Regional airports: runways to regional economic growth?

Evaluating the role of regional airports as regional economic catalysts in Europe

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REGIONAL AIRPORTS: RUNWAYS TO REGIONAL ECONOMIC GROWTH?

Evaluating the role of regional airports as regional economic catalysts in Europe

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Preface

The front cover of this thesis captures many elements why studying regional airports is so interesting. It features an aerial view of Münster Osnabrück International Airport in North Rhine-Westphalia, Germany. The airport is very representative for many regional airports across Europe. Founded by the British army as a military landing strip in the nineteen-fifties, the airport expanded along the way by constructing a modern passenger terminal building as well as a 2,000 metres long runway facilitating modern mid-size commercial aircraft as soon as commercial opportunities arisen. Due to its location in an aesthetic and quiet rural area, every attempt to expand the airport has been met with great criticism from local residents fearing growing negative externalities such as nuisance. Public debates on infrastructure planning and funding are often dominated by rather subjective arguments, possibly unnecessarily exposing many people to negative externalities. For regional airports this debate is particularly interesting as their core function of connecting people is often under-exposed, while their supposed role in generating economic benefits is dominating the debate. As a completion of the Master's degree programme of Economic Geography at the University of Groningen at the faculty of Spatial Sciences, I attempt to clarify this public debate regarding funding regional airports by evaluating this relationship.

This thesis is particularly interesting for those that are involved or interested in the policy debate on funding regional airports. The supposed role of regional airports as regional economic catalysts are critically evaluated. Additionally, insights are provided regarding the justification of state aid to regional airports and the proposed EU policies regarding state aid to airports are reflected upon.

I want to thank dr. Sierdjan Koster for his helpful and quick feedback guiding me onto the right track throughout writing process and prof. dr. Philip McCann for helping me out starting up the project. Furthermore, I want to thank my family and my boyfriend Daan for for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of writing this thesis. This accomplishment would not have been possible without them. Thank you.

Felix Pot
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Summary

European aviation market liberalisations and the following rise of low-cost carriers have resulted in the commercialisation of many regional airports. Many of these airports are operating at loss and are funded by taxpayer money in their mission to attract carriers and upkeep operations. New guidelines imposed by the EU to restrict funding to smaller airports have been met with great criticism by airport associations, local governments and regional business circles stressing the importance of air connectedness provided by regional airports in generating economic spillovers. However, the relationship between air traffic and economic benefits is blurred due to causality issues, and evidence of positive spillovers is mostly found at major hub airports in metropolitan areas while it is unclear whether regional airports generate similar benefits. The goal in this thesis is to clarify the policy debate on the justification of state aid to regional airports by evaluating the role of air traffic at regional airports in regional air connectedness and regional economic growth.

Through a spatial analysis, the role of regional airports in providing air connectedness across Europe is assessed. For most European regions, regional airports play a very marginal role in providing regional air connectedness due to competing major airports. However, in predominantly sparely populated and peripheral regions, most connectivity through air is provided by regional airports. By means of an OLS regression, a positive link between regional air connectedness and GDP has been found. However, this link is weaker for regional airports than for airports in general, possibly due to lower levels of connectivity at regional airports. By means of a 'Granger causality' analysis over two five-year time frames, no evidence is found on growing regional air connectedness causing growth in GDP in the long run. In general, causality runs from GDP developments to developments in regional air connectedness as higher incomes allow for more air travel or is rather simultaneous process reflecting airline strategies that follow GDP forecasts. However, for regional airports no causal relationship is found either way. For low-cost carriers, that dominate traffic at regional airports, constant relocation of assets to other airports to minimise operational costs and obtain favourable deals and subsidies is a key strategy to generate higher efficiency over their fleet. This fickle competitive environment results in the lack of connection between economic development and air traffic at regional airports in the long term.

While no ground is found for promoting state aid to regional airports for reasons of economic growth, state aid may be justified for social equity reasons to guarantee a minimum level of global air connectivity in peripheral regions where regional airports are essential in providing regional air connectedness. Additionally, regional airports may play a role as regional marketing tools and in generating consumer surplus. When these considerations are brought at the forefront of the policy debate, very different trade-offs with respect to the (societal) costs and benefits related to air traffic at regional airports will arise and the policy debate concerning state aid to regional airports will be more balanced.

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List of Abbreviations

ACI	Airports Council International
ADL	Autoregressive distributed lag
AER	Assembly of European Regions
GDP	Gross Domestic Product
EC	European Commission
ECA	European Court of Auditors
FSNC	Full service network carrier
LCC	Low cost carrier
MAR	Marshall-Arrow-Romer (externalities)
NEG	New Economic Geography
OLS	Ordinary least squares
PPP	Purchasing power parity
PPS	Purchasing power standard
TEN-T	Trans-European Network for Transport

List of Symbols

Sets

N	Set of airports
K	Subset of regional airports where $K \subseteq N$
R	Set of European NUTS-2 regions

Indices

i	Origin airport with $i \in N$
k	Regional airport with $k \in K$
r	Region $r \in R$
t	Year

Parameters

$BRIT$	Dummy representing regions in Ireland and the United Kingdom
CON_{rt}	Regional air connectedness per inhabitant of region r in year t
$CONT_{rt}$	Contribution of regional airports to regional air connectedness per inhabitant in region r in year t
$EAST$	Dummy representing regions in Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithouania, Poland, Romania, Slovakia and Slovenia
$GDPrt$	Level of GDP per capita in PPS in region r in year t
EDU_{rt}	Persons with tertiary education in region r at time t, as % of the total population
KI_{it}	Employment in technology and knowledge-intensice sectors, as % of total employment in region r in year t
$NORTH$	Dummy representing regions in Denmark, Finland and Sweden
$pax_{it,kt}$	Number of passengers handled at origin airport i or regional airport k in year t
pop_{rt}	Population of region r in year t
RD_{rt}	Inmural research and development expenditure in region r in year t, in €per inhabitant
$SOUTH$	Dummy representing regions in Cyprus, Greece, Italy, Malta, Portugal and Spain
T_{ir}	Travel time from airport i to the regional centre of region r
DEN_{rt}	Population density of region r in year t
w_{ir}	Relevance of airport i for region r
$WEST$	Dummy representing regions in Austria, Belgium, France,Germany, Luxembourg and the Netherlands

Chapter 1

Introduction

1.1 Debating the economic benefits from regional airports

Over the past two decades, the competitive arena of airports and airlines in Europe has changed dramatically mainly being the result of liberalisations in the European air transport market during the nineteen-nineties. These liberalizations have paved the way for the rise of low-cost carriers (LCCs), as market entry and routing and pricing restrictions were dropped (Copenhagen Economics, 2012 and EC, 2014a). LCCs prefer uncongested airports to minimise operating and handling costs to be able to offer the most competitive services possible (Barbot, 2006; Barrett, 2004; Belobaba et al., 2015; Copehnagen Economics, 2012; Zhang et al., 2008). Cost-minimising strategies of LCCs have resulted in opportunities for the creation, commercialisation and expansion of secondary regional airports. Additionally, increased mobility resulting from free movement of people within the Schengen Area has decreased barriers to fly from foreign airports. Therefore, catchment areas and consumer pools have enlarged, also contributing to the commercial opportunities for regional airports (Barett, 2000; Copenhagen Economics, 2012; Lieshout et al., 2016). These commercialisation opportunities have led to the multiplication and expansion of regional airports, while being supported by regional governments that try to boost regional international connectivity and accessibility. Regional airports now comprise the majority of airports in Europe. While there certainly are cases of vast increases of traffic at regional airports being successful in attracting LCCs, many regional airports are underutilised and in extreme cases are considered as 'ghost airports'. Low traffic results in around half of all regional airports operating at loss, while draining public treasuries for their upkeep (ACI Europe, 2016a; EC, 2014a; ECA, 2014; Francis et al., 2004).

In 2014, the European Commission (EC) adopted restrictions on the extend to which Member States can support airports, to get rid of inefficient subsidy streams to regional airports. This clamping down on state aid has fuelled the debate on whether state aid to unprofitable regional airports is justified. Regional stakeholders often emphasise positive economic spillover effects for the surrounding region. At a time when Europe is opening up to global markets, the global connectivity provided by airports is often considered to be playing a key role in driving the regional economy. Increasing traffic at regional airports would generate employment, facilitate trade, attract inbound tourism and create greater market access for local internationally oriented firms (AER, 2013; Brueckner, 2003; Button and Taylor, 2000; Graham and Guyer, 2000; Oum et al., 2008; Reuters, 2014; Sheard, 2014). Additionally, regional airports may play a role in driving up regional profiles by functioning as regional marketing tools for attracting firms to the region (Kramer, 1990). While there is a vast literature on evidence for economic benefits related to air traffic, this evidence is blurred as causal relations between air transport services and regional economic development can be circular (Graham, 2014; Green, 2007; Williams and Baláž, 2009; York Aviation, 2004). Also, most evidence of positive spillovers from air traffic is related to larger hub airports within metropolitan areas (e.g. Bel and Fageda, 2008; Button et al., 1999; Hakfoort et al., 2001), while some case studies show that economic benefits related to regional airports may be far from expected or non-existent (e.g. ECA, 2014; Noordelijke Rekenkamer, 2013).

1.2 Research objectives

1.2.1 Research problem

New rules to clamp down on state aid to unprofitable regional airports has fuelled the debate on economic benefits from air traffic at regional airports. Regional stakeholders stress the importance of air connectedness provided by regional airports in regional economic growth. However, evidence on the relation between increased air traffic and economic benefits is blurred, very case specific and often derived from major hub airports, while it is not clear whether regional airports fit in the same picture. This raises the question whether the new European guidelines on state aid have indeed overlooked the importance of regional airports in providing air connectivity and generating wider economic impacts and restrictions on state aid to regional airports should be relaxed.

1.2.2 Research goal

The goal in this thesis is to evaluate the relationship between air traffic at regional airports and regional economic growth to clarify the policy debate on justifying state aid to regional airports in Europe.

1.2.3 Research questions

To evaluate the role of regional airports as regional economic catalysts. The following research questions are considered.

Main question

To what extent does air traffic at regional airports drive regional economic growth in European regions?

Sub-questions

- How do regional airports contribute to regional air connectedness across European regions?
- How is air traffic at regional airports associated with regional economic output compared to airports in general?
- How is the causal relationship regarding the development of air traffic at European regional airports and regional economic growth shaped in the long term?

1.3 Societal relevance

Since taxpayers' money is involved, the policy dilemma on funding regional airports is by nature a societal debate. Many airports across Europe are supported by governments, while not meeting operational expectations.

In Poland, investments in Lodz, Rzeszow and Lublin airports have been about 245 million euros of which 105 million through EU funding between 2007 and 2013 (Reuters, 2014). The remaining mainly came from central and local governments. In 2007, Polish authorities projected that 3 million passengers a year would pass through the three airports for the following years. In 2013, it was just over 1 million (Reuters, 2014). Lodz airport expanded in 2012, but failed to meet ex-ante expectations on passenger volumes. In 2009, a feasibility study done by advisory firm EY predicted a minimum of 1 million passengers for Lodz airport in 2013. Only 300,000 passengers actually passed through the airport in 2013 (Reuters, 2014).

In Germany, regional airports also perform variably. LCCs have been setting up bases helping airports like Bremen, Cologne/Bonn, Memmingen and Weeze to grow, while other airports consistently have been losing traffic (Maertens, 2012). In 2014, the regional airports of Lübeck and Zweibrücken filed for bankruptcy, as a result of the footloose relocation strategies of LCCs that used to provide traffic at these airports. The last scheduled commercial flight left Lübeck Airport in 2016 after LCCs RyanAir and Wizz-Air relocated to Hamburg Airport (Aero.de, 2016 and Focus, 2014). Saarbrücken Airport needed to pay unlawfully obtained EU subsidies back resulting in financial struggles. Also, Münster-Osnabrück Airport has seen traffic declines and LCCs RyanAir and Flybe leaving the airport in recent years (Airliners.de, 2015; German Airports Association, 2017). Therefore, even a highly successful airport such as Weeze Airport may be at risk, when the only one airline (RyanAir), providing over 90 percent the airport's traffic, decides to leave the airport (Maertens, 2012).

In the northern part of the Netherlands, Groningen Airport Eelde has been subject to a huge public debate as well regarding the question whether local and regional governments should subsidise new routes, a runway extension and fill financial operating gaps. Lieshout et al. (2013) calculated that Groningen Airport Eelde will not reach a financial break-even financial before the year 2030 if all carriers would continue their services and grow conform global traffic forecasts. However, Ryanair already cancelled their services from Groningen Airport Eelde in 2015, again representing the footloose and unpredictable behaviour of LCCs that are often the largest traffic providers for regional airports. Local entrepreneurs, as seen in many cases (see Brueckner, 2003), still stress the importance of airline services for the regional competitive position of the Northern Netherlands. This economic importance for the Northern Netherlands, however, has proven to be not based on reliable cost-benefit analyses (Noordelijke Rekenkamer, 2013), making it very questionable whether Dutch taxpayer money is spent well.

In some extreme cases, the multiplication of regional airports through state subsidies or EU funding has led to the existence of 'ghost-airports'. Some of Spain's new airports have to date failed to attract commercial flights. Ciudad Real Airport in central Spain opened in 2008. Santiago Moreno, a spokesman for the socialist PSOE party that controlled the regional government at the time, states that *"expert studies commissioned by the airport investors said it would create 6,000 jobs and a boom for the economy. There would have been a before and after for Ciudad Real"* (BBC News, 2012). The airport closed in 2011 and was sold at an auction for 10.000 (100.0000 times less than it cost to build) in 2015 (BBC News, 2015). Additionally, Castellon-Costa Airport close to Valencia was built in 2011 and did only see its first flight in 2015 (BBC News, 2015).

Finally, negative externalities such as nuisance and environmental impacts are at the forefront of the debate regarding airport expansion and tend to be overlooked or underestimated in studies related to economic benefits (Grampella et al., 2017). In Rotterdam (the Netherlands), local action groups have been directly opposed to local business communities regarding the expansion of Rotterdam-The Hague Airport (Don, 2017). Local residents fear nuisance, while already experiencing negative externalities of current traffic to both Rotterdam-The Hague and Schiphol Amsterdam airports. Regional employers state that the economic importance of the airport is underestimated by local activists (Kok, 2017). However, these benefits remain poorly grounded, while the multiplication airports would almost certainly leads to more European citizens being confronted with negative externalities caused by air traffic.

The funding streams from local governments to regional airports trying to lure LCCs to their airports in a search to boost their local economies can be very risky taking into account the footloose character of these carriers. Also well-defined external impacts such as nuisance and environmental impacts are often underestimated or ignored by local policy makers and local business circles, while the economic benefits of air traffic through regional airports are poorly grounded. From a societal point of view, this thesis is supposed to bring more clarity to the public debate on the role of regional airports as regional economic drivers by evaluating these economic benefits on an aggregate level based on historical data. This way, perceived economic benefits can be put in better perspective, leading to a more balanced debate on whether, or in what cases, state aid restrictions should be relaxed.

