0.036**	-0.012	-0.007
(i.e. annual trend)	*(0.015)*	*(0.009)*	*(0.012)*	*(0.020)*	*(0.014)*	*(0.033)*	*(0.037)*
Nobs	43	43	43	43	43	39	43
Adjusted R²	0.43	0.57	0.39	0.14	0.05	0.12	0.15

$* p < 0.1$; $** p < 0.05$; $*** p < 0.01$

ICAO Balanced panel of countries over 1994-2013 - Regional aggregates

Δ(ln.Passenger)	World	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East North Africa	East Asia	South Asia
	(118 countries)	*(28 countries)*	*(15 countries)*	*(21 countries)*	*(8 countries)*	*(12 countries)*	*(6 countries)*
Δ(ln.GDP)	2.214***	1.788***	1.532**	1.544	0.879	1.959***	3.900***
(i.e. GDP-elasticity)	*(0.709)*	*(0.472)*	*(0.726)*	*(1.080)*	*(0.963)*	*(0.559)*	*(0.910)*
Constant	-0.033	-0.005	0.015	-0.016	0.019	-0.049	-0.160**
(i.e. annual trend)	*(0.026)*	*(0.013)*	*(0.023)*	*(0.046)*	*(0.028)*	*(0.037)*	*(0.058)*
Nobs	19	19	19	19	19	19	19
Adjusted R²	0.45	0.46	0.24	0.09	-0.04	0.16	0.47

$* p < 0.1$; $** p < 0.05$; $*** p < 0.01$

ACI Balanced panel of airports over 1994-2013 - Regional aggregates

Δ(ln.Passenger)	World	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East North Africa	East Asia	South Asia
	(83 countries)	*(28 countries)*	*(6 countries)*	*(15 countries)*	*(6 countries)*	*(6 countries)*	*(2 countries)*
Δ(ln.GDP)	2.008***	1.821***	1.449***	0.606	2.585	1.414**	2.927***
(i.e. GDP-elasticity)	*(0.325)*	*(0.305)*	*(0.407)*	*(0.756)*	*(1.565)*	*(0.540)*	*(0.569)*
Constant	-0.039***	-0.014	0.013	0.022	-0.061	-0.032	-0.116***
(i.e. annual trend)	*(0.013)*	*(0.008)*	*(0.016)*	*(0.043)*	*(0.070)*	*(0.043)*	*(0.036)*
Nobs	19	19	19	19	19	19	19
Adjusted R²	0.57	0.59	0.37	-0.02	0.14	0.15	0.54

$* p < 0.1$; $** p < 0.05$; $*** p < 0.01$

a) *Elasticity estimates are the regression coefficients of the rate of growth of air traffic over the rate of growth of GDP, the constant in that regression being an estimate of the autonomous time trend. NB: to compute the elasticity estimates at the regional level, it was necessary to balance the data accounting for missing observations both in the GDP series and in the traffic series at the country level. The number of countries in each group is thus again different.*

b) *Standard error in brackets and italics.*

A possible reason for these rather aberrant results is the brevity of the period of observation. The effect of brevity is well illustrated in the middle of *Table 2*, which reports results of regressions run on the ICAO database but over the same period as ACI Data – i.e. 1994-2013. Again, rather aberrant results are obtained for South Asia with a huge GDP elasticity compensated by an equally huge negative time trend. As before the elasticity estimates are not significantly different from zero for Sub-Saharan Africa and the Middle East/North Africa region.

Overall, there is a considerable imprecision in these regional estimates of the GDP elasticity of air traffic to GDP, mostly due to some uncertainty about the coverage of the data – in particular ICAO data when compared to ACI data on the 1994-2013 period – and, for ACI data, the paucity of observations. These constraints make it difficult to test other specifications of the dynamics of the relationship between economic activity and air traffic and to test other possible explanatory variables. With both data bases, it is also the case that regional GDP-elasticity estimates are likely to be very much influenced by the largest countries in regional samples. It is thus sufficient that the data be of dubious quality for one or two large countries for the regional estimates to be severely biased.

A way out of these difficulties, i.e. the paucity of observations and the dominance of large countries in regional samples, is to shift the analysis from the region to the country level, assuming that air traffic in given subsets of countries, and primarily in geographic regions, follows some common pattern. This is the approach adopted in the next section.

3. Economic determinants of passenger air traffic: a country panel analysis

If they offer the advantage of smoothing measurement error at the country level, aggregate regional data used in the preceding section ignore a huge mass of information at the country level. Analyzing in more detail the way in which air traffic may depend on GDP and other domestic variables requires working with the country as the unit of analysis. When working with ACI data, however, the period of observation is too short to analyze in any detail the full dynamics of the GDP-air traffic dynamics at the country level. Hence the focus of this section on panel data models, which essentially assume that some key coefficients are common to all countries in a regional subset, or possibly worldwide. Being available on longer time periods, ICAO data would theoretically permit a less restrictive specification. Yet, as seen above there are doubts about the time consistency of this database in the case of some countries, in particular in Africa. It will be seen later in this section that these doubts are well grounded.

The standard dynamic panel data model has the following autoregressive form:

$$A_{i,t} = \theta . A_{i,t-1} + \alpha . Y_{i,t} + {}^{t}\boldsymbol{\beta} . \boldsymbol{X_{i,t}} + \upsilon_i + \varepsilon_{i,t} \; ; \; t \in [\![1;T]\!], \;\; i \in I \qquad \textbf{\textit{(1)}}$$

where $A_{i,t}$ stands for the volume of passenger air traffic in country *i* at time *t* (in logarithm), $Y_{i,t}$for the logarithm of GDP, whereas $\mathbf{X_{i,t}}$ represents a vector of additional potential economic determinants of air traffic and $\varepsilon_{i,t}$ the effect of unobservables as well as measurement errors, assumed to be independent of the other variables on the right-hand side of ***(1)***. The parameters of interest are the GDP-elasticity α, and the $\boldsymbol{\beta}$-coefficients that describe the impact of non-GDP determinants. The constant υ_i somehow represents the scale/size of passenger air traffic in country *i*. It is a 'fixed effect' specific to country *i*, standing for the constant effect of that country's specific characteristics, unlike the coefficients α and $\boldsymbol{\beta}$, which are assumed to be common to all countries in the specific grouping *I*, that defines the panel. Finally the autoregressive term in ***(1)*** allows describing in a simple way the time structure of the effects of the variables on the right-hand side.

It is well-known since Nickell (1981) that the standard fixed effects (FE) approach using OLS with country dummy-variables to account for the fixed effects υ_i leads to biased estimates when the number of time observations is limited. This is due to the demeaning of the dependent and independent variables in ***(1)*** through the fixed effects procedure. In a balanced panel and in presence of a large number of panel observations – i.e. countries – the bias in the estimation of θ is negative and, as both $Y_{i,t}$ and $\boldsymbol{X_{i,t}}$ are likely to be correlated with $A_{i,t-1}$, the estimates of α and $\boldsymbol{\beta}$ are also biased.

A well-known unbiased alternative to this standard procedure is the Arellano-Bond approach to ***(1)***, which consists in estimating ***(1)*** in differenced form using a Generalized Method of Moment (GMM) or the "system-GMM", which jointly estimates the level and the difference equations. In the present case, however, these methods face a major difficulty, which is that the dependent variable, air traffic, as well as some independent variable, GDP in particular, are most likely to be non-stationary variables, i.e. random walks, stochastic trend processes or so-called I(1) variables. Under these conditions, the Arellano-Bond approach which consists of using level variables to instrument time variations is severely biased. Indeed, this is equivalent to instrumenting stationary variables (time variations) with non-stationary variables (levels). Binder et al. (2005) show that this is also the case with system GMM, even with additional moment conditions. The alternative proposed by these authors is rather heavy to implement, however.

Applying the formal unit-root test to the two main variables of our analysis, the log of air traffic and that of GDP, reveals that indeed for almost all countries the hypothesis of a unit root – i.e. the autocorrelation coefficient being equal to unity – cannot be rejected. This is true using the standard Dickey-Fuller test, but also when it is assumed that the variable contains a deterministic trend and when the lag structure of the underlying stochastic process is assumed to be more complicated – Augmented Dickey Fuller test. The results of the test for each country are displayed in *Appendix 2*. In the ACI database (130 countries with at least 10 contiguous observations between 1994 and 2013) the ADF tests leads to the dropping of only 12 countries.

- *Co-integration test with panel data*

It is easily seen that model ***(1)*** above is compatible for I(1) variables only if these variables are co-integrated. To see this, subtract $A_{i,t-1}$ from each side to get:

$$\Delta A_{i,t} = (\theta - 1).A_{i,t-1} + \alpha.Y_{i,t} + {}^{t}\boldsymbol{\beta}.\boldsymbol{X_{i,t}} + \upsilon_i + \varepsilon_{i,t}\ ;\ t \in [\![1;T]\!],\quad i \in I$$

The LHS of that equation is stationary, which implies that the linear combination of I(1) variables on the RHS must be stationary. This means that $A_{i,t}$, $Y_{i,t}$ and those variables in $\boldsymbol{X_{i,t}}$ which are I(1) must be co-integrated.

In view of this property of the data, a natural approach to estimating the relationship between air traffic and economic variables is to rely on co-integration techniques for panel data. Several co-integration tests for panel data are available in the literature – see for instance the survey by Hurlin and Mignon (2007). In the present case, however, note that the test is not whether non-stationary air traffic and GDP variables are co-integrated within each country but whether they are co-integrated with the same co-integrating coefficients. A simple way of testing the latter hypothesis has been proposed by Kao in the case of two I(1) variables. It consists of regressing one over the other using panel OLS with fixed effects and then testing whether the auto-correlation coefficient of the residuals across countries is low enough to reject the hypothesis of a unit root – see Kao (1999, p.8) or Hurlin and Mignon (2007, p.255).

