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The effect of airports on the growth of service exports

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The Effect of Airports on the Growth of Service Exports

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Abstract
This paper studies the causal effect of airports on the growth of service exports. We exploit the location of historic military-built airfields as instruments for the current stock of international airports across UK regions. The estimates show that an additional airport increases the growth rate of exports by 76% over an 8-year time period. Airports affect exports by increasing both the intensive and extensive margins. The evidence is consistent with airports improving market access and reducing fixed and variable trade costs. These results are robust to the addition of contemporaneous and historic controls and various falsification and robustness tests.

JEL codes: F14, H54, L80, R49
Keywords: airports, exports, service sector

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1. Introduction

In this paper, we study the effect of airport infrastructure on the growth of service exports. The joint production requirement of many services suggests that airports influence both sides of the market. Airports increase market size by providing firms with access to international customer networks. This raises market size and provokes exporting. Airports also affect the supply side by reducing transport costs, offering fast and low-cost access to international markets relative to other transportation modes. In a Melitz (2003) framework this results in a lower export-productivity threshold and therefore a greater number exporters, but also greater export volumes by existing exporters.

Understanding the effects of airport infrastructure on service exports is of interest for a number of reasons. First, exports of services are of growing importance at a global level. In 2016 world service exports were $4.9 trillion (UNCTAD, 2017), around a third of total world exports. Yet, much of our understanding of the links between exports and transportation infrastructure is for trade in goods (Durnaton et al., 2014; Donalsdon, 2014; and Bernhofen et al., 2016).[1] The mode of delivery for many services is distinct from that of goods, such that services are more likely to be sensitive to infrastructures, such as airports, that enable the speedy and reliable movement of either people and/or information.[2] Second, investments in airports are costly and subject to fierce debate over their often competing environmental and economic impacts. Despite the huge, and often publicly funded, cost associated with constructing airports there is limited evidence that quantifies the economic benefits of airports and none that estimates the effects on service exports. To begin an accurate evaluation of the various trade-offs from airport infrastructure first requires robust empirical evidence of the type provided here.

Anecdotal evidence suggests that airports are important in driving service exports. Figure 1 shows that the evolution of United Kingdom (UK) service exports between 1980 and 2015 and the number of international business passengers transiting through three major UK airports display similar trends. While this correlational evidence suggests a positive link, isolating causal inferences is beset by econometric challenges. For example, airports may be located in economically depressed areas where the opportunity cost of land is lower because policymakers believe airports improve local economic performance (Sheard, 2014). Alternatively, planners may situate airports in regions where service exports are high or are expected to grow rapidly in future. Naïve regressions are therefore likely to yield biased estimates of the airports-service exports relationship.

[1] For a literature that has studied the effects of airports on outcomes such as growth and employment see Brueckner (2003), Green (2007), Sheard (2014) and Campante and Yanagizawa-Drott (2018). We discuss these in more detail in the next section of the paper.

[2] Existing empirical literature largely focuses on the response of service exports to changes in the costs of communication exchange through computers and related technologies such as the internet (see, for example, Freund and Weinhold, 2002, 2004; Clarke and Wallsten, 2006; Abramovsky and Griffith, 2006; and Kneller and Timmis, 2016).

Our identification strategy revolves around instrumental variable estimations. We exploit the location of military airfields built before 1945 as instruments for the current stock of international airports across UK regions. The military airfields in existence towards the end of Second World War were constructed in response to the short-term military needs of this period and the earlier 1914-1918 conflict. They were also built in large numbers. Some 528 military airfields were built across the UK during the years 1939 to 1945. As the locations chosen for these historic military airfields were not based on the needs of future service exporters, they are plausibly exogenous with respect to contemporary service export growth (Falconer, 2012).

[Insert Figure 1: Evolution of UK Service Exports and Aviation Passenger Traffic]

Military airfields are, however, relevant in explaining contemporary airport locations. Alongside their immediate military requirement, airfield locations were chosen by the Royal Air Force (RAF) based on a narrow range of geological and topological characteristics of the landscape. Specifically, a site had to have a flat plain, good drainage, and lie between 50 and 600 feet above sea level (Falconer, 2012). Sites that met these conditions were requisitioned and the infrastructure was constructed following a common blueprint. Historic military built airfields are good predictors of current airport locations because the geography requirements of modern airfields are largely the same. In addition, during the post-war period the monetary and non-monetary costs of building airports on green-field sites led to some modern airports being constructed on decommissioned military airfields. Our econometric tests show a strong correlation between our instruments and the location of modern international airports.

Using instrumental variables estimation, we find robust evidence that airports impact service exports. Estimates of the local average treatment effect (LATE) indicate that an additional airport causes service exports to grow 76% faster over the 8-year period between 1997 and 2005, an average annual growth rate of around 7%. Subsequent tests provide insights into the underlying mechanisms. Airports lead to substantial increases in the share of firms that export and the export intensity of these firms (the ratio of exports to sales). The patterns in the data are therefore consistent with airports improving market access and reducing fixed and variable trade costs. We also find a link between airports and manufacturing exports. However, the LATE is smaller compared to our estimates for service industries. An additional airport is estimated to lead to a 21% faster growth in manufactured exports over the 8-year sample window, around a quarter of the effect for service exports.

A series of robustness tests confirm that our findings are not driven by confounds. To contaminate our inferences, an omitted variable must correlate with the location of historic military airfields and explain the growth of service exports some 60 years later. We obtain similar LATEs despite controlling for regions' levels of agglomeration, income, educational attainment, sectoral employment shares and a range of other historic factors around the time of the 1914-1918 and 1939-1945 military conflicts. Diagnostic tests also confirm that military airfield locations were not systematically determined by historic socioeconomic characteristics. These pieces of evidence rule out that our findings derive from historic factors that have persistent economic effects across time.

We also establish that contemporary factors do not confound our inferences. For example, we rule out developments within the airline industry such as changes in airport size (Sheard, 2012), expansions of carriers' route networks, and hub airports (Brueckner, 2003). Contemporary firms' size and productivity, changes in population, the spread of broadband internet, the growth of international high-speed rail connections, other types of infrastructure, and shocks to sectors' employment mix also do not drive the results.

Placebo tests provide further reassurance that the effects we estimate are due to airport infrastructure. Alongside international airports, our instruments are capable of predicting the current location of other airports in the UK that are used exclusively for leisure purposes and domestic intra-UK flights. As domestic airports do not provide access to international markets, they should not affect service exports. This is what the data show. Service exports therefore only respond to the presence of airports that link regions to international markets.

Finally, we investigate whether access to international airports led to a net increase in UK service exports, or a reorganisation of exporters to be close to airports with little or no net effect. Following an approach outlined in Redding and Turner (2015), who consider this question in relation to infrastructure and city size, we find evidence that shows airports have a positive net effect on UK service exports. Moreover, we find evidence that suggests that any reorganisation effects are small in magnitude.

The paper proceeds as follows. Section 2 provides a summary of related studies. In Section 3 we describe the data set and the identification strategy. We describe the background to military airfields in Section 4. Econometric results, extensions and robustness tests are reported in Section 5 and we draw conclusions from the analysis in Section 6.

2. Related Literature

Our paper bridges two strands of literature. One body of research studies the determinants of international trade in services. Within this literature some researchers argue that service exports are affected by the same factors as those of goods exports (Bhagwati et al. 2004), whereas others, because of differences in their mode of delivery, emphasise their uniqueness (Kimura and Lee, 2006; Lennon et al., 2009). Our focus is on the infrastructure that supports the delivery of service exports. We can find no examples of previous studies that that have considered the potential role of airports in this way. Most closely related are studies on the response of service exports to computing and internet technologies. These typically find a positive effect (see, for example, Freund and Weinhold, 2002, 2004; Clarke and Wallsten, 2006; Abramovsky and Griffith, 2006; and Kneller and Timmis, 2016). Harrigan (2010) compares the types of goods traded internationally using air freight versus those that are shipped.

Our paper also fits into a much larger literature considering the broader employment and growth effects of various infrastructure. One part of this literature has studied the effect of the air transport industry more broadly, including airports. An early example is Brueckner (2003), who finds a positive link between airport infrastructure and employment. Other work in this area explores the relationship between air passenger numbers and regional growth (Green, 2007). More recent studies have tried to establish causal effects using an array of methods. Blonigen and Cristea (2012) study how population growth responds to air passenger growth by exploiting the 1978 US Deregulation Act, which liberalized the US air transport market. Using difference-in-difference estimations they find differential effects across city sizes. Cristea (2011) exploits cross US-state variation in bilateral exports and business class travel. More recently, Campante and Yanagizawa-Drott (2018) use a regression discontinuity approach to study the effect of long-range business flights on business connections and economic development. Within this literature, the most similar approach to ours is Sheard (2014), who uses the 1944 US civil aeronautics administration plan as an instrument for current airport sizes. He finds that airports lead to changes in the employment share of industries across US cities. Finally, a number of studies report associations between airline routes and the productivity and size of firms (Rosenthal and Strange, 2004; Brueckner, 2003; Green, 2007). Bel and Fageda (2008) and Brueckner (2003) report that the location of an airport affects the location decision of new firms, while Strauss-Kahn and Vives (2009) obtains a similar finding for the location of firm headquarters.