1.4 Scientific relevance

On a scientific level, one of the most fundamental issues in spatial sciences is addressed: the dispersion and concentration of economic activity across space. Within various regional science disciplines, transportation (and particularly transportation costs) traditionally play a key role in explaining the spatial distribution of economic activity or production factor inputs (e.g. Christaller, 1933; Glaeser et al., 1992; Hotelling, 1929; Moses, 1958; Von Thünen, 1826; Weber, 1909). More recently, geographical economical theories like New Economic Geography (NEG) models as well attribute a crucial role for transport costs in explaining dispersion and concentration of economic activity (see Brakman et al., 2009; Krugman, 1991a; McCann, 2008).

The existence or extension of transportation infrastructures lowers costs associated with distance. In core-periphery models, lower transport costs increase concentration as agglomeration benefits will outweigh spatial costs (Brakman et al., 2009). Various studies have found positive relationships between air traffic and the development and concentration of economic activities (see ACI Europe, 2014; Basile et al., 2006; Bel and Fageda, 2008; Brueckner, 2003; Cooper and Smith, 2005; Doeringer et al., 2004; Hakfoort et al., 2001; Hoare, 1975; Hong, 2007; InterVISTAS, 2015; PwC, 2014; Sellner and Nagl, 2010; Strauss-Kahn and Vives, 2009). However, it remains difficult to draw clear-cut conclusions as the causality between air transport services and regional economic development are often likely to be circular (Green, 2007). There is still limited insight on causality between air connectedness and regional economic development. Additionally, most of the evidence around positive spillovers from air traffic to regional economies is related to metropolitan areas and major hub airports (e.g. Bel and Fageda, 2008 and Hakfoort et al., 2001). The question remains whether conclusions drawn from these studies can be extrapolated to situations regarding smaller regional airports, which are mainly serving non-metropolitan areas.

1.5 Research demarcation

The observation that many regional airports are unviable from a pure financing and accounting perspective accompanied by dubitable economic impacts, clearly poses a policy dilemma whether these regional airports should be supported with taxpayers' money. It is beyond the scope of this research to assess financial performances, direct economic effects and negative external effects of individual airports. Evaluating these direct effects is done more effectively by individual case studies (e.g. ECA, 2014 and Noordelijke Rekenkamer, 2013). Effects from incoming tourism are also not analysed explicitly as these impacts particularly tend to be very dependent on specific destination attributes and personal consumer perceptions and (Ahmed, 2010; Herrington et al., 2013; Moutinho, 1986; Woodside and Lysonski, 1989). For this reason, measuring tourism effects would limit the possibility to generalise economic effects for all regional airports. Furthermore, the analysis is only considering the role of passenger air traffic in regional economic development rather than freight. Particularly in the developed world, the ability to move people is considered to be a more powerful factor in economic growth than moving goods (Green, 2007; Lovely et al., 2005), as these economies are driven by knowledge-intensive service industries (Caniels, 2000; Crafts, 2004; Fingleton, 2003; Florida, 2002; Gaspar and Glaeser, 1998). Additionally, passenger traffic is mostly the core business for regional airports and in particular of the LCCs that dominate operations at regional airports.

Considering these demarcations, this thesis will not provide clear-cut answers on which airports are worth supporting and which are not. In stead, it is evaluated how regional airports contribute to regional air connectedness across Europe and assessed whether there can be found evidence on the role of regional airports as economic catalysts in European regions.

1.6 Thesis structure

This thesis is organised as follows: In chapter 2 the current competitive environment of European aviation is described to generate an understanding on the way how the state aid policy dilemma has emerged. Chapter 3 provides a review of the academic literature on transportation costs and connectivity and its implications for regional economic development. These insights are then connected to possible benefits of air traffic. The used data and methodology are described in chapter 4, while chapter 5 presents the results and chapter 6 discusses and reflects upon these results and presents the final answers to the research questions as well as some policy implications.

Chapter 2

Contextual framework

Europe counts over more than 450 airports (Eurostat, 2018a), carrying about 40% of the value of Europe's exports and imports (EC, 2014a), with over 1,8 billion passengers passing through European airports every year (ACI Europe, 2016a). More than half of these airports can be considered as regional airports, handling on average less than 3 million passengers per year with more than half of these servicing only 1 million passengers per year (EC, 2014a; Eurostat, 2018a). In order to assess what role regional airports play in regional economic development, it is vital to understand how they emerged, how their competitive environment is shaped and under which policy regimes they operate. This chapter will provide an overview of how regional airports have established their position in European aviation, how new state aid rules adopted by the EC could threaten their existence and why some airport interest groups and regional stakeholders fear dramatic consequences caused by restrictions on state aid to airports and airlines for regional economic development.

2.1 The competitive environment of aviation in Europe

2.1.1 European aviation market liberalisations and the rise of footloose LCCs

The liberalisation of the European aviation market in the nineteen-nineties resulted in a competitive environment without any restrictions on market access, capacity and pricing with respect to air services (Copenhagen Economics, 2012). Prior to the deregulation, the European aviation market was characterised by fragmentation and protection through bilateral agreements between pairs of nations (Belobaba et al., 2015; Laurino and Beria, 2014)[1].In the old situation, entry barriers for airlines to enter routes resulted in most routes being only operated by one or two national full service network carriers (FSNCs) while being constrained in terms of capacity and pricing by national governments (Lieshout et al., 2016). In order to create a single free market for air transport, the EU liberalised its air transport sector by: disallowing governments to object to the introduction of new fares; allowing greater flexibility over the setting of fares; giving the right to carry an unlimited number of passengers or cargo between their home country and another EU country and introducing the right for any airline based in one Member State to operate

[1]This restrictive market environment was a result of the Chicago Convention in 1944, where international regulations on civil aviation were framed for the first time. European nations advocated a more restrictive system to ensure national security and airspace sovereignty (Belobaba et al., 2015).

routes to, between and within any other Member State[2]. These operational liberalisations have made the entry for new airlines easier and in particular allowed for the rise of the LCC business model, as these airlines benefit the most from the route flexibility granted in a free market environment in their quest to minimise costs (Copenhagen Economics, 2012; Zhang et al., 2008). The entry of LCCs and the increasing competition with traditional carriers resulted in a better match between route demand and supply, bankruptcies of unprofitable inefficient airlines (Fu et al., 2010; Lieshout et al., 2016). In 1992, over 65% of passenger seats were sold by incumbent traditional FSNCs and only 1.5% by LCCs. In 2011, LCCs (42.4%) exceeded the market share of FSNCs (42.2%) for the first time[3]. In spite of a large failure rate regarding new airlines, which is as high as 77% in Europe between the years 1992 and 2012 (Budd et al., 2014), the trend of the new LCCs emerging has continued in recent years (EC, 2014a). For consumers, low ticket prices are considered to be the key decision-making determinant that has shifted traffic towards LCCs (Pearson et al., 2015). Therefore, the entry of LCCs[4] has caused more competition among all airlines (both FNSCs and LCCs) and airports resulting in: overall lower fares, increased frequencies and more travel options for air travellers, adding to the mobility of millions of Europeans (Copenhagen Economics, 2012; Dresner et al., 1996; EC, 2014a; Mason, 2005).

2.1.2 Regional airport commercialisation

The rise of LCCs has undoubtedly contributed to the growth of air traffic at regional airports. While the LCC business model actually covers a variety of business models[5], all LCCs aim for cost reductions to offer the most competitive prices possible on the routes they serve (Budd et al., 2014). Therefore, LCCs traditionally preferably operate from secondary (regional) airports as substitutes for primary airports (Barbot, 2006; Barrett, 2004; DLR, 2008; Doganis, 2006; Zhang et al., 2008). At regional airports, LCCs benefit from a wider availability of slots, allowing for more flexibility in time schedule designing to achieve higher aircraft utilisation rates (Belobaba et al., 2015). Furthermore, regional airports allow for quick turnaround times reducing costs from potential delays. Finally, regional airports charge lower aeronautical and passenger handling fees and are more flexible in negotiating deals with airlines, as regional governments are often willing to increase traffic at regional airports[6] (Barrett, 2004; Copenhagen Economics, 2012; Francis et al., 2003; Francis et al., 2004; IATA, 2013).

On the demand side, for consumers, fare levels have been found to be more important than travel time in choosing an airport to depart from (i.e. passengers are willing to travel more for lower air fares) (Cohas et al., 1995; Hess et al., 2007; Loo, 2008; Marcucci and Gatta, 2011; Njegovan, 2006; Proussaloglou and Koppelman, 1999; Pels et al.,

[2]In essence all 9 'freedoms of the air' are granted within the EU single market (see Belobaba et al., 2015).

[3]The remaining market is mostly covered by holiday (charter) carriers, regional (feeder) carriers and private aviation (DLR, 2008).

[4]According to the definition International Civil Aviation Organisation, IACO (2017), there are 31 LCCs operating in Europe (see Burghout and De Wit (2015) for an overview).

[5]Budd et al. (2014) distinguish LCCs between 'pure' LCCs such as EasyJet, Norwegian, Wizz Air, and Ryanair; charter operators such as Air Berlin, Jet2 and Transavia; and full-service carrier subsidiaries such as Vueling and Germanwings.

[6]See Warnock-Smith and Potter (2005) for an extensive analysis on LCC airport choice based on a survey carried out among European carriers.

2001; Windle and Dresner, 1995). Additionally, the Schengen Convention[7] has ensured free movement of people, so airports are also able to attract passengers from other Member States that substitute airports for foreign alternatives (Thelle and La Cour Sonne, 2017). Finally, consumers have become much more informed and empowered through the internet, which allows them to compare prices, quality of service and even destinations easier (Copenhagen Economics, 2012). Therefore, remote airports that are successful in attracting LCCs that offe cheap flights can benefit from larger consumer pools (Buyck, 2004).

High ticket price elasticity on the demand side and the preference of LCCs to operate from secondary airports on the supply side has resulted in opportunities for regional and secondary airports to commercialise by attracting LCCs (Barrett, 2000). Many of Europe's secondary airports were initially built for military or civil purposes, but then commercialised and began to serve as regional commercial airports (Barbot, 2006)[8]. In recent years, attitudes towards regional airports' role have from a public utility to a commercially oriented business (Graham, 2003). Regional airports are now considered by local governments and entrepreneurs as *"leading players in regard to economic, productive, tourist and commercial upgrades of a territory, thanks to the "multiplier effect" in the number of potential business transactions they may stimulate"* (Jarach, 2005, p. 1). Many regional airports in Europe are still publicly owned but started to operate more at arms-length from their governments through corporatised entities (ACI Euorope, 2010; Graham, 2014)[9]. Regional airports can commercialise at relatively low costs, since LCCs often do not require many facilities such as check-in areas or extensive handling systems compared to FSNCs (Barbot, 2006; Belobaba et al., 2015; Bush and Starkie, 2014; Copenhagen Economics, 2012; Njoya and Niemeier, 2011). Also, secondary airports are often located outside metropolitan areas, which entails that land prices are lower, resulting in lower construction and operating costs of terminals and guest services. This way some new regional airports opened their doors to carriers and some have grown tremendously as a result of the traffic provided by LCCs (Barbot, 2006)[10]. Between 1996 and 2008 the number of airports offering commercial jet services in Europe increased from 441 to 522 (Reynolds-Feighan, 2010). The multiplication of airports now seems to have reached its end, as more major airports[11] closed than opened between 2006-2016 (see figure 2.1).

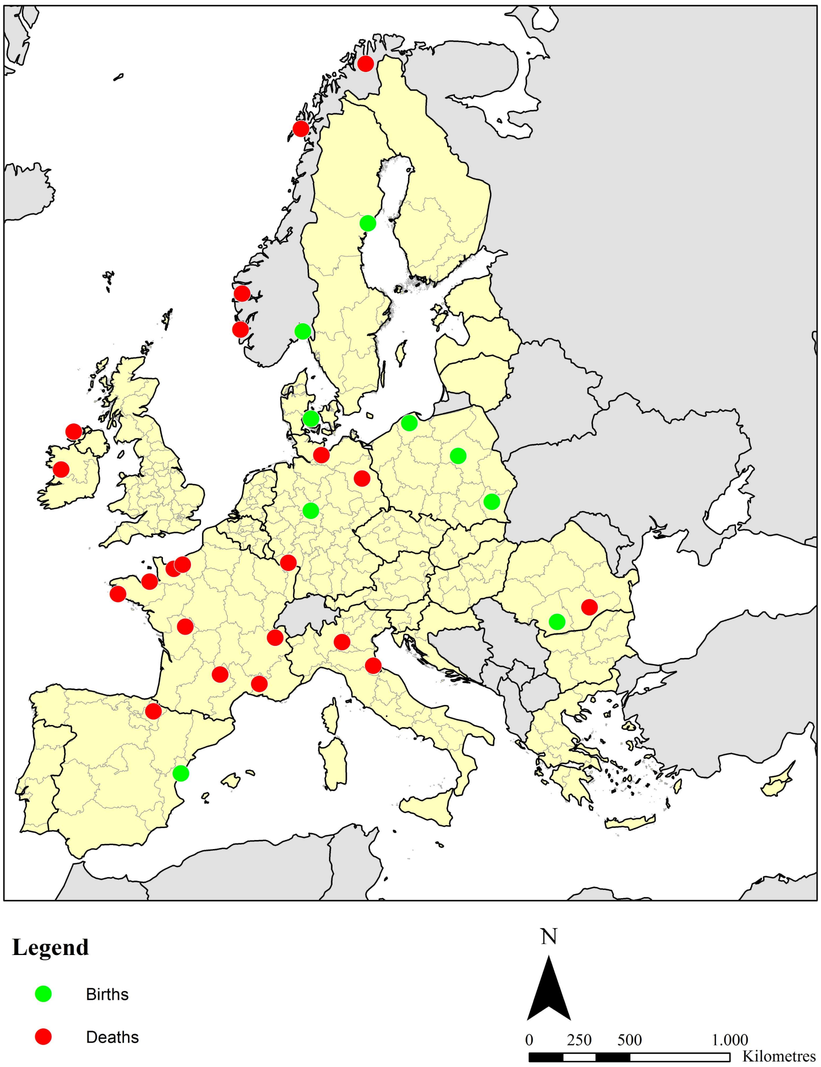
[7] The Schengen Convention has led to the abolition of internal border controls and a common visa policy. As a result, the Schengen area operates much like a single state in terms of international transportation without internal border controls.

[8] Examples of military airfields starting to function as regional airports include Milan Bergamo Airport in 1972 and Frankfurt-Hahn Airport in 1993.

[9] In 2010, over 20% of airports in Europe were privatized or operated as public–private partnerships, while 74% of the remaining publicly owned airports were operated as corporatised entities (ACI Europe, 2016b).

[10] The number of travellers at Charleroi Airport increased from 20,000 in 1997 to 1.27 million in 2002 since Ryanair began to operate there in 1998 (Barbot, 2006). Similar developments were seen at other airports as Glasgow Patwick Airport, Frankfurt-Hahn Airport and London Luton (EC, 2014a).

[11] Airports that handle(d) more than 100,000 passengers a year.



Source: Eurostat (2018a).