In fact, Kao (1999, p. 21) proposes a co-integration test that applies to more than two I(1) variables with a deterministic trend, but we present here the argument for two variables. Kao's theorem 4 (p. 22) can be summarized as follows. Let the co-integration equation be in the present case:

$$A_{i,t} = \alpha^{*}.Y_{i,t} + \upsilon_i + \varepsilon_{i,t} \qquad \textbf{\textit{(2)}}$$

Let A and Y be two I(1) variables with deterministic trends, $\delta_i^A.t$ and $\delta_i^Y.t$ respectively. Finally, let $\hat{e}_{it}$ be the residual of equation ***(2)*** when applying OLS with fixed effects. Then, it can be shown that the co-integration unit-root test for $\hat{e}_{it}$ has the same asymptotic distribution as the unit root test for testing ρ *=1* in the following regression:

$$m_{i,t} = \rho.m_{i,t-1} + \gamma_i.\mathrm{t} + \upsilon_i + u_{i,t} \quad with \quad m_{i,t} = A_{i,t} - \left(\frac{\delta_i^A}{\delta_i^Y}\right).Y_{it} \qquad \textbf{(3)}$$

The intuition here is derived from the property that, in an I(1) series with a deterministic trend, the trend asymptotically dominates the stochastic part. The switch from $A_{i,t}$ to $m_{i,t}$ in ***(3)*** is equivalent to de-trending $A_{i,t}$. Then regressing $m_{i,t}$ on $Y_{i,t}$ and a trend is asymptotically equivalent to regressing the $m_{i,t}$ on a (country specific) trend only. This is because $Y_{i,t}$ is asymptotically equivalent to a trend. The first part of ***(3)*** is thus equivalent to testing the stationarity of the residual of the co-integration equation ***(2)***.

Under some general assumptions, Kao (1999, p. 22) gives the asymptotic distribution of $(\hat{\rho} - 1)$. Namely, under the null of no-homogeneous co-integration,

$$K = \frac{\sqrt{N}\left[T(\hat{\rho} - 1) - \frac{\mu}{\pi}\right]}{\sqrt{\frac{2895}{112}}} \Longrightarrow \mathcal{N}(0\,;\,1) \qquad \textbf{\textit{(4)}}$$

where:

$$\begin{cases} \mu = \mathbb{E}\left[\frac{1}{T}\sum_{t=1}^{T}\widetilde{m}_{i,t-1} \times u_{it}\right] \\ \pi = \mathbb{E}\left[\frac{1}{T^2}\sum_{t=1}^{T}\left(\widetilde{m}_{i,t-1}\right)^2\right] \end{cases}$$

and:

$$\begin{cases} \widetilde{m}_{i,t} = m_{i,t} - \overline{m}_i - d_i & ; \quad \overline{m}_i = \frac{1}{T}.\sum_{t=1}^{T} m_{i,t} \\ d_i = \frac{\sum_{t=1}^{T}(t - \bar{t}).m_{i,t}}{\sum_{t=1}^{T}(t - \bar{t})^2} & ; \quad \bar{t} = \frac{T+1}{2} \end{cases}$$

Other tests are proposed by Kao (1999) which apply to the t-statistic associated with the estimation of ρ or extend the Augmented Dickey Fuller test. They proved less restrictive than the test above in all the applications developed in the present paper.

- *Applying Kao's test to ACI data*

The results obtained with the ACI and ICAO data are summarized in *Table 3*. This table shows for various regional or economic – i.e. OECD – groupings of countries the number of countries (N) the average number of observation per country (T), the ρ coefficient in ***(3)*** and the Kao statistic, K in ***(4)***.

Although covering the same geographical area, the exact composition of the country groupings cannot be constrained to be the same as in the preceding section. Indeed, on the one hand, the panelization that was necessary to aggregate the data regionally in the preceding section is no longer required. On the other hand, the ADF tests on PIB and traffic series lead to the dropping of some countries in this new approach. Another difference with the aggregate regional results lies in the gathering of South Asia and East Asia into a single region. The reason for this is that the tests developed by Kao are asymptotic with respect to the number of countries in a group, and there were too few countries in South Asia for this condition to be approximately satisfied. In this respect, it must be noted that it would have been possible to design other country groupings than those used in this paper, distinguishing for instance between various parts of Africa or between South and Central America. Alternatively, possibly different results might also have been obtained by using various combinations of countries from a geographic region. Some attempts were made in this direction, but no conclusive results came out of the analysis. All countries for which both the log of air traffic and the log of GDP were found to be I(1) were included in their respective region or grouping.

Table 3 shows that the hypothesis of no homogeneous co-integration of the log of air traffic and the log of GDP across countries can be rather safely rejected for the various developing regions, for the OECD countries and even for the whole set of more than 100 countries which passed the ADF test on air traffic and GDP. This is true for both the ACI and the ICAO data over the 1994-2013 period, and also over the whole period 1970-2013 period for the latter. It can be observed that in all cases, the estimated auto-correlation coefficient ρ is very significantly below unity, which is equivalent to the condition for the stationarity of the residual in ***(2)*** and therefore for co-integration.

The panel co-integration test is so uniformly positive in *Table 3* that one may worry that it is not discriminatory enough. Although results are not reported here, however, it turns out that some sub-regional groupings do not pass the test. This is the case for instance of the East-Africa region with ICAO data over 1994-2013, despite the fact that the database for that region includes 9 countries. Similarly, Central Asia (4 countries) does not pass the test. As for ACI data, the OECD (22 countries) fails the test, as well as West Europe (16 countries).

It should be noted that the co-integration tests reported in *Table 3* refer to two variables only, the log of air traffic and the log of GDP. Kao tests may easily be extended to more than two variables when variables are I(1) with deterministic trends. It turned out that the other variables that could have been taken into account into the analysis were either very close to trends, as it would be the case for population for instance, or themselves stationary as it is the case with the openness of the economy or the terms of trade – see below. Of course, there are also many country characteristics that may explain a different relationship between air traffic and GDP like the size of a country, whether it is an island or whether it exerts touristic attraction. But these characteristics are all included in the country fixed effect present in the co-integration tests.

Table 3: Test of the absence of homogeneous co-integration in regional country panels[a] [b]

ACI 'MainAirports' database 1994-2013

Country groupings	All	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Nb. of countries	118	30	19	27	11	16
Average Nb. of obs.	17.0	18.5	15.4	16.9	17.5	15.8
Rho (ρ)	0,634***	0.804***	0.474***	0.543***	0.617***	0.588***
Standard Error	*-0,037*	*(0.058)*	*(0.037)*	*(0.091)*	*(0.062)*	*(0.073)*
Kao DF ρ - statistic	-12.748***	-3.927***	-6.871***	-7.613***	-4.378***	-4.668***
p-value (2 tails-test)	0.000	0.038	0.000	0.000	0.000	0.000

ICAO database (1994-2013)

Country groupings	All	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Nb of countries	126	29	16	22	14	25
Average Nb of obs.	18.0	18.8	18.5	17.5	16.4	17.7
Rho (ρ)	0.692***	0.750***	0.532***	0.739***	0.509***	0.560***
Standard Error	*(0.034)*	*(0.021)*	*(0.114)*	*(0.067)*	*(0.102)*	*(0.067)*
Kao DF ρ -statistic	-12.049***	-4.868***	-6.853***	-4.006***	-5.971***	-7.558***
p-value (2 tails-test)	0.000	0.000	0.000	0.000	0.000	0.000

ICAO database (1970-2013)

Country groupings	All	OECD	Latin America Caribbean	Sub-Saharan Africa	Middle East Northern Africa	South and East Asia
Nb of countries	142	28	21	36	11	25
Average Nb of obs.	34.0	38.2	38.3	32.6	37.8	33.7
Rho (ρ)	0.781***	0.795***	0.865***	0.808***	0.805***	0.758***
Standard Error	*(0.025)*	*(0.021)*	*(0.040)*	*(0.031)*	*(0.003)*	*(0.025)*
Kao DF ρ -statistic	-17.222***	-7.953***	-4.793***	-6.844***	-4.813***	-7.550***
p-value (2 tails-test)	0.000	0.000	0.000	0.000	0.000	0.000

[a] *Standard errors in brackets and italics, * p>.1, ** p>.05, *** p>.01*

[b] *The databases are restricted to those countries with at least 10 continuous years of observation, and with I(1) GDP and traffic variables (cf. ADF procedure above).*

Now that the panel homogeneous co-integration tests have been satisfactorily passed, it is time to return to our original goal to estimate the dynamics of the relationship between passenger air traffic and GDP on the basis of regional country panels. A convenient way of representing the short-run and long-run dynamics of that relationship, and a way consistent with the co-integration property, is provided by the Error Correction Model (ECM) specification. Formally, this specification writes:

$$\Delta A_{it} = -\phi . [A_{it-1} - \chi . Y_{it-1} - \upsilon_i] + \sum_{s=1}^{+V} (\psi_{As} . \Delta A_{it-s}) + \sum_{s=-U}^{+U} (\psi_{Ys} . \Delta Y_{it-s}) + {}^t\boldsymbol{\omega} . \boldsymbol{X}_{it} + \varepsilon'_{it} \qquad \textbf{\textit{(5)}}$$

The term in square bracket corresponds to the co-integration or long-run relationship so that, at any point in time, the growth rate of air traffic compensates part of the observed gap in that relationship, with an 'error correction' coefficient ϕ, which is assumed to be the same across countries. The second term on the RHS stands for the dynamics of that correction, as it introduces some dependency between the current and past growth of air traffic. The following term describes the direct effect of past, present and possibly future changes in the independent variables on the current growth of air traffic. For the co-integration logics to go through, however, it is important that these variables be stationary. The last term before the white noise allows considering variables the levels of which might directly affect the evolution of air traffic on the short run, as well as a deterministic trend. Overall, the dynamics that can be represented by this specification thus seems rather complete.

The main results of the ECM estimation are shown in *Table 4* for the ACI database. Two specifications of equation ***(5)*** are reported on that table (with and without time trend). Given the already limited time depth of the series, the regressions only include one lag of the dependent variable ($\forall s > 1,\ \psi_{As} = 0$). For the same reason, only are contemporary and first lag values of the differentiated explanatory variable (GDP) considered ($\forall s \neq 0\ or\ 1,\ \psi_{Ys} = 0$). The models include two auxiliary variable X: the terms of trade (TOT) as well as the presence and magnitude of political disorders, taken from the Cross-National Time-Series Data Archive, a political science database that was initially launched by A. Banks.[10] The variable used in this paper aggregates various dimensions of political disorders, from major protests to political assassinations and civil conflicts.[11] In the present case, it has been normalized to lay between zero and one by dividing it by the largest value in the whole sample.