Our use of instruments based on historical infrastructure builds most closely on a separate part of this economic geography literature, which also includes Sheard (2014). Redding and Turner (2015) highlight that endogeneity bias is omnipresent in empirical inquiries into the economic effects of infrastructure. They outline three instrumental variable strategies to deal with the problem. They label these as planned route IV, historical route IV and inconsequential place approach. The motivation for our choice of instrument set is taken from this literature and most closely aligns with the planned route and historical route approaches. The validity of our instruments therefore hinges on similar arguments.

Planned route IVs exploit differences between the planned and actual infrastructure network. For example, the US interstate highway network was constructed following plans developed much by the US military during the interwar years. This type of approach is typified by Baum-Snow (2007), Michaels et al. (2012) and Hsu and Zhang (2012). The validity of instruments in that setting rest on the assumption that these military needs are orthogonal to post-war outcomes. The historical IV approach was developed in a series of papers by Duranton and Turner (2011, 2012) and Duranton et al. (2014), where they use railroad routes and exploration maps as historic instruments, along with the US interstate highway plan. Historic instruments are valid providing the unobservable determinants of these historic networks do not determine current economic activity. For example, Duranton et al. (2014) argue the US rail network was built to serve a largely agrarian economy and had little to do with modern manufacturing. Yet because railroad networks could be converted to highways, they meet the instrument relevance condition.[3]

3. Estimation Strategy, Data Description and Summary

3.1 Estimation Strategy

The simplest way of understanding how exports respond to access to airports would be to estimate

$$y_{it} = \beta_1 a_{it} + \varepsilon_{it}, \quad (1)$$

where y_{it} is the log of the level of exports ($y_{it} = \ln Y_{it}$) in region i in year t; a_{it}, is the number of airports in each region at time t; ε_{it} is the error term.

A concern when estimating β_1 is the presence of omitted variables that are correlated with the location of airports and service exports from the region. For example, airports locations are determined in part by the potential demand for commercial air transport and in part by geographic features of the landscape in which they sit, such as topography and the water table. In a UK context both of these tend to favour the South and East of England, which because it is flatter has a more favourable geography (Stamp, 1960), and because average income levels are higher. The effect of such region-specific time invariant characteristics can be removed using a first-differenced form of the regression equation as follows:

$$\Delta y_{it} = \beta_1 \Delta a_{it} + \Delta\varepsilon_{it}. \quad (2)$$

Access to airports in time period t is assumed to depend on the stock of airports in the preceding period, on random shocks (ε_{it}) and on some other initial conditions (x_{it-1})

$$\Delta a_{it} = \alpha a_{it-1} + \gamma x_{it-1} + \varepsilon_{it} \, . \quad (3)$$

Which we substitute into (2) to give our estimating equation

$$\Delta y_{it} = \theta_1 a_{it-1} + \gamma x_{it-1} + \Delta\varepsilon_{it}, \quad (4)$$

that is, the change in exports between $t-1$ and t is explained by the initial access to airports, some other initial conditions, and random shocks.

If the location of IATA airports in 1997 were exogenous with respect to future exporting growth, conditional on the removed time invariant characteristics and any differences in the trend of export sales that are correlated with initial location characteristics, equation (4) would provide the causal effect of airports on exports. However, such an outcome is unlikely, and the direction of bias could be in either direction. If airports were located near cities that were expected in the future to have large tradable

[3] Of interest to this study, Durnaton et al. (2014) find no effect from interstate highways on the total value of exports between US states, although there is an effect on its weight. Consistent with this latter finding they also report that cities with greater transport infrastructure tend to specialise in sectors producing heavy goods. We extend this to study an infrastructure that supports trade in weightless services.

service sectors then the OLS estimates are likely to be upward biased.[4] Alternatively, as the environmental and noise pollution produced by airports have long been known (Fordham, 1970), sites in regions with relatively poor economic prospects are more likely to be chosen. OLS estimates would then be downward biased. To solve this endogeneity problem we instrument for the location of international airports in the UK with that of historical military built airfields. Before discussing instruments in detail we briefly introduce the data and its sources.

3.2 Data Sources and Summary

Our data set contains observations for each travel to work area (TTWA) in the United Kingdom (UK) for 1997 and 2005. TTWAs represent the regions i in equation (4). TTWAs are statistical regions used by UK government agencies to indicate an area inside which approximately 85% of the population commute to work. As service exports often rely on international connections through a local airport, TTWAs are an appropriate geographical area in which airports may affect exports. The final sample includes a total of 200 TTWAs.[5]

3.3 Dependent Variables

Data on service-sector exports is taken from the International Trade in Services (ITIS) database provided by the Office for National Statistics.[6] For the years 1997 to 2005, the ITIS data contain firm-level information on the annual value of exports and precise firm location. This data is described in detail in Breinlich and Criscuolo (2011).[7] For each year, we aggregate firm-level exports to the TTWA level and then calculate the regional growth rate of exports between 1997 and 2005. The ITIS data allow us to move beyond aggregate export values and generate measures of the intensive and extensive export margins, along with the destination-extensive margin. Specifically, to capture the intensive margin we use the average ratio of exports to turnover of firms within each TTWA; we measure the extensive margin as the ratio of exporting firms to total firms in the TTWA; and the destination margin as the number of country destinations services are sent to in each TTWA. We subsequently calculate the growth rate of these intensive and extensive margins between 1997 and 2005. In a similar way, we

[4] An example of a modern airport of this type would be London City Airport. This airport was built on reclaimed former docks to the East of the centre of London in 1987 to serve the growing business community of the Docklands district.
[5] We exclude TTWAs from the Scottish islands on the grounds that they are not comparable to the other TTWAs and contain airports for which it was difficult to identify precise opening dates (often because they are on beaches with limited infrastructure).
[6] Following convention, the service sector comprises two-digit ISIC industries from 45 to 82. The estimations focus on industry codes between 50 and 74 where public providers do not operate. See Appendix Table B.1 for a description of the industries. To avoid a potential problem of a low number of observations within a TTWA we do not report results by service type. These results are available on request.
[7] The ITIS dataset also contains information on imports. We find similar effects of airports on imports. These results are available on request.

calculate the growth rate of manufacturing exports between 1997 and 2005 in each TTWA using data aggregated from the firm level within the Annual Respondents Database (ARD).[8]

Patterns in the service export data conform with economic intuition. The largest value of service exports are from London, while other southern TTWAs such as Heathrow and Slough, Guilford and Reading also feature prominently among the most export intensive UK regions. Basic summary statistics on export growth are shown in Table 1. For the mean travel to work area service exports grew by around 14% per annum over the sample period, which equates to 185% over the 8-year period between 1997 and 2005.

[Insert Table 1: Summary Statistics]

3.4 Explanatory Variables

The key explanatory variable a_{it-1} in equation (4) is measured by the number of airports servicing international routes within each TTWA in 1997. All UK airports are assigned an International Civil Aviation Code (ICAO). A sub-set airports, those offering international flights, are also assigned an IATA code. Given our interest in international passenger flight connections we focus on airports that have an International Air Transport Association (IATA) code. There are 109 such airports in the UK and no IATA airports opened or closed in the UK during the period 1997 to 2005. For each airport we have information on the precise latitude and longitude which allows us to match airports to TTWAs. The number of IATA airports per TTWA ranges between 0 and 4 with a mean of 0.40. Around 30% of TTWAs include at least one IATA airport. In robustness tests we measure airport infrastructure using an airport dummy which equals 1 if there is at least one IATA airport within a TTWA, 0 otherwise.

As mentioned above the list of IATA airports does not define all airports in the UK. The airports without an IATA code are minor airports used for domestic flights, pilot training, and leisure purposes. There are 120 minor airports of this type in the UK. We argue that international airports influence service exports through the cross-country connections they offer. We therefore use minor airports in falsification tests.