Figure 2.1: Major airport births and deaths, 2006-2016

2.1.3 Regional airport competition

While the rise of LCCs certainly has benefited consumers and created opportunities for regional airports to commercialise, increasingly overlapping catchment areas and the footloose business strategies of LCCs also resulted in fierce competition among regional airports (Copenhagen Economics, 2012). LCCs are known for frequent switching between airports by closing existing routes and opening new ones (Thelle and La Cour Sonne, 2017; De Wit and Zuidberg, 2016). Relocation of assets is a key element of LCC business models to achieve higher efficiency over their fleet. Switching figures confirm an overall annual route churn rate of 15-20% where 75-80% of route switching is by LCCs (Copenhagen Economics, 2012; IATA, 2013)[12]. LCCs are particularly able to switch routes as they operate point-to-point networks and are less historically tied to hub airports than traditional national FSNCs that operate hub-and-spoke networks facilitating transfer traffic

[12]For an extensive analysis on which routes and regions particularly experience churning, see De Wit and Zuidberg (2016).

at these hubs and are more committed to serve their local catchment areas (Copenhagen Economics, 2012; Thelle and La Cour Sonne, 2017). Switching costs are low for LCCs, since they don't need to relocate many assets. Switching costs for LCCs mainly include relocation of assets[13], staff relocation and the marketing of new routes (IATA, 2013). For LCCs, greater operational efficiency, new growth opportunities in new secondary markets or subsidies at a new airport, in many cases, outweigh the costs of switching. LCCs are therefore often characterised as footloose and have great flexibility in switching routes through trial and error strategies on a relatively short notice (Copenhagen Economics, 2012; De Wit and Zuidberg, 2016; Malighetti et al., 2016).

The combination of airport multiplication and price sensitive consumers implies that airport catchment areas increasingly overlap (Lieshout, 2012). Airport competition increased in most European regions between 2002 and 2012 (Lieshout et al., 2016). Nearly two-thirds (63%) of European citizens are within a two-hour drive of at least two airports (Copenhagen Economics, 2012). In the case when airports are located near to each other, airports are pushed to compete even harder (through low charges, low handling fees, subsidies and co-marketing agreements) to attract carriers (Barret, 2004). Competition among European airports is strongest along the 'Blue Banana' corridor (Lieshout et al., 2016)[14]. This is mainly due to the presence of multiple large and medium sized airports offering similar services. In these regions, consumers have the most access to passenger flights (EC, 2014c). In large parts of Eastern Europe, France, Ireland, Italy, Portugal, Spain, and Scandinavia, passengers have in general a limited choice with respect to their departure airport, resulting in lower airport competition (Lieshout et al., 2016). Figure 2.2 gives an overview of the locations and sizes of European commercial airports (see appendix A for a list of European airports).

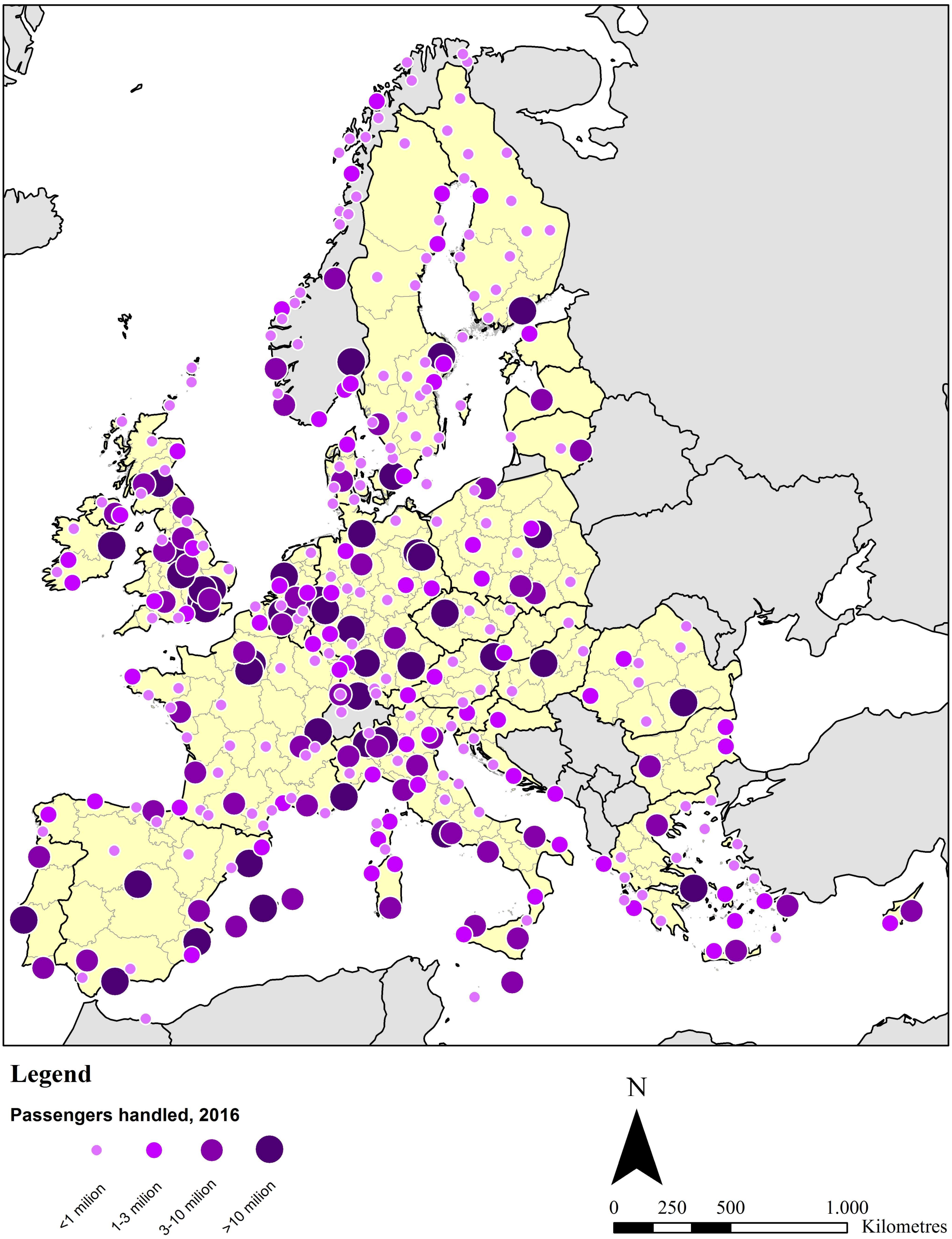
Due to high airport competition, LCCs can choose between multiple airports while serving the same consumer pool. In order to attract footloose LCCs, airports are forced to negotiate with airlines (Graham, 2013; Starkie, 2012). The capability of LCCs to guarantee high levels of traffic creates an asymmetry between airlines and airports, with more negotiation power for the airlines (Barbot, 2006; Gillen and Lall, 2004). LCCs try to force airports to charge lower fees by threatening to go elsewhere once these demands are not met (Lei and Papatheodorou, 2010). LCCs use arguments such as economic and tourism benefits for the region through enhanced connectedness (Papatheodorou and Lei, 2006). Some LCCs are known for their occasionally aggressive approaches to obtain favourable deals with airports (Malighetti et al., 2016)[15]. 84% of European airports have a single dominant airline occupying more than 40% of the airport's capacity (ACI Europe, 2013), making these airports very vulnerable for route switching by LCCs. In some cases, airports abandoned by LCCs have almost no chance to recover traffic through other carriers, following the assumption that no carrier will be able to commercially serve a market if even LCCs fail to do so (Malighetti et al., 2016). This may eventually result in bankruptcies of airports[16].

[13]These assets include aircraft, airline specific terminal facilities and maintenance facilities (IATA, 2013).

[14]The 'Blue Banana' include the United Kingdom, Belgium the Netherlands, Luxemburg, Western Germany, Switzerland and Northern Italy

[15]In 2013 Ryanair cut flights from London Stansted, its main base, and Oslo Rygge because of increased fees and passenger taxes.

[16]For example: Forli airport in Italy went bankrupt and had to close all activities in 2013 after its main carrier, Ryanair, abandoned the airport in 2010.



Source: Eurostat (2018a).

Figure 2.2: European commercial airports sizes, in terms of passengers handled, 2016

2.2 Regional airport policy

2.2.1 State aid to unprofitable regional airports

Around half of Europe's regional airports is operating at loss (ACI Europe, 2016a; EC, 2014a; Francis et al., 2004). Most of these are smaller regional airports with less than 1 million passengers per year, which comprise the majority all airports within the EU (ACI Europe, 2016a; EC, 2014a). Relative inefficiency of smaller airports can be explained by little traffic relative to the costs associated with operating the airport (Adler et al., 2013; Minato and Morimoto, 2011). Many of these operating expenses are fixed or vary little with the scale of operations (Copenhagen Economics, 2012)[17]. It is estimated that marginal costs with respect to additional aircraft movements comprise around 10% of total costs, meaning that up to 90% of the costs are largely invariant to scale (Copenhagen Economics, 2012)[18]. As a result, the costs incurred per movement at smaller airports are substantially higher than at larger airports that can compensate the fixed costs by large amounts of traffic. Consequently, regional airports have a need to seek other ways of generating revenues with commercial activities (Francis et al., 2004)[19]. Regional airports can try to maximise economic benefits by increasing revenues from retail services (Graham, 2014). However, most regional airports lack substantial traffic, making retail revenue generation difficult (Lei and Papatheodorou, 2010). This entails that regional airports generally struggle to generate any profits.

Regional airports are predominately (at least partly) publicly owned or subsidised by public authorities or (indirectly) through EU funds to ensure their upkeep (ACI Europe, 2016a; ACI Europe, 2016b; EC, 2014a; Humphreys and Francis, 2002)[20]. Many regional public authorities are actively supporting regional airports in their efforts to attract LCC traffic (ECA, 2014). Funding takes place by funding infrastructure investments, by providing subsidies for incoming airlines or by bridging operational funding gaps at the airport. The underlying reasoning is that connectivity provided by regional airports is essential in connecting the region to the outside world and stimulating regional economic development (Breidenbach, 2015). Next to governmental funding, public funding is made available by the EU through its regional funding programmes. The European Court of Auditors (ECA) (2014) states that the EU has spent more than 4.5 billion Euros in investments related to airport infrastructure through the European Regional Development Fund, the Cohesion Fund and the Trans-European Network for Transport (TEN-T) fund between the years 2000 and 2013. The ECA (2014) concluded that state aid to regional airport in many cases has been 'poor value for money'. Only half of the audited airports had been successful in increasing their passenger volume, while seven of the twenty airports studied risked closure when no public support would be available. The ECA has found only little evidence that additional jobs were created as a result of public EU investments in airport infrastructure (ECA, 2014). Following these findings, the EC stated that: *"Public funding*

[17] Operating expenses consist of airport security (27%), terminal and landside operations (29%), airside operations (20%), administration (16%), sales and marketing (4%) and other costs (4%) (Copenhagen Economics, 2012).

[18] See also Link et al. (2009) who estimate a cost function for Helsinki Airport and find marginal costs of 22 for every extra aircraft movement, representing 11% of total costs. Morrison and Winston (1989) find a similar estimate for US airports of $22 per aircraft.

[19] For an extensive review on determinants of commercial revenues at regional airports, see Castilo-Manzano (2010).

[20] In 2010, 77% of airports were fully publicly owned and 9% were fully privately owned (ACI Europe, 2016b)

to airport infrastructure has often resulted in duplication of unprofitable civil airports in the same catchment area, creating ghost airports and overcapacity at regional airports." (EC, 2014b, p. 2). Also, when airports and airlines receive aid, their more efficient and more innovative competitors see the rewards for their efforts disappear. FSNCs and larger airports have often opposed public support to small airports as they state this puts them at competitive disadvantage (Barbot, 2006).

2.2.2 New EU guidelines on state aid to airports and airlines

The poor returns to public investments in regional airports observed by both the EC (2014b) and the ECA (2014) and the distortion of competition between regional and major airports resulted in the adoption of stricter guidelines for state aid to airports and airlines to adjust to the new economic context in 2014 (EC, 2014a). The main objectives of these new guidelines are to eliminate superfluous subsidies and generate fair competition among airports and airlines within the Single Market.

State aid to airports is subdivided into operating, investment aid and start-up aid. Subsidies covering operational losses are restricted to airports handling less than 3 million passengers a year and such aid will be completely phased out by the end of the transitional period in 2024 (see table 2.1). In order to receive operating aid, the EC requires that airports demonstrate that they will be fully able to cover their operational costs at the end of a ten-year transitional period through business plans. During the transitional period, 50% of the initial average operating funding gaps over the five years preceding the transitional period (2009-2014) is allowed to be covered by state aid (80% for airports handling less than 700,000 passengers a year). The size of the airport in terms of passengers handled per year (*pax*) determines the maximum aid received by airports to cover the funding gap of new infrastructures (investment aid) (see table 2.2). In 'outermost' regions[21] the maximum permissible investment aid is 20% higher. 'Start-up' aid for launching new routes aid is exclusively available for airports serving less than 3 million passengers a year, with an intensity of maximum 50% of the funding gap for a maximum period of 3 years. Additionally, routes that are already operated by high-speed rail services or by another airport in the same catchment area, will not be eligible for investment aid. It is important to note that non-economic (fixed) operating costs regarding safety or air traffic control, which covers around one-third of operating costs (Copenhagen Economics, 2012), are not treated as state aid in the new Guidelines, since those activities fall under Nation State responsibility.

Table 2.1: Allowed airport operating aid intensity during transitional period

Airport size (*pax*/year)	Maximum operating aid intensity
$>$ 3 Million	No operating aid allowed
700,000-3 Million	50% of the initial average operating funding gap
$<$ 700,000	80% of the initial average operating funding gap

[21] 'Outermost' regions include: Malta, Cyprus, Ceuta, Melilla, islands part of a Member State's territory and sparsely populated areas.

Table 2.2: Allowed airport investment aid intensity

Airport size (*pax*/year)	Maximum investment aid intensity
> 5 Million	No investment aid allowed
3-5 Million*	Up to 25%
1-3 Million	Up to 50%
< 1 Million	Up to 75%**

*Under certain case-specific circumstances

**May exceed 75% in exceptional circumstances subject to case-by-case assessment

2.2.3 Criticism regarding new EU guidelines

The new guidelines on clamping down on state aid have been met by great criticism and concerns by aviation trade industry association Airports Council International Europe (ACI Europe) representing 450 European airports, the Assembly of European Regions (AER) and many regional stakeholders (see ACI Europe, 2013; AER, 2013; AER and ACI Europe, 2013 Breidenbach, 2015). Regional stakeholders have been pressing the EC to allow for more flexibility over these new guidelines, warning for "damaging consequences" for local economies (AER, 2013). As business markets are becoming more globally integrated, airports are increasingly believed to be 'engines' for local economic development in facilitating employment and international trade (see Brueckner, 2003; Button and Taylor, 2000; Graham and Guyer, 2000; Rasker et al., 2009; Sheard, 2014). To illustrate, Per Inge Bjerknes, chairman of the AER Working Group on Regional Airports and Vice-Chairman of the County Council of Østfold, Norway, commented: *"For our regions, there is no escaping the fact that airports are strategic public infrastructure and that they need to be treated as such. Part of these new State aid rules seem to show that the Commission is more concerned with fiscal austerity than promoting growth and jobs."* (AER, 2013, p. 2).