Other variables describing the countries' economic structures have been tried without success. This has been the case for instance with variables representing the sectoral structure of the GDP or the degree of openness of the economy, assuming that a more open economy would use air transportation more intensively. None of them came out significantly. Note however that, on average over the observation period, this does not mean that they do not play some role in the relationship between air traffic and GDP. Their effect may simply be hidden in the fixed effect coefficients $\upsilon_i$of the panel ECM ***(5)***. For example, the fact that the GDP-export share does not come out significantly in the estimation of ***(5)*** simply means that variations in openness during the observation period did not lead to significant changes in the volume of air traffic. This does not necessarily contradict the view that a more open economy may be more intensive in air traffic. Yet, this pure cross-sectional property is not investigated in the present paper.

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[10] Banks, Arthur S., Wilson, Kenneth A. 2015. Cross-National Time-Series Data Archive. Databanks International. Jerusalem, Israel; see http://www.databanksinternational.com

[11] This is the variable labelled *"Domestic09"* in the database.

The second specification in *Table 4* simply adds a time trend to the auxiliary variables X. It is expected that such an autonomous source of growth reduces the estimated GDP elasticity of passenger air traffic.

Table 4: Estimates of the dynamics of the air traffic/GDP relationship (ECM specification) ACI data 1994- 2013 $^{a) \, b) \, c)}$

Country groupings	**All**	**High Income OECD**	**Latin America Caribbean**	**Sub-Saharan Africa**	**Middle East Northern Africa**	**South and East Asia**
Dependant variable = growth of traffic (Δ Log Traffic)						
Error Correction Model (fixed effects, no trend)						
Lagged Log Traffic (-ϕ)	-0.194*** *(0.029)*	-0.137*** *(0.034)*	-0.329** *(0.111)*	-0.359*** *(0.052)*	-0.134 *(0.080)*	-0.197** *(0.053)*
Lagged Log GDP (ϕχ)	0.324*** *(0.042)*	0.265*** *(0.063)*	0.391** *(0.134)*	0.519*** *(0.078)*	0.140 *(0.095)*	0.373** *(0.111)*
Political Disorder (ω_1)	-0.188 *(0.180)*	0.186 *(0.323)*	-0.073 *(0.397)*	-0.495** *(0.147)*	0.489 *(0.441)*	-0.375 *(0.272)*
Terms of Trade (ω_2)	0.020 *(0.025)*	0.024 *(0.034)*	0.050 *(0.089)*	0.063 *(0.053)*	0.043 *(0.047)*	-0.110 *(0.091)*
Growth of GDP (ψ_{Y0})	1.056*** *(0.216)*	1.708*** *(0.128)*	1.018*** *(0.230)*	0.855 *(0.491)*	0.370 *(0.276)*	1.707*** *(0.284)*
Long-run GDP-elasticity of air traffic (χ)	1.668*** *(0.118)*	1.942*** *(0.179)*	1.188*** *(0.163)*	1.444*** *(0.117)*	1.044** *(0.389)*	1.893*** *(0.151)*
Testing ($\chi - \psi_{Y0}$)=0	0.613** *(0.213)*	0.233 *(0.201)*	0.170 *(0.163)*	0.589 *(0.517)*	0.674 *(0.466)*	0.186 *(0.238)*
R² (within)	0.173	0.369	0.249	0.198	0.074	0.308
Error Correction Model (fixed effects, with country-specific trends)						
Lagged Log Traffic (-ϕ)	-0.525*** *(0.037)*	-0.343*** *(0.033)*	-0.639*** *(0.061)*	-0.663*** *(0.059)*	-0.566*** *(0.101)*	-0.482*** *(0.067)*
Lagged Log GDP (ϕχ)	0.459*** *(0.073)*	0.171 *(0.135)*	0.470* *(0.191)*	0.372 *(0.236)*	0.339* *(0.135)*	0.650* *(0.298)*
Political Disorder (ω_1)	-0.145 *(0.175)*	-0.144 *(0.260)*	0.811 *(0.539)*	-0.320 *(0.278)*	0.208 *(0.480)*	-0.414 *(0.222)*
Terms of Trade (ω_2)	0.067* *(0.032)*	0.215* *(0.091)*	0.040 *(0.081)*	0.114* *(0.052)*	0.043 *(0.080)*	-0.209 *(0.197)*
Growth of GDP (ψ_{Y0})	0.978*** *(0.224)*	1.605*** *(0.162)*	0.807** *(0.267)*	0.745 *(0.561)*	0.232 *(0.288)*	1.611*** *(0.314)*
Average time trend	1.56%*** *(0.37%)*	1.39%*** *(0.34%)*	1.47%* *(0.76%)*	2.73%*** *(0.98%)*	1.85%* *(0.97%)*	0.94% *(1.30%)*
# neg. Trend // # pos. Trend	***13** <0 // **27** ~ // **78** >0*	***0** <0 // **6** ~ // **24** >0*	***2** <0 // **11** ~ // **6** >0*	***2** <0 // **10** ~ // **15** >0*	***0** <0 // **6** ~ // **5**> 0*	***1** <0 // **14** ~ // 1>0*
Long-run GDP-elasticity of air traffic (χ)	0.874*** *(0.157)*	0.498 *(0.379)*	0.736* *(0.309)*	0.562 *(0.347)*	0.599* *(0.278)*	1.348* *(0.599)*
Testing ($\chi - \psi_{Y0}$)=0	-0.103 *(0.193)*	-1.107** *(0.417)*	-0.071 *(0.141)*	-0.183 *(0.465)*	0.367 *(0.253)*	-0.263 *(0.440)*
R² (within)	0.376	0.488	0.447	0.397	0.338	0.445
Nb of obs.	1887	524	274	428	182	237
Nb of countries	118	30	19	27	11	16
Average Nb of obs.	15.99	17.47	14.42	15.85	16.55	14.81

$^{a)}$ *Standard errors in brackets and italics, * p>.1, ** p>.05, *** p>.01*

$^{b)}$ *The ACI database is restricted to those countries with at least 10 continuous years of observation, and with I(1) GDP and traffic variables (cf. ADF procedure above).*

$^{c)}$ *In the second sub-table, we indicate the average of the country-specific time trends for the considered group, obtained through a linear combination of the corresponding coefficients. We report below the number of countries for which the time trend is significantly negative (<0), non-significantly different from zero (~), and significantly positive (>0).*

As can be seen from ***(5)*** the long-run GDP elasticity of air traffic is given by the ratio of the coefficient of lagged *ln(GDP)* and that of *ln(air traffic)*. The corresponding estimates and their standard errors appear at the bottom of the first block – i.e. no time trend specification – of *Table 4*. Overall, these figures are comparable if not rigorously identical to those obtained in the preceding section on the basis of regional aggregates. The main difference is that they are more precise, even though their standard error is still high in the Middle East/North Africa. In general across regions, the 95% confidence interval lies between 1 and 2. More precisely, the smallest lower bound is reached with Latin America (0.86) and the largest upper bound is for the OECD (2.30).As before, it is worth stressing that, on the basis of these confidence intervals, the long-run GDP elasticity of air traffic does not appear to be different across regions. The ECM specification enables to investigate in more detail the true dynamics of the air traffic/GDP relationship and in particular to distinguish between the short-run elasticity (that is the immediate reaction of air traffic to a variation of GDP) and the long-run elasticity (or in other words, the increase in air traffic when this variation is permanent). Interestingly enough, the figures reported in the "Growth of GDP" row of *Table 4* show that the short-run elasticity is quite substantial, as a matter of fact of the same order of magnitude as the long-run elasticity. This holds for all regions, except perhaps in the Middle East and Africa, where the short term elasticity estimate is smaller and less precise. We tested whether the short-term and long term elasticity coefficients were different (*cf* the "Testing $(\chi - \psi_{Y0}) = 0$" row of *Table 4*), and only for the whole set of 118 countries does the difference come up as statistically significant.

The political disorder and terms of trade variables turned out to be the only variables that had some significant impact on air traffic among the set of additional variables that were tried. Not surprisingly, when significant, political disorders reduce air traffic for a given GDP. Not surprisingly either, over the 1994-2013 period, this variable is significant only in Sub-Saharan Africa, the region most affected by political conflicts. Without time trends, the terms of trade variable is never significant.

The bottom part of *Table 4* shows the results of introducing an autonomous and country-specific time trend in the specification of the model. As could be expected, the country-level time trends contribute to reducing the long-term GDP elasticity of air traffic. It is indeed more than halved when all countries are considered together, as well as in the case of High-Income OECD countries and Sub-Saharan Africa. The drop in the long-run GDP elasticity estimate is accompanied by a sizable increase in its standard error, so that the long-run elasticity is not significantly different from zero anymore for two groups. Although still negative, the impact of the political disorders is no longer significantly different from zero in Africa. The variable does not come out as significant in any of the groupings when a country-specific time trend is accounted for. However, the terms of trade variable is now significant at the 10% level in the OECD and Sub-Saharan Africa, as well as for the set of all available countries. In all three cases, the coefficient is positive, indicating that better terms of trade tend to increase air traffic.

We looked more closely at the content of the country-specific time trends. We report in the table their simple average for each group of countries, and we also provide an indication on their distribution. Indeed, we report the number of countries with a significantly negative trend ("*<0*"), with a trend non-significantly different from zero ("*~*"), and with a significantly positive trend ("*>0*")[12]. Except from Asia, the average trends are significantly positive. If one focuses on the country specific trends obtained with the full sample, one can see that they lie between a significant -2.25% for Tonga and a significant 7.10% for Latvia. The BRICs are all associated

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[12] For a given country, the trend estimated with the whole set and that obtained with the regional set needs not be the same. The trend coefficients are deemed statistically significant if their p-value is smaller than 0.05.

with a significantly positive trend (point estimates between 3.48% for India and 5.39% for China).

