The impact of Air Transportation on Trade Flows: A Natural Experiment on Causality Applied to Italy

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Abstract

Efficient air transportation services can boost regional economic development by allowing access to the world market, facilitating integration and labor mobility, and fostering local industries. In this regard, aviation can act as a means of both transporting traded "goods" and providing complementary services of labor mobility. The Lombardy region in Italy is an interesting case, as it is one of Europe's wealthiest and most industrialized areas with almost 10 million inhabitants. It has three of the top four Italian airports—Milan Malpensa (MXP), Bergamo Orio al Serio (BGY), and Milan Linate (LIN)—as well as a small airport in Brescia Montichiari (VBS) mainly used for cargo flights. On March 31, 2008, Malpensa Airport experienced the de-hubbing of Alitalia. This exogenous event allows us to study the relation between international trade and civil aviation by exploiting a quasi-natural experiment without endogeneity problems. We investigate this relation by estimating a before/after augmented gravity-econometric model applied to a panel data set for the period of 2004–2014. The data set includes, for each of the considered 30 European countries, information on trade flows divided by commodities sector, distance from Lombardy, GDP per capita, population, transport infrastructures and a set of other control variables. We estimate the gravity model under three different econometric specifications: random effect panel data, PPML, and PPML with fixed effects to include countries' multilateral resistance. Furthermore we estimate a DID model as a robustness check for possible endogeneity among trade and aviation, using the region of Veneto (similar to Lombardy but not affected by the de-hubbing) as a control case. We find that civil aviation has a positive impact on international trade, with elasticity ranging from +0.003% to 0.13% in the different econometric specifications, and that this effect is stronger in high tech- and medium-tech manufacturing sectors.

KEY WORDS: International trade; civil aviation; sector civil aviation elasticity of international trade

JEL Codes: L93, B17, N77.

1. Introduction

As stated by the European Commission, civil aviation is "a strategically important sector that makes a vital contribution to the EU's overall economy and employment." The industry generates about 5 million jobs and produces 2.1% of the European GDP.[1] In the U.S., civil aviation contributes to about $460 billion (5.4% of GDP) to the economy and supports 11.8 million jobs (FAA, 2015). It has been acknowledged that civil aviation provides essential infrastructure for the economy and supports innovative activity, the exploration of new economic opportunities, and connections for business and social relationships. This vital role is further emphasized when considering local economies; that is, residents, businessmen, and policymakers regard an efficient local aviation system to be a crucial gateway to the regional economy as well as to the global market. In some peripheral regions, aviation is the main infrastructure for mobility. This has stimulated research on the regional development-aviation relationship in order to identify the casual relation and magnitude of the effect.[2]

Interestingly, most previous contributions have not investigated the impact of civil aviation on regional trade. Other papers have studied the impact on local employment (Benell & Prentice, 1993; Button et al., 1999; Button & Taylor, 2000; Brueckner, 2003; Green, 2007; Percoco, 2010; Neal, 2012; Mukkala & Tervo, 2013), income (Button et al., 2009; Sellner & Nagl, 2010; Mukkala & Tervo, 2013; Button & Yuan, 2013; Allroggen & Malina, 2014; Baker et al., 2015; Baltaci et al., 2015; Blonigen & Cristea, 2015; Fernandes & Pacheco, 2015; Hu et al., 2015), population growth (Green, 2007; Blonigen & Cristea, 2015) and wages (Bilotkach, 2015). To the best of our knowledge, the only previous studies that have investigated such a relation are those of Kulendran & Wilson (2000) and Van De Vijver et al. (2014). However, both studies mainly focus on testing the causality links between these two variables, rather than estimating the effects of aviation on trade (after dealing with the possible endogeneity). Hence, this paper is an attempt to fill this gap by studying the relationship between trade and air transportation. The latter is investigated by looking at the various

[1] See the website of DG Transport of the European Commission: http://ec.europa.eu/transport/modes/air/index_en.htm.
2 See Baker et al. (2015) for a updated review of previous studies and findings.

types of industries that may be affected by civil aviation (i.e., the manufacturing sector, high-tech industries, low-tech industries, and so forth.) The relationship is estimated using an econometric model that takes into account the possible endogeneity between trade flows and aviation activity. We then apply the model to a data set covering the trade flows between Lombardy, the richest and most populated (10 million inhabitants) Italian region, and 30 European countries from 2004 to 2014.

In dealing with the possible endogeneity issue we exploit a quasi-natural experiment that stems from the exogenous shock in the regional aviation system of Lombardy that occurred on March 31, 2008. Alitalia, the main Italian carrier (the former flag carrier), decided to de-hub from Malpensa Airport, cutting 181 flights per day (two-thirds of its total daily Malpensa flights) and transfer 14 intercontinental routes (out of a total of 17) to Rome Fiumicino (Redondi et al., 2012), which, since that day, has become the unique Alitalia hub. In this case, we exploit the significant change in civil aviation due to a formerly dominant airline's decision to identify the impact of air transportation on trade. The variation in traffic after the Malpensa de-hubbing is relevant because it was not due to trade variation in Lombardy, but rather to Alitalia's financial crisis, which lost € 844 million in 2004, € 168 million in 2005, € 627 million in 2006, and € 495 million in 2007. In an attempt to rescue Alitalia, which was privatized in 2005 but still retained a 49.9% stake under public control, management launched a restructuring plan. It dropped the previous business model based on two hubs (Milan Malpensa and Rome Fiumicino) to concentrate activities in Rome and exploit the possible savings coming from a single hub-and-spoke system. Alitalia's financial crisis has been a long-running phenomenon, dating back to 1992, when the European market began to liberalize and the company was unable to operate in a competitive market (Malighetti et al., 2009). Since then, the Italian government pumped public money into the company, about € 7.4 billion. Thus, Alitalia's de-hubbing decision could be considered as exogenous to a possible variation in trade between Italy and other European countries during the observed period. Such an exogenous change in civil aviation determines a variation on Lombardy's 2008 air transportation activity, and we employ a before/after econometric model to identify a casual impact on trade, as well as to obtain a non-endogenous estimate of the contribution of civil aviation on trade. Furthermore, as a robustness check in our investigation, we analyze a difference-in-difference (DID) model to further control for possible endogeneity between trade and air transportation by including another Italian region, Veneto, which was not affected by Alitalia's de-hubbing decision.

We analyze the civil aviation-trade relationship through several perspectives that include total trade, aggregate agriculture and industrial trade, total agriculture trade, total industrial trade, the manufacturing trade, the high-tech sector trade, the medium-high sector trade, the medium-low sector trade, and the low-tech sector trade. We intend to determine whether some sectors are more sensitive to civil aviation-trade ability than others. Moreover, following recent trends in international trade literature, we develop an augmented gravity model (Anderson and Van Wincoop, 2003) taking explicitly into account countries' multilateral resistance (MR) using fixed effects (Feenstra, 2004; Zhang et al., 2016);[3] moreover we consider possible distortions in coefficient estimates by adopting alternative econometrics models (panel data and a Poisson pseudo-maximum likelihood (PPML) estimator, as suggested by Santos Silva and Tenreyro, 2006).[4] Hence, this paper is one of the first attempts to consider the potential endogeneity problem in gravity models, a topic that has been largely neglected in the air transportation gravity-model literature, as stated by Zhang et al. (2016). To ensure that the effect of civil aviation on trade is not influenced by other factors—and in line with other gravity-model studies—we introduce in our model a number of control variables. These variables include the distance between Lombardy and each European country in the data set, the real per-capita income in each European country, whether the country is a member of the European Union, whether it is under the Schengen Agreement (institutional settings reducing possible barriers to trade), and a time effect to take the business cycle into account.