Additionally, in a report by ACI Europe (2013) it is argued that limiting aid to small airports would cause competitive distortions. Regional airports are by definition at a competitive disadvantage and that subsidies to regional airports are justified as their fixed costs are relatively high opposed to bigger airports handling more passengers. Smaller airports are less able to cover their fixed costs by non-aeronautical revenues that depend on passenger volumes[22]. When operating aid is phased out, smaller airports are forced to charge higher fees to airlines resulting in either higher ticket prices or difficulties in attracting traffic and existential issues for some airports that cannot overcome their costs (Malighetti et al., 2016). The AER (2013) estimates that the new guidelines could lead to over 100 airport closures. However, Redondi et al. (2013) find that the average connectivity loss should be relatively small on a country level in Europe, when airports handling less than 2 million passengers per year would all close. In contrast, ACI Europe (2013) stresses that regional airports play a vital role within local and European air connectedness. Currently 68 airports (circa 20%) which have been designated by the EC as 'core' or 'comprehensive' within the TEN-T network, handle between 200,000 and 1 million passengers per year. These are considered to be the airports that will experience the most problems when state aid is clamped down. When these airports lose traffic or close, some major holes may arise within the TEN-T resulting in an overall loss of European connectivity and cohesion. Additionally, the closure of airports may lead to relocation of routes towards bigger airports

[22] The EC (2014a) considers airports handling over 3 million passengers per year to be profitable enough to cover all of their operational expenses.

within the same catchment area. As it is already predicted that 19 out of 20 of Europe's largest airports will be heavily congested by 2030 (EUROCONTROL, 2010), the closure of regional airports will not be beneficial in solving congestion issues at bigger airports. Finally, ACI Europe (2013) addresses a preferential position for the rail transport sector, which is not faced with restrictive guidelines on state aid. No start-up aid is eligible to air routes already covered by high-speed rail. Therefore, ACI Europe (2013) states that restrictions on state aid to airports and airlines can considered to be unfair and should be more flexible especially taking the regional economic benefits European aviation generates in a globalising economy.

Chapter 3

Theoretical framework

The relation between regional economic development and air connectivity has been widely studied in academics. In this thesis, the main angle of approach for framing this relationship is the role of connectivity and transportation for economic development in cities and regions in a modern globalised economy. Therefore, this section starts with an evaluation on how transportation matters for regional economies from a (New) Economic Geography (NEG) perspective. This is followed by a survey on how the link between air traffic and economic growth is discussed in academic literature and reports. Finally, the current EU guidelines on aid to airports and airlines are framed within academic debates on transportation policy.

3.1 Economic globalization and uneven economic geography

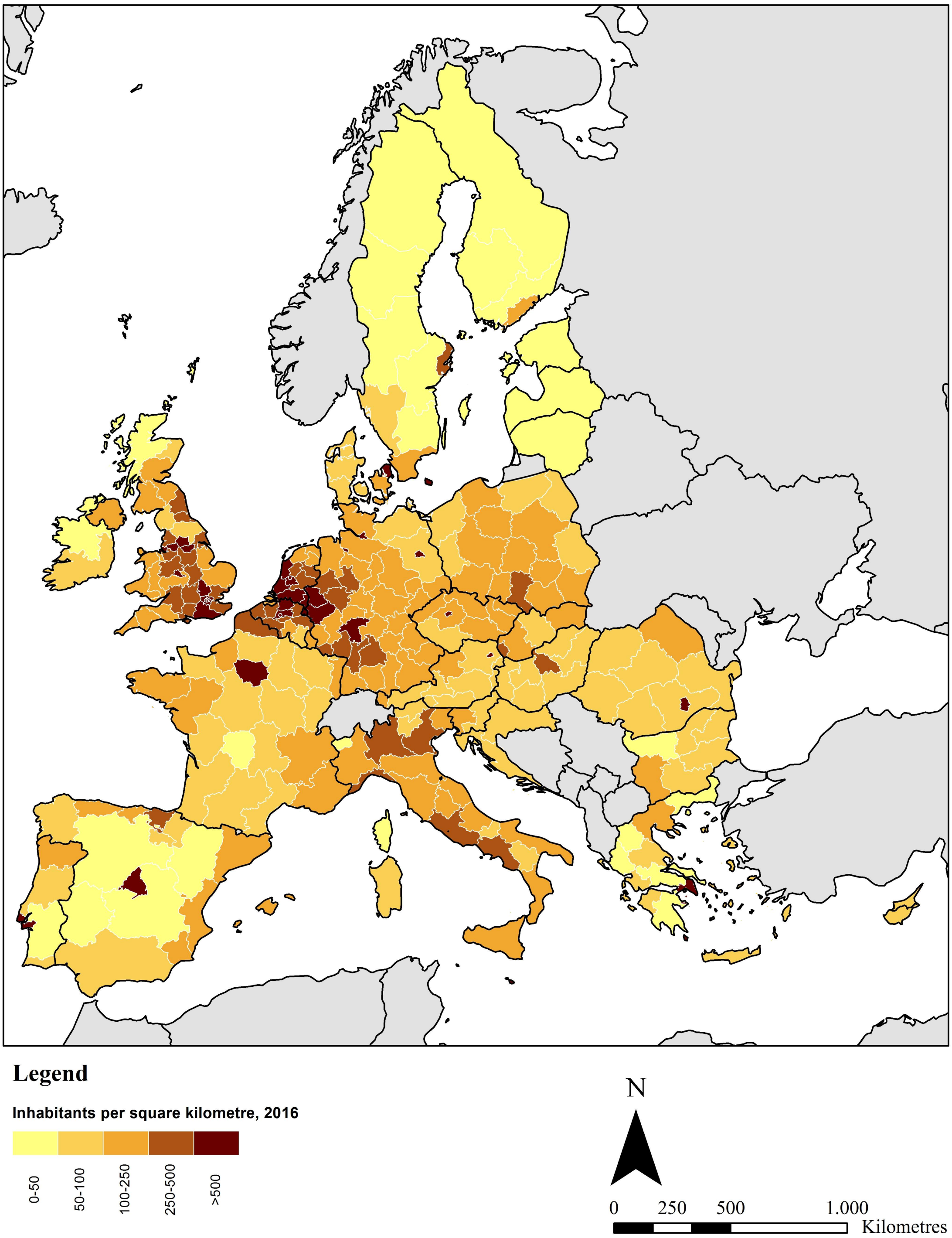
3.1.1 The relevance of spatial concentration

Cities and regions are argued to be more than ever subjected to the impacts of modern globalisation (McCann, 2013). Globalisation is widely addressed in cultural to political, geographical, institutional or economic issues and can be defined as *"the growing interdependence between countries through increased trade and/or increased factor mobility"* (Brakman et al., 2009, p. 56). Transportation developments and the dismantling of trade barriers are at the core of creating a truly global commodity market (Williamson, 2002). Falling costs related to moving goods and information (so called spatial transmission costs (McCann, 2013)) and increased use of information and communications technologies have wide implications for the distribution of economic activities across space (Brakman et al., 2009; Ioannides et al., 2008). Glaeser and Kohlhase (2004) suggest that the costs of transportation of goods fell by as much as 95% during the 20^{th} century. Technological innovations could imply that the costs of moving goods and knowledge over distance have fallen so dramatically that the location of economic activity ceases to be of importance (see Cairncross, 1997; O'Brien, 1992). Friedman (2007) has argued that falling spatial transmission costs have actually led to a situation that the current world can be referred to as "flat" and that geographical peripherality is becoming relatively less of a barrier to access global markets, resulting in economic convergence across space. This argument is supported by observations of de-urbanisation in the developed world in the 1980s (Fothergill et al., 1985) and in accordance with classical monocentric city models (e.g. Von Thünen, 1826) that imply that a fall in transport costs allows economic activity to move farther away from the market.

However, there is a great deal of evidence that economic convergence across space is slow or non-existent and geographical distance is still dominant in many aspects of international trade and the distribution of economic activity (Brakman and Van Marrewijk, 2008). Also, evidence on urbanisation suggests that urban concentrations still are very relevant in the global economy (McCann, 2008; PwC, 2009). The world's population is increasingly concentrating in cities reaching levels over 50% of the total population living in urban areas for the first time in 2008 (World Bank, 2018a). Figures 3.1 and 3.2 picture recent population density and gross domestic product (GDP) figures across Europe's regions. It is evident that spatial concentration is still very much occurring. These recent observations can be interpreted as a re-emerging economic importance of urban concentrations (Glaeser, 1998; Glaeser and Gottlieb, 2009). The benefits from concentrating economic activity arise from internal and external returns to scale. Internal economies of scale are reached when fixed costs of production are being spread over an increasing output (Brakman et al., 2009). External agglomeration economies come about through city-specific Jacobs urbanization externalities (see Jacobs, 1969) or sector-specific Marshall-Arrow-Romer (MAR) localisation externalities (Brakman et al., 2009; Glaeser et al., 1992). The main sources of these agglomeration externalities are (i) information or knowledge spillovers; (ii) labour market pooling; and (iii) the sharing of (specialised) inputs, or *sharing, matching and learning* as Duranton and Puga (2004) summarise[23]. This includes a wide range of factors such as the access to specialised business-to-business services, the formation of a specialised labour force, the production of new ideas, based on the accumulation of human capital and face-to-face communications, and the access to efficient infrastructure. The paradoxical observation of falling spatial transmission costs and continuing economic concentration to benefit from agglomeration externalities, points in the way that total spatial transaction costs have actually risen (McCann, 2008). The costs of moving information and goods have fallen dramatically, while the costs of moving people and transacting tacit knowledge have actually risen due to an increasing importance for face-to-face contact in developed economies[24] (Glaeser and Kohlhase, 2004; McCann, 2008). Improvements in communication technologies have increased the quantity, variety and complexity of the knowledge handled and information produced (Gaspar and Glaeser, 1998). This has resulted in increased costs associated with acquiring and transacting knowledge across space and face-to-face contact has become more essential to maintain understanding and mutual trust and because of increased time opportunity costs associated with not having continuous face-to-face contact (Gaspar and Glaeser, 1998; McCann, 2008; Storper and Venables, 2004; Rietveld and Vickerman, 2004). Therefore, agglomeration economies, especially through knowledge spillovers, are more relevant than ever in explaining spatial dispersion of economic activity. Assuming that due to globalisation forces markets become more globally integrated and spatial transaction costs related to knowledge are growing (McCann, 2008), there might be a vital role for air connectivity in lowering these spatial transaction costs and facilitating regional economic development.

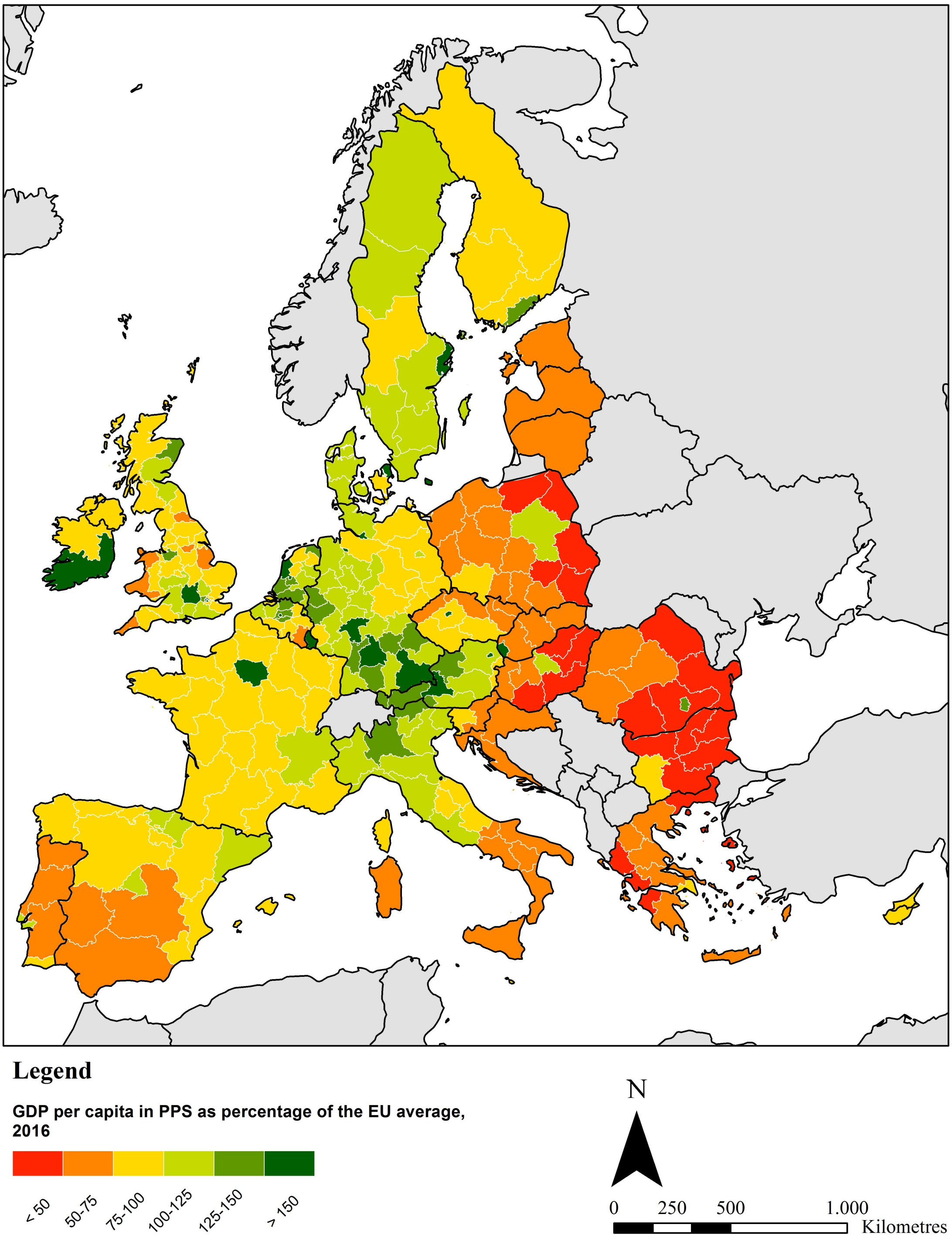
[23]Rosenthal and Strange (2004) survey additional sources of agglomeration economies to explain the existence of cities and their size variations such as: natural advantages through differences in factor endowments; home market effects; consumption driven externalities through city-specific amenities and rent seeking behaviour.

[24]For a comprehensive overview of empirical evidence regarding increasing spatial transaction costs see McCann (2013, box 9.1).



Source: Eurostat (2018b).