Estimation results obtained with the ICAO database over the period 1994-2013 are shown in *Table 5.*[13]

Table 5: Estimates of the dynamics of the air traffic/GDP relationship (ECM specification) ICAO data, 1994-2013 $^{a)\ b)\ c)}$

ICAO database starting 1994 (1994-2013)

Country groupings	**All**	**High Income OECD**	**Latin America Caribbean**	**Sub-Saharan Africa**	**Middle East Northern Africa**	**South and East Asia**
	Dependant variable = growth of traffic (Δ Log Traffic)					
Error Correction Model (fixed effects, no trend)						
Lagged Log Traffic ($-\phi$)	-0.171***	-0.278***	-0.208***	-0.120	-0.324***	-0.209***
	(0.040)	*(0.062)*	*(0.044)*	*(0.070)*	*(0.070)*	*(0.032)*
Lagged Log GDP ($\phi\chi$)	0.254***	0.421***	0.416***	0.206	0.487***	0.387***
	(0.074)	*(0.111)*	*(0.070)*	*(0.162)*	*(0.078)*	*(0.068)*
Political Disorder (ω_1)	-0.141	1.100	-0.312	-0.197	0.253	-0.527***
	(0.177)	*(0.835)*	*(0.586)*	*(0.374)*	*(0.193)*	*(0.071)*
Terms of Trade (ω_2)	0.025	0.078	0.080	0.035	-0.090	-0.030
	(0.041)	*(0.065)*	*(0.096)*	*(0.099)*	*(0.048)*	*(0.032)*
Growth of GDP (ψ_{Y0})	0.697***	1.299*	0.953**	0.246	0.201	1.055***
	(0.144)	*(0.494)*	*(0.314)*	*(0.211)*	*(0.255)*	*(0.195)*
Long-run GDP-elasticity of air traffic (χ)	1.486***	1.516***	1.995***	1.711**	1.505***	1.851***
	(0.245)	*(0.202)*	*(0.507)*	*(0.630)*	*(0.113)*	*(0.208)*
Testing ($\chi - \psi_{Y0}$)=0	0.789***	0.217	1.042	1.465*	1.305***	0.795**
	(0.236)	*(0.618)*	*(0.605)*	*(0.694)*	*(0.311)*	*(0.307)*
R² (within)	0.073	0.163	0.194	0.036	0.200	0.173
Error Correction Model (fixed effects, with country-specific trends)						
Lagged Log Traffic ($-\phi$)	-0.326***	-0.368***	-0.398***	-0.237*	-0.556***	-0.506***
	(0.044)	*(0.016)*	*(0.038)*	*(0.086)*	*(0.098)*	*(0.050)*
Lagged Log GDP ($\phi\chi$)	0.244	0.136	0.272	0.072	0.305	1.050***
	(0.233)	*(0.331)*	*(0.306)*	*(0.440)*	*(0.305)*	*(0.179)*
Political Disorder (ω_1)	-0.212	0.524	-0.139	-0.787	0.562*	-0.309*
	(0.173)	*(0.481)*	*(0.649)*	*(0.471)*	*(0.230)*	*(0.128)*
Terms of Trade (ω_2)	0.063	0.211	0.287*	0.119	-0.087	-0.005
	(0.070)	*(0.226)*	*(0.116)*	*(0.117)*	*(0.095)*	*(0.074)*
Growth of GDP (ψ_{Y0})	0.578***	1.534***	0.541	0.185	-0.080	1.073***
	(0.159)	*(0.403)*	*(0.458)*	*(0.267)*	*(0.268)*	*(0.220)*
Average time trend	0.58%	1.20%	0.91%	0.02%	2.78%	-1.56%*
	(0.81%)	*(1.14%)*	*(1.15%)*	*(0.17%)*	*(1.59%)*	*(0.80%)*
# neg. Trend // # pos. Trend	***14*** *<0 //* ***71*** *~ //* ***41*** *>0*	***1*** *<0 //* ***21*** *~ //* ***7*** *>0*	***1*** *<0 //* ***14*** *~ //* ***1*** *>0*	***4*** *<0 //* ***16*** *~ //* ***2*** *>0*	***0*** *<0 //* ***10*** *~ //* ***4>*** *0*	***9*** *<0 //* ***13*** *~ // 3>0*
Long-run GDP-elasticity of air traffic (χ)	0.748	0.370	0.684	0.302	0.549	2.074***
	(0.644)	*(0.890)*	*(0.799)*	*(1.782)*	*(0.596)*	*(0.331)*
Testing ($\chi - \psi_{Y0}$)=0	0.169	-1.164	0.143	0.117	0.629	1.001**
	(0.557)	*(0.652)*	*(0.551)*	*(1.641)*	*(0.440)*	*(0.352)*
R² (within)	0.221	0.247	0.307	0.204	0.312	0.318
Nb of obs.	2137	515	280	362	216	418
Nb of countries	126	29	16	22	14	25
Average Nb of obs.	16.96	17.76	17.50	16.45	15.43	16.72

$^{a)}$ *Standard errors in brackets and italics, * p>.1, ** p>.05, *** p>.01*

$^{b)}$ *The ICAO database is restricted to those countries with at least 10 continuous years of observation, and with I(1) GDP and traffic variables (cf. ADF procedure above).*

$^{c)}$ *In the second sub-table, we indicate the average of the country-specific time trends for the considered group, obtained through a linear combination of the corresponding coefficients. We report below the number of countries for which the time trend is significantly negative (<0), non-significantly different from zero (~), and significantly positive (>0).*

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[13] The model was also tested on the ICAO data over the 1970-2013 period, and the results are presented in *Appendix 3*.

If the long-run GDP elasticity estimates in the top of *Table 5* do not appear to be significantly different from those obtained with the ACI data, except perhaps for Latin America, some major differences appear. The first one is the lower level of explanatory power of the ECM in comparison with the preceding table (the only exception being the Middle East/North Africa region). Indeed, the R^2 statistic, which corresponds to the percentage of the variance within countries explained by the ECM variables, is rather low: it even represents less than 10% for the set of all countries or for Sub-Saharan Africa. Second, some variables lose all significance in some regions, despite their obvious relevance: GDP has no significant immediate impact on air traffic in the case of Sub-Saharan Africa and the Middle East/North Africa; political disorder is no longer significant in the case of Sub-Saharan Africa, although this is probably where it is expected to be have a major negative impact, yet it now plays a significantly negative role in Asia.

The effect of introducing a country-specific time trend in the co-integration equation is also somewhat different from what was observed with the ACI data. Except for Asia, no long-term elasticity is statistically different from zero. Even the short term elasticities lose all significance for Latin America, Sub-Saharan Africa and the Middle East. The time trends themselves are much less often significant.

Based on that comparison of ECM estimates and in agreement with our initial intuition of a lesser quality of the ICAO data due to its focus on nationally registered companies only, we tend to have more confidence in the results obtained with the ACI data. The results obtained with this data and an estimation procedure based on country panels by region confirm the role of economic activity as a determinant of the volume of passenger air traffic. For the various regions considered in this paper, the hypothesis cannot be rejected that GDP and air traffic are cointegrated variables, each with a powerful trend. When not controlling for this trend, the long-run elasticities of air traffic to GDP are of the same order of magnitude as the aggregate regional estimates reported in the previous section of this paper, but thanks to the panel specification they are more precisely estimated, even though the 95 percent interval remains rather large in several instances. Interestingly enough, the short-run elasticities most often are of the same order of magnitude as the long-run elasticities, so that the impact of GDP on air traffic seems close to being instantaneous. However, things are different when autonomous trends are taken into account, which the aggregate regional analysis failed to identify. In general, allowing for such trends substantially reduces the GDP-elasticity.

The preceding analyses on the relationship between air traffic and GDP are complemented with an investigation of the link between the development level and air transportation. We merely substitute per-capita GDP to the GDP variable in *Equation (5)*, assuming that the population variable would be represented by a time trend. The ADF procedure mentioned in the beginning of *Section 3* (and the results of which are reported in *Appendix 2*) applied to the per-capita variable leads to the rejection of the same countries plus Guinea. The Kao tests of panel co-integration (for traffic and per-capita GDP) are passed for each sub-region (although only at the 10% confidence level for the Middle-East). The estimation results are displayed in *Table 6*.

Table 6: Estimates of the dynamics of the air traffic/GDP per capita relationship (ECM specification) ACI data 1994- 2013 [a) b) c)]

Country groupings	**All**	**High Income OECD**	**Latin America Caribbean**	**Sub-Saharan Africa**	**Middle East Northern Africa**	**South and East Asia**
Kao DF *ρ*-statistic	-13.669	-2.073	-5.449	-4.998	-1.700	-5.853
p-value (2 tails-test)	*0.000*	*0,038*	*0.000*	*0.000*	*0,089*	*0.000*
	Dependant variable = growth of traffic (Δ Log Traffic)					
Error Correction Model (fixed effects, no trend)						
Lagged Log Traffic $(-\phi)$	-0.138***	-0.151**	-0.271**	-0.217**	-0.067	-0.155***
	(0.039)	*(0.042)*	*(0.089)*	*(0.060)*	*(0.041)*	*(0.036)*
Lagged Log GDP ***per capita*** $(\phi\chi)$	0.280**	0.353***	0.384*	0.446**	-0.000	0.373***
	(0.092)	*(0.092)*	*(0.137)*	*(0.157)*	*(0.063)*	*(0.084)*
Political Disorder (ω_1)	-0.173	0.267	-0.183	-0.475**	0.662	-0.445
	(0.172)	*(0.333)*	*(0.364)*	*(0.130)*	*(0.458)*	*(0.313)*
Terms of Trade (ω_2)	0.061*	0.055	0.077	0.054	0.076	-0.093
	(0.027)	*(0.044)*	*(0.071)*	*(0.058)*	*(0.045)*	*(0.100)*
Growth of GDP ***per capita*** (ψ_{Y0})	1.041***	1.706***	1.061***	0.873	0.079	1.656***
	(0.225)	*(0.131)*	*(0.236)*	*(0.574)*	*(0.220)*	*(0.291)*
Long-run GDP***pc***-elasticity of air traffic (χ)	2.039***	2.342***	1.416***	2.056***	-0.001	2.412***
	(0.204)	*(0.172)*	*(0.235)*	*(0.329)*	*(0.948)*	*(0.270)*
Testing $(\chi - \psi_{Y0})=0$	0.998***	0.636**	0.355	1.183*	-0.080	0.756*
	(0.219)	*(0.210)*	*(0.200)*	*(0.592)*	*(0.944)*	*(0.316)*
R² (within)	0.142	0.365	0.223	0.114	0.042	0.272