The paper is organized as follows. Section 2 presents the literature review. Section 3 discusses the

[3] **Multilateral resistance captures the general costs when exporting and importing with other countries (Zhang et al., 2016)**.

[4] A **PPML is particularly indicated in the presence of countries with zero trade values, which may create problems in estimation if the values are not randomly distributed. Moreover, as shown by Santos Silva and Tenreyro (2006), a PPML can also deal with possible heteroscedasticity problems. We are grateful to an anonymous referee for raising this issue.**

econometric model. Section 4 examines the data set, while Section 5 shows the obtained empirical results and robustness checks. Section 6 draws some conclusions.

2. Literature Review

This paper is linked with two streams of research. Although a large number of previous contributions have analyzed the relationship between civil aviation and regional or urban development, few papers have focused on the relationship between air transportation and international trade.

The first stream of research has studied the impact of civil aviation on a number of variables representing regional growth and investigated the causal relationship between these two variables. The majority of papers find a positive impact of aviation on regional/urban growth. Benell & Prentice (1993) analyze the relation between employment and revenue generated by airport activities and the number of enplaned passengers in 38 Canadian airports during 1998, and find a positive elasticity of enplaned passengers equal to +0.75% in employment and +0.49% in revenues. Button et al. (1999) study the effect of hub proximity to high-tech local employment across 321 U.S. Metropolitan Statistical Areas (MSAs) in 1994 and find a positive effect. They also investigate the issue of causality and employ the Granger causality test to data in the Cincinnati area from 1979 to 1997, and show that passenger traffic creates employment in that MSA. Button & Taylor (2000) examine the relation between high-tech employment and European-enplaned passengers, European destinations, and total enplanements in the areas surrounding 41 U.S. airports in 1996 and find a positive effect of all three aviation-related variables. Brueckner (2003) finds an elasticity of passenger enplanements on employment in service-related industries equal to +0.1% using data from 91 U.S. MSAs in 1996. Controlling for endogeneity, the author uses an IV approach and adopts two instruments: a dummy variable for a hub airport and a variable capturing the traffic diversion effect of proximity to a large airport. Green (2007) also investigates the relationship between population and employment growth using the IV approach, as applied to data regarding 83 U.S. MSAs in 1990. He finds a positive effect of aviation passengers on both growth variables after using the distance of an airport from a fixed point and lagged local population as instruments. Percoco (2010) investigates the relationship between civil aviation and local development using data from Italy in 2002 again adopting an IV approach to deal with endogeneity (the instruments are the number of tourists in the province and a dummy for the hub airport). The author finds that the elasticity of airport passengers on county service-sector employment is +0.05%, and that airports generate a spillover effect on the same type of employment in neighboring counties with no airport, which is equal to +0.02%. Neal (2012) focuses on all U.S. MSAs served by airports with at least 250,000 passengers during the 2001–2008 period. The author tests for Granger causality in the local economies between creative employment and air passengers, and finds that in periods of national economic growth, civil aviation creates local employment. A similar exercise is implemented by Mukkala & Tervo (2013) using a data set for 86 European regions in the 1991–2000 period. The authors find that civil aviation Granger creates local development in peripheral regions, while this causality is less evident in core regions. Baker et al. (2015) study Granger causality between airport activity and local economic growth in Australia over the 1985–2011 period, and find that causality goes in both directions, while Bilotkach (2015) investigates all U.S. MSAs during the 1993–2009 period. The author employs a dynamic panel data model with an Arellano-Bond GMM estimator and finds that the elasticity of airport flights on local average wage is +0.01%, while that of destinations is +0.02%.[5]

Blonigen & Cristea (2015)'s contribution is in the set of papers that analyze the relationship between civil aviation and regional growth, and has stronger methodological links to our work. The authors study a quasi-natural experiment exploiting the U.S. Air Deregulation Act approved in 1978 to identify the effects of air transportation on local development without biased estimates caused by the endogeneity problem. They use data from 263 U.S. MSAs over the 1969–1991 period and implement a before/after econometric model to provide evidence that a 50% increase in an average city-aviation

[5] Button et al. (2009) provide evidence for Virginia during 1990–2007 period and Sellner & Nagl (2010) study the civil aviation-regional growth in the EU-15 for the 1993–2006 period. Button & Yuan (2013) are the only scholars observing the impact of airfreight on regional growth and find that it Granger causes local development. Allroggen & Malina (2014) study Germany during 1997–2006 period, looking at the impact of 19 German airports.

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activity growth generates an additional +7.4% increase in real GDP over 20 years. In our work, we also adopt a similar before/after econometric model to avoid the possible endogeneity between international trade and civil aviation.

A second set of papers has looked at the relationship between international trade and civil aviation, and the results of these contributions are more relevant for establishing the originality of our effort. Kulendran & Wilson (2000) study the international trade flows between Australia and the U.S., Japan, the U.K., and New Zealand using co-integration and Granger causality for the 1982–1997 period. Although finding that a relationship exists between international travel and international trade, the authors do not provide an estimate of the effect of civil aviation on trade and the study is limited to very few country-level comparisons. Poole (2010) analyzes the relation between foreign business passengers flying from/to the U.S. and finds that it leads to a strong increase in U.S. producers' export sales. Van De Vijver et al. (2014) explore the causality link between international trade and aviation during the 1980–2010 period, focusing on nine countries in the Asia-Pacific region.[6] The authors study Granger causality and find that air transportation increases trade for exchanges between more developed and less developed countries. Our paper extends these results in several directions. First, it provides evidence on a larger number of exchanges (28 European countries versus Lombardy). Second, it exploits a quasi-natural experiment that allows us to avoid the possible endogeneity arising between trade and civil aviation. Third, it controls for a number of variables that may affect the estimated effect of aviation on trade. Fourth, it provides an estimate of the effect of aviation on trade and not just a sign of the causal relationship. Last, we present evidence not only at the country level, but also at the sector level, identifying the effect for agriculture, industry, and high tech-, medium high-, medium low-, and low tech- manufacturing sectors.

As a final issue of the literature review, it is worth mentioning that the gravity model is the theoretical framework adopted by the vast majority of previous contributions investigating the relationship

[6] Australia, New Zealand, China, South Korea, Malaysia, Indonesia, Thailand, the Philippines, and Singapore.

between international trade and air transportation activity. Baier and Bergstrand (2010) and Zhang et al. (2016) provide comprehensive reviews of gravity-model applications to air transportation, explaining the flows of people and freight among different origins and destinations. However, the issue of possible endogeneity between international trade and some measure of air transportation activity (e.g., available seats) has been generally neglected in previous contributions (Zhang et al., 2016). Hence, this paper also attempts to address the issue of the casual relationship between trade and aviation.