Figure 3.1: Population density by NUTS-2 regions, 2016

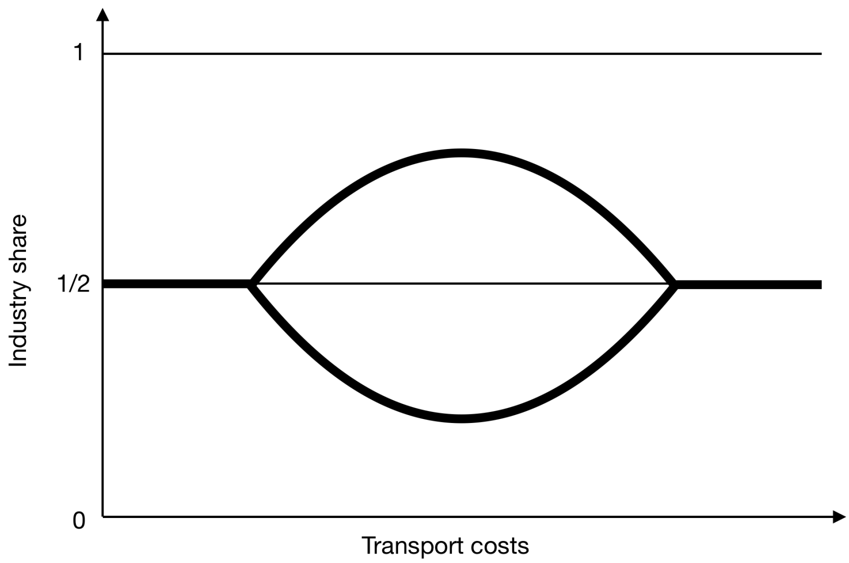


Source: Eurostat (2018c).

Figure 3.2: GDP per capita in PPS, in % of the EU average, 2016

3.1.2 Transportation costs and spatial distribution of economic activity

Transport costs traditionally have played a central role in explaining the spatial organisation of economic activity and cities with a tradition going back to Christaller (1933), Hotelling (1929), Von Thünen (1826) and Weber (1909)[25]. More recent attempts, grounded in international trade theory, regarding the spatial distribution of economic activity rely strongly on increasing returns to scale (introduced by Krugman (1979)), which implies that average costs decrease with an increasing output resulting in an incentive to concentrate production. Based on the fundamental implication of the increasing returns to scale framework that not all product and services can be individually produced next to individual consumers[26], scale economies and transportation costs are the prime drivers for the concentration of economic activity (Fujita and Thisse, 2002). Recent NEG models explaining the spatial pattern of economic activity are characterised by combining concentrating forces related to agglomeration externalities with spreading forces resulting in a spatial equilibrium setting where transport costs are crucial in determining the balance between agglomerating and spreading forces (see Fujita et al., 1999; Krugman, 1991a, 1991b)[27]. Within a NEG setting, firms locate where market potential is high and transport costs are low in order to easily access other markets and achieve the highest possible returns to scale (Redding and Venables, 2004). In a two-region core-periphery setting, the long-run relationship between transportation costs and the dispersion of economic activity might look like a bell-shaped curve (figure 3.3) (Brakman et al., 2009; Head and Mayer, 2004; Ottaviano and Thisse, 2004).



Based on: Brakman et al. (2009, p. 164).

Figure 3.3: Core-periphery bell-shaped curve

[25] See McCann (2013) for an in-depth survey on classical (industrial) location theories.

[26] Also referred to as *'backyard capitalism'* which allows for avoiding any transport costs to reach demand (Ottaviano and Puga, 1997).

[27] In NEG-model simulations, economic globalisation is incorporated by decreasing transport costs (see Brakman et al., 2009). To overcome incorporating a separate transport-sector, transportation costs in NEG models are defined in terms of 'iceberg' transport costs following Samuelson (1952) and Mundell (1957), being the amount of goods that needs to be shipped in order to ensure one unit arrives.

For high values of transport costs, there is spreading of economic activity as it is too expensive to serve both regions from only one location. When transport costs fall, resulting from for example the construction or expansion of air transport facilities, firms agglomerate in one region to benefit from agglomeration advantages such as MAR-externalities as these will increasingly outweigh the costs of transportation to serve the other market. However, for extremely low levels of costs associated with distance, spreading forces start to dominate again as advantages of agglomeration through externalities are outweighed by low transport costs (i.e. Friedman's (2007) 'flat world' scenario). However, when considering rising spatial transaction costs in the developed world (McCann, 2008) and recent urbanisation trends, the latter scenario to date seems far from reality. Finally, it is worth noting that competition forces and congestion costs within regions can also add to the dispersion of economic activity (see Brakman et al. (2009) for an extensive overview of various NEG models and extensions).

3.1.3 Regional competitiveness and the importance of connectivity

Next to spatial concentration, the clue to why particular regions are highly productive lies in the type of firms which are located there (Porter, 1990) and their activities related to the wider global market. Following the economic base model which is widely used in regional multiplier analyses, a regional economy is divided in an aggregated basic sector, dependent on outside market conditions and a non-basic sector, serving the local economy. Following the economic base model, the total performance of a region is a function of the employment generated by the basic sector (McCann, 2013)[28].

Multinational businesses are now at the forefront of economic performance of cities and regions (McCann, 2013), which is in accordance with the economic base model that suggests that regional employment is driven by firms with outputs outside the local economy. As described in subsections 3.1.1 and 3.1.2, there is an increasing premium for face-to-face interactions with foreign markets, suppliers and collaborators for internationally oriented companies (McCann, 2007, 2008). This is particularly evident in the developed world where the dominance of globally competitive firms is associated with the density of knowledge (Simmie, 2004). Multinational companies and their globally interacting behaviour account for a great deal of economic growth (McCann, 2013) and the probability of success for small and medium-sized non-basic firms is higher in globally connected regions through potential spillovers and global market opportunities associated with local international companies (Andersson and Weiss, 2012; Johansson and Loof, 2009). Therefore, global connectivity generated through international transport linkages may play a more important role in economic development, rather than urban scale (McCann and Acs, 2011).

3.2 Air traffic and the regional economy

There is a great deal of evidence on the importance of urban connectivity generated by transportation systems for internationally oriented firms. By nature, air transportation links facilitate international interactions. Global air traffic systems allow firms to easily access wider markets (Wickham and Vecchi, 2008) and determine the geographical patterns

[28]The economic base model implies that the overall performance of a region is a function of the performance of the basic sector. See McCann (2013) for an extended summary on the economic base model.

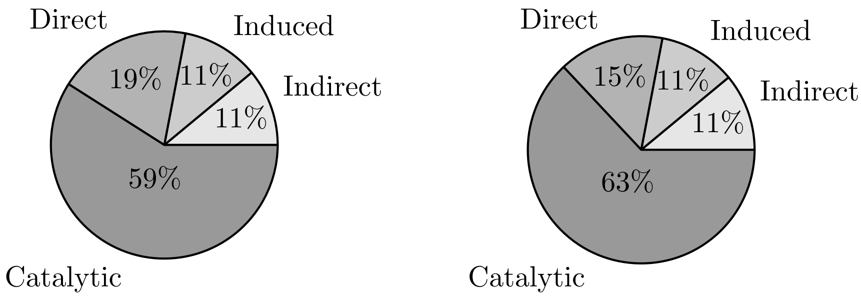
of knowledge flows through facilitating face-to-face contact between decision makers from other locations (Aguilera, 2008; Bowen, 2002). Therefore, in the modern global economy, urban and regional connectedness generated by airports could be crucial for facilitating multinational or internationally oriented firms' interactions and performance (Brueckner, 2003; Carod et al., 2010; Doeringer et al., 2004; Hong, 2007; Neal, 2010; Rasker et al., 2009; Straus-Kahn and Vives, 2005) and therefore the economic development and competitive position of regions drawing on Porters' rationale (1990) that not regions are competing but the firms located in those regions.

3.2.1 Breaking down economic effects associated with air traffic

Section 3.1 has provided a theoretical foundation for the economic importance of air transport infrastructures for its regions in a context of modern economic globalisation. Regional economic impact analyses related to air traffic typically features four main types of impact (see ATAG, 2005; InterVISTAS, 2015; Percoco, 2010; York Aviation, 2004):

- *Direct impacts* related to the employment, income and GDP associated with the operation and management of activities at the airport. This includes activities by the airport operator, the airlines, airport air traffic control, general aviation, ground handlers, airport security, immigration and customs, aircraft maintenance, and other activities at the airport.
- *Indirect impacts* related to the employment, income and GDP generated by downstream industries that supply and support the activities at the airport including: wholesalers providing food for in-flight catering, companies providing services to airlines or travel agents.
- *Induced impacts* capturing the economic activity generated by the employees of firms directly or indirectly connected to the airport spending their income in the regional economy.
- *Catalytic impacts* related to the wider role of the airport on regional development through a number of cooperating mechanisms (IATA, 2007):
  - Investment decisions made by (multinational) companies taking the proximity of an international airport into account as a factor for location decisions of firm divisions (see Bel and Fageda, 2008; Brueckner, 2003; Kramer, 1990; Strauss-Kahn and Vives, 2005).
  - Trade of goods and services through provided connections to export provides a larger costumer base and enables face-to-face contact (see Aguilera, 2008).
  - Effective networking and collaboration between firms around the globe by facilitating face-to-face contact.
  - Incoming and outgoing tourism facilitated by the airport supporting a wide range of tourism-related businesses in the region (see Bieger and Wittmer, 2006; Papatheodorou and Lei, 2006).
  - Optimization of supply-chains for firms relying on just-in-time operations through greater flexibility and minimizing stock costs.
  - Productivity growth driven by the access to new markets which in turn enables businesses to achieve greater economies of scale and the ability for companies to attract high-quality employees (see Button et al., 1999; Rosenthal and Strange, 2004).

The overall effect of all these mechanisms is an increase in employment and GDP. InterVISTAS (2015) estimates that European airports contribute to the employment of 12.3 million people earning €356 billion in income annually, and generate €675 billion in GDP each year, equal to 4.1% of GDP of Europe. Figure 3.4 displays that catalytic impacts are estimated to be the main drivers behind the generation of jobs and GDP. However, as Green (2007) points out, these impacts seem to be the most difficult to evaluate due to causation issues.



(a) Income **(b)** GDP

Based on: InterVISTAS (2015, p. 64).

Figure 3.4: Estimated break down of economic impacts regarding European airports

3.2.2 Empirics of airports as regional economic catalysts

The perceived ability of airports to generate jobs and attract new businesses is being used in many locations as a justification for public investments in airport support, construction and expansion (Breidenbach, 2015). York Aviation (2004) points out that the contribution of airports to the economy of the areas they serve could be substantial. Many studies show significant impacts from air transport of which a selected survey is presented in table 3.1.

Additionally, a number of rather qualitative oriented studies at the firm level confirm a significant role for air connectivity in their business operations (see IATA, 2007) or location decisions (see Hansen and Herstein, 1991). IATA (2007) has found that 25% of surveyed businesses in five countries indicated that 25% of their sales were dependent on good air transport links. 30% of Chinese firms surveyed, reported that they had changed investment decisions because of constraints on air services. Hansen and Gerstein (1991) have found that the amount of Japanese investment in each U.S. state was causally linked to the air service between Japan and that state. For 100 foreign-owned businesses in Germany it has been found that access to air connectivity was the third most important factor affecting location decisions (out of 30 factors considered in the survey), with 86% of businesses indicating that air connectivity was important to location decisions. Furthermore, 57% of businesses indicated that they would have chosen another location if air connectivity had been weaker. Nonetheless, it is difficult to isolate and measure these impacts since causalities between air transport services and regional economic development is dynamic, blurred and possibly circular (Green, 2007). Additionally, most of these studies have a strong focus on metropolitan areas and major hub airports (e.g. Bel and Fageda, 2008; Button et al., 1999; Hakfoort et al., 2001), so the question still remains how regional smaller airports, which are mostly located outside metropolitan areas, fit into that picture and how regional policies should be shaped.

Table 3.1: Selected studies on the relationship between air transport and regional economic development

Reference	**Finding**
ACI Europe (2014)	Strong correlation between how well connected a country is by air and its level of wealth measured in GDP per capita ($R^2 = 0.71$).
Basile et al. (2006)	Some Italian regions attracted significantly less firms than others, possibly explained by the low level of infrastructures.
Bel and Fageda (2008)	A 10% increase in supply of air service at an airport covering intercontinental flights is associated with a 4% increase in the number of large firm headquarters nearby.
Brueckner (2003)	A 10% increase in passengers in a metropolitan area generates a 1% increase in regional employment.
Cooper and Smith (2005)	A 10% increase in air transportation usage increases business investment by 1.6%.
Doeringer et al. (2014)	A 1% increase in international seat capacity was associated with a 0.47% increase in FDI inflows and a 0.19% increase in FDI outflows.
Hoare (1975)	The geography of FDI in the UK is related to the accessibility to airports.
Hong (2007)	Foreign investors emphasize cheap labour and convenient airway transport in location decisions.
InterVISTAS (2015)	European airports contribute to the employment of 12.3 million people earning €356 billion in income annually, and generate €675 billion in GDP each year, equal to 4.1% of GDP of Europe
Kramer (1990)	Airports can function as a regional marketing tool by influencing location decisions of firms that are not functionally related tot the airport.
McCann and Acs (2011)	The size of a city is less important than its level of global connectivity for international investments.
Sellner and Nagl (2010)	Air accessibility has positive impact investment growth.
Strauss-Kahn and Vives (2005)	Among other factors, headquarters relocate to metropolitan areas with good airport facilities.

3.3 Regional economic policy regarding transportation

In regional economic policies, transportation and regional accessibility are often important elements. Transport infrastructures can be considered as quasi-public goods, which entails that market forces usually do not result in an efficient allocation of resources (Annema, 2013). The transportation market is particularly prone to market failures related to external effects. Therefore, governments tend to be the main suppliers of transport infrastructure and subsidise or tax certain transport modes to get a grip on these market failures. Usually, transportation policies regarding stimulating economic activity consist of attempts to improve local accessibility (Annema, 2013; Vickermann, 1991). Accessibility is essential for businesses and the performance of especially the firms that are operating interregionally (McCann, 2013). However, these judgments can be very much subject to false estimations of costs and benefits. As Flyvbjerg et al. (2003) show, cost and demand estimates for infrastructure are often very inaccurate. While exact outcomes are very hard to predict, psychological explanations state that politicians could be overly optimistic, rather than rationally weigh gains, losses and probabilities (Lovallo and Kahneman, 2003). Next to policies aimed at improving welfare, governments implement transport policies out of equity reasons in order to distribute connectivity evenly, as they judge that to be fair for more peripheral regions. Governments can argue that people in peripheral regions should have a certain level of connectedness, even if the costs of building and maintaining infrastructures do not outweigh the benefits (Annema, 2013). This makes decision-making for equity reasons a rather subjective and debatable matter.

Recent debates on regional development policies can be divided into two camps of space-blind policies (e.g. Sapir et al., 2004; World Bank, 2009) and place-based policies (e.g. Barca, 2009; CAF, 2010; OECD, 2009a, 2009b). Space-blind approaches, partly in line with home market effect arguments in NEG models, suggest that agglomeration leads to productivity growth and optimal development policies should encourage factor migration to larger regions to achieve agglomeration advantages. Policies with a focus on places or regions would inhibit (factor) migration regulations and therefore be inefficient for society as a whole (Winnick, 1966). There is a strong focus on concentration rather than an equal distribution. On the other hand, place-based approaches, which are much more in line with the 'equity' argument, acknowledge the role of agglomeration economies in driving development, while emphasising the importance of the economic context (McCann, 2013). Space-blind policies never have space-neutral outcomes. Therefore, in place-based reports (e.g. Barca, 2009; CAF, 2010; OECD, 2009a, 2009b), it is emphasised that development strategies should not be space-blind in order to reach economic cohesion.