We merge in a number of additional variables that act as controls in the regressions. We retrieve information on the average size (measured using employment) and labour productivity (the ratio of turnover to employees) of service-sector firms within each TTWA from the ARD database. To capture sectoral determinants of exporting we retrieve information on the share of employment in the manufacturing (the ratio of employment in manufacturing to total employment) and service sectors (the ratio of employment in service sector firms to total employment) from the ARD. In addition, we use total employment within the TTWA as a further size proxy. To capture the level of interconnectedness between UK regions we use the total number of domestic air passengers handled by IATA airports in

[8] The manufacturing sector spans ISIC codes 10 to 33. The ARD is also constructed by the ONS and underlies the UK National Accounts.

each TTWA. We measure the size of airports using the annual number of passengers and the length of runways. Using information provided by the UK Civil Aviation Authority we merge in data on the number of destination countries and cities flown by carriers from each airport. To capture the spread of broadband technologies, we retrieve the year in which a TTWA was connected to the ADSL broadband network reported by DeStefano et al. (2018). From the ONS Postcode Directory we calculate the physical size of each TTWA in square kilometres and calculate urbanization rates as the ratio of urban to total postcodes within the TTWA.[9] Finally, within the empirical analysis we seek to rule out the possibility our findings are driven by historical factors which have persistent effects on exports. We construct these historic controls using digitised versions of the UK census provided by the Vision in Britain website. These sources provide data on population and employment by industry at the city/district level which we aggregate to modern TTWAs. This provides information on total population in 1911, 1921 and 1931, the share of manufacturing and services in total employment for the years 1921, 1931 and 1951 and the unemployment rate in 1933.[10]

3.5 Instrumental Variables

Our instrument set relies on hand-collected information on the location of 765 airfields in use by the Royal Air Force (RAF) at the end of December 1944. This information has been collated from a variety of published and unpublished sources (e.g. Falconer, 2012), largely put together by military enthusiasts using military archives and made available to us. Within this data we have information about the location of the airfield, whether the airfield was built for military purposes or not, the year in which it opened and the purpose of its use in December 1944. To construct our instrument we focus on military built airfields only and therefore exclude those built for civil aviation purposes and requisitioned for military use during the 1939-1945 war (of which there are 44). This includes the largest airport in the UK, Heathrow. The remaining 721 airfields form the basis of our instrument. We divide these airfields into one of four types based on the wartime function of each airfield: fighter, bomber, coastal or other.[11] Using the longitude and latitude of the airfield allows us to generate a measure of historic military built airfields within each TTWA. Summary statistics reported in Table 1 show that the average TTWA contains 0.63 fighter airfields, 0.84 bomber airfields, 0.40 coastal airfields and 0.99 other airfields.

4. Historic Military Airfields

[9] This data is available from the ONS postcode directory. Urban location are define as those within settlements with a population of 10,000 or more.
[10] There was no census in the UK in 1941.
[11] Classification of airfield type relies on information provided by John Woodside. Fighter airfields are those which were used to launch Supermarine Spitfire and Hawker Hurricane aircraft. Bomber airfields are those used by four-engine aircraft (such as the Avro Lancaster) to conduct bombing missions. Coastal airfields are those which were used to defend coastal locations and ports. The other airfields variable comprises a range of different types of military airfields. For example, landing strips which were used for emergency landings as well as airfields used for training purposes, aircraft part stockpiles and munitions dumps.

Historical accounts report that the UK government constructed military airfields for purely short-term military purposes (Falconer, 2012). Along with their military requirements, airfield locations were chosen on their topography and geological characteristics. Each site was required to be reasonably flat with good drainage, free from obstructions, and between 50 and 600ft above sea level (Stamp, 1960; Blake, 2002, 2009; Falconer, 2012).[12] If a site was deemed suitable it was requisitioned under the Emergency Powers (Defence) Act of 1939. The necessary infrastructure for an airfield were then constructed following a common design specified by the Air Military Defence Ground Works (Falconer, 2012).[13]

The majority of the historic military airfields of interest to us were built during the Second World War (528 airfields). The other episodes of airfield construction activity occurred during the First World War when 85 were built,[14] during the interwar years when 99 military airfields were constructed, and as the UK prepared for the possible outbreak of hostilities from 1935 to 1938 (61 airfields). The distribution of airfield opening dates is illustrated in Figure 2.[15] Military historians report that a large number of airfields were needed for the primary reason that the Axis Powers had the advantage of knowing where they would attack, whereas the RAF were acting to defend.

[Insert Figure 2: Timing of Military Airfield Construction]

Out of the 721 military built airfields, 566 are no longer in use. These were sold at the end of the war under the 1939 Compensation Defence Act, the 1945 Requisitioned Land and War Works and then additionally in 1972 following the Nugent Report. According to data from Blake (2009) most disposals occurred relatively quickly following the end of the war and then in continuous phases as the Cold war first heightened and then waned. By 1957 just 21.4% of the airfields in active service at the end 1944 survived, which had fallen to 11.9% by 1968 and 5.7% by 2008.[16]

[Insert Figure 3: Airfield Locations]

Figure 3 shows the location of military airfields. There are no obvious patterns in the data except that the concentration of airfields is somewhat higher along the eastern coast of England. Military planners prioritized construction of airfields in this region as they believed it more likely that raids by the Luftwaffe would be concentrated on this area as it lies on a similar latitude to Germany (Falconer, 2012), but also because it has a geography favourable to airport construction. That airfields were built

[12] According to Blake (2002, 2009) the ideal environment for military airfields was a surface gradient flatter than 1 in 80, well-drained sub-soil, light woodland cover, nucleated rural settlements with road and rail connections.
[13] Airfields in this period were typically constructed with one paved runway of 1,400 yards and two subsidiaries of 1,100 yards long (Falconer, 2012). Owing to the surge in building activity during World War 2 pre-fabricated buildings were the fastest way to install the necessary facilities and airfields took approximately 5 to 7 months to build. The average cost of constructing an airfield was approximately £528,000 (Falconer, 2012).
[14] According to Falconer (2012), by 1924 just 27 airfields built during World War 1 or before, remained in use by the RAF.
[15] A small number of civilian-built airfields were also constructed during the interwar years. These were established mainly for leisure reasons and by aviation companies testing airplane designs. These do not form part of the instrument set.
[16] Government papers on the need for military airfields were published in 1957, 1968, 1973 (the Nugent report), 1975, 1990 and 1999.

across all parts of the UK reflects the military response to the changing conflict during World War 2. For example, the successful invasion of France, Belgium, and later the Netherlands and Scandinavia by the Axis Powers meant that airfields were required to defend the south coast of England, and all the way up to the Scottish Islands. Moreover, at the start of World War 2 airfields were initially required to support fighting in continental Europe, followed by the defence of UK cities (a period known as the Battle of Britain), and followed still later by support for fighting in continental Europe again. Airfields were also needed to support warships, rescue airmen that ejected over the sea, as training sites, and as emergency and satellite landing grounds.

For each airfield we also have information on which military Command the airfield belonged to in December 1944. For example, the airfield may be operated by RAF Fighter Command (145 airfields), RAF Bomber Command (188 airfields), or RAF Coastal Command (107 airfields). We assign the remaining airfields to a heterogeneous "Other" category which comprises landing grounds, training facilities and munitions dumps. These are spread quite differently across the UK. For example, 69 TTWAs have a fighter airfield, 51 a bomber airfield, 55 a coastal airfield, and 101 have other types of airfield.

To formally investigate the location determinants of these different types of historic military built airfield locations we estimate the following equation

$$military\ airfields_{ij} = \alpha + \beta X_i + \varepsilon_i, \qquad (5)$$

where $military\ airfields_i$ is the number of military airfields constructed in TTWA i of type j (fighter, bomber, coastal, other) between 1904 and December 1944; X_i is a vector of historical control variables; ε_i is the error term. We estimate equation (5) separately for each airfield type and report the estimates in Table 2.

[Insert Table 2: Historic Military Built Airfield Location Determinants]

Across all four columns of Table 2 we find no systematic relationships between TTWA's socio-economic characteristics and military airfield locations. The estimates in column 1 of Table 2 show that the number of military built airfields under control of fighter command in 1944 is uncorrelated with any of the historic control variables, the measure of the landmass of the TTWA and a measure of access to ports. A similar result is present in column 2 for the number of airfield under bomber command, except for a negative and significant relationship with the size of the manufacturing sector in 1951. This probably reflects the fact that these airports were a military target themselves and therefore were not built factors requisitioned for various wartime arms and munition production. We find in column 3 of Table 2 that the only statistically significant determinant of coastal airfields is whether it is near a port. Given that these airfields were used to help provide defence to the naval fleet this is not a surprising outcome. Finally, in column 4 we find that TTWAs with a larger landmass have more other airfields.

These econometric findings are consistent with historical studies of airfield locations. Specifically, economic conditions at the time did not systematically determine where the military decided to locate airfields. However, as is standard in recent studies of the economic impact of infrastructure (for example, Duranton et al., 2014) our subsequent estimations include the historical control variables to ensure that our estimates do not capture persistent effects of those variables that correlate with the stock of military airfields in Table 2.

4.1 Instrument Relevance

There are two reasons to believe that military airfields should determine current airport locations. First, planning constraints and land costs make new airports expensive to construct such that they exhibit strong persistence in their location across time (Redding et al., 2011). These time persistent planning issues are particularly severe in the UK due to political factors.[17] As military airfields had existing facilities, they could be cheaply converted for civil aviation purposes leading to the establishment of airports on military airfields. This conversion took place largely in the period after the end of WW2. It is for this reason that our instrument uses the stock of airfields at the end of 1944 rather than an earlier date. Of the 109 international airports in the sample, 67 are built on a historic military airfield. The number of current UK airports along with their military origins are summarised in Table 3.

[Insert Table 3: Origin of UK International Commercial Passenger Airports]

A second reason why historic airfields predict current airports is due to the fact that military airfields were chosen on sites that had suitable topography and drainage to house an airfield. These sites were acquired from previous landowners under the 1939 Compensation Defense Act and constructed to a common design organised by the Air Ministry Directorate General of Works (Falconer, 2012). Hence, military airfields' physical characteristics were well suited to the establishment of modern international airports which have similar requirements.