3. The Econometric Model

In this section we design an econometric model that investigates the relationship between international trade and civil aviation over the 2004–2014 period (11 years). International trade regards the export and import of goods and services between Lombardy and 30 European countries. Lombardy is the richest and most populated Italian region: its GDP is equal to € 348.615 million (year 2014, 22% of Italian GDP), larger than many other European countries (e.g., Austria's GDP in the same year was € 329.296 million, Denmark's is € 260.582 million) and very close to the GDP of other Western Europe countries (Belgium's GDP in 2014 was € 400.643 million, with Sweden at € 430.642 million, and Switzerland at € 528.780 million). Moreover, Lombardy has a population of 10,002,615 inhabitants (17% of Italian population), comparable with other Western European countries (e.g., Belgium has 11 million inhabitants and the Netherlands has 6 million inhabitants). It is therefore comparable to a medium-sized European country both in terms of overall income and population. In addition, a constitutional reform that was implemented in 2001 has decentralized many regional policies (e.g., education, health care, transport), hence Lombardy enjoys a certain degree of independence in politics that enables us to treat it an "economy" and to study its international trade activities with other European countries.

We consider the trade between Lombardy and every other European country with the exception of

Belarus, Bosnia-Herzegovina, Cyprus, Kosovo, Moldova, Montenegro, and Serbia. Hence, our data set includes all of the Western European countries and the majority of Eastern European countries. Furthermore we have data regarding international trade at 2-digit level sectors, for a total of 42 sectors, ranging from all agricultural sectors to all industrial sectors and to some service sectors (mainly editorial activities and media production).

The abovementioned data imply that we could study a panel data set composed of 42 sectors for 30 countries and 11 years. However, as civil aviation activities at the sector level are not available, it is not possible to study a panel model at the sector level. Hence, we focus on a panel econometric model at the country level, provided by 30 countries over 11 years. Since we have data at the sector level, we can observe the relationship between international trade and civil aviation at different sector levels, using various levels of aggregation. We can also investigate the impact of air transportation on total trade, agricultural trade, industrial trade, manufacturing trade, and within the latter, in different technology sectors: from traditional low-tech sectors (e.g., food, textiles), to medium-low sectors (e.g., glass, cutlery), medium-high sectors (e.g., industrial gases, chemicals), and to high-tech sectors (e.g., pharmaceutical, electronics). This implies that we can discriminate whether sectors with different technological intensity benefit more from civil aviation.

In principle, although we could investigate the data by applying the seemingly unrelated regression model (SURE), we have a special case in which the SURE and OLS models are equivalent—that is, our regressors on the right-hand side of each sectorial-equation are the same. Hence, we implement a panel data econometric model independently for each sector level at which we aim to identify the effect of civil aviation on trade.

An important empirical issue to address is related to the possible endogeneity arising from international trade and civil aviation. In principle, it is not possible to infer that the causal relationship is from civil aviation to trade; we can also surmise that since international trade is lagging (booming) then civil aviation activity is rather low (high). As previously discussed, because our main goal is to estimate the effect of aviation on trade and not to test the direction of the causal effect (i.e., we are not going to apply Granger causality models), we could follow previous works (e.g., Brueckner, 2003, Percoco, 2010) and adopt an IV/2SLS approach. The latter implies the choice and data availability of a good instrument, which is not always feasible. However, we have the chance to exploit a quasi-natural experiment that allows identifying the effect of a variation in civil aviation on international trade between Lombardy and other 30 European countries. The de-hubbing of Alitalia from the Malpensa Airport in March 2008 introduced a relevant change in civil aviation activity in Lombardy. Figure 1 shows the strong impact of the Alitalia de-hubbing in the Malpensa Airport on flight departures in Lombardy during the 2004–2014 period. This is an exogenous shift in civil aviation and enables us to observe the impact of such variation on international trade in Lombardy. That is, the dramatic change in total flights from Malpensa modified air transportation activities. These activities were not caused by a previous change in international trade, but rather, as mentioned before, by Alitalia's financial crises that were due to bad management. Hence, using a before/after econometric model we can observe civil aviation effects on international trade without endogeneity problems.

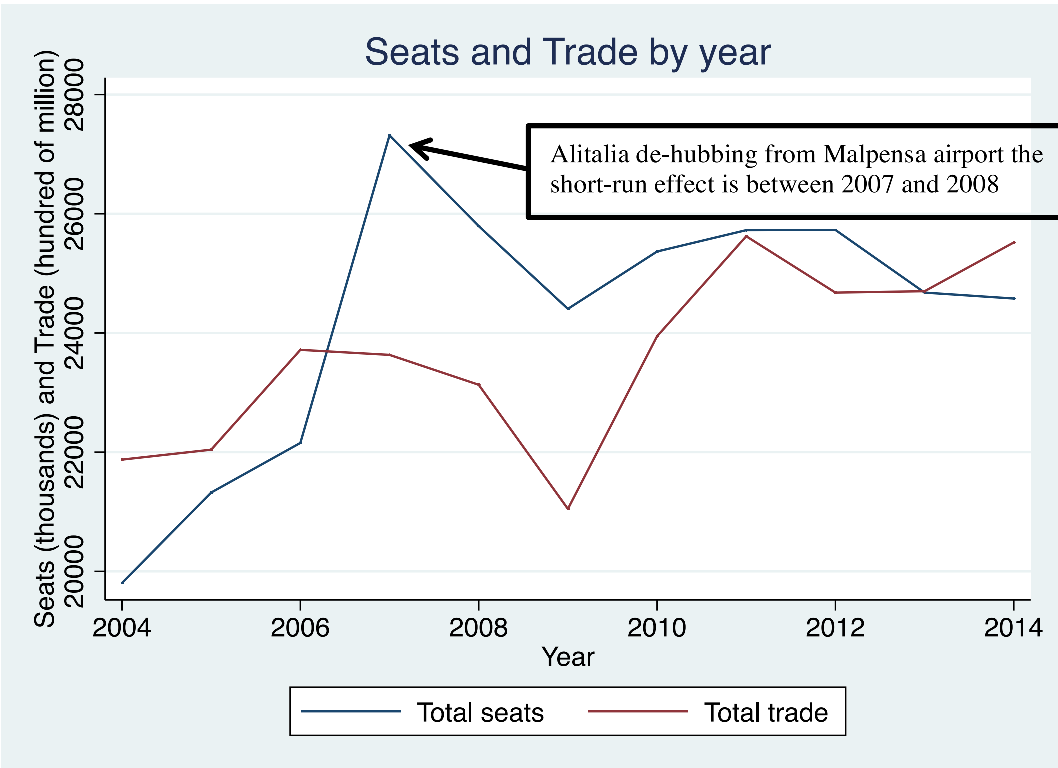

Figure 1. International trade and available seats in Lombardy with the Alitalia de-hubbing event.