The new EC guidelines regarding state aid to European airlines and airports can be classified as a rather space-blind and cost-minimising approach. All airports and airlines throughout Europe are faced with the same rules, while regional outcomes are likely to differ. The AER (2013) claims that airport closures, resulting from policy reforms, can particularly be devastating for European peripheral regions with low accessibility levels, regardless of positive economic spillovers associated with air traffic. This could be an obstacle in achieving EC goals on economic cohesion and an equal distribution of welfare throughout Europe. However, as with many infrastructure projects (see Flyvbjerg, 2003), the estimation of benefits from regional airports is in practice very hard, leading to possible inefficiencies and debatable subsidies. This again raises the need for objective evaluations on the role regional airports have as regional economic catalysts.

Chapter 4

Methods

In chapters 1, 2 and 3 the research problem and its theoretical and contextual background are presented. The methods used to tackle this research problem are presented in this chapter. Regional air connectedness is assessed by means of the connectivity offered by airports that serve a region. Once regional air connectedness levels are obtained, the extend to which regional airports contribute to these levels is evaluated. After that levels of regional air connectedness are linked with regional economic output. By means of a historical analysis, it is assessed in how causality runs regarding the link between the development of regional air connectedness from regional airports and development in regional economic output.

4.1 Airport connectivity

This section elaborates on the methods for assessing how regional airports contribute to regional connectedness. Before it is possible to assess the contribution of regional airports to regional connectedness, it is needed to evaluate the connectivity each individual airport provides. Burghouwt and Redondi (2013) define connectivity as the degree to which a node is connected to the entire network. With these values, it is possible to derive how connected regions are through the air and to what extend regional airports contribute to that.

4.1.1 Airport connectivity indices

Connectivity of an airport is essentially measured based the number of passengers handled combined with number and quality of the airport's destinations. The aggregate connectivity derived from these elements can be evaluated by a variety of indices combining the total number of passengers handled, number of (in)direct connections, size of destination airports, available seats, schedule convenience, route frequencies, and travel times (PwC, 2014). A selected overview of commonly used indices is presented in table 4.1.

Table 4.1: Airport connectivity indices used in aviation economics literature

Index	**Description**
IATA Air Connectivity Index	Captures the importance of destinations by the size of destination airports.

Table 4.1 continued: Airport connectivity indices used in aviation economics literature

Index	**Description**
NetScan Connectivity Index	Captures both direct and indirect connections and its qualities. Accounts for potential delays and transfer times.
York Aviation Business Connectivity Index	Weights for economic importance of destinations, evaluating the value of connectivity for businesses.
World Bank Air Connectivity Index	Estimates the values of routes based on the number of onward connections available.

Source: PwC (2014).

The World Bank Air Connectivity Index assesses the connectivity of an airport by means of the number destinations available at destination airports (Arvis and Shepherd, 2011). The IATA Connectivity Index combines the frequency and the availability of seats on all routes serviced by an airport, while the importance of destination airports are weighted by means of their size. The York Aviation Business Connectivity Index weighs destinations of an airport through global city rankings constructed by Globalisation and World Cities Research Network (GaWC)[29]. The NetScan Connectivity Index relies is widely referred to by airports and sector associations when assessing airport connectivity (see ACI Europe, 2014, 2016c). This index relies strongly on combining the availability and quality of direct and indirect connections (Veldhuis, 1997). It does not only account for the theoretical number of available connections at destination airports but also qualitative measures such as transfer times and risk for delays[30]. This is a more realistic measure as unfeasible connections are left out and the quality of available connections is carefully weighted for.

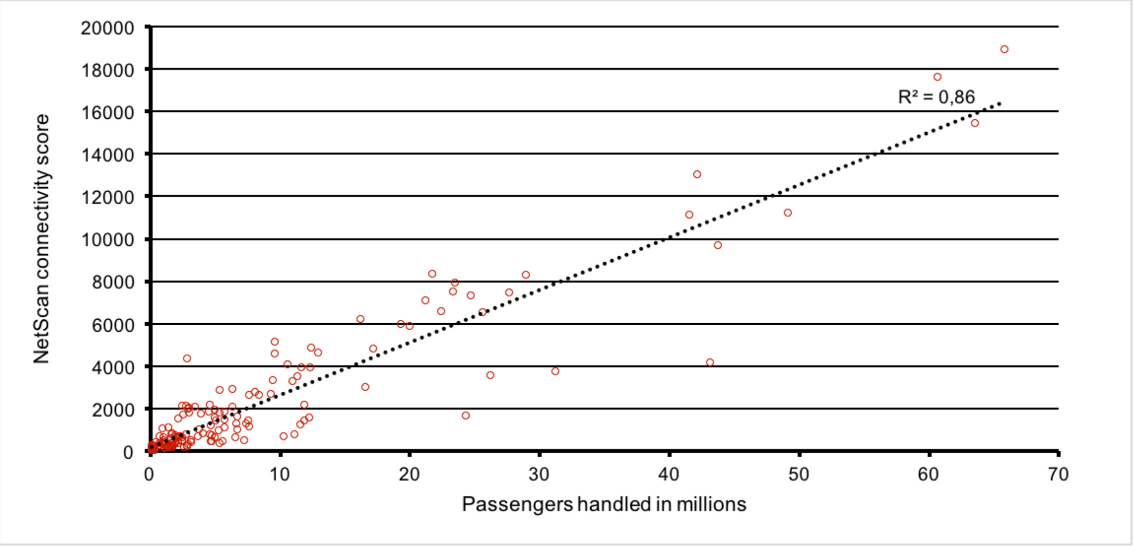
4.1.2 Airport size as a proxy

While an extensive assessment of airport connectivity is vital for airline and airport management (Burghouwt and Redondi, 2013), it requires very extensive data on qualitative measures regarding routes offered at an airport. This data is not publicly available. As it is beyond the scope of this thesis to assess individual airport's performances and competitive positions, a more straightforward aggregate measure is used. It is likely that airport size can serve as a proxy for airport connectivity. The most 'connected' airports in terms of available destinations and capacity are hub airports, which are traditionally larger in size to accommodate hub-and-spoke networks (De Neufville and Odoni, 2013). Due to relatively fixed aircraft sizes, the more passengers handled at an airport, the more flights are available, translated into more available destinations and higher service frequencies. Both are main inputs for all common connectivity indices as listed by PwC (2014) (see table 4.1), suggesting a strong correlation between airport connectivity and the number of passengers handled. This is confirmed when published NetScan and IATA connectivity scores are set off against passengers handled at the airport (see figures 4.1 and 4.2), which

[29]GaWC (2017) probes to rank cities in terms of their global interactions (connectivity) with other cities. Cities are sorted into categories of "Alpha" world cities, "Beta" world cities, "Gamma" world cities and additional cities with "High sufficiency" or "Sufficiency" presence.

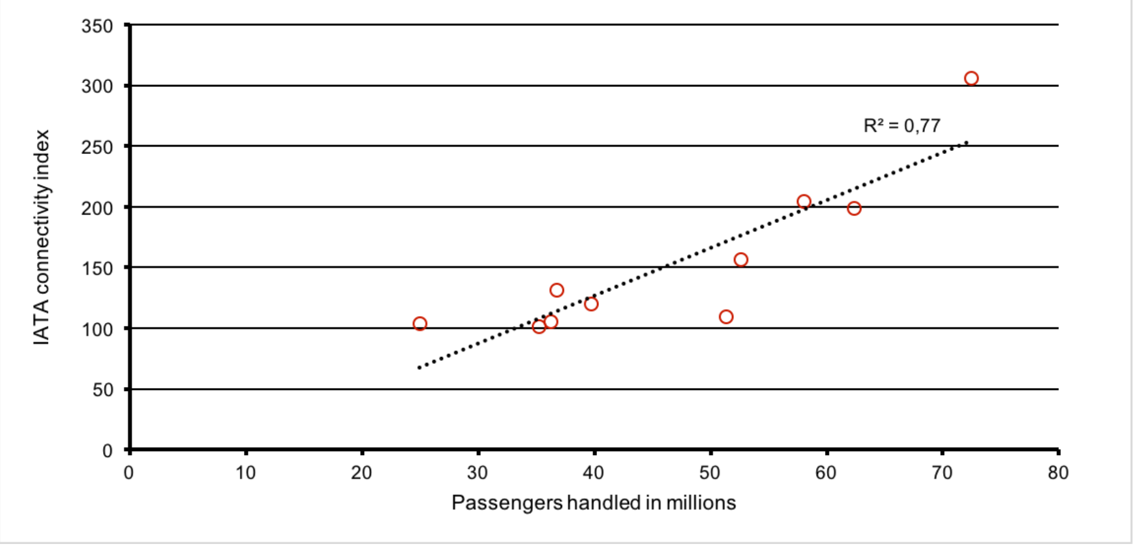
[30]For en extensive mathematical breakdown of this index, see Veldhuis (1997).

for both results in very strong and significant relationships with 86% (for NetScan) and 77% (for IATA) of the variances in connectivity scores being explained by the number of passengers handled per year. The number of passengers handled therefore is an appropriate proxy for an airport connectivity score and flaws in the results should be limited. Additionally, by using a simpler measure such as number of passengers handled, these results can be more easily interpreted policy debates. Regional policies regarding regional airports are mostly concerned with increasing traffic rather than network optimisation by increasing the quality of destinations as LCCs, which are the dominant carriers at regional airports, only operate point-to-point networks in which indirect connections do not play any significant role (Belobaba et al., 2015).



Sources: ACI Europe (2016c) and Eurostat (2018a).

Figure 4.1: Link between the NetScan connectivity index and the number of passengers handled, 2016



Sources: Eurostat (2018a) and InterVISTAS (2015).

Figure 4.2: Link between the IATA connectivity index and the number of passengers handled, 2013

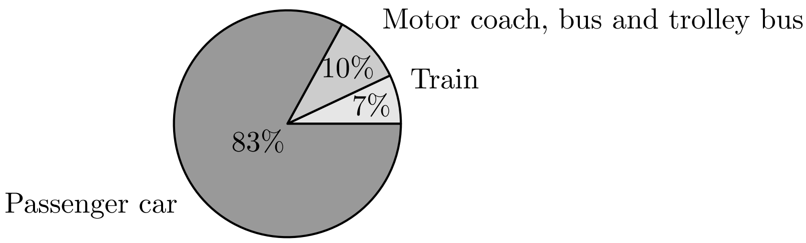
4.2 Air connectivity of a region

The air connectivity of a region (regional air connectedness) is based on the connectivity provided by all airports serving the region. Regional air connectedness is assessed through the size in terms of passengers handled of near airports while weighted for the distance to the region.

4.2.1 Assessing airport's catchment areas

The air connectedness of a region is determined by all airports that have a share of their catchment area in the region. In many cases regions are served by multiple airports, raising the need for finding a way to take multiple airports into account when evaluating regional levels of air connectedness. Defining catchment areas, however, is complex as these areas are influenced indirectly by the number and character of the air routes available from competing airports in the region (Lieshout, 2012; Reynolds-Feighan, 2010). Some (often long haul) air routes generate demand from larger areas, while more competitive destinations that are widely offered by other airports have more narrow catchment areas (Lieshout, 2012). LCCs, and thus regional airports may as well, often attract passengers from a wider geographical region than traditional carriers do, because the lower fares outweigh the costs of extra access time (Dresner et al., 1996; Gillen and Lall, 2004). Next to price and time sensitivity, consumer preference heterogeneity also holds for quality and type of service and other individual preferences (see Jung and Yoo, 2016; Paliska et al., 2016 and Pels et al., 2001). These observations entail that airports have no static catchment areas. However, it is beyond the scope of this thesis to extensively evaluate traveller's choice behaviour regarding airports. Therefore, the most common threshold of two hours (120 minutes) (see Malighetti et al., 2016; Paliska et al., 2016) access time is applied to estimate an airport's catchment area.

The only determinant for evaluating which airports are relevant for a region is travel time to the airport. Following Zuidberg and Veldhuis (2012), central node points are assigned based on population for every European NUTS-2 region and the assumption is made that the connectivity of the region equals the connectivity of its main centre (see appendix B for a list of regions and corresponding central nodes). These centres are likely to be most relevant for the economic performances of regions. The travel time T is defined by the driving time by car from the regional centre to an airport. These access times define the weight that represents the relevance of an airport for a region. The justification for using only road data is that the share of kilometres travelled by passenger car is by far the largest of all ground transport modes see (figure 4.3).



Source: Eurostat (2018d).

Figure 4.3: Modal split of EU passenger ground transport, in % of total kilometers travelled, 2015

The calculation of travel times between regional centres and airports is done by means of the Google Maps Distance Matrix API (Google, 2018). This is an accurate and reliable way to obtain the travel times that determine which airports are relevant for a region. When using a GIS network analysis, speeds would have to be assigned arbitrarily to all European road segments, leading to inevitable inaccuracies in the resulting travel times. However, it should be noted that the Google Maps Distance Matrix API uses very up to date 2018 data, which might be slightly off from the time frames this thesis handles.

After assessing airport access times, the next step in estimating regional air connectedness is to quantify the contribution of airports for the regions within their catchment areas. Following Zuidberg and Veldhuis (2012), this contribution decreases linearly with increasing access time to the airport until zero for airports further than 120 minutes away. The relevance of an airport for a region's connectedness is defined mathematically equation 4.1:

$$w_{ir} = \begin{cases} 0 & \text{if } T_{ir} > 120 \\ 1 - \frac{T_{ir}}{120} & \text{otherwise} \end{cases} \tag{4.1}$$

where: w_{ir} = weight of airport i for region r; and
T_{ir} = travel time by car in minutes to airport i with respect to region r.

It should be noted that some regions will have airports within their administrative boundaries that are more than 120 minutes away from their regional centre. In this case, these (often small) airports are not considered to contribute to the regional connectivity and economic development as they are not linked to the regional centre. As is argued in chapter 3, cities are considered to be the main drivers for regional development and therefore it would not harm to leave airports that are too far away from these regional centres out of the analysis. Additionally, nearby airports that are outside the EU and the Schengen Area are also considered to be not relevant for a region, as the access to the airport will not meet the assumption regarding free movement of people (see chapter 2).

4.2.2 Estimating regional air connectedness

Once the relevant airports and their weights are determined, the level of regional air connectedness can be calculated. The regional air connectedness of a region is assessed by taking the sum of the sizes of near airports, weighted for their distance with respect to the region. In the case when an airports has a larger access time than 120 minutes or when no passengers are handled at the airport, the contribution of that airport to a region's regional air connectedness is zero. When this measure is divided by regional population, the regional air connectedness per capita is obtained. The connectivity score is divided by the population to control for size of demand effects (i.e. regions large populations generally have higher initial demand for air services). This way, regional differences in population are controlled for (see equation 4.2).

$$CON_{rt} = \frac{\sum_{i \in N} pax_{it} w_{ir}}{pop_{rt}} \tag{4.2}$$

where: CON_{rt} = regional air connectedness per capita of region r in year t;
pax_{it} = size of airport i in year t;
pop_{rt} = population of region r in year t; and
w_{ir} = weight of airport i for region r.