Initial empirical support for the instrument relevance condition is shown in Table 4 where the correlation between the 1944 stock of military airports and the current number of IATA airports is 0.57. The correlation between the stock of military airports and the IATA airport dummy variable is approximately 0.40. It is also clear from Table 4 that the correlation between military airfields and current airports varies across airfield types. For example, the correlation is 0.45 for other airfields versus 0.23 for coastal airfields.

[17] The severity of political interference and constraints is demonstrated by the recent debate about airport expansion in London. In 1990 a Government funded study recommended a third runway at Heathrow. The same recommendation was made in a 2003 White Paper. This was again proposed in 2009 by the Labour administration, but reversed in 2010 by the incoming Conservative-Liberal Democrat coalition government, and then reversed back again in 2015 by a report by the Airports Commission. Current estimates of the yet to be commissioned third runway at Heathrow are £17.6 billion while the cost of adding a second runway at Gatwick Airport is £9.3 billion. For comparison, a four-runway airport opened in Paris (Charles de Gaulle) in 1974, a third runway was opened at Frankfurt Airport in 1984 and a fourth in 2011, while a fifth runway was opened Amsterdam (Schipol) in 2003.

[Insert Table 4: Instrument Relevance]

5. Econometric Results

Estimates of equation (4) are reported in Table 5. Column 1 reports results using OLS and includes no control variables. The effect of airports reported in column 1 suggests that increasing the number of IATA airports within a TTWA by one is associated with a 55% increase in the growth rate of service exports between 1997 and 2005. This is a relatively large effect and reflects the fact that close to 70% of TTWAs have no airports within their boundaries and therefore an increase of 1 airport is a large change. The coefficient is precisely estimated and is statistically significant at the 1% level.[18]

[Insert Table 5: Export Results]

A danger is that the airport coefficient estimated using OLS is biased. We therefore turn to two stage least squares estimation (2SLS). Beginning with a regression with no controls, the first-stage results reported in column 2 of Table 5 show that the different types of historic military airfields are statistically significant predictors of current IATA airport locations. It is also apparent that the economic magnitude of the relationship between military airfields and the stock of IATA airports in a TTWA varies depending on their use during the war. An additional fighter, coastal or other WW2 airfield increases the number of current international airports by 0.11, 0.16 and 0.15, respectively, whereas the bomber airfields coefficient is estimated to be only 0.06. The heterogeneity in the effect sizes stems from the fact that bomber airfields tended to be located away from urban centres. Based on the evidence of the first-stage results, our instrument set is highly relevant in explaining the contemporary stock of IATA airports across TTWAs.

The second-stage estimates of reported in column 3 of Table 5 show that an additional international airport causes exports to grow by approximately 113% within a TTWA during the sample period.[19] The coefficient estimate is precisely estimated and is statistically significant at the 1% level. That the IATA airport coefficient estimate obtained using instrumental variables is larger than that found when using OLS, suggests that the naive estimates are biased downward. This indicates that modern airports are typically cited in locations that export less than a randomly selected UK TTWA, consistent with the noise and environmental pollution associated with airports.[20]

[18] Unreported regressions using firm-level data provide evidence that firms export services to the destinations to which carriers at their local airport fly to. This suggests that firms do indeed use airports to deliver service exports. Specifically, we find a significant correlation between the volume of exports firm i exports to country c and a dummy variable that is equal to 1 if there is a flight connection between an IATA airport in firm i's TTWA and country c. A firm's exports to a connected country are approximately 104% higher compared to destinations not served by the IATA airport. See Appendix A for further details.

[19] This effect on exports is likely to occur through a combination of a direct effects on established exporters and through the location of production. That is, exporting firms choosing to locate near production. Separating these two channels requires a source of exogenous variation in firm location as well as exogenous variation in the location of airports. We note that this affects the interpretation of our results not their validity (Duranton et al., 2014). We return to the point in Section 6.2.

[20] Sheard (2014) also finds that instrumental variable estimates of the economic effects of airports are typically larger than those derived using OLS. This is also the case in Baum-Snow (2007) and Duranton and Turner (2012).

In the remainder of the table we append the estimating equation with an increasing number of controls. We begin with the controls for urbanization, the size of the TTWA and a substitute technology for service delivery in the form of broadband internet. The service sector tends to cluster in urban areas, while airports are often located nearby cities. The geographic units we use, TTWAs, are not symmetric in terms of geographical size and it is therefore possible that larger TTWAs contain more exporters and due to their greater land mass are also more likely to contain an airport. To capture the role of the availability of broadband technologies we include the average year in which telephone exchanges within the TTWA were enabled for ADSL broadband. Based on data from DeStefano et al. (2018), the earlier an exchange was ADSL enabled, the longer residents have had broadband access, such that this variable is expected to have a negative effect on service exports.

The estimates reported in column 4 show a 10% increase in urbanization is associated with a 3.4% higher rate of export growth, while a similar increase in TTWA size is associated with a 0.74% faster rate of export growth. The broadband coefficient estimate has the expected sign but is statistically insignificant, although we note that this result is conditional on the inclusion of the TTWA size variable. Once we exclude this size variable we find a significant effect, suggesting that earlier broadband availability increased service exports. The IATA airport variable remains statistically significant in this regression, although it is smaller in size compared to column 3.

Next, we add controls for the average number of employees per firm and labour productivity of firms operating within each TTWA. Controlling for employment is motivated by evidence found in that infrastructure is often associated with employment growth (Redding and Turner, 2015). If airport locations affect employment and larger firms are on average more likely to export (Greenaway and Kneller, 2007) then we might expect the inclusion of this control to impact on the relationship between airports and export growth. A similar argument might be made about labour productivity. While we find a positive association between average employment and export growth there is a negative effect from the growth in labour productivity in column 5 of Table 5. This latter result is somewhat surprising, although we note that there is a negative relationship between initial productivity levels and future productivity growth, and therefore appears to be driven by productivity convergence. If we use initial productivity levels we find that this has a significant positive relationship with future export growth.[21] The IATA airport variable again remains significant in column 5.

Another explanation for the relationship we observe between airports and exports could be that airports tend to be located in regions where the service sector has grown over time. To capture the effects of industrial composition we control for the share of employment in the manufacturing and service sectors in each TTWA at the start of the time period and report the results in column 6 of Table 5. Neither of

[21] For brevity we have chosen not to report this regression. It is available from the authors on request.

the additional control variables enters significantly and the IATA airport coefficient remains robust to this change.

While the evidence above demonstrates that military airfields empirically determine the location of IATA airports, it is possible that their relationship with the growth of service exports occurs through other channels. Most obviously, some military airfields were built to defend centers of population, locations in which military equipment was manufactured during the war and other sites of strategic or cultural importance. On the other hand, the airfields themselves were a military target, leading to them being located in more rural locations to camouflage their presence. These are factors that are persistent across time and it may be this effect that our instruments capture. We confront this issue by including contemporaneous as well as historic controls for population, the employment mix and for economic deprivation (for which we use the unemployment rate) in the remaining regressions in the table.

Column 7 of Table 5 reports estimates including the current level of employment in each TTWA. While the rate of export growth is significantly slower in TTWAs with large workforces, the IATA airport coefficient remains positive and statistically significant. Next, we append the model with a host of historical controls and report the results in column 8 of the table. We find no significant relationship between the rate of export growth during the sample and the historic sectoral composition of employment 1921 and 1931, the size of the population in 1911, 1921 and 1931 and the unemployment rate in 1933. Moreover, the IATA airport coefficient retains a similar economic magnitude and statistical significance compared to earlier regressions reported in the table. We conclude from this that our findings are not driven by historical factors that have persistent effects on exports.

Finally, we consider the way that we have measured airports. In column 9 we replace our count measure with a dummy variable if the region has an IATA airport or not. Measured in this way we find an effect of airports that is consistent with the previous evidence presented in the table. The effect is however larger than before; according to these new estimates exports grew approximately 120% faster between 1997 and 2005 in TTWAs with an IATA airport relative to regions without an IATA airport. This suggests a form of non-linearity in the relationship between the number of airports and exports, with the marginal effect of the first IATA airport larger compared to the effect from additional airports.

Importantly, across columns 4 to 10 of Table 4 the diagnostic checks continue to demonstrate that our instruments are valid. In all of the specifications the instruments are found to be highly relevant and jointly significant. Specifically, the Kleibergen-Paap F-statistic ranges between 17.37 and 25.35 and comfortably exceeds the Stock-Yogo critical value of 10. Throughout all of the tests we find the instrument set to be exogenous. The p-value on the Hansen J-statistic ranges between 0.15 and 0.45 depending upon which control variables are included in the estimating equation. Hence, we cannot reject the null hypothesis that the instruments are exogenous with respect to the second-stage error term in any specification at conventional levels of statistical significance.