To exploit the exogenous de-hubbing decision, we implement an econometric model applied to the panel data. The temporal interval is split into two periods: before the de-hubbing (from 2004 until 2008) and after (from 2009 until 2014). Equation (1) presents the econometric model:

$$\log TRADE_{it} = \alpha + \beta_1 \times \log SEAT_{it} + \beta_2 \times \log DIST_i + \beta_3 \times \log GDPCAP_{it} + \\ + \delta_1 \times YEAR_t + \delta_2 \times UE_{it} + \delta_3 \times SCHEN_{it} + \gamma_1 \times POST_t + \gamma_2 \times POST_t \times \log SEAT_{it} + \epsilon_{it}, \quad (1)$$

where the dependent variable is the natural logarithm of international trade (*TRADE*) between Lombardy and country i (i = 1, 2, …, 30) in period t (t = 1, 2, … 11) (i.e., the sum of exports and imports), and the independent variable representing civil aviation activities is the natural logarithm of available seats in flights departing from one of the Lombardy airports with country i destination in year t. The other regressors are control variables introduced in the empirical analysis to clean possible disturbances on the estimated effects of civil aviation. They are given by the flight distance (*DIST*), the real GDP per capita in the destination country (*GDPCAP*) since it may affect exports, a variable for the macroeconomic business cycle (*YEAR*) that influences the level of international trade, and two dummy variables to take into account for possible barriers to trade between Lombardy and the destination country. If the county is a member of the EU-28, *UE* is equal to 1, and *SCHEN* is equal to 1 if the country is part of the European Schengen Agreement that facilitates mobility within the member countries.[7] As previously mentioned, we run different equations similar to that shown in expression (1) but with different specifications of the dependent variable *TRADE*. Table 1 presents the variables involved in the econometric model, their descriptions, and units of measure.

[7] The Schengen Agreement is an international treaty among some European countries such that no custom duties exist at the Schengen countries' borders. It allows citizens to move among Schengen countries without passport controls at the borders and implements a centralized control system at the external borders of such countries.

Variable	Description	Unit of measure	Source
Before/after model variables			
$TRADE_{it}$	Total trade between Lombardy and country *i* in year *t*	€	Lombardy Region
$TRADE\_AGR\_IND_{it}$	Total trade in agricultural and industrial sector between Lombardy and country *i* in year *t*	€	Lombardy Region
$TRADE\_AGR_{it}$	Total trade in agricultural sector between Lombardy and country *i* in year *t*	€	Lombardy Region
$TRADE\_IND_{it}$	Total trade in industrial sector between Lombardy and country *i* in year *t*	€	Lombardy Region
$TRADE\_MAN_{it}$	Total trade in manufacturing sectors between Lombardy and country *i* in year *t*	€	Lombardy Region
$TRADE\_HIGH\_TECH_{it}$	Total trade in high-tech sectors between Lombardy and country *i* in year *t*	€	Lombardy Region
$TRADE\_MEDIUM\_HIGH_{it}$	Total trade in medium-high sectors between Lombardy and country *i* in year *t*	€	Lombardy Region
$TRADE\_MEDIUM\_LOW_{it}$	Total trade in medium-low sectors between Lombardy and country *i* in year *t*	€	Lombardy Region
$TRADE\_LOW\_TECH_{it}$	Total trade in low-tech sectors between Lombardy and country *i* in year *t*	€	Lombardy Region
$SEAT_{it}$	Total available seats in flights from/to Lombardy and country *i* in year *t*	€	OAG
$DIST_i$	Direct distance between Milan and the capital of country *i*	km	Google
$GDPCAP_{it}$	Nominal GDP per capita in country *i* in year *t*	€	Eurostat
$YEAR_t$	Time variable	number	
UE_{it}	Dummy variable equal to 1 if country *i* is a member of EU-28 in year *t*		
$SCHEN_{it}$	Dummy variable equal to 1 if country *i* is a member of Schengen in year *t*		
$POST_t$	Dummy variable equal to 1 if year is after 2008 (de-hubbing period)		
DID variable (added to the before/after ones)			
$TREAT_r$	Dummy variable equal to 1 if observation is for Lombardy (treated group), and 0 if it is for Veneto (control group)		

Table 1. Variable Description and Source

A key role in our empirical strategy is played by the dummy variable *POST*, which defines the before/after de-hubbing period. It is equal to 1 for years between 2009 and 2014; year 2008 is not included in the after period because the de-hubbing took place at the end of March 2008. The variable *POST* is also interacted with *SEAT*, since our aim is to estimate two marginal effects; that is, the impact of *SEAT* depends upon the before/after period. By taking the first derivative of Eq. (1) with respect to *SEAT*, we obtain $\beta_1 + \gamma_2 \times POST_t$, and since *POST* is a dummy variable, it is equal to β_1

before the de-hubbing and to $\beta_1 + \gamma_2$ after the de-hubbing. Hence, the estimated coefficient γ_2 shows the impact of de-hubbing on international trade. Our hypothesis is that seats have a positive effect on trade and that $\hat{\gamma}_2$ has a negative sign.

The variable *POST* gives the impact of de-hubbing on trade. Because it is a dummy variable, computing the first derivative is meaningless. In order to study its impact, it is necessary to compute the value of trade when POST is equal to 1, as well as to 0, and compare the difference between these two levels of trade. Furthermore, because the dependent variable is the natural logarithm of trade in Eq. (1), to isolate the impact on trade we need to first compute the exponential of Eq. (1) (both sides) and then compute the difference when *POST* is equal to 1 and when it is 0. In percentage terms, this is equal to $e^{\hat{\gamma}_1} \times SEAT^{\hat{\gamma}_2} - 1$. Clearly the difference depends upon the level of seats, which can be taken at different points of the seat distribution (e.g., 25th percentile, median, mean, 75th percentile).

Equation (1) can be interpreted as an augmented gravity model in which the origin of international trade is Lombardy and the destinations are the majority of European countries; moreover, Lombardy receives an inflow of goods from the same countries included in the sample. As mentioned in the Introduction, we adopt three different econometric specifications to estimate the augmented gravity model: (1) a panel data model (testing for fixed or random effects), (2) a PPML model to take possible distortions into account in estimated coefficients, and (3) a PPML with destination countries' fixed effects to take multilateral resistance into account.

As a robustness check regarding the quasi-natural experiment, we adopt a DID econometric model, in which Lombardy, and consequently its international trade, is regarded as the "treated" subject and another Italian region provides the "control" data. Lombardy is subject to de-hubbing (the "treatment), while the other region acts as a control since it is not affected by the de-hubbing. As a control region, we choose Veneto. Located in the Northern Italy as Lombardy, Veneto's economy is similar to that of Lombardy in terms of a strong presence of small and medium enterprises (SMEs), with a strong orientation to international trade, similar income and institutional levels, and the same number of airports operating in the two regions. Hence, our DID model is shown in Equation (2):

$$\begin{gathered}\log TRADE_{rit} = \alpha + \beta_1 \times \log SEAT_{rit} + \beta_2 \times \log DIST_{ri} + \beta_3 \times \log GDPCAP_{it} + \\ + \delta_1 \times YEAR_t + \delta_2 \times UE_{it} + \delta_3 \times SCHEN_{it} + \gamma_1 \times POST_t + \gamma_2 \times POST_t \times \log SEAT_{rit} + \\ + \theta_1 \times TREAT_r + \theta_2 \times TREAT_r \times \log SEAT_{rit} + \theta_3 \times TREAT_r \times POST_t \times \log SEAT_{rit} + \epsilon_{rit}\end{gathered} \quad , (2)$$

where r = 1, 2, and takes the value of 1 for Lombardy and 2 for Veneto, while $TREAT$ is a dummy variable taking the value of 1 if data are related to Lombardy and 0 otherwise, representing information of the level of trade between the treated and the control observations. The treatment variable is interacted with $POST$ (providing the difference before and after the de-hubbing) and with the logarithm of seats. Hence the estimated coefficient $\hat{\theta}_3$ allows us to identify the causal effect of seats on Lombardy's international trade without endogeneity issues, as it captures the variation on trade of seats in Lombardy as a difference with Veneto, which has not been affected by the de-hubbing. Any statistical significant difference (positive or negative) is a test that seats have an effect on trade, and not vice versa. A negative estimated coefficient implies that not only do seats have an effect on trade, but also that the de-hubbing has reduced this effect. Since the data regarding flights in Veneto cover fewer countries that for Lombardy, we restrict the sample to 22 European countries.[8]