Error Correction Model (fixed effects, with country-specific trends)						
Lagged Log Traffic $(-\phi)$	-0.513***	-0.337***	-0.641***	-0.675***	-0.549***	-0.482***
	(0.037)	*(0.032)*	*(0.063)*	*(0.065)*	*(0.098)*	*(0.062)*
Lagged Log GDP ***per capita*** $(\phi\chi)$	0.425***	0.210	0.483*	0.488	0.034	0.650*
	(0.079)	*(0.132)*	*(0.220)*	*(0.285)*	*(0.133)*	*(0.291)*
Political Disorder (ω_1)	-0.180	-0.128	0.807	-0.346	0.090	-0.449
	(0.176)	*(0.261)*	*(0.535)*	*(0.286)*	*(0.459)*	*(0.237)*
Terms of Trade (ω_2)	0.074*	0.228*	0.038	0.101	0.080	-0.213
	(0.032)	*(0.095)*	*(0.084)*	*(0.055)*	*(0.075)*	*(0.200)*
Growth of GDP ***per capita*** (ψ_{Y0})	0.920***	1.595***	0.813*	0.787	-0.045	1.529***
	(0.218)	*(0.166)*	*(0.285)*	*(0.556)*	*(0.214)*	*(0.319)*
Average time trend	2.26%***	1.40%***	2.02%***	3.75%***	3.17%***	1.84%*
	(0.29%)	*(0.27%)*	*(0.58%)*	*(0.50%)*	*(0.63%)*	*(0.91%)*
# neg. Trend // # pos. Trend	4 <0 // 15 ~ // 99 >0	0 <0 // 2 ~ // 28 >0	2 <0 // 8 ~ // 9 >0	0 <0 // 4 ~ // 22 >0	0 <0 //2 ~ // 10> 0	1 <0 //9 ~ // 6>0
Long-run GDP***pc***-elasticity of air traffic (χ)	0.828***	0.623	0.754*	0.723	0.063	1.350*
	(0.167)	*(0.380)*	*(0.342)*	*(0.395)*	*(0.246)*	*(0.593)*
Testing $(\chi - \psi_{Y0})=0$	-0.091	-0.972*	-0.059	-0.064	0.108	-0.179
	(0.182)	*(0.401)*	*(0.134)*	*(0.474)*	*(0.230)*	*(0.442)*
R² (within)	0.371	0.483	0.447	0.404	0.315	0.437

Nb of obs.	1886	524	274	410	199	237
Nb of countries	118	30	19	26	12	16
Average Nb of obs.	15.98	17.47	14.42	15.77	16.58	14.81

[a)] *Standard errors in brackets and italics, * p>.1, ** p>.05, *** p>.01*

[b)] *The ACI database is restricted to those countries with at least 10 continuous years of observation, and with I(1) GDP per capita and traffic variables (cf. ADF procedure above).*

[c)] *In the second sub-table, we indicate the average of the country-specific time trends for the considered group, obtained through a linear combination of the corresponding coefficients. We report below the number of countries for which the time trend is significantly negative (<0), non-significantly different from zero (~), and significantly positive (>0).*

Using Per-capita GDP does not significantly alter the results. One can notice a slight increase in the long-term elasticity coefficients (when no trend is added) or in the trend coefficients (when they are present). This is probably due to the need to account for the population growth trend in the new specification). Another noticeable fact is that the long term elasticity coefficient is no longer significantly different from zero for the Middle-East (with and without trend). The proximity of these results to those obtained with GDP is not really surprising. The population size in most countries is close to a time trend, especially on a less than 20 year period. As GDP per capita also includes a time trend, it can hardly be distinguished from GDP in the preceding regressions.

4. Conclusion.

This paper tried to estimate the GDP-elasticity of air traffic in developing countries, with the idea of testing whether that relationship is different from what is observed and what is known in developed countries, and in particular this common view of an elasticity around 2.

Two types of analyses were conducted. Looking at regional aggregates, it would indeed seem that the GDP-elasticity of air traffic is rather high – with an average point estimate around 1.4 – and not significantly different across regions of the world. With one data base, it is not even sure that the whole relationship between air traffic and GDP differs across regions. In other words, it cannot be excluded that air traffic in East Asia or Latin America will be the same as in the whole set of developed countries when GDP will be of the same order of magnitude. A limitation of this analysis, however, is the imprecision of all estimates. When point estimates are around 1.4 on average, it cannot really be excluded that actual elasticities are close to 2 or close to 1!

To gain in precision, the analysis was then led at the country level assuming that the relationship between GDP and air traffic would be the same across countries, up to some fixed effect, in the same geographical region. Using panel co-integration techniques and an Error Correction Model specification to estimate the dynamics of the GDP-air traffic relationship, results were found to be consistent with the aggregate regional analysis when excluding the possibility that the relationship could include powerful country-specific autonomous trends. Yet, quite different results were obtained when allowing for such trends. GDP-elasticities of air traffic were much lower, and in several instances not statistically different from zero – but not significantly different from unity either! Substituting GDP with per-capita-GDP does not significantly alter the conclusions.

Based on the data used in this paper, three important conclusions seem to come out. a) There does not seem to be significant differences between developing regions, nor between them and developed countries, in the way economic activity affects air traffic. This is even true for the least advanced countries in Sub-Saharan Africa. b) But, the GDP-elasticity of air traffic seems to be significantly much lower than the commonly held view that it should be around 2, as soon as country specific autonomous time trends are taken into account. A unit elasticity, which would correspond to a rather intuitive economic argument, can certainly not be ruled out. c) The estimates of the present paper are rather imprecise possibly because of the rather imperfect coverage of the data and/or the brevity of the observation period.

The latter conclusion points to the need to improve the kind of analysis pursued in this paper with better data. It is indeed rather surprising that no fully reliable data set on national air traffic for most countries in the world is presently freely available.

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Appendix 1 : Procedure for constructing the "ACI Main Airport dataset"

We detail below the selection procedure which allowed us to come up with the database we eventually used for the country-panel analysis.

First we identified the countries represented in the original ACI database by only one airport. Most of the time, those countries are either very small (Luxembourg, Malta, Qatar, Hong Kong…) or in early stages of development. It is therefore not surprising that they should only have one airport. Yet in some cases, the airport reported in the database is surprising (see for instance Iraq which is not represented by Baghdad international airport, but rather by Erbil's).

Table 2 : List of countries with only one available airport
(in the grid, the blue squares represent the years for which we have traffic information)

COUNTRY	CITY	AIRPORT	IATA code	#obs	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
AFR = 23 countries																								
Angola	Luanda	I.A. 4 de Fevereiro	LAD	7	■	□	□	□	□	□	□	□	□	■	■	■	■	□	■	■	□	□	□	□
Benin	Cotonou	I.A. Cotonou	COO	18	■	■	■	■	■	■	■	■	■	■	□	□	■	■	■	■	■	■	■	■
Burundi	Bujumbura	I.A. Bujumbura	BJM	19	■	■	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Comoros	Moroni	I.A. Moroni	HAH	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Congo (Dem Rep)	Kinshasa	A. Kinshasa/Ndjili	FIH	17	□	■	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cote D'Ivoire	Abidjan	A. Felix Houphouet Boigny	ABJ	19	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Djibouti	Djibouti	I.A. Djibouti-Ambouli	JIB	12	□	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	□
Eq. Guinea	Malabo	Malabo I.A.	SSG	3	□	□	□	□	□	□	□	□	□	□	□	□	□	■	■	■	□	□	□	□
Eritrea	Asmara	Asmara I.A.	ASM	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Gambia	Banjul	Banjul I.A.	BJL	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Ghana	Accra	Kotoka I.A.	ACC	17	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Guinea	Conakry	A. Conakry G'Bessia	CKY	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Liberia	Monrovia	Roberts I.A.	ROB	10	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	□	□	□	□
Malawi	Lilongwe	Lilongwe I.A.	LLW	18	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□
Mali	Bamako	I.A. Bamako-Sénou	BKO	16	□	□	□	■	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mauritius	Plaine Magnien	SSR I.A.	MRU	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mayotte	Dzaoudzi	Dzaoudzi Pamandzi I.A.	DZA	3	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	■	■	■
Rwanda	Kigali	Kigali I.A.	KGL	19	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Seychelles	Victoria	Seychelles I.A.	SEZ	5	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	■	■	■	■	■
Sudan	Khartoum	Khartoum I.A.	KRT	7	□	□	□	□	□	□	□	□	□	□	□	■	■	■	■	■	□	□	■	■
Swaziland	Manzini	Matsapha I.A.	MTS	5	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	■	■	■	■	■
Togo	Lome	A. Lomé-Tokoin	LFW	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Uganda	Entebbe	Entebbe I.A.	EBB	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
ASP = 17 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Am. Samoa	Pago Pago	Pago Pago I.A.	PPG	8	□	□	□	□	□	□	■	■	■	□	□	□	□	■	■	■	■	■	□	□
Bangladesh	Dhaka	Shahjalal I.A.	DAC	12	■	■	■	■	□	■	■	■	■	□	□	□	■	■	■	■	□	□	□	□
Brunei	Bandar Seri Begawan	Brunei I.A.	BWN	14	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□
Guam	Hagatña	Guam I.A.	GUM	14	□	□	□	□	■	■	■	■	■	□	□	■	■	■	■	■	■	■	■	■
Hong Kong, China	Hong Kong	Hong Kong I.A.	HKG	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Macau, China	Macau	Macau I.A.	MFM	18	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Maldives	Malé	Male' Ibrahim Nasir I.A.	MLE	17	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□	□	□
Marshall Isl.	Majuro	Majuro I.A.	MAJ	4	□	□	□	□	□	□	□	□	□	□	□	□	□	■	■	□	□	■	■	□
Micronesia	Pohnpei	Pohnpei I.A.	PNI	11	□	□	□	■	■	■	□	□	□	□	□	■	■	■	■	■	□	■	■	■
Mongolia	Ulaanbaatar	Chinggis Khaan I.A.	ULN	10	□	□	□	□	□	■	□	□	□	□	□	■	■	■	■	■	■	■	■	■
Nepal	Kathmandu	Tribhuvan I.A.	KTM	15	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Papua NewG.	Port Moresby	Port Moresby I.A.	POM	2	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	■	■
Singapore	Singapore	Singapore Changi A.	SIN	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Sri Lanka	Colombo	Bandaranaike I.A.	CMB	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tonga	Nuku'Alofa	Fua'amotu I.A.	TBU	11	□	□	□	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■
Vanuatu	Port Vila	Port Vila (Bauerfield) I.A.	VLI	10	□	□	□	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	□
Wallis & Fortuna	Hihifo	Wallis Hihifo A.	WLS	2	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	■	■
EUR = 12 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Albania	Tirana	Tirana I.A. Nene Tereza	TIA	12	□	□	□	■	□	□	□	□	■	■	□	■	■	■	■	■	■	■	■	■
Armenia	Yerevan	Zvartnots I.A.	EVN	13	□	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■
Belarus	Minsk	Minsk N.A.	MSQ	15	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Estonia	Tallinn	Tallinn A.	TLL	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Gibraltar	Gibraltar	Gibraltar A.	GIB	4	□	□	□	□	□	□	□	□	□	□	□	■	■	■	■	□	□	□	□	□
Hungary	Budapest	Budapest Ferihegy I.A.	BUD	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Kosovo	Pristina	Pristina I.A.	PRN	11	□	□	□	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■
Latvia	Riga	Riga I.A.	RIX	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Luxembourg	Luxembourg	Luxembourg-Findel I.A.	LUX	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Malta	Malta	Malta I.A.	MLA	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Moldova	Chisinau	Chisinau A.	KIV	19	■	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Monaco	Monaco	H. Monaco-Fontvielle	MCM	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Continued next page