5.1 Margins of Trade and Destinations

Having found evidence of a link between airports and the growth of exports, we dig deeper by examining the channels through which this relationship arises. We first explore how airports affect the firm-intensive margin, measured as the average exports per firm in a TTWA, the firm-extensive margins, measured by the number of exporting firms, in columns 1 and 2 of Table 6, respectively. In column 3 of Table 7 we consider instead the number of country destinations exported to. In columns 1 and 2 the effect on the firm-intensive and firm-extensive margin is estimated to be positive and strongly statistically significant in both cases. An additional airport leads to a 76% increase in growth of the ratio of exports to sales, with a similar sized effect on the firm extensive margin. This contrasts with the destination margin in column 3, where we find no statistically significant evidence that the number of export destinations exported to from a TTWA are affected by the presence of international airport, although we note that the parameter estimate itself is positive.

[Insert Table 6: Export Dimensions]

The next set of regressions use the information on country destinations within the UK service export data further and we investigate whether exports to Europe (column 4 Table 6) and non-European countries (column 5 Table 7) are more strongly affected by the presence of international airports. In both instances the IATA airport variable has a statistically significant effect at conventional levels, although it is somewhat larger for exports to non-Europe.

So far, our estimations have only considered service exports. However, airports may also affect manufacturing exports by improving market access and expanding access to freight services. The final column of Table 7 reports estimates using the growth rate of manufacturing exports as the dependent variable. IATA airports continue to have a statistically significant effect on export growth rates although the economic magnitude is smaller than before. An additional IATA airport is estimated to cause a 21% faster rate of growth in manufacturing exports over an 8-year period, an average annual growth rate of close to 2.4%.

5.2 Falsification and Robustness Tests

In this section, we conduct a host of sensitivity checks to affirm our key findings. Perhaps the most serious threat to identification are factors in the wider business environment which systematically correlate with airport infrastructure and simultaneously drive exports. We therefore conduct falsification tests using airports that do not enhance access to international markets. Finding significant relationships between such types of airports and exports would suggest that our baseline results are capturing some spurious force. In column 1 of Table 7 we measure airport infrastructure using the number of minor domestic airports (those without IATA codes, but with an ICAO licence) in each TTWA. Minor airports exclusively operate domestic flights, most of which are for leisure purposes. As expected we find that the presence of minor airport is uncorrelated with service export growth. This falsification tests is consistent with an interpretation that our main findings for international airports are not being driven because of some unobservable feature of airports that makes it more attractive for service exporters to be co-located with them, but rather because of the international connections IATA airports provide.

[Insert Table 7: Falsification and Robustness Tests]

In columns 2 and 3 we consider alternative ways of constructing the instrument set. Thus far our instrument has been based on the stock of military-built airfields in active service at the end of 1944. As discussed in Section 3, this is largely made up of airfields built during the military build-up and the duration of the Second World War, but it also includes airfields built in earlier time periods such as the 1914-1918 conflict. Airfields that survived in existence beyond the end of 1918 may have better topography and drainage, which may also affect the location of business properties in modern times. This raises a concern that baseline estimates capture this effect. To remove this possibility we focus only on airfields built by the military during the period 1934 to 1945. That is, in the period leading up to and the duration of the war in Europe, where we again disaggregate by type of airfield. The results from this regression are presented in column 2 of Table 7. We again find that the instruments are relevant and exogenous.[22] We also find that there remains a strong significant and positive effect from modern IATA airports on the growth of service exports between 1997 and 2005 using this alternative instrument set.

The argument we present for the relevancy of our instrument rests in part on the idea that the costs of converting a military airfield for civilian air travel were much lower than the costs of building an airport from scratch. The example of Stansted, which was chosen as London's third airport following its demilitarisation by the U.S. in the 1960s on the basis that it had a long runway demonstrates this point.[23] In column 3 of table 8 we consider this point more formally by constructing two new instruments. The first is a measure of the number of military-built airfields that were de-commissioned and closed at the end of the war (we take 1948 as the cut-off). As a second instrument we use those that were retained by the military at the end of the war, but were closed as part of the military restructuring by the UK government after a review of military needs following the Suez crisis in 1956 (we take 1959 for the end of this process). That is, we focus only on airfields that could have been converted for civilian use in the post-war period as instruments for current international airports. The results in column 3 show that once again we find that the instruments positively correlate with the location of IATA airports. The F-

[22] First-stage estimates are available on request.

[23] In 1968 the Roskill Commission identified capacity at Heathrow and Gatwick as 'virtually-exhausted' and recommended opening a third airport. After identifying a long list of possible sites, four potential sites were chosen. Stansted was not included on this list. The site eventually chosen was Maplin Sands to the east of London and which required the building of a new airport. An Act of Parliament was passed to approve its construction in 1973, and then shelved by a change in government the next year following the oil crisis. Stansted Airport, which was converted for commercial use following its closure as a US Air Force base in 1965, was chosen instead. As Fordham wrote in a paper published in *The Economic Journal* in 1970 and based on his submission to the Roskill Commission "The criteria for this choice was not clear (apart from the fact that a long runway was already in existence) and were never made clear" (Fordham, 1970, pp. 307).

stat on the excluded instruments is smaller than in previous tables, but remains comfortably above generally accepted levels of significance. In the first-stage regression there is a modestly stronger effect from the airfields closed at the end of the war, versus those closed as part of the Roskill commission report at the end of the 1950s.[24] In the second-stage regression we also continue to find a positive and significant effect from airport location on the growth of exports.

Next, we turn to the possibility that our results are driven by Heathrow, by far the largest airport in the UK, and London, which has the largest agglomeration of service firms. A concern is that our inferences are capturing the effects of different types of airport infrastructure. For example, hub airports may greatly improve access to export markets whereas more typical, non-hub airports have a smaller effect. London Heathrow is the only hub airport in the UK and we report estimates in column 4 of Table 7 based on a sample that excludes Slough and Heathrow, the TTWA in which London Heathrow airport is located. The economic magnitude of the LATE is in fact larger in this regression compared to the baseline estimates in Table 4. The evidence in column 5 of Table 7, which excludes London from the sample, demonstrates that this has little influence on our conclusions.

Previous research has linked the size of airports to economic outcomes (Sheard, 2014). A concern might be that our estimates are picking up the effect of airport size, rather than the presence of airport infrastructure. To address this concern we append the regression equation with controls for two size proxies: growth in passenger volume between 1997 and 2005 and runway length. The results provided in columns 6 and 7 of Table 7 show that including these controls has little impact on the IATA airport coefficient estimate which remains similar in magnitude and statistical significance compared to before.

Our period spans a time when low-cost airlines began to aggressively expand their route networks. To capture the market size effect arising from these changes we append equation (4) with controls for growth of the number of destinations from airports in each TTWA. Specifically, we calculate the growth rate in the number of city routes (e.g. Heathrow-Boston) and the number of country routes. The IATA airport coefficient reported in column 8 is robust to this change.

Our time period begins shortly after the opening of high-speed rail connections between the UK and continental Europe. Previous evidence has demonstrated that high-speed rail connections affect aspects of firm performance and supply networks (Bernard et al., 2018). Eurostar, a high-speed railroad, connects the UK to France and Belgium through the Channel Tunnel. The Eurostar network only has three stations (located in three TTWAs) in the UK. We therefore test the robustness of our findings to including a dummy variable equal to 1 if a TTWA has a high-speed rail connection, 0 otherwise. The LATE of IATA airports on exports reported in column 9 is robust to this change.

[24] In the unreported first-stage regression, the coefficient (t-statistic) for the post-WW2 and Cold War count variables is 0.1323 (3.68) and 0.1111 (2.01), respectively.

Next we consider whether other types of infrastructure confound our estimates. It seems unlikely that access to ports drive our inferences for service exports given that passenger services are limited and typically long. Consistent with these arguments, the ports coefficient in column 10 is close to zero and statistically insignificant. Moreover, the IATA airport coefficient remains robust.

5.3 Net export growth or reorganisation?

The positive effect from IATA airports on the growth of UK service exports in our estimations is likely to occur through a combination of a direct effect on established firms and through the relocation of existing or potential exporters to be near airports. This raises the possibility that airports, rather than increasing net exporting volumes for the UK as a whole, simply leads to a reorganisation of production.[25]

To make progress on this issue we follow Redding and Turner (2015), who make a similar point in the context of their review of the effects of infrastructure on city growth. They suggest separating regions into three groups; the treated region, who are subject to the benefits of the infrastructure and any displacement effects from elsewhere, untreated regions, who are near treated regions and suffer displacement effects, and a residual group of regions who neither benefit from the infrastructure nor lose from displacement effects. The magnitude of the net benefits of infrastructure versus displacement effects can then be estimated by comparing outcomes for different pair-wise combinations of the three types of regions (treated-untreated, treated-residual and untreated-residual). As Redding and Turner (2015) note, this requires an assumption to be made as to how local any displacement effects are. We assume that displacement effects are confined to TTWA regions that neighbour those with international airports. Constructed in this way gives 65 treated TTWAs in our sample, 115 untreated and 20 residual TTWAs. We report the results for each pairwise comparison in Table 8 along with a regression where we include our original international airport variable alongside a measure of international airports in neighbouring regions. In this latter regression we add to the instrument set historic military built airfields in neighbouring TTWAs.