The contribution of regional airports

As the total levels of regional air connectedness are defined by the sum of the contribution of regional airports, it is possible to determine the total contribution of regional airports. The threshold for an airport to be considered as 'regional' is based on maximum number of passengers handled to be eligible for receiving state aid (see table 2.2). When an airport handles on average 3 million passengers or less during the time frames considered in this thesis, the airport is marked to be 'regional'. The total contribution of regional airports to regional air connectedness can be evaluated as follows:

$$CONT_{rt} = \frac{\sum_{k \in K} pax_{kt} w_{kr}}{CON_{rt}} \times 100\% \tag{4.3}$$

where: $CONT_{rt}$ = contribution of regional airports to the total number of passengers handled in region r in year t;
pax_{kt} = passengers handled at regional airport k in year t;
w_{kr} = weight of regional airport k for region r; and
CON_{rt} = regional air connectedness per capita of region r in year t.

Example: Regional air connectedness Groningen (NL11), 2016

Tables 4.2 provides an example of how regional air connectedness and the contribution of regional airports are assessed for the Dutch region of Groningen (NL11). Four airports contribute to the regional air connectedness of the region, of which three are considered to be regional airports. Groningen-Eelde airport, has the largest weight attached due to its closeness to the regional central node. When summing the contribution of all regional airports, it is found that regional airports provide 6.5% of the region's air connectedness. Being the only main airport, Schiphol airport has the largest contribution to the regional air connectedness of the region (93.5%). While being farther away, and therefore having a lower weight, the initial size of the airport makes it the most essential airport for connecting the region by air.

Table 4.2: Regional air connectedness, Groningen (NL11), 2016

IATA	Name	Regional airport	T_{iNL11}	w_{iNL11}	$pax_{i2016} \times \mathrm{w}_{i2016}$
AMS	Schiphol	No	104	0.13	8,497,689
BRE	Bremen	Yes	103	0.14	364,958
FMO	Münster-Osnabrück	Yes	113	0.06	45,291
GRQ	Groningen-Eelde	Yes	14	0.88	179,941
Total					9,087,880
Per capita*					15.57
Regional					590,190
Per capita*					1.01
Contribution					6.5%

*$pop_{NL112016} = 583,721$

4.3 The role of regional airports as regional economic catalysts

Air transport should provide businesses with access to outside markets and facilitate businesses in a globalising market (see Aguilera, 2008; Bowen, 2002; Brueckner, 2003; Button et al., 1999; Carod et al., 2010; Rosenthal and Strange, 2004; Wickham and Vecchi, 2008). Therefore, regions with high levels of air connectedness should perform better. GDP per capita is the central measure for summarizing the economic output and position of a country or region. It is comprised of all economic interactions and transactions within an economy. This makes GDP an appropriate way to catch catalytic effects from air traffic. In order to correct for price level differences between countries, purchasing power parities (PPPs)[31] are used to obtain a purchasing power standard (PPS). This way, comparing GDP per capita levels between countries is not hindered by differences in price levels in the economic transactions underlying the calculation of regional GDP. This section provides the models used to evaluate the role of regional air connectedness in generating GDP, with special attention to regional airports.

Variable definition

Control variables are implemented to control for other factors than regional air connectedness that may contribute to regional economic output. Next to access to transportation and infrastructure services, it is widely accepted that factors such as market access, physical geography, institutional quality, political stability and openness of trade all contribute to regional economic development (Breinlich et al., 2014). While these factors are difficult to control for, there is a wide consensus that regional prosperity and the amount human capital are strongly associated (see Glaeser and Gottlieb, 2009; Moretti, 2012) Therefore, when linking the growth of regional airports with GDP, a control variable related to higher education level needs to be implemented. In this thesis, a measure capturing the number of people that have attained tertiary education is used. External effects, such as MAR-externalities, resulting from spatial concentration may also contribute to the performance of a region (Brakman et al., 2009; Glaeser et al., 1992). Therefore, a control variable representing population density is implemented to capture agglomeration economies. Additionally, the dominance of globally competitive firms in regional economic development is associated with the density of knowledge (Simmie, 2004). Control variable regarding the spending in research and development and the employment in technology and knowledge-intensive sectors are implemented. Finally, regional dummies are added to control for any unmodelled factors. Table 4.3 describes all variables used in the regression models and figure 4.4 depicts the regional subdivision concerning the regional dummies.

[31]PPPs are obtained by comparing price levels of comparable goods and services that are selected to be representative of consumption patterns in comparing countries.

Table 4.3: Variable descriptions

Variable	Description
Main	
CON_{rt}	Level of regional air connectedness per capita of region r in year t
ΔCON_{rt}	Change in regional air connectedness of region r during t, in %
GDP_{rt}	Level of GDP per capita in PPS in region r in year t
ΔGDP_{rt}	Change in GDP per capita in PPS in region r during t, in %
Control	
DEN_{rt}	Population density in region r in year t
EDU_{rt}	Persons with tertiary education in region r as % of total population in year t
KI_{rt}	Employment in technology and knowledge-intensive sectors, as % of total employment in region r in year t
RD_{rt}	Inmural research and development expenditure in € per capita in region r in year t
Regional dummies	
$BRIT$	Dummy representing regions in Ireland and the United Kingdom
$EAST$	Dummy representing regions in Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithouania, Poland, Romania, Slovakia and Slovenia
$NORTH$	Dummy representing regions in Denmark, Finland and Sweden
$SOUTH$	Dummy representing regions in Cyprus, Greece, Italy, Malta, Portugal and Spain
$WEST$	Dummy representing regions in Austria, Belgium, France, Germany, Luxembourg and the Netherlands

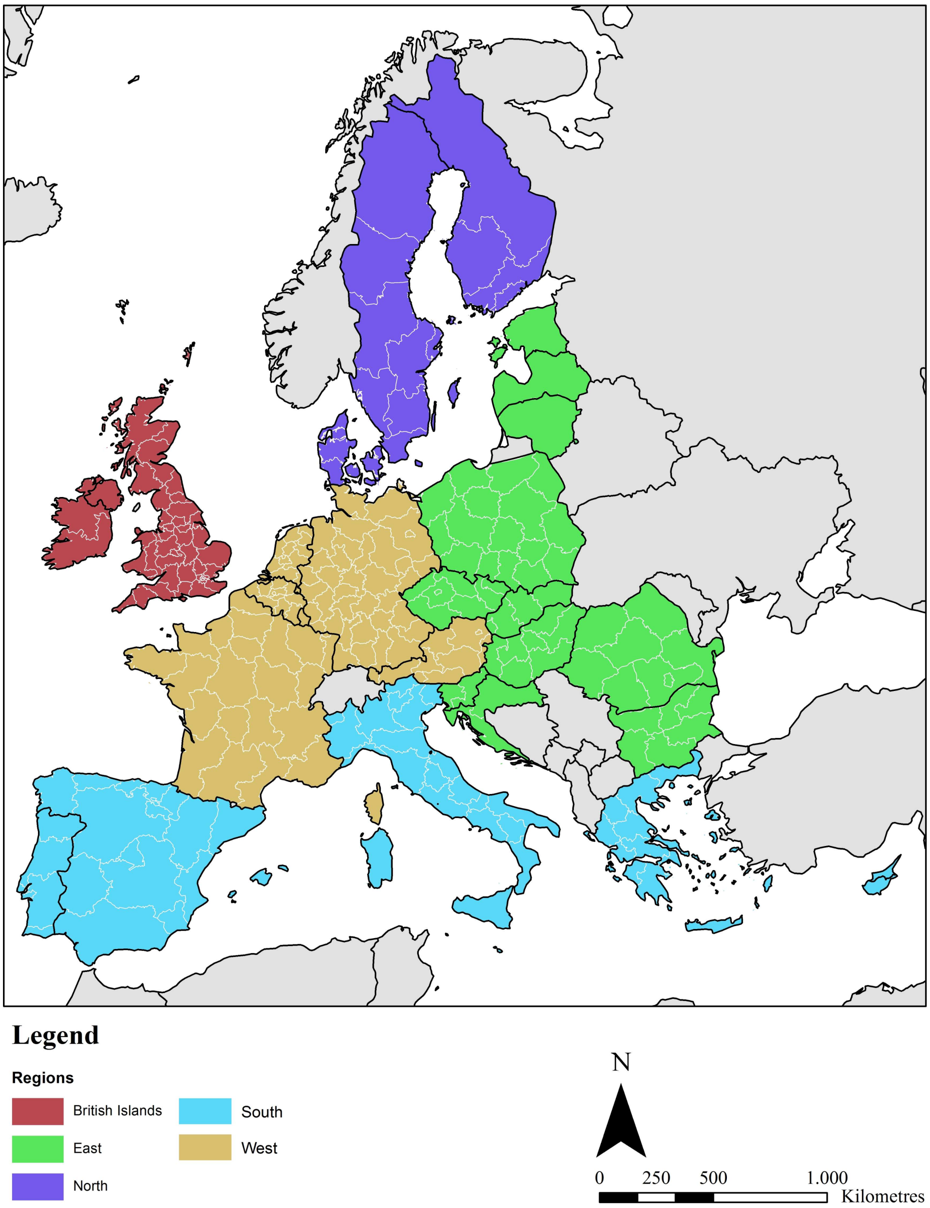


Figure 4.4: Regional subdivision of Europe

4.3.1 Estimating the correlation between regional air connectedness and GDP

An ordinary least squares (OLS) regression model is used to evaluate whether the level of regional air connectedness is correlated with the level of regional economic output. For the year 2016, regional levels in GDP per capita in PPS are regressed with regional air connectedness measures. All models are run for both all airports and regional airports only. This way it can be evaluated how regional air connectedness originating from regional airports only relates to the level of GDP compared with the situation when considering all airports.

OLS models setup

The OLS regression analysis is performed in three stages: stage 1 only incorporates the variables of interest, stage 2 adds the control variables and stage 3 adds dummies for European regions. A log-log formulation is used to correct for the skewness of the distributions of the variables considered. Additionally, extreme outlying cases are excluded as well.

Stage 1

$$\ln GDP_{r2016} = \beta_0 + \beta_1 \ln CON_{r2016} + \varepsilon_{r2016} \tag{4.4}$$

Stage 2

$$\begin{aligned} \ln GDP_{r2016} = \beta_0 &+ \beta_1 \ \ln CON_{r2016} + \beta_2 \ \ln EDU_{r2016} \\ &+ \beta_3 \ln RD_{r2016} + \beta_4 \ln DEN_{r206} + \beta_5 \ln KI_{r206} + \varepsilon_{r2016} \end{aligned} \tag{4.5}$$

Stage 3

$$\begin{aligned} \ln GDP_{r2016} = \beta_0 &+ \beta_1 \ \ln CON_{r2016} + \beta_2 \ \ln EDU_{r2016} \\ &+ \beta_3 \ln RD_{r2016} + \beta_4 \ln DEN_{r206} + \beta_5 \ln KI_{r206} \\ &+ \beta_6 \ BRIT + \beta_7 \ EAST + \beta_8 \ NORTH \\ &+ \beta_9 \ SOUTH + \beta_{10} \ WEST + \varepsilon_{r2016} \end{aligned} \tag{4.6}$$

For the OLS model the following hypothesis is considered:

H_0: There is no linear relationship between the level of regional air connectedness per capita and GDP per capita in PPS.

H_1: There is a linear relationship between the level of regional air connectedness per capita and GDP per capita in PPS.

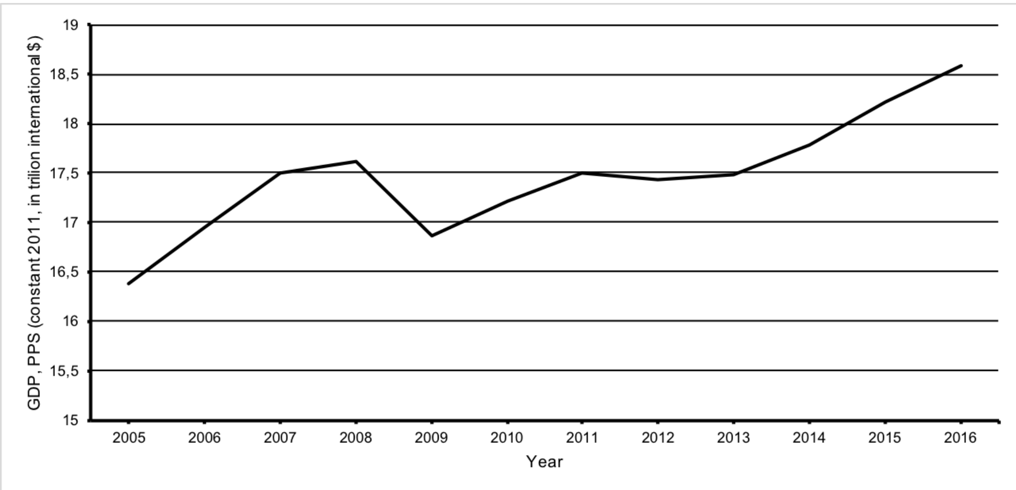
4.3.2 Granger causality

An OLS regression analysis can demonstrate correlation but does not necessarily demonstrate causality. Any correlation between air traffic or regional air connectedness and GDP levels are constrained by causality issues (Green, 2007). The level GDP could be explained by air connectivity, however it could also very much be possible that it is the other way around. To overcome this causality problem, a time frame analysis is performed. While controlling for variables related to GDP growth it is evaluated whether growth of regional airports can be significantly linked to the growth of GDP in a subsequent time frame through by means of a Granger causality analysis.

Granger causality analysis is a forecasting technique introduced by C. Granger to determine whether values of a dependent variable Y_t can be improved by considering lags of regressor X_t (Granger, 1969). A variable X that changes over time 'Granger-causes' another changing variable Y if values of Y are predicted better when considering its own past values and the past values of X than when only considering the past values of Y. This is evaluated by means of an Autoregressive Distributed Lag (ADL) model. An ADL(p,q) model is a linear regression in which Y_t is regressed on p lags of Y and q lags of X. In this thesis, two time frames are considered and therefore one lag is included in the ADL model. In this case where one lag is considered, a regressor X is said to 'Granger-cause' Y if the t-statistic of the lagged value of X is significant.

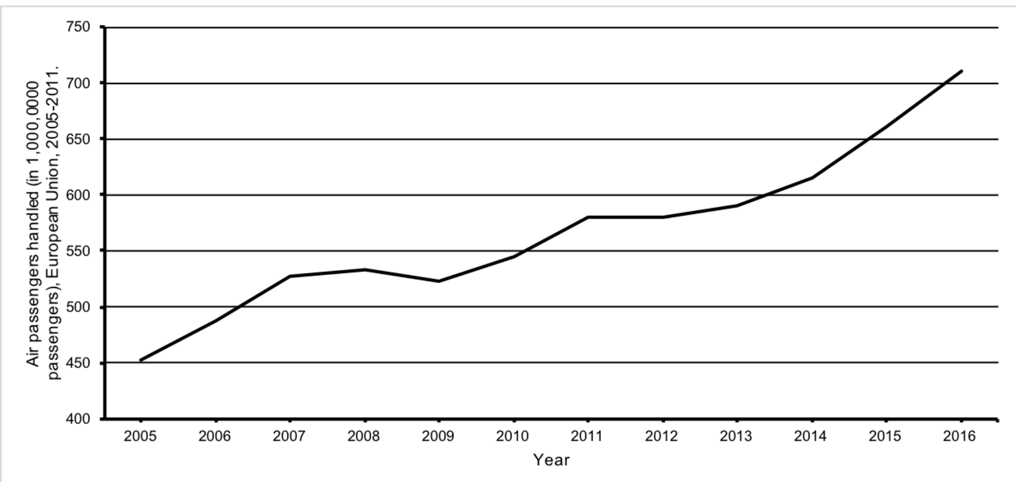
Time frames definition

In order to define correct time frames for the historical analysis, it needs to be mentioned that GDP growth is not something that happens overnight. The catalytic effects of growing air connectedness need time to consolidate before these can also be seen in GDP figures. Therefore, a consolidation time of 5 years is considered. Using the most recent available data this would entail a time frame from 2011 to 2016. A logical preceding period for evaluating a regional airport's connectedness contribution would be the five years before that, 2006-2011. However, this comes with one remark: the economic crisis that emerged in 2008 had major impacts on both air traffic as well as GDP development (see figures 4.5 and 4.6), which might hinder the analysis using these time frames. Both measures show very similar trends. In 2009 both GDP and air traffic dropped. By 2011 both measures caught up and from then on follow an almost identical trend again. As the impact of the economic crisis of 2008 regarding air traffic already deceases within this time frame, it should not harm to use the 2006-2011 time frame to evaluate both trends.