LAC = 17 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Antigua	St John'S	V. C. Bird I.A.	ANU	3														■	■	■				
Bahamas	Nassau	Lynden Pindling I.A.	NAS	5															■	■	■	■	■	
Barbados	Bridgetown	Grantley Adams I.A.	BGI	15				■			■	■	■	■	■	■	■	■	■	■	■	■	■	■
Belize	Belize City	Philip S.W. Goldson I.A.	BZE	11	■	■	■	■	■	■	■	■	■	■	■									
Bermuda	Bermuda	L.F. Wade I.A.	BDA	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Costa Rica	San Jose	Juan Santamaria I.A.	SJO	11										■	■	■	■	■	■	■	■	■	■	■
Cuba	Havana	I.A. "José Martí"	HAV	12	■				■	■		■	■	■	■	■	■	■	■	■				
El Salvador	San Salvador	I.A. El Salvador	SAL	19	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
French Guiana	Cayenne	A. Cayenne-Rochambeau	CAY	14				■	■	■	■				■	■	■	■	■	■	■	■	■	■
Grenada	St George's	Maurice Bishop I.A.	GND	16				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Guadeloupe	Pointe-A-Pitre	A. Guadeloupe/Caraïbes	PTP	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Guatemala	Guatemala City	A. La Aurora	GUA	2		■																■		
Guyana	Georgetown	Cheddi Jagan I.A.	GEO	9												■	■	■	■	■	■	■	■	■
Haiti	Port-Au-Prince	I.A. Port-au-Prince	PAP	8			■	■		■	■	■	■	■						■				
Martinique	Fort-De-France	A. Martinique-Le Lamentin	FDF	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Nicaragua	Managua	I.A. Managua	MGA	18	■		■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Panama	Panama City	I.A. Tocumen	PTY	13		■	■							■	■	■	■	■	■	■	■	■	■	■

MEA = 6 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Bahrain	Bahrain	Bahrain I.A.	BAH	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Iraq	Erbil	Erbil I.A.	EBL	4																	■	■	■	■
Kuwait	Kuwait	Kuwait I.A.	KWI	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Lebanon	Beirut	Rafic Hariri I.A.	BEY	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Oman	Muscat	Muscat I.A.	MCT	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Qatar	Doha	Doha I.A.	DOH	12									■	■	■	■	■	■	■	■	■	■	■	■

Out of the 186 territories for which the ACI database provides data, 75 fell in the group of those represented by only one airport. We included these observations in the final database.

The next step consisted in identifying the largest city (in terms of passenger traffic) for the countries with multiple airports information, and we selected the corresponding airport (if there was only one airport for the largest city). This procedure enabled us to associate traffic data to 89 additional countries. NB: in general, but not always, the largest airport is also the one with the longest series.

Table 7 : List of countries with only one airport in the largest city
(in the grid, the blue squares represent the years for which we have traffic information)

COUNTRY	CITY	AIRPORT	IATA code	#obs	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
AFR = 26 countries																								
Algeria	Algiers	A. Alger Houari Boumédiène	ALG	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Botswana	Gaborone	Sir Seretse Khama I.A.	GBE	16		■	■			■	■	■	■	■	■		■	■	■	■	■	■	■	■
Burkina Faso	Ouagadougou	A. Ouagadougou	OUA	15				■		■	■	■	■	■	■		■	■	■	■	■	■	■	■
Cameroon	Douala	I.A. Douala	DLA	19	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cape Verde	Ilha Do Sal	Amilcar Cabral I.A.	SID	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Central Af. Rep.	Bangui	A. Bangui M'Poko	BGF	16		■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Chad	N'Djamena	N'Djamena A.	NDJ	2				■		■														
Congo	Brazzaville	I.A. Brazzaville Maya-Maya	BZV	15					■	■	■		■	■	■	■	■	■	■	■	■	■	■	■
Egypt	Cairo	Cairo I.A.	CAI	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Ethiopia	Addis Ababa	Addis Ababa Bole I.A.	ADD	19		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Gabon	Libreville	I.A. Léon-Mba	LBV	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Kenya	Nairobi	Jomo Kenyatta I.A.	NBO	19		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
La Reunion	Saint-Denis	A. la Réunion Roland Garros	RUN	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Madagascar	Antananarivo	Antananarivo-Ivato A.	TNR	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mauritania	Nouakchott	A. Nouakchott	NKC	10				■		■			■				■	■	■	■	■	■	■	
Morocco	Casablanca	A. Mohammed V	CMN	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mozambique	Maputo	Maputo I.A.	MPM	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Niger	Niamey	A. Niamey	NIM	17				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Nigeria	Lagos	Murtala Muhammed I.A.	LOS	12									■	■	■	■	■	■	■	■	■	■	■	■
Senegal	Dakar	I.A. Léopold Sédar Senghor	DKR	19		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Sierra Leone	Freetown	Lungi I.A.	FNA	9									■	■				■	■	■	■	■	■	■
South Africa	Johannesburg	OR Tambo I.A.	JNB	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tanzania	Dar Es Salaam	Julius Nyerere I.A.	DAR	18			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Tunisia	Tunis	I.A. Tunis Carthage	TUN	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Zambia	Lusaka	Lusaka I.A.	LUN	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Zimbabwe	Harare	Harare I.A.	HRE	13	■							■	■	■	■	■	■	■	■	■		■	■	■

Continued next page

ASP = 18 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Australia	Sydney	Sydney I.A.	SYD	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cambodia	Siem Reap	Siem Reap I.A.	REP	13	□	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■
Chinese Taipei	Taipei	Taiwan Taoyuan I.A.	TPE	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cook Islands	Rarotonga	Rarotonga I.A.	RAR	8	□	■	□	□	□	□	□	□	□	□	□	□	□	■	■	■	■	■	■	■
Fiji	Nadi	Nadi I.A.	NAN	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
French Polynesia	Papeete	A. Tahiti-Faa'a	PPT	19	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
India	New Delhi	Indira Gandhi I.A.	DEL	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Kazakhstan	Astana	I.A. Astana	TSE	15	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□
Korea (Rep)	Incheon	Incheon I.A.	ICN	14	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Malaysia	Kuala Lumpur	KL I.A.	KUL	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Myanmar	Yangon	Yangon I.A.	RGN	2	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	■	■
New Caledonia	Noumea	I.A. Noumea La Tontouta	NOU	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
New Zealand	Auckland	Auckland I.A.	AKL	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Northern Mariana I.	Saipan	Saipan I.A.	SPN	15	■	□	□	□	■	■	■	■	■	■	■	□	■	■	■	■	□	■	■	■
Pakistan	Karachi	Jinnah I.A.	KHI	11	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	□	□	□	■
Samoa	Apia	Faleolo I.A.	APW	17	□	□	■	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Uzbekistan	Tashkent	Tashkent I.A.	TAS	16	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□	□	□	□
Vietnam	Ho Chi Minh City	Tan Son Nhat I.A.	SGN	12	□	■	□	□	□	□	□	■	■	■	■	■	■	■	■	□	□	■	■	■

EUR = 24 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Austria	Vienna	Vienna I.A.	VIE	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Belgium	Brussels	Brussels I.A.	BRU	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Bosnia & Herz.	Sarajevo	Sarajevo I.A.	SJJ	17	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Bulgaria	Sofia	Sofia A.	SOF	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Croatia	Zagreb	Zagreb A.	ZAG	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Cyprus	Larnaca	Larnaca I.A.	LCA	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Czech Rep.	Prague	Prague A.	PRG	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Denmark	Copenhagen	Copenhagen I.A.	CPH	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Finland	Helsinki	Helsinki-Vantaa A.	HEL	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Georgia	Tbilisi	Tbilisi I.A.	TBS	13	□	□	□	□	■	■	■	■	□	□	□	■	■	■	■	■	■	■	■	■
Germany	Frankfurt	A. Frankfurt/Main	FRA	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Greece	Athens	Athens I.A.	ATH	14	■	□	■	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■
Iceland	Keflavik	Keflavik I.A.	KEF	19	■	■	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Ireland	Dublin	Dublin A.	DUB	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Lithuania	Vilnius	Vilnius I.A.	VNO	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Macedonia	Skopje	Skopje Alexander the Great A.	SKP	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Montenegro	Tivat	Tivat A.	TIV	12	□	□	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■
Netherlands	Amsterdam	Amsterdam A.	AMS	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Poland	Warsaw	Warsaw Frederic Chopin A.	WAW	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Portugal	Lisbon	Lisbon A.	LIS	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Serbia	Belgrade	Belgrade Nikola Tesla A.	BEG	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Slovak Rep.	Bratislava	Bratislava A.	BTS	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Slovenia	Ljubljana	Aerodrom Ljubljana I.A.	LJU	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Switzerland	Zurich	A. Zürich	ZRH	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