[Insert Table8: Net Export Growth versus Displacement]

Throughout this table we continue to find that IATA airports, whether in the same or in neighbouring regions, have a positive effect on service export growth. If one assumes that displacement effects are confined to contiguous regions, a particularly interesting comparison is the regression restricted to untreated and residual regions (column 3). If displacement effects were strong, we would expect to find a negative effect of IATA airports in contiguous regions. The effect of IATA airports is smaller in this regression, at close to 0.3, but remains positive. We take the lack of negative effects from airports in this table as evidence consistent with the view that displacement effects are not an issue, perhaps

[25] Separating these two channels requires a source of exogenous variation in firm location as well as exogenous variation in the location of airports. We note that this affects the interpretation of our results not their validity (Duranton et al., 2014).

because of the noise pollution associated with being located close to an international airport. An estimate of the size of any displacement effects can be gained by comparing the results between the regressions for treated and residual regions (column 4) with that for treated and untreated regions (column 2). Again, under the assumption that displacement effects for are confined to regions that neighbour those with an international airport, the difference in the coefficient estimates (0.7 and 0.65 respectively) for the two regressions provides an estimate of the effects of displacement. The relatively small difference between these two coefficients of -0.05 suggests that displacement effects occur but are small.

6. Conclusions

This paper examines the effect of airport infrastructure on the growth rate of service exports in the UK. We find that export growth increases rapidly in response to airports. Using instrumental variable methods, increasing the number of IATA airports within a UK region causes exports to grow almost 80% faster between 1997 and 2005. This effect is driven by airports provoking increases in both the extensive and intensive margins of trade. These findings are consistent with airports reducing both the fixed and variable costs of international trade and improving market access.

This topic is important for policy evaluation. Airports are costly, impose negative externalities on local communities and are often constructed using public funds. However, airports are invariably viewed as important for economic development and positively affects their local economies. However, there is little evidence which substantiates these claims. This paper provides novel insights into one aspect of this debate – whether airports foster international trade.

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Tables

Table 1: Summary Statistics

Variable	Observations	Mean	Std. Dev.
Δ *Exports*$_{1997\text{-}2005}$	200	0.4053	3.404
IATA airports	200	0.3959	0.651
IATA airport dummy	200	0.3250	0.470
Military built fighter airfields$_{1945}$	223	0.6323	1.325
Military built Bomber airfields$_{1945}$	223	0.8430	2.357
Military built Coastal airfields$_{1945}$	223	0.4036	0.890
Military built Other WW airfields$_{1945}$	223	0.9910	1.750
Broadband adoption$_{2005}$	200	2003	0.899
Δ *Productivity*$_{1997\text{-}2005}$	200	-1.5032	1.341
Δ *Employment*$_{1997\text{-}2005}$	200	-3.5632	3.079
TTWA size	200	19.2825	5.782
Urbanization	200	46.1207	33.936
Manufacturing share$_{2005}$	200	0.1909	0.574
Services share$_{2005}$	200	19.4159	16.601
TTWA employment	200	41.0833	8.418
Manufacturing share$_{1951}$	200	19.0871	9.137
Services share$_{1951}$	200	39.3432	11.762
Agricultural share$_{1951}$	200	12.4679	9.618
Population$_{1911}$	200	10.7198	3.992
Unemployment$_{1933}$	200	7.4222	1.128
Δ *Export intensity*$_{1997\text{-}2005}$	200	0.0812	3.282
Δ *Exporters*$_{1997\text{-}2005}$	200	-1.4687	2.316
Δ *Export Destinations*$_{1997\text{-}2005}$	200	3.7445	0.548
Δ *Exports Europe*$_{1997\text{-}2005}$	200	-0.2782	3.533
Δ *Exports non-Europe*$_{1997\text{-}2005}$	200	0.3097	3.606
Δ *Manufacturing exports* $_{1997\text{-}2005}$	200	-0.7303	1.884
RAF airports$_{1997}$	200	0.1878	0.572
Minor Airports$_{1997}$	200	1.8680	2.796
International airports in contiguous TTWAS$_{1997}$	200	4.6701	7.559
Distance	200	-0.5379	4.798
IATA passengers	200	-3.6789	6.595
Runway length	200	1.4107	3.046
Δ *Cities*$_{1997\text{-}2005}$	200	0.5678	2.033
Δ *Countries*$_{1997\text{-}2005}$	200	0.3293	1.253

Notes: Data confidentiality rules mean that we cannot report minimum and maximum values.

Table 2: Historic Military Built Airfield Location Determinants

Column	**1**	**2**	**3**	**4**
Dependent variable:	**Fighter airfields**	**Bomber airfields**	**Coastal airfields**	**Other airfields**
Population$_{1911}$	0.0655	-0.1983	-0.1229	-0.4638
	(0.2377)	(0.3919)	(0.6758)	(1.2287)
Population$_{1921}$	0.1482	0.5174	0.2313	0.6710
	(0.4759)	(0.9040)	(1.1251)	(1.5719)
Population$_{1931}$	0.2679	-0.2211	-0.1518	-0.2108
	(1.0763)	(0.4832)	(0.9238)	(0.6178)
Manufacturing Employment Share$_{1921}$	-0.3200	1.5513	-0.4608	0.1013
	(0.4506)	(1.1886)	(0.9827)	(0.1041)
Services Employment Share$_{1921}$	0.2645	-0.9032	0.3004	0.6892
	(0.4400)	(0.8177)	(0.7570)	(0.8365)
Manufacturing Employment Share$_{1931}$	-0.0020	-0.6161	0.1956	0.1823
	(0.0029)	(0.4891)	(0.4322)	(0.1940)
Services Employment Share$_{1931}$	1.0306	0.7084	-0.3863	0.3464
	(1.5222)	(0.5693)	(0.8640)	(0.3732)
Manufacturing Employment Share$_{1951}$	-0.5357	-1.2721*	-0.0232	0.2619
	(1.4047)	(1.8148)	(0.0921)	(0.5009)
Services Employment Share$_{1951}$	0.3041	-0.3969	-0.1072	-1.0746
	(0.5606)	(0.3981)	(0.2994)	(1.4453)
Unemployment rate$_{1933}$	-0.0181	0.3530	-0.0638	-0.0952
	(0.1169)	(1.2379)	(0.6230)	(0.4475)
Ports	0.0021	-0.0702	0.0532***	-0.0362
	(0.0913)	(1.6388)	(3.4589)	(1.1333)
TTWA size	-0.0030	0.7746***	0.0260	0.4193**
	(0.0208)	(2.9130)	(0.2722)	(2.1140)
R^2	200	200	200	200
Observations	0.1421	0.0976	0.1276	0.0570

Notes: This table reports estimates of equation (5). The dependent variables are the number of military built airfields (built by December 1944) of a particular function. Heteroskedasticity robust t-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 3: Origin of UK International Commercial Passenger Airports

IATA Airport (observations)	**Military built, before Dec.1944**	**Use in Dec. 1944**
IATA (109)	Yes (67)	Fighter (15) Bomber (13) Coastal (17) Other (22)
	No (42)	Civil (31) Other (11)

Notes: This table reports the number of IATA airports across the UK. IATA airports are defined as those with an ICAO and an IATA code.

Table 4: Instrument Relevance

Variable	**IATA Airports**	**IATA Airport dummy**
Military built airfields$_{1945}$	0.5687	0.3950
Fighter airfields$_{1945}$	0.3434	0.2571
Bomber airfields$_{1945}$	0.3331	0.1927
Coastal airfields$_{1945}$	0.2314	0.2445
Other airfields$_{1945}$	0.4457	0.3051

Notes: This table reports the correlation between the number of IATA airports in each TTWA or an IATA airport dummy (equals 1 if there is at least 1 IATA airport in the TTWA, 0 otherwise) and the total number of military airfields built in each TTWA by December 1944 as well as the number of fighter, bomber, coastal and other military airfields built in each TTWA by December 1944.

Table 5: Exports Results

Column	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Estimator	**OLS**	**IV-FS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**
Dependent variable:	**ΔExports**	**International airport**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**
IATA Airport	0.5536***		1.1267***	0.8261***	0.7625***	0.7575***	0.8699***	0.7608***	
	(3.2385)		(3.5033)	(2.9551)	(2.8162)	(2.8145)	(2.9167)	(2.6562)	
IATA Airport Dummy									1.1979**
									(2.0355)
Fighter airfields		0.1103**							
		(2.4772)							
Bomber airfields		0.0593***							
		(3.1638)							
Coastal airfields		0.1597***							
		(4.0705)							
Other airfields		0.1228***							
		(6.6252)							
Urbanization				0.0314***	0.0296***	0.0293***	0.0275***	0.0408***	0.0402***
				(4.9843)	(4.6364)	(4.4826)	(4.2234)	(5.4860)	(5.4284)
TTWA size				0.0675***	0.0660***	0.0479**	0.0561**	0.5142*	0.5751**
				(3.5095)	(3.2447)	(2.0053)	(2.3608)	(1.8421)	(2.0911)
Broadband adoption year				0.0021	-0.0344	-0.0271	-0.2097	-0.3779	-0.5016**
				(0.0110)	(0.1776)	(0.1357)	(1.0063)	(1.4507)	(-2.0098)
Productivity					-0.1358**	-0.1568***	-0.1542**	-0.1633***	-0.1672***
					(2.3721)	(2.6851)	(2.5716)	(2.6701)	(-2.6013)
Employment					0.0126	0.0137	0.0187	0.0047	-0.0037
					(0.3389)	(0.3639)	(0.4930)	(0.1275)	(-0.0996)
Manufacturing$_{2005}$						-0.0256	-0.0583	-0.1256	-0.1285
						(0.2814)	(0.6265)	(1.2901)	(-1.3155)
Services$_{2005}$						-0.0270	-0.0925	-0.2104	-0.2153
						(0.1491)	(0.4993)	(1.1049)	(-1.1246)
Population$_{2005}$							-0.4967***	-0.3313*	-0.2661
							(3.0839)	(1.6662)	(-1.3097)
Population$_{1911}$								-0.3141	-0.3677
								(0.7685)	(-0.9217)
Population$_{1921}$								-0.3117	-0.3699
								(0.7812)	(-0.9543)
Population$_{1931}$								0.1179	0.0840
								(0.4976)	(0.3475)
Manufacturing Emp. Share$_{1921}$								-0.9859	-0.9859
								(1.0870)	(-1.0595)
Services Emp. Share$_{1921}$								0.8469	0.7992
								(0.9607)	(0.8421)