We apply the DID model with three econometrics approaches: panel data, a PPML, and a PPML with fixed effects. Since it is a robustness check, we limit the analysis at the country level. One crucial requirement of the DID model is the parallel trend assumption, which is usually tested by comparing groups before the treatment (in our case the de-hubbing) is implemented. Figure 2 shows the test of the parallel trend assumption in our data set. The period before the de-hubbing shows that the common trend is a sufficiently reasonable assumption, while the trend between 2007 and 2009 is rather different between Lombardy (subject to the de-hubbing) and Veneto.

[8] In the DID model we do not consider Bulgaria, Croatia, Estonia, Iceland, Latvia, Lithuania, Luxembourg, and Slovakia. Airports in Veneto have no flights connecting them to these countries.

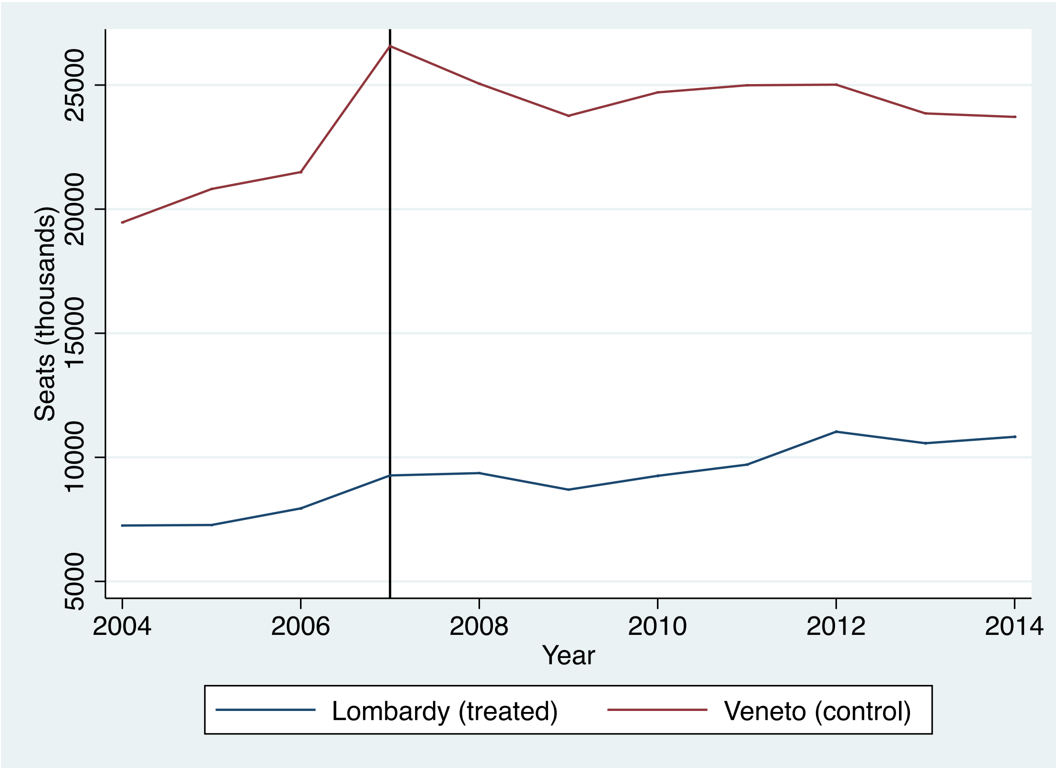

Figure 2. DID model: the test of the parallel trend assumption for Lombardy and Veneto.

4. The Data

We have observations regarding 41 2-digit sectors involving international trade between Lombardy and 30 countries for 11 years; thus we have 13,530 observations for trade and 330 observations for all other variables. This is shown in Table 2 along with some descriptive statistics of the variables used in the econometric estimation.

Variable	Obs	Mean	Std Dev	Min	Max
TRADE	13,530	78,800,000,000	128,000,000.000	134,000,000	678,000,000,000
SEAT	330	808,707.6	1,148,891	2,646	5,009,438
DIST	330	1,176.3	580.9	199	2,822
GDPCAP	330	26,962.7	22,121.4	1,459.9	106,148.8
UE	330	0.78	0.41	0	1
SCHEN	330	0.63	0.48	0	1

Table 2. Descriptive Statistics of Variables used in the Econometric Estimation

The average total trade (export+import) is about € 79 million, the average annual number of available seats (across all 30 countries) is about 809 thousand, the average distance covered by flights is 1,176 kilometres, and the average nominal GDP per-capita is about € 27,000 (with a very high variation among countries, as the standard deviation is € 22,000). Seventy-eight percent of the observed countries are EU-28 members, while only a few others (88%) are in the Schengen agreement. The highest coefficient of variation (the ratio between the mean and the standard deviation) is the Schengen dummy (2.67), the lowest for total trade (0.33).

5. Empirical Evidence

In this section we report the empirical evidence obtained by estimating the before/after econometric model designed to assess the civil aviation impact on international trade, using the data set presented in Section 4. Moreover, we also present the results of the DID econometric model as a robustness check regarding the possible endogeneity between trade and aviation. Table 3 shows the econometric results of the before/after model when the dependent variables are the logarithm of total trade ("Country" column), total trade in the agriculture and industrial sectors ("Agr + Ind" columns), total trade in the agricultural sector ("Agriculture"), total trade in the industrial sector ("Industry"), and total trade in the manufacturing sector ("Manufacturing"). For each trade level we present the results of the random effect panel data model (the first column of each trade level), the PPML model (the second column), and the PPML with the fixed effect model (the third column).[9]

In all econometric specifications, the first-order estimated coefficient for civil aviation (*SEAT*) is generally positive and statistically significant, thus confirming the positive effect of aviation on trade.

[9] **A fixed effect panel data model cannot be estimated since many countries have time invariant variables (e.g., the dummy variables for European Union membership and being part of the Schengen Agreement).**

However, the overall effect of air transportation on international trade is estimated by computing the marginal effects (see Table 4). The estimated coefficient for distance (*DIST*) is generally negative and statistically significant in all econometric specifications (-0.831), while the per capita GDP is positive and statistically significant in all econometric specifications only at the country level. We find weak evidence of a positive effect for the time trend variable (*YEAR*) in agriculture. There is a positive and significant effect on EU member trade at the country level, in the industrial sector, and in manufacturing (with the random effect econometric model). More evidence is collected, in all specifications, of the positive and significant effect of being part of the Schengen area, at the country level, in agriculture and industry together, in industry alone, and in manufacturing.