LAC = 16 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Cayman I.	Grand Cayman	Owen Roberts I.A.	GCM	11	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	□	□	□	□
Chile	Santiago	I.A. Arturo Merino Benitez	SCL	19	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Colombia	Bogota	I.A. El Dorado	BOG	14	□	■	■	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■
Dominican Rep.	Punta Cana	I.A. Punta Cana	PUJ	19	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Ecuador	Quito	Mariscal Sucre I.A.	UIO	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Honduras	San Pedro Sula	I.A. Ramón Villeda Morales	SAP	19	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Jamaica	Montego Bay	Sangster I.A.	MBJ	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mexico	Mexico City	I.A. México DF Lic Benito Juárez	MEX	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Netherlands Antilles	Aruba	Reina Beatrix	AUA	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Paraguay	Asuncion	I.A. Silvio Pettirossi	ASU	12	□	□	□	□	□	■	□	□	■	■	■	□	■	■	■	■	■	■	■	■
Peru	Lima	I.A. Jorge Chávez	LIM	17	■	□	□	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Saint Lucia	St Lucia	Hewanorra A.	UVF	19	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	□
Trinidad & Tobago	Port of Spain	Piarco I.A.	POS	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Uruguay	Montevideo	I.A. Carrasco	MVD	13	■	■	□	□	□	□	□	□	□	■	■	■	■	■	■	■	■	■	■	■
Venezuela	Caracas	Símon Bolívar I.A. Maiquetia	CCS	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Virgin I. (U.S.)	St Thomas	Cyril E King A.	STT	4	□	□	□	□	□	□	□	□	□	□	□	■	■	■	■	□	□	□	□	□

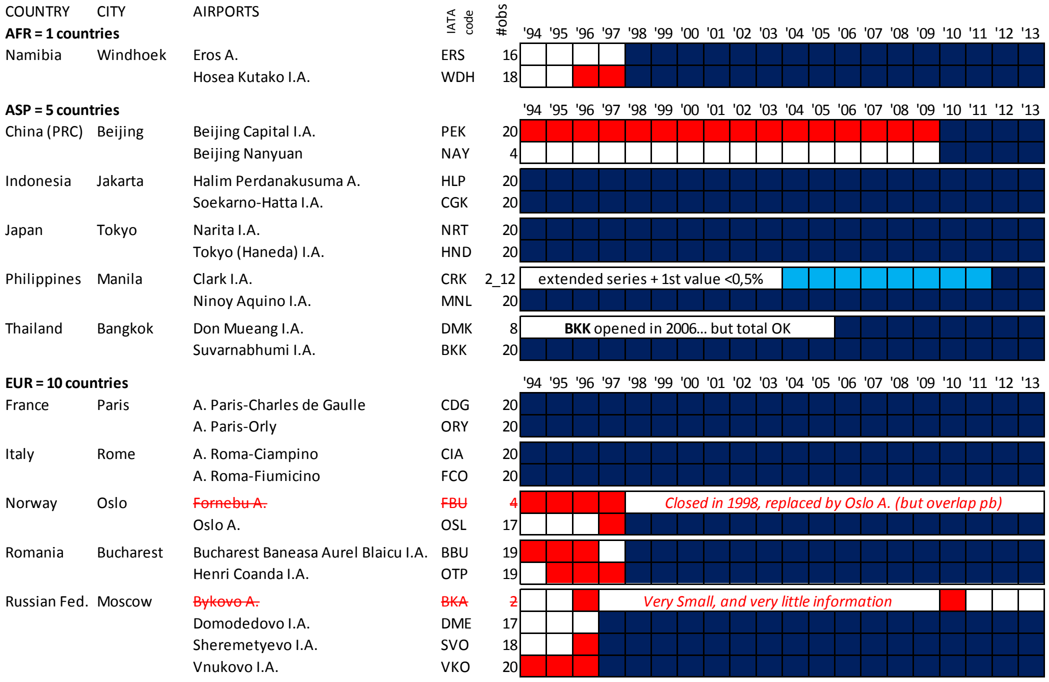
MEA = 4 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Israel	Tel-Aviv	Ben Gurion I.A.	TLV	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Saudi Arabia	Jeddah	King Abulaziz I.A.	JED	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
United Arab Emirates	Dubai	Dubai I.A.	DXB	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Yemen	Sana'a	Sana'a I.A.	SAH	12	□	□	□	□	□	■	■	■	■	■	■	■	■	■	□	□	□	■	■	■

NAM = 1 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
USA	Atlanta GA	Hartsfield-Jackson Atlanta I.A.	ATL	20	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

We were left with 22 countries for which the largest city in terms of traffic had multiple airports. When, for a given city, the airports' series did not cover the same time span, we had to understand clearly why this was the case. Was it because the historical airport was being supplemented by a new airport (in which case summing the series and considering the data before the opening of the new facility did have a sense)? Or was it because the airports did not report their data for several years (in which case the sum would create artificial jumps in the evaluation of traffic). In some cases, we were able to complement the data with publicly available figures (in light blue below). In other cases, the airport with missing values was small enough compared to the other airports of the city to simply drop it. In yet other cases, however, it was not possible to identify the cause of the missing values, nor find data to reconstruct the series, nor consider that the missing values were proper zeros (see for instance the case of Beijing Nanyuan airport, the reporting of which starts in 2010). We therefore chose to aggregate the airports data only on the common years, and drop the other observations (in red the dropped observations in the table below).

As dropping China would be problematic in terms of representativeness, we decided to apply a specific treatment to that country. In order to dilute the impact of the late entry of Nanyuan airport into the set, we summed the traffic information available for both Beijing and Shanghai. Indeed, the traffic in those two cities is of comparable magnitude (more than 80 million in 2013). The series for Hongqiao International Airport[14] starts in 1995, and that for Pudong International Airport[15] in 1999 (but this is the date of its inauguration). Consequently, China is represented, in the Main Airport ACI dataset by the aggregation of four airports (Beijing and Shanghai) from 1995 to 2013.

Table 8: List of countries with multiple airports for the largest city
(in the grid, the blue squares represent the years for which we have traffic information)



COUNTRY	CITY	AIRPORTS	IATA code	#obs	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
AFR = 1 countries																								
Namibia	Windhoek	Eros A.	ERS	16					🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Hosea Kutako I.A.	WDH	18			🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
ASP = 5 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
China (PRC)	Beijing	Beijing Capital I.A.	PEK	20	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟦	🟦	🟦	🟦
		Beijing Nanyuan	NAY	4																	🟦	🟦	🟦	🟦
Indonesia	Jakarta	Halim Perdanakusuma A.	HLP	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Soekarno-Hatta I.A.	CGK	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Japan	Tokyo	Narita I.A.	NRT	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Tokyo (Haneda) I.A.	HND	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Philippines	Manila	Clark I.A.	CRK	2_12	extended series + 1st value <0,5%										▨	▨	▨	▨	▨	▨	▨	▨	🟦	🟦
		Ninoy Aquino I.A.	MNL	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Thailand	Bangkok	Don Mueang I.A.	DMK	8	**BKK** opened in 2006... but total OK												🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Suvarnabhumi I.A.	BKK	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
EUR = 10 countries					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
France	Paris	A. Paris-Charles de Gaulle	CDG	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		A. Paris-Orly	ORY	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Italy	Rome	A. Roma-Ciampino	CIA	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		A. Roma-Fiumicino	FCO	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Norway	Oslo	~~Fornebu A.~~	~~FBU~~	~~4~~	🟥	🟥	🟥	🟥	*Closed in 1998, replaced by Oslo A. (but overlap pb)*															
		Oslo A.	OSL	17				🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Romania	Bucharest	Bucharest Baneasa Aurel Blaicu I.A.	BBU	19	🟥	🟥	🟥		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Henri Coanda I.A.	OTP	19		🟥	🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Russian Fed.	Moscow	~~Bykovo A.~~	~~BKA~~	~~2~~			🟥	*Very Small, and very little information*													🟥			
		Domodedovo I.A.	DME	17				🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Sheremetyevo I.A.	SVO	18			🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Vnukovo I.A.	VKO	20	🟥	🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦

Continued next page

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[14] Hongqiao International Airport (Shanghai) : IATA code SHA

[15] Pudong International Airport (Shanghai) : IATA code PVG

Spain	Madrid	A. Barajas	MAD	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		~~A. Torrejon de Ardoz~~	~~TOJ~~	~~14~~	*very small*						🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Sweden	Stockholm	Stockholm-Arlanda A.	ARN	20	🟥	🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Stockholm-Bromma A.	BMA	20	🟥	🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Stockholm-Skavsta A.	NYO	8_17	⬜	⬜	⬜	🔷	🔷	🔷	🔷	🔷	🔷	🔷	🔷	🔷	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Stockholm-Västerås A.	VST	8_17	⬜	⬜	⬜	🔷	🔷	🔷	🔷	🔷	🔷	🔷	🔷	🔷	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Turkey	Istanbul	Atatürk I.A.	IST	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Sabiha Gökçen I.A.	SAW	13	Opened in 2003							🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Ukraine	Kiev	Borispol State I.A.	KBP	20	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Kiev-Zhulhany I.A.	IEV	13	⬜	⬜	⬜	🟥	🟥	🟥	🟥	🟥	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
UK	London	Gatwick A.	LGW	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Heathrow A.	LHR	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		London City A.	LCY	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		London Luton A.	LTN	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Stansted A.	STN	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦

LAC = 3 countries

					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Argentina	Buenos Aires	I.A. Ezeiza	EZE	16	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		~~I.A. Don Torcuato Roberto Laplace~~	~~DOT~~	~~7~~	⬜	⬜	⬜	⬜	🟥	🟥	🟥	🟥	🟥	🟥	🟥	*at most 0,25% of total*								
		A. Jorge Newberry	AEP	16	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Brazil	São Paulo	~~Campo de Marte A.~~	~~CBW~~	~~6~~	*at most 0,5% of total*											🟥	🟥	🟥	🟥	🟥	🟥	⬜	⬜	⬜
		Congonhas I.A.	CGH	13	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Guarulhos I.A.	GRU	20	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Puerto Rico	San Juan	~~A. Isla Grande~~	~~SIG~~	~~2~~	*Small, no information*																		🟥	🟥
		Luis Muñoz Marin I.A.	SJU	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟥	🟥

MEA = 2 countries

					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Iran	Tehran	Imam Khomeini I.A.	IKA	6	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦	🟦	🟦	🟦
		Mehrabad I.A.	THR	14	⬜	⬜	⬜	🟥	🟥	🟥	⬜	⬜	⬜	🟥	🟥	🟥	🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦
Jordan	Amman	Marka I.A.	ADJ	3	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	⬜	🟦	🟦	🟦
		Queen Alia I.A.	AMM	20	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟦	🟦	🟦

NAM = 1 countries

					'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13
Canada	Toronto ON	Billy Bishop Toronto City A.	YTZ	12	<0,3% of total in 2002								🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
		Toronto Pearson I.A.	YYZ	20	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦

Appendix 2: p-values of the Augmented Dickey-Fuller test statistics at the country level (ACI – Main Airports database: 130 countries in the set, 12 that do not pass the test)