Manufacturing Emp. Share$_{1931}$								0.3204	0.3362
								(0.4202)	(0.4285)
Services Emp. Share$_{1931}$								-1.3824	-1.4878
								(1.4694)	(-1.5537)
Manufacturing Emp. Share$_{1951}$								0.1401	0.0165
								(0.2293)	(0.0275)
Services Emp. Share$_{1951}$								-1.6067*	-1.7239**
								(1.9306)	(-2.0612)
Unemployment rate$_{1933}$								-0.0522	-0.0824
								(0.2872)	(-0.4531)
Kleibergen-Paap F-statistic	-	-	25.35	24.69	22.81	24.40	21.03	22.81	17.37
Hansen J-statistic (p-value)	-	-	0.15	0.71	0.56	0.45	0.62	0.27	0.50
R^2	0.0312	0.3570	0.344	0.3650	0.3836	0.3899	0.3908	0.4560	0.4463
Observations	200	200	200	200	200	200	200	200	200

Notes: This table reports estimates of equation (5). The dependent variables is the change in service exports between 1997 and 2005 in UK travel to work areas. Heteroskedasticity robust t-statistics are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Table 6: Export Dimensions

Column	1	2	3	4	5	6
Estimator	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**
Dependent variable	**ΔExport intensity**	**ΔExporters**	**Δ Export Destinations**	**ΔExports Europe**	**ΔExports non-Europe**	**ΔManufacturing exports**
IATA Airport	0.7606***	0.7884***	0.1142	0.2883***	0.3954***	0.2052***
	(2.6499)	(2.8704)	(0.6171)	(3.9155)	(5.1065)	(4.3301)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap F-statistic	22.81	22.81	22.81	22.81	22.81	22.81
Hansen J-statistic (p-value)	0.26	0.26	0.14	0.48	0.19	0.35
R^2	0.4379	0.4674	0.0937	0.6143	0.5973	0.6144
Observations	200	200	200	200	200	200

Notes: The control variables are the same as those reported in column 8 of Table 5. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 7: Falsification and Robustness Tests

Column	1	2	3	4	5	6	7	8	9	10
Estimator	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**
Comment	**Leisure airports**	**Alternative Instruments**	**Alternative Instruments**	**Excluding Heathrow airport**	**Excluding London**	**Airport growth**	**Airport size**	**Country destinations**	**Other infrastructure**	**Other infrastructure**
Dependent variable:	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**
Minor airports	-0.0421									
	(0.76)									
IATA Airport		0.6163**	0.6535**	0.7634***	0.8267***	0.8447***	0.8220**	0.7694***	0.7874***	0.7721***
		(2.2112)	(2.0769)	(2.6679)	(2.7978)	(2.5779)	(2.5586)	(2.6978)	(2.7096)	(2.6806)
Δ Passengers						-0.0380				
						(1.6193)				
Runway length							-0.0639			
							(1.4659)			
Δ City routes								-0.0719		
								(0.1059)		
Δ Country routes								0.0067		
								(0.0090)		
High-speed rail									1.3394	
									(1.6055)	
Ports										-0.0656
										(0.3912)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
K-P F-statistic	11.23	19.16	11.56	23.67	21.42	14.51	15.25	21.42	21.78	22.60
Hansen J-stat. (p-value)	0.68	0.94	0.84	0.26	0.30	0.17	0.19	0.27	0.15	0.29
R^2	0.1489	0.4658	0.4636	0.4583	0.4537	0.4593	0.4573	0.4568	0.4571	0.4555
Observations	200	200	200	199	199	200	200	200	200	200

Notes: The control variables are the same as those reported in column 8 of Table 5. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

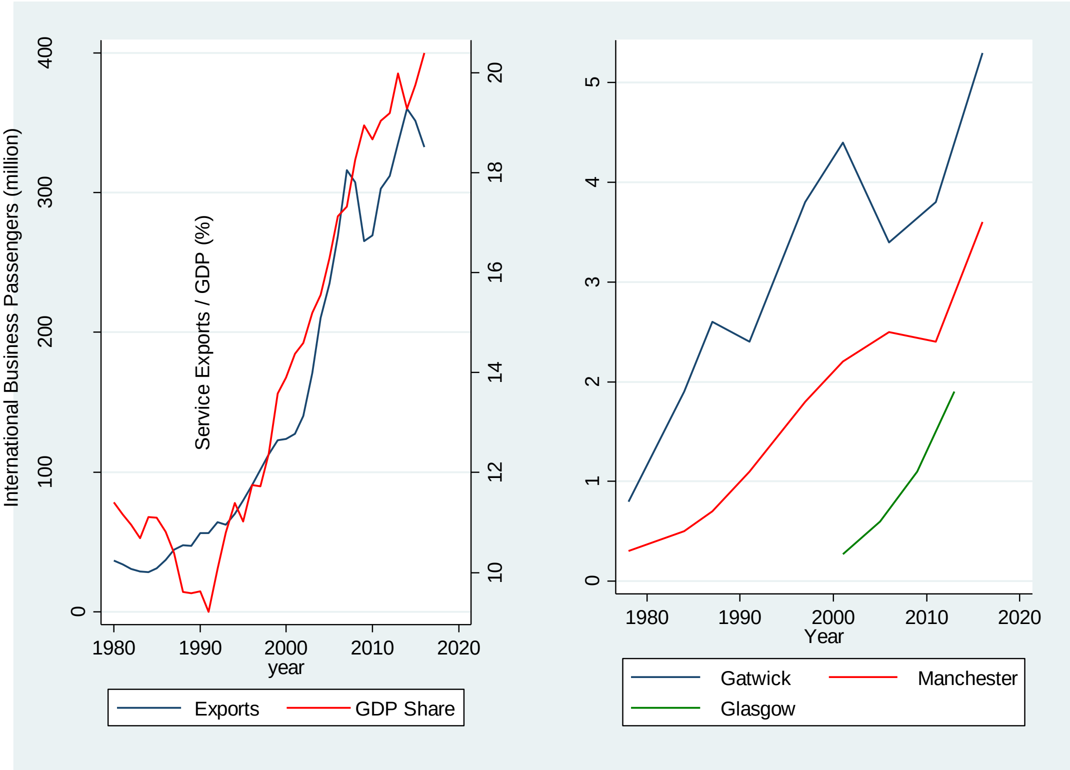
Table 8: Net Export Growth versus Displacement

Column	**1**	**2**	**3**	**4**
Sample	**All regions**	**Treated & Untreated**	**Untreated & Residual**	**Treated & Residual**
Estimator	**IV-SS**	**IV-SS**	**IV-SS**	**IV-SS**
Dependent variable:	**ΔExports**	**ΔExports**	**ΔExports**	**ΔExports**
IATA airports	0.5380*	0.6493**		0.6999**
	(1.9186)	(2.3142)		(2.0975)
IATA airports in Neighbouring TTWAs	0.2000**		0.2887***	
	(2.4034)		(2.7834)	
Control variables	Yes	Yes	Yes	Yes
1st stage for International Airports				
Kleibergen-Paap F-statistic	11.79	17.94		17.13
1st stage for International Airports in neighbouring TTWAs				
Kleibergen-Paap F-statistic	37.70		50.72	
Hansen J-statistic (p-value)	0.64	0.10	0.05	0.81
R^2	0.4707	0.4307	0.4978	0.5914
Observations	200	180	135	85

Notes: The control variables are the same as those reported in column 8 of Table 5. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