Indep. variables	**Dependent variable: log $TRADE_{it}$**														
	Country			**Agr + Ind**			**Agriculture**			**Industry**			**Manufacturing**		
	RE	**PPML**	**PPML + FE**	**RE**	**PPML**	**PPML + FE**	**RE**	**PPML**	**PPML + FE**	**RE**	**PPML**	**PPML + FE**	**RE**	**PPML**	**PPML + FE**
log $SEAT_{it}$	0.139***	0.029***	0.031***	0.218***	0.035***	0.001	0.280**	0.073***	-0.014	0.221***	0.035***	0.001	0.201***	0.035***	0.003**
	(0.051)	(0.003)	(0.006)	(0.041)	(0.002)	(0.003)	(0.114)	(0.009)	(0.009)	(0.041)	(0.002)	(0.003)	(0.035)	(0.002)	(0.002)
log $DIST_{it}$	-1.237***	-0.036***	-0.051***	-1.282***	0.045***	0.005	-1.796***	-0.092***	0.145**	-1.284***	-0.046***	0.003	-1-167***	-0.046***	0.014
	(0.243)	(0.004)	(0.009)	(0.195)	(0.003)	(0.025)	(0.492)	(0.011)	(0.064)	(0.194)	(0.003)	(0.026)	(0.189)	(0.003)	(0.022)
log $GDPCAP_{it}$	0.259***	0.014***	0.030***	0.102	0.001	0.012	-0.041	-0.024***	0.055	0.117	0.001	0.014*	0.130	-0.0002	0.014*
	(0.077)	(0.003)	(0.003)	(0.111)	(0.002)	(0.008)	(0.292)	(0.008)	(0.046)	(0.111)	(0.002)	(0.008)	(0.101)	(0.002)	(0.007)
$YEAR_t$	0.0002	-0.003**	-0.004***	0.017	-0.001	0.001***	0.115***	0.040*	0.007***	0.110	-0.010*	0.001**	0.031	-0.003	0.001***
	(0.013)	(0.001)	(0.001)	(0.011)	(0.001)	(0.0004)	(0.032)	(0.024)	(0.001)	(0.100)	(0.006)	(0.000)	(0.083)	(0.005)	(0.0004)
UE_t	0.297**	0.043***	0.069***	0.111	-0.009*	-0.002	0.140	-0.005	-0.028	0.224***	0.002	-0.002	0.143**	0.0003	-0.005*
	(0.119)	(0.014)	(0.015)	(0.100)	(0.006)	(0.003)	(0.285)	(0.014)	(0.019)	(0.074)	(0.003)	(0.003)	(0.061)	(0.003)	(0.003)
$SCHEN_t$	0.223***	0.008*	0.006	0.226***	0.003	0.011***	-0.087	0.003	-0.006	0.014	-0.001	0.011***	0.028***	-0.0003	0.008***
	(0.086)	(0.004)	(0.006)	(0.074)	(0.003)	(0.003)	(0.213)	(0.003)	(0.012)	(0.011)	(0.001)	(0.003)	(0.009)	(0.001)	(0.002)
$POST_t$	-0.278	-0.040	-0.046	0.446	0.011	0.019	-0.028	-0.032	-0.011	0.471*	0.013	0.020	0.571**	0.015	0.021
	(0.352)	(0.044)	(0.032)	(0.284)	(0.032)	(0.015)	(0.823)	(0.146)	(0.069)	(0.284)	(0.032)	(0.015)	(0.232)	(0.030)	(0.014)
$POST_t$ x log $SEAT_{it}$	0.016	0.004	0.004*	0.041*	-0.001	-0.002*	-0.047	0.0004	-0.002	-0.043**	-0.001	-0.002*	-0.058***	-0.001	-0.002**
	(0.027)	(0.003)	(0.002)	(0.022)	(0.002)	(0.001)	(0.062)	(0.011)	(0.005)	(0.022)	(0.002)	(0.001)	(0.018)	(0.002)	(0.001)
Constant	29.485***	2.981***	2.943***	29.200***	3.038***	3.105***	25.574***	2.570***	1.990***	29.111***	3.040***	3.112***	28.508***	3.043***	3.012***
	(1.874)	(0.050)	(0.071)	(1.554)	(0.033)	(0.174)	(4.012)	(0.130)	(0.427)	(1.551)	(0.033)	(0.179)	(1.470)	(0.032)	(0.151)
Observations	330	330	330	297	297	297	297	297	297	297	297	297	297	297	297
R^2	0.54	0.75	0.91	0.67	0.88	0.98	0.51	0.69	0.94	0.68	0.88	0.98	0.66	0.89	0.99
Prob > X^2	0.000			0.000			0.000			0.000			0.000		

Legend: * = 10% statistical significance; ** = 5%; *** = 1%. Standard errors in parentheses

Table 3. International Trade at the Country and Macro-sector levels with Alternative Econometric Models

The effect of civil aviation on international trade can be estimated by calculating the marginal effects of the variable *SEAT*, which in turn depends upon the interacting variable, *POST*. Hence we have a marginal effect before (*POST* = 0) and after (*POST* = 1). Table 4 shows the estimated effects related to these marginal effects in all of the tested econometric specifications. The marginal effect is always positive, and in general, it is larger when estimated with the random effect panel data model than under the PPML approach. It is interesting to note that, in the case of trade at the industry and manufacturing level, the marginal effect after the de-hubbing—i.e., when *POST* = 1, it is lower than that when *POST* = 0, that is, before the de-hubbing. Hence we have identified that the effect of aviation on trade in these sectors is lower after the de-hubbing due to an exogenous shift in the aviation activity, and this provides evidence that civil aviation impacts trade and not vice versa. In the case of agriculture and industry together, industry alone, and with the PPML with fixed effects model, the marginal effect after de-hubbing is negative, a result that reinforces the casual relation from aviation to trade. The estimated elasticity is +0.031% before the de-hubbing with the PPML+fixed effect model at the country level and +0.035% after. In manufacturing, the elasticity is +0.003% before and -0.001 after.

Table 4 reports also the effect of *POST* on trade, which depends on the level of seats. This effect is computed for values of seats corresponding to the 25th percentile of seat distribution to the median, the mean, and the 75th percentile. There is general evidence that the impact of de-hubbing on trade is negative. The percentage reduction under the PPML model with fixed effects ranges from -0.8% for agriculture and industry together to -0.6% for manufacturing, with the highest percentage reduction for agriculture, -3.8% (these values are for seats at the mean). Higher negative-percentage variations (at the mean of seats) are observed under the random effect model, with a very high -48.8% for agriculture, and a -5.9% for total trade.