Source: World Bank (2018b).

Figure 4.5: GDP in PPS trend, European Union, 2005-2016



Source: World Bank (2018c).

Figure 4.6: Air traffic trend, European Union, 2005-2016

ADL(1,1) models setup

Applying the Granger causality technique within the scope of this thesis entails that it is tested whether the growth of regional air connectedness results in growth of GDP or the other way around. For the first analysis, the dependent variable is therefore defined as the growth of GDP in time frame 2. For the opposite direction, the growth of regional air connectedness in time frame 2 is regressed with the growth of GDP in time frame 1. Again, the first stage only incorporates the variables of interest, the second adds relevant variables and stage 3 adds dummies for European regions. Also, all ADL(1,1) models are run for both all and only regional airports. Extreme outliers are again excluded.

The ADL(1,1) models used for evaluating causality between growth of regional connectedness in time frame 1 and growth of GDP in time frame 2 are depicted below. An additional control variable representing the level of GDP at the end of time frame 1 is included to correct for the fact that high levels of growth in terms of percentages is more easily reached with lower initial levels of GDP.

Stage 1

$$\Delta GDP_{r2011-2016} = \beta_0 + \beta_1\ \Delta GDP_{r2006-2011} + \beta_2\ \Delta CON_{r2006-2011} + \varepsilon_{r2011-2016} \tag{4.7}$$

Stage 2

$$\begin{aligned} \Delta GDP_{r2011-2016} = \beta_0 &+ \beta_1\ \Delta GDP_{r2006-2011} + \beta_2\ \Delta CON_{r2006-2011} \\ &+ \beta_3 EDU_{r2011} + \beta_4 GDP_{r2011} + \beta_5 DEN_{r2011} \\ &+ \beta_6 RD_{r2011} + \beta_7 KI_{r2011} + \varepsilon_{r2011-2016} \end{aligned} \tag{4.8}$$

Stage 3

$$\begin{aligned} \Delta GDP_{r2011-2016} = \beta_0 &+ \beta_1\ \Delta GDP_{r2006-2011} + \beta_2\ \Delta CON_{r2006-2011} \\ &+ \beta_3 EDU_{r2011} + \beta_4 GDP_{r2011} + \beta_5 DEN_{r2011} \\ &+ \beta_6 RD_{r2011} + \beta_7 KI_{r2011} + \beta_8\ BRIT + \beta_9\ EAST \\ &+ \beta_{10}\ NORTH + \beta_{11}\ SOUTH + \beta_{12}\ WEST + \varepsilon_{r2011-2016} \end{aligned} \tag{4.9}$$

Regarding these models the following hypothesis is tested:

H_0: The growth of regional air connectedness does not 'Granger-cause' growth of GDP per capita in PPS.

H_1: The growth of regional air connectedness 'Granger-causes' the growth of GDP per capita in PPS.

For evaluating the causal relationship in the opposite direction, only control variables regarding population density and the level of GDP are included. These factors are considered to be main forecasting variables on which airlines base their route and frequency planning (Belobaba et al., 2015). Again, extreme outliers are excluded.

Stage 1

$$\Delta CON_{r2011-2016} = \beta_0 + \beta_1\ \Delta CON_{r2006-2011} + \beta_2\ \Delta GDP_{r2006-2011} + \varepsilon_{r2011-2016} \tag{4.10}$$

Stage 2

$$\begin{aligned} \Delta CON_{r2011-2016} = \beta_0 &+ \beta_1\ \Delta CON_{r2006-2011} + \beta_2\ \Delta GDP_{r2006-2011} \\ &+ \beta_3 GDP_{r2011} + \beta_4 DEN_{r2011} + \varepsilon_{r2011-2016} \end{aligned} \tag{4.11}$$

Stage 3

$$\begin{aligned}\Delta CON_{r2011-2016} = \beta_0 + \beta_1\ \Delta CON_{r2006-2011} + \beta_2\ \Delta GDP_{r2006-2011} \\ + \beta_3 GDP_{r2011} + \beta_4 DEN_{r2011} + \beta_5 BRIT + \beta_6 EAST \\ + \beta_7\ NORTH + \beta_8\ SOUTH + \beta_9\ WEST + \varepsilon_{r2011-2016}\end{aligned} \tag{4.12}$$

Regarding these models the following hypothesis is tested:

H_0: The growth of GDP per capita in PPS does not 'Granger-cause' growth of regional air connectedness.

H_1: The growth of GDP per capita in PPS 'Granger-causes' growth of regional air connectedness.

Chapter 5

Results

In this chapter all model results are presented. First, levels of regional air connectedness and the contribution of regional airports to that are evaluated. Afterwards model results regarding the relationship between regional air connectedness and levels of GDP for both including all airports and considering regional airports only are presented.

5.1 Regional air connectedness across Europe

This section presents how well regions are connected through the air and how regional airports contribute to that. As described in section 4.2.2, the level of regional air connectedness of a region is defined by the sum of the sizes of all airports within reach of a region while being weighted for their distance to the region. Next to that a measure is included, that corrects the level of regional air connectedness for regional population (CON). When population is high, the demand for air traffic would naturally be higher The latter measure is also used to model the relationship between air connectivity and regional GDP figures. Figure 5.1 depicts the total uncorrected regional air connectedness, while figure 5.2 presents regional air connectedness levels per capita.

Larger airports are, logically, mostly located near metropolitan areas. Regions that have access to large airports, obviously have high levels of regional air connectedness. This pattern is very well reflected in levels of total regional air connectedness. Connectedness levels are particularly high along the 'Blue Banana' corridor running from London to Milan. This is also the area where airport competition is considered to be very high (Lieshout et al., 2016). However, this is a rather natural matter as these densely populated places are likely to generate more demand and thus opportunities for airports to grow. More remarkable is that a very similar pattern occurs when levels of regional air connectedness are corrected for regional population size. The most connected areas still include regions located along the corridor and other metropolitan areas. Levels are particularly high in the United Kingdom, Belgium, the Netherlands and Western and Southern parts of Germany. The lowest values of regional air connectedness are found in peripheral European regions. These regions include peripheral parts of Greece, France, Spain and Southern Italy and large parts of Eastern Europe. The Polish regions of Podlaskie and Warminsko-Mazurskie as well as the Romanian Centru region and the Bulgarian region of Severozapaden even have no airport providing any regional air connectedness. See appendix C for a complete overview of regional air connectedness levels.

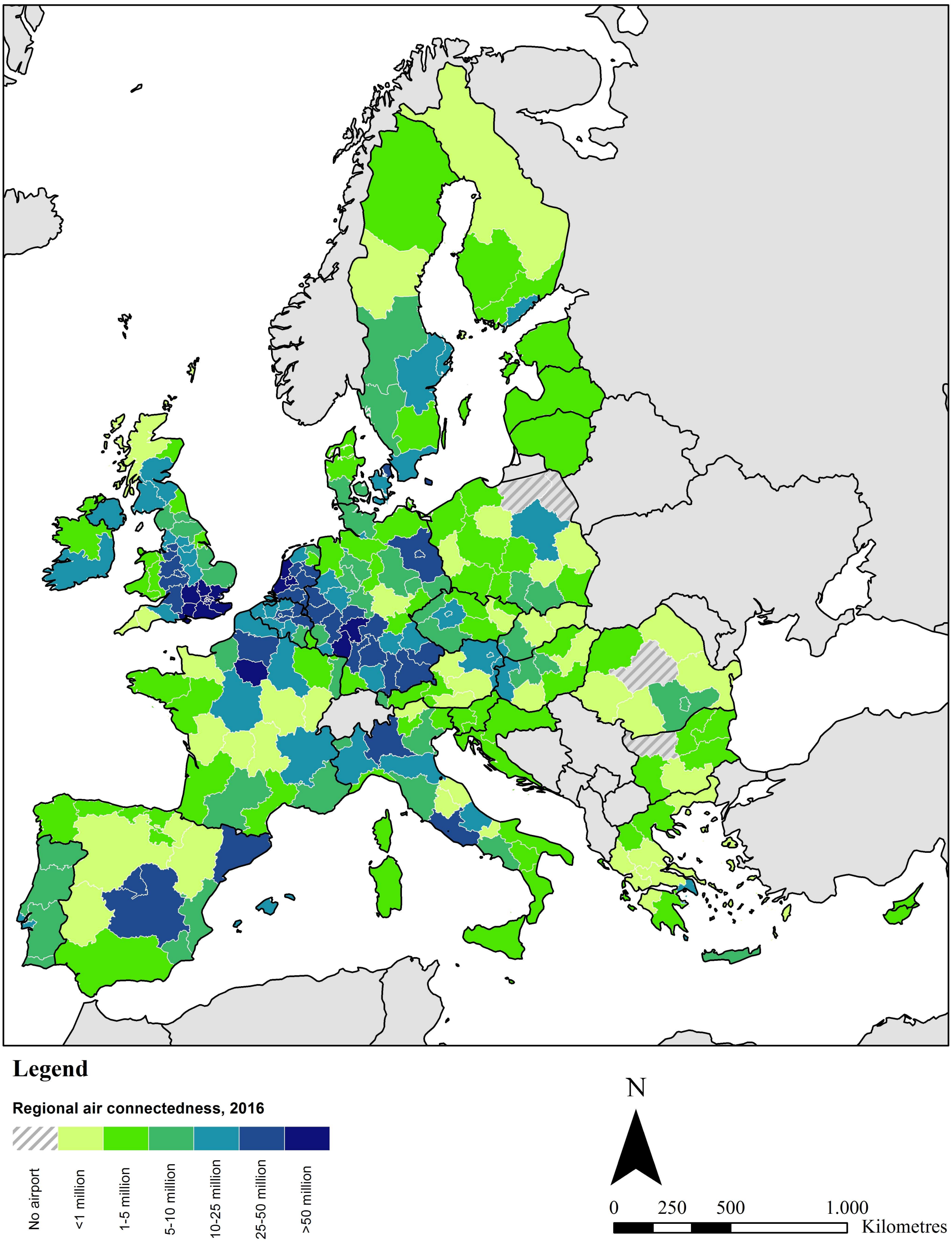


Figure 5.1: Regional air connectedness, 2016

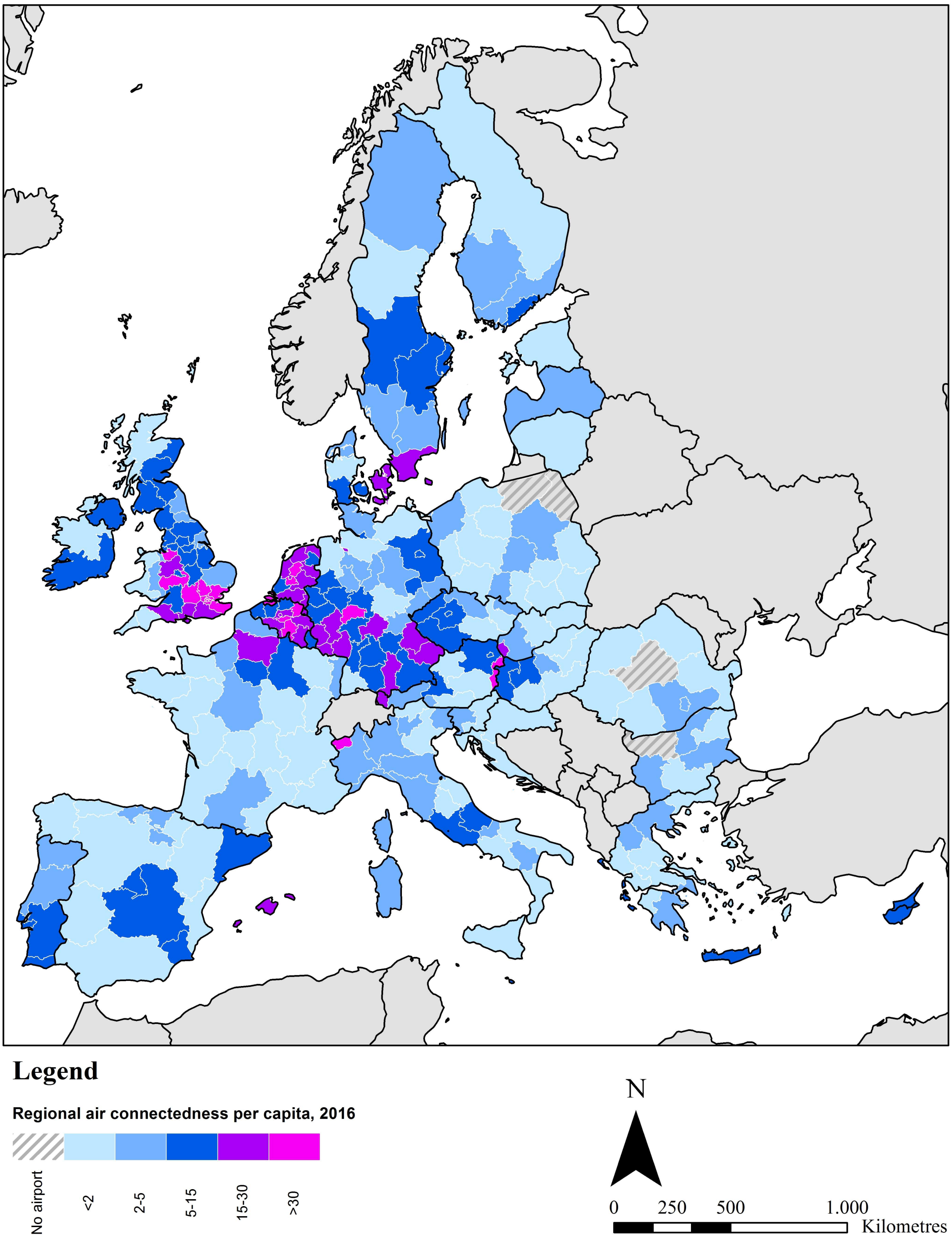


Figure 5.2: Regional air connectedness per capita, 2016

5.1.1 The contribution of regional airports

Many local stakeholders argue that even though regional airports are small, they play a vital role in connecting European regions by air. This is evaluated by assessing the contribution of regional airports to the total level of regional air connectedness, as described in section 4.2.2. Figure