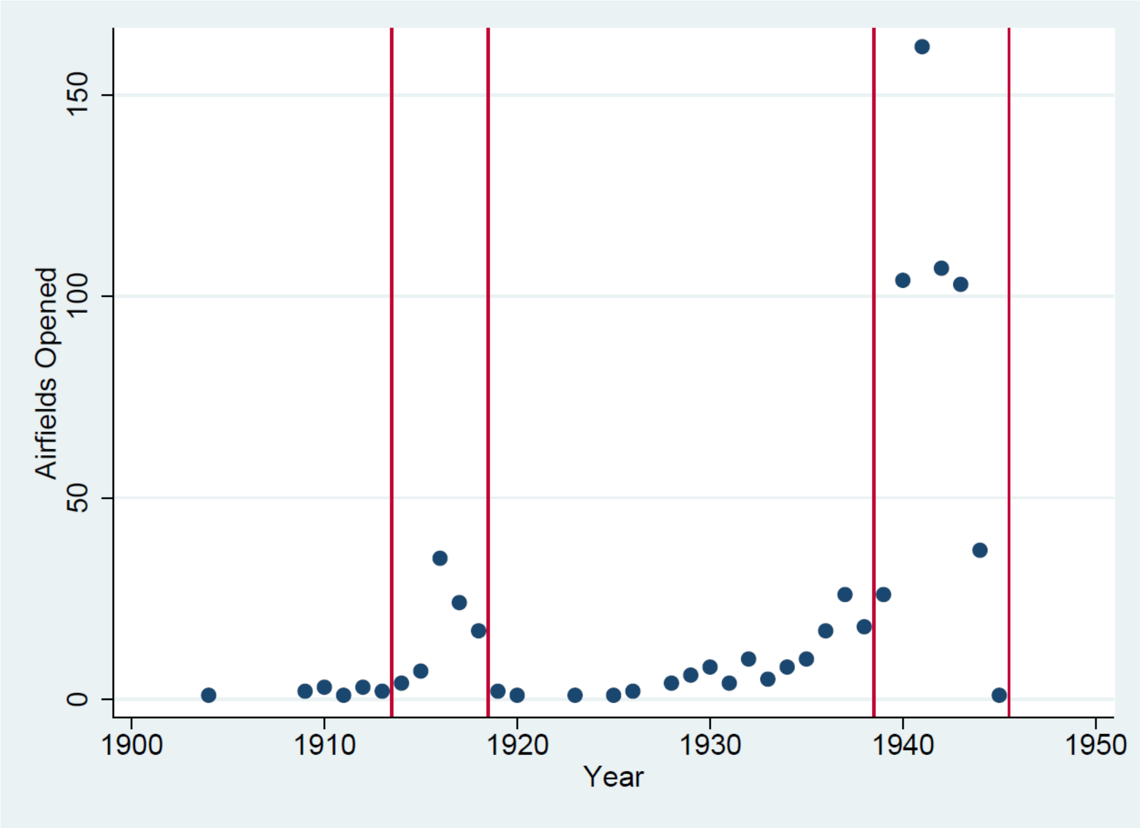
Figures

Figure 1: Evolution of UK Service Exports and Aviation Passenger Traffic



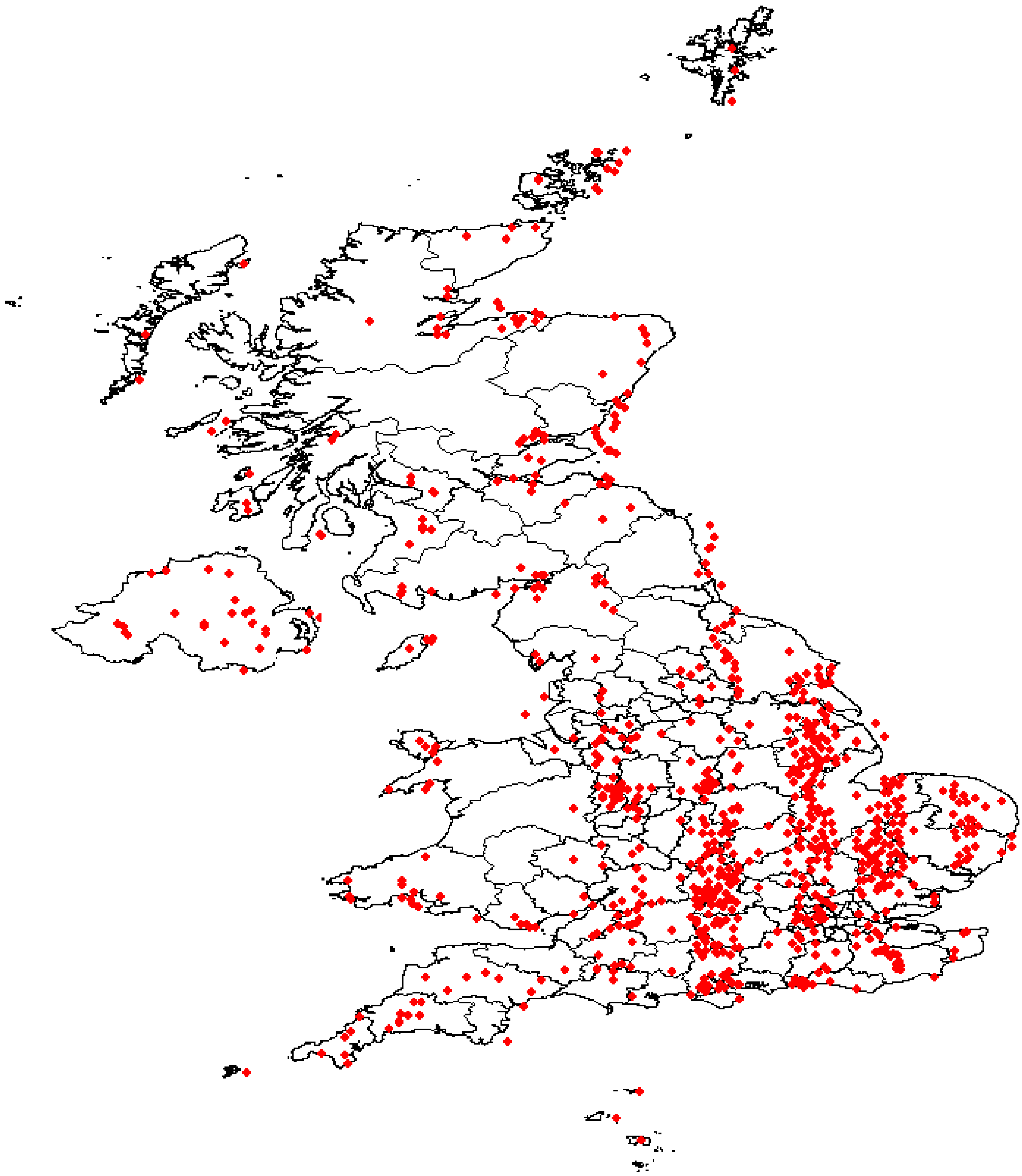
Notes: The panel on the left illustrates the volume of UK service exports in billions of US dollars and the ratio of service exports to GDP between 1980 and 2015. The panel on the right shows the number of international business passengers transiting through three major UK airports, Gatwick, Glasgow and Manchester.

Figure 2: Timing of Military Airfield Construction



Notes: This figure reports the number of military airfields built during each year between 1900 and 1950 in the UK. The vertical red lines represent the start and end of the World Wars.

Figure 3: Military Airfield Locations



Notes: This figure illustrates the location of all military airfields built before December 1944.

Appendix A: Do Firms use Local Airports to Export?

To examine whether airports foster exports, we examine whether there are significant differences in the volume of exports between region i and country j depending on whether there is a flight connection between the IATA airport in region i and country j. A unique feature of our data is that it provides information on the destination country to which firms sell exports. We estimate the equation

$$\ln Exports_{ijt} = \alpha_i + \beta Connection_{ijt} + \gamma_j + \gamma_t + \varepsilon_{ijt},$$

where $Exports_{ijt}$ is the natural logarithm of the value of exports from region i to country j during year t; $Connection_{ijt}$ is a dummy variable equal to 1 if there exists a flight connection between an IATA airport in region i to country j at time t; α_i, γ_j, and γ_t are region, country and year fixed effects, respectively; ε_{ijt} is the error term.

We estimate the coefficient β (t-statistic) to be 1.0448 (6.94) using a sample of 4,577 observations. The result is consistent with the idea that IATA airports lead local firms to destinations which can be accessed using flights from a local airport. Economically, the estimate implies that exports are approximately 104% higher to destination countries which are connected to the local airport, relative to destinations without a connection. While we stress that the effects cannot be interpreted as causal in nature, they are instructive and the patterns are consistent with IATA airports playing a role in fostering exports.

Appendix B: Service Industries Description

Table B.1: Service Industries in the Data Set

SIC (1992) 2-Digit Industry Code	Industry Description
50	Sale, maintenance, and repair of motor vehicles and motorcycles; retail sale of automotive fuel
51	Wholesale trade and commission trade, except of motor vehicels and motorcycles
52	Retail trade, except of motor vehicles and motorcycles, repair of personal an household goods
55	Hotels and restaurants
60	Land transport; transport via pipelines
61	Water transport
62	Air transport
63	Supporting and auxiliary transport activities; activities of travel agencies
64	Post and telecommunications
65	Financial intermediation, except insurance and pension funding
66	Insurance and pension funding, except compulsory social security
67	Activities auxiliary to financial intermediation
70	Real estate activities
71	Renting of machinery and equipment without operator and of personal and household goods
72	Computer and relate d activities
73	Research and development
74	Other business activities