	# obs	ADF Passenger	ADF GDP
Algeria	20	0,725	0,797
Argentina	16	0,841	0,919
Armenia	13	0,227	0,311
Aruba	20	0,495	0,128
Australia	20	0,969	0,168
Austria	20	0,633	0,385
Bahrain	20	0,795	0,921
Barbados	14	0,737	0,156
Belarus	15	0,997	0,576
Belgium	20	0,377	0,188
Belize	11	0,922	0,979
Benin	10	0,016	0,783
Bosnia and Herzegovina	17	0,176	0,398
Brazil	13	0,792	0,861
Brunei Darussalam	14	0,476	0,429
Bulgaria	20	0,778	0,938
Burundi	17	0,362	0,942
Cabo Verde	20	0,520	0,249
Cambodia	13	0,897	0,547
Cameroon	18	0,005	0,996
Canada	20	0,530	0,278
Central African Rep.	14	0,761	0,968
Chile	19	0,978	0,977
China (PRC)	19	0,918	0,938
Colombia	12	0,044	0,779
Comoros	20	0,718	0,981
Congo	12	0,992	0,904
Congo (DRC)	16	0,204	0,953
Costa Rica	11	0,096	0,599
Côte d'Ivoire	19	0,188	0,971
Croatia	20	0,864	0,406
Cyprus	20	0,510	0,599
Czech Rep.	20	0,446	0,800
Denmark	20	0,760	0,145
Djibouti	12	0,522	0,957
Dominican Rep.	19	0,515	0,884
Ecuador	20	0,941	0,996
Egypt	20	0,028	0,663
El Salvador	17	0,019	0,702
Eritrea	20	0,054	0,161
Estonia	20	0,642	0,484
Ethiopia	19	0,998	0,998
Fiji	20	0,976	0,629
Finland	20	0,432	0,101
France	20	0,361	0,246
FYR of Macedonia	20	0,242	0,921
Gabon	20	0,163	0,933
Gambia	20	0,194	0,935
Germany	20	0,700	0,739
Ghana	17	0,996	0,999
Greece	12	-	0,428
Grenada	16	0,730	0,081
Guinea	20	0,110	0,142
Honduras	19	0,082	0,922
Hungary	20	0,353	0,437
Iceland	17	0,863	0,649
India	20	0,953	0,979
Indonesia	20	0,991	0,992
Ireland	20	0,319	0,094
Israel	20	0,943	0,950
Italy	20	0,475	0,290
Jamaica	20	0,110	0,610
Japan	20	0,792	0,700
Kazakhstan	15	0,885	0,032
Kenya	19	0,918	0,999
Kuwait	20	0,982	0,840
Latvia	20	0,865	0,467
Lebanon	20	0,941	0,987
Liberia	10	0,895	0,704
Lithuania	20	0,905	0,631
Luxembourg	20	0,918	0,300
Madagascar	20	0,129	0,805
Malawi	18	0,720	0,985
Malaysia	20	0,671	0,931
Maldives	17	0,825	0,803
Mali	15	0,687	0,001
Malta	20	0,985	0,036
Mauritius	20	0,105	0,421
Mexico	20	0,505	0,310
Morocco	20	0,794	0,990
Mozambique	20	0,894	0,013
Namibia	16	0,900	0,989
Nepal	15	0,940	0,989
Netherlands	20	0,193	0,153
New Zealand	20	0,866	0,748
Nicaragua	16	0,170	0,974
Niger	17	0,996	0,998
Nigeria	12	0,371	0,602
Norway	17	0,984	0,525
Oman	20	0,981	0,986
Pakistan	10	0,775	0,276
Panama	11	0,845	0,964
Peru	16	0,994	0,995
Philippines	20	0,999	0,997
Poland	20	0,954	0,701
Portugal	20	0,890	0,082
Qatar	12	0,367	0,358
Rep. of Korea	14	0,986	0,214
Rep. of Moldova	18	0,988	0,978
Romania	16	0,676	0,484
Russian Fed.	17	0,983	0,235
Rwanda	19	0,943	0,562
Saint Lucia	19	0,171	0,664
Samoa	16	0,344	0,004
Saudi Arabia	20	0,894	0,995
Senegal	19	0,541	0,338
Singapore	20	0,991	0,941
Slovakia	20	0,526	0,779
Slovenia	20	0,570	0,291
South Africa	20	0,003	0,878
Spain	20	0,270	0,222
Sri Lanka	20	0,952	0,998
Sweden	17	0,766	0,361
Switzerland	20	0,747	0,891
Thailand	20	0,978	0,976
Togo	20	0,978	0,993
Tonga	11	0,206	0,440
Trinidad and Tobago	20	0,412	0,268
Tunisia	20	0,273	0,076
Turkey	20	0,997	0,921
U.K.	20	0,184	0,328
U.S.A.	20	0,169	0,195
Uganda	20	0,972	0,819
United Arab Emirates	20	0,996	0,633
United Rep. of Tanzania	18	0,874	0,995
Uruguay	11	0,662	0,827
Uzbekistan	16	0,197	0,999
Vanuatu	10	0,929	0,075
Venezuela (Boliv. Rep.)	20	0,480	0,878
Zambia	20	0,955	1,000

Appendix 3: Error correction model estimations with ICAO data over 1970-2013 a) b) c)

ICAO full database (1970-2013)

Country groupings	**All**	**High Income OECD**	**Latin America Caribbean**	**Sub-Saharan Africa**	**Middle East Northern Africa**	**South and East Asia**
Dependant variable = growth of traffic (Δ Log Traffic)						
Error Correction Model (fixed effects, no trend)						
Lagged Log Traffic ($-\phi$)	-0.124***	-0.174*	-0.084	-0.113***	-0.138**	-0.117***
	(0.028)	*(0.074)*	*(0.059)*	*(0.026)*	*(0.042)*	*(0.021)*
Lagged Log GDP ($\phi\chi$)	0.146***	0.301*	0.119	0.067	0.181*	0.155***
	(0.040)	*(0.124)*	*(0.098)*	*(0.046)*	*(0.065)*	*(0.027)*
Political Disorder (ω_1)	-0.361**	-0.125	-0.787*	0.171	-0.819	-0.503***
	(0.117)	*(0.276)*	*(0.320)*	*(0.406)*	*(0.792)*	*(0.074)*
Terms of Trade (ω_2)	0.053	-0.025	0.065	0.083	0.017	-0.047
	(0.029)	*(0.055)*	*(0.056)*	*(0.042)*	*(0.041)*	*(0.024)*
Growth of GDP (ψ_{Y0})	0.726***	1.213***	0.266	0.387**	0.923	0.796**
	(0.197)	*(0.239)*	*(0.310)*	*(0.125)*	*(0.482)*	*(0.232)*
Long-run GDP-elasticity of air traffic (χ)	1.181***	1.725***	1.418***	0.591	1.314***	1.327***
	(0.115)	*(0.180)*	*(0.390)*	*(0.305)*	*(0.194)*	*(0.159)*
Testing (χ - ψ_{Y0})=0	0.456*	0.512	1.152*	0.203	0.391	0.532
	(0.219)	*(0.304)*	*(0.473)*	*(0.335)*	*(0.508)*	*(0.271)*
R² (within)	0.091	0.133	0.049	0.058	0.278	0.083

Error Correction Model (fixed effects, with country-specific trends)						
Lagged Log Traffic ($-\phi$)	-0.248***	-0.279***	-0.177**	-0.159***	-0.228**	-0.258***
	(0.046)	*(0.045)*	*(0.054)*	*(0.032)*	*(0.051)*	*(0.023)*
Lagged Log GDP ($\phi\chi$)	0.325***	0.277**	0.181	0.337**	0.338*	0.198
	(0.083)	*(0.082)*	*(0.094)*	*(0.111)*	*(0.147)*	*(0.116)*
Political Disorder (ω_1)	-0.264	0.132	-0.992*	0.406	-0.640	-0.330**
	(0.138)	*(0.296)*	*(0.363)*	*(0.558)*	*(0.888)*	*(0.113)*
Terms of Trade (ω_2)	0.015	0.031	0.081*	0.027	0.009	-0.066*
	(0.026)	*(0.044)*	*(0.036)*	*(0.052)*	*(0.052)*	*(0.030)*
Growth of GDP (ψ_{Y0})	0.748***	1.111***	0.215	0.492***	0.903	0.801**
	(0.201)	*(0.265)*	*(0.326)*	*(0.129)*	*(0.469)*	*(0.221)*
Average time trend	-0.29%***	0.58%	0.03%	-1.23%***	-0.27%	0.89%
	(0.23%)	*(0.39%)*	*(0.25%)*	*(0.35%)*	*(0.35%)*	*(0.55%)*
# neg. Trend // # pos. Trend	***45*** *<0* ***// 61*** *~* ***// 36*** *>0*	***1*** *<0* ***// 17*** *~* ***// 10*** *>0*	***1*** *<0* ***// 16*** *~* ***// 4*** *>0*	***20*** *<0* ***// 15*** *~* ***// 1*** *>0*	***2*** *<0* ***// 7*** *~* ***// 2*** *>0*	***2*** *<0* ***// 14*** *~* ***//*** *9>0*
Long-run GDP-elasticity of air traffic (χ)	1.309***	0.993**	1.026*	2.121**	1.481**	0.769
	(0.258)	*(0.338)*	*(0.483)*	*(0.735)*	*(0.482)*	*(0.454)*
Testing (χ - ψ_{Y0})=0	0.561**	-0.118	0.810	1.629*	0.579	-0.032
	(0.212)	*(0.345)*	*(0.537)*	*(0.708)*	*(0.423)*	*(0.498)*
R² (within)	0.188	0.215	0.159	0.152	0.353	0.163

Nb of obs.	4690	1041	783	1137	405	818
Nb of countries	142	28	21	36	11	25
Average Nb of obs.	33.03	37.18	37.29	31.58	36.82	32.72

a) _Standard errors in brackets and italics, * p>.1, ** p>.05, *** p>.01_

b) _The ICAO database is restricted to those countries with at least 10 continuous years of observation, and with I(1) GDP and traffic variables._

c) _In the second sub-table, we indicate the average of the country-specific time trends for the considered group, obtained through a linear combination of the corresponding coefficients. We report below the number of countries for which the time trend is significantly negative (<0), non-significantly different from zero (~), and significantly positive (>0)._