Marginal effect	**Dependent variable: TRADE**														
	Country			**Agr + Ind**			**Agriculture**			**Industry**			**Manufacturing**		
	RE	**PPML**	**PPML + FE**	**RE**	**PPML**	**PPML + FE**	**RE**	**PPML**	**PPML + FE**	**RE**	**PPML**	**PPML + FE**	**RE**	**PPML**	**PPML + FE**
SEATS															
POST = 0	0.139	0.029	0.031	0.218	0.035	0.001	0.280	0.073	-0.014	0.221	0.035	0.001	0.201	0.035	0.003
POST = 1	0.154	0.033	0.035	0.259	0.034	-0.001	0.233	0.073	-0.016	0.178	0.034	-0.001	0.143	0.034	0.001
POST															
SEATS: 25*th* percentile	-0.083	0.008	0.002	-0.048	0.003	-0.005	-0.445	-0.026	-0.034	-0.041	0.004	-0.004	-0.116	0.00002	-0.003
SEATS: median	-0.069	0.012	0.006	-0.086	0.003	-0.007	-0.470	-0.026	-0.036	-0.080	0.003	-0.006	-0.166	-0.001	-0.005
SEATS: mean	-0.059	0.015	0.008	-0.113	0.002	-0.008	-0.488	-0.025	-0.038	-0.107	0.002	-0.007	-0.201	-0.002	-0.006
SEATS: 75*th* percentile	-0.060	0.014	0.008	-0.109	0.002	-0.008	-0.485	-0.025	-0.037	-0.103	0.002	-0.007	-0.196	-0.002	-0.006

Table 4. The Marginal Effect of Civil Aviation on International Trade at the Country and Macro-sector Level, with Alternative Econometric Models

Table 5 shows the econometric results when total trade is related to industries with different technological classifications within the manufacturing segment—from high-tech to low-tech. Again the first-order estimated coefficient for civil aviation is in general positive and statistically significant in all technological categories and under all the econometric specifications. **Distance has a negative and significant impact, while the GDP per capita has an overall positive and significant effect (the only exceptions are for the medium high- and low-tech industry under the PPML without fixed effects specification), which is higher for high tech- and medium-tech industries. Hence, taking into account the results shown in Tables 3 and 5, the GDP per capita has a positive effect on international trade, with elasticity estimates equal to +0.26% at the regional level, +0.54% for high-tech industries, and +0.71% for medium-high industries. Similar positive estimates for overall GDP (equal to +0.46) are found by Zhang and Zhang (2016). Moreover, the authors also provide evidence that government expenditure on science has a positive impact on trade, a result that is similar to our empirical insight showing that GDP per capita has a positive impact on high tech- and medium-high industries.** A positive trend effect (variable *YEAR*) is found for medium low- and low-tech trade. Interestingly, being an EU member has a positive and significant effect on high-tech trade, while the same result is not observed in other technological categories. Instead, Schengen countries have higher low-tech trade.

Indep. variables	Dependent variable: log *TRADE*$_{it}$											
	High-tech			Medium-high			Medium-low			Low-tech		
	RE	PPML	PPML + FE	RE	PPML	PPML + FE	RE	PPML	PPML + FE	RE	PPML	PPML + FE
log $SEAT_{it}$	0.255***	0.043***	0.001	0.103***	0.039***	-0.002	0.271***	0.042***	0.006*	0.076**	0.038***	-0.002
	(0.059)	(0.002)	(0.004)	(0.037)	(0.002)	(0.002)	(0.045)	(0.002)	(0.003)	(0.032)	(0.002)	(0.002)
log $DIST_{it}$	-1.717***	-0.071***	-0.006	-0.986***	-0.044***	-0.004	-1.295***	-0.059***	-0.005	-1.101***	-0.050***	0.009
	(0.273)	(0.004)	(0.034)	(0.222)	(0.004)	(0.012)	(0.215)	(0.004)	(0.039)	(0.200)	(0.003)	(0.012)
log $GDPCAP_{it}$	0.537***	0.022***	0.050***	0.707***	-0.006**	0.062***	0.195	-0.005*	0.023*	0.132	-0.008***	0.019***
	(0.157)	(0.004)	(0.013)	(0.112)	(0.003)	(0.007)	(0.122)	(0.003)	(0.013)	(0.099)	(0.002)	(0.007)
$YEAR_t$	-0.014	-0.002	-0.001	0.005	-0.0004	-0.0003	0.053***	0.002	0.003***	0.026***	-0.001	0.001***
	(0.016)	(0.002)	(0.001)	(0.010)	(0.001)	(0.0004)	(0.012)	(0.001)	(0.001)	(0.008)	(0.001)	(0.0004)
UE_t	0.526***	0.042***	0.013	-0.026	-0.010	-0.012***	0.061	-0.037***	-0.004	-0.061	0.008	-0.010*
	(0.145)	(0.007)	(0.008)	(0.087)	(0.007)	(0.003)	(0.109)	(0.007)	(0.005)	(0.076)	(0.006)	(0.006)
$SCHEN_t$	0.073	-0.018**	0.005	0.099	0.009**	0.002	0.113	0.018***	0.006*	0.166***	-0.001	0.008***
	(0.108)	(0.007)	(0.005)	(0.064)	(0.004)	(0.002)	(0.081)	(0.005)	(0.003)	(0.056)	(0.004)	(0.002)
$POST_t$	-0.366	-0.007	-0.024	-0.565**	-0.051	-0.032***	1.640***	0.066*	0.084***	-0.272	-0.032	-0.017**
	(0.413)	(0.039)	(0.024)	(0.241)	(0.041)	(0.012)	(0.309)	(0.037)	(0.025)	(0.209)	(0.038)	(0.008)
$POST_t$ x log $SEAT_{it}$	0.024	0.001	0.001	0.026	0.003	0.002*	-0.147***	-0.006**	-0.008***	0.012	0.003	0.001
	(0.031)	(0.003)	(0.002)	(0.018)	(0.003)	(0.001)	(0.023)	(0.003)	(0.002)	(0.016)	(0.003)	(0.001)
Constant	26.701***	2.857***	2.850***	24.776***	2.895***	2.948***	25.157***	2.928***	2.957***	27.652***	2.955***	3.010***
	(2.187)	(0.044)	(0.236)	(1.694)	(0.045)	(0.087)	(1.709)	(0.041)	(0.265)	(1.517)	(0.041)	(0.084)
Observations	297	297	297	297	297	297	297	297	297	297	297	297
R^2	0.71	0.84	0.98	0.34	0.86	0.99	0.64	0.84	0.98	0.48	0.89	0.99
Prob > X^2	0.000			0.000			0.000			0.000		

Legend: * = 10% statistical significance; ** = 5%; *** = 1%. Standard errors in parentheses

Table 5. International Trade at the manufacturing levels with Alternative Econometric Models

Table 6 presents the marginal effects of seats and the impact of de-hubbing on trade under all the tested econometric specifications. Regarding seats, the marginal effect is again always positive, and overall larger when estimated with the random effect panel data model than under the PPML approach. It is interesting to note that, in the case of trade at the medium-low industry level, the marginal effect after de-hubbing—i.e., when *POST* = 1, is lower than that when *POST* = 0, that is, before the de-hubbing. The estimated impact of civil aviation is overall larger in high-tech trade (in the random effect model, the elasticity of seats on trade is +0.25% before de-hubbing and +0.28% after), medium-high trade (+0.1% before and +0.13 after) and medium-low trade (+0.27 before and +0.12% after) sectors. The lowest elasticity estimate is for low-tech industry trade is equal to +0.08% with the random effect mode, to +0.04% with the PPML, and is even negative with PPML plus fixed effects. Hence, we find evidence that civil aviation has a positive effect on international trade in all manufacturing sectors with the exception of low-tech products. This finding confirms the anecdotal insight that air transportation is a key factor in the export and import of high-tech/medium-tech goods (e.g., pharmaceutical products) with high value added and small sizes, and less important in the export and import of low-tech, labor-intensive goods.

Table 6 also displays the effect of *POST* on trade, computed at different points of the seat distribution. There is general evidence that the impact of de-hubbing on trade is negative in medium high- and medium-low industry trade. The percentage reduction under the PPML with the fixed effects models is -0.5% for medium-tech industries and -2.5% for trade in medium-low industries (at the seats' mean level).

Marginal effect	Dependent variable: TRADE											
	High-tech			Medium-high			Medium-low			Low-tech		
	RE	PPML	PPML + FE	RE	PPML	PPML + FE	RE	PPML	PPML + FE	RE	PPML	PPML + FE
SEATS												
POST = 0	0.255	0.043	0.001	0.103	0.039	-0.002	0.271	0.042	0.006	0.076	0.038	-0.002
POST = 1	0.279	0.044	0.002	0.129	0.042	0.000	0.124	0.036	-0.002	0.088	0.041	-0.001
POST												
SEATS: 25*th* percentile	-0.075	0.006	-0.012	-0.227	-0.011	-0.008	-0.107	-0.004	-0.012	-0.121	0.0002	-0.005
SEATS: median	-0.053	0.007	-0.011	-0.207	-0.008	-0.006	-0.226	-0.010	-0.019	-0.111	0.003	-0.004
SEATS: mean	-0.037	0.007	-0.010	-0.192	-0.006	-0.005	-0.304	-0.014	-0.025	-0.103	0.005	-0.003
SEATS: 75*th* percentile	-0.039	0.007	-0.010	-0.194	-0.006	-0.005	-0.293	-0.013	-0.024	-0.105	0.004	-0.003

Table 6. The Marginal Effect of Civil Aviation on International Trade at Different Technological Levels, with Alternative Econometric Models

As a robustness check on the possible trade and aviation endogeneity, we have estimated a DID model applied to Lombardy (the treated case) and Veneto. The results are shown in Table 7. The estimated coefficients regarding distance, GDP per capita, temporal trend, and EU-Schengen memberships have the expected signs and are overall statistically significant. The most important coefficient is $\hat{\theta}_3$, which identifies the de-hubbing effect on the treated case—i.e., Lombardy—captured by the interaction variable $POST \times TREAT \times \log SEAT$. In the random effect model it is negative and statistically significant (-0.007); in the PPML model it is negative but insignificant (-0.001); and in the PPML with fixed effects model it is negative and significant (-0.001). Hence, the de-hubbing from Malpensa has a significant negative impact on the trade in Lombardy (the treated case) compared with Veneto (the control case). This is sufficiently robust evidence that a casual relationship exists from aviation to trade and that previous analyses do not suffer from endogeneity problems.

Indep. variables	Dependent variable: log $\textbf{\textit{TRADE}}_{it}$		
	RE	**PPML**	**PPML + FE**
log $SEAT_{it}$	0.002	0.009***	0.004***
	(0.021)	(0.002)	(0.002)
log $DIST_{it}$	-1.036***	-0.033***	-0.041***
	(0.195)	(0.003)	(0.007)
log $GDPCAP_{it}$	0.333***	0.019***	0.009
	(0.048)	(0.002)	(0.010)
$YEAR_t$	0.028***	-0.001	0.001
	(0.006)	(0.001)	(0.001)
UE_t	0.019	0.059***	-0.002
	(0.063)	(0.009)	(0.005)
$SCHEN_t$	0.231***	0.022***	0.016***
	(0.043)	(0.004)	(0.003)
$POST_t$	-0.892***	-0.103***	-0.089***
	(0.165)	(0.034)	(0.023)
$POST_t$ x log $SEAT_{it}$	0.058***	0.008***	0.007***
	(0.014)	(0.003)	(0.002)
$TREAT_i$	4.424***	-0.143***	-0.063
	(0.626)	(0.034)	(0.039)
$TREAT_i$ x log $SEAT_{it}$	-0.075*	0.021***	0.016***
	(0.044)	(0.003)	(0.003)
$POST_t$ x $TREAT_i$ x log $SEAT_{it}$	-0.007**	-0.001	-0.001**
	(0.003)	(0.001)	(0.0004)
Constant	26.750***	3.046***	3.086***
	(1.390)	(0.038)	(0.056)
Observations	484	484	484
R^2	69	0.77	0.96
Hausman test (X^2)	75.75		
Prob > X^2	0.000		

Legend: * = 10% statistical significance; ** = 5%; *** = 1%. Standard errors in parentheses

Table 7. The Impact of Aviation on Trade – DID Model for Lombardy and Veneto

6. Conclusions

In this paper we exploit a quasi-natural experiment to estimate the impact of civil aviation on international trade. We observe the effects on trade between Lombardy and 30 European countries of exogenous variation in overall air transportation activities in regards to Alitalia and the de-hubbing of Malpensa Airport in March 2008. We obtain an estimate of this effect by implementing a before/after econometric model that resolves the possible endogenity between aviation and international trade.

Furthermore, as a robustness check regarding possible endogeneity problems, we develop and estimate a DID model in which Lombardy is the treated group and Veneto, another Italian region with similar characteristics, is the control group. We show that civil aviation has a positive effect on international trade. We obtain this result by estimating an augmented gravity model under different econometric specifications: random effect panel data, PPML, and PPML with fixed effects. The estimated coefficient of civil aviation elasticities ranges from +0.13% under the random effect model to +0.03% in the PPML (region level). For manufacturing, the estimates elasticity varies between +0.2% and +0.003%. In some cases this elasticity decreases after the de-hubbing (industry as a whole and manufacturing). Regarding the typical technological classification of manufacturing sectors, we find that the highest aviation elasticity is for high-tech sectors (computers, biotech, optics) and medium-high tech (chemicals, electrical equipment) sectors; the same elasticity is lower in medium-low tech sectors (oil products, rubber, plastics, glass, building products, steel, metal products) and in the low-tech sectors (food, textiles, clothing, etc.). Last, the DID model confirms that a statistically significant casual relationship exists from aviation to international trade.

The empirical evidence on the trade-civil aviation relationship supports the policy implication that air transportation is an essential infrastructure for the openness of a regional economy and its ability to export and import goods. This finding means that policymakers should take into account, when designing their mobility programs, that a good air transportation system may boost international trade, and that such an improvement is more likely in high-tech and medium-tech sectors, thus producing low-size/high-value added goods. Orientating regional mobility programs to ensure efficient air transportation systems also means regulating the "quality" of the civil aviation network. Indeed, this paper shows that the Alitalia de-hubbing at Malpensa Airport, yielding the cancellation of more than 180 daily flights and more than 80% of the intercontinental connections, has damaged the international trade in Lombardy, with long-lasting effects. This implies providing incentives to airlines and airports to develop an efficient aviation network, with cooperation between different agents (regional officers, airport managers and airline executives) involved in this process.

The paper could be extended in several directions. First, intercontinental trade and civil aviation connections might be investigated. Second, it would be helpful to have a measure of the civil aviation demand by a two-digit sector, which would allow an estimation of the relationship between trade and aviation at the sector level. A SURE econometric model would also be helpful, having the benefit of estimating a system of equations, which take inter-sector variability into account. These extensions are left for future research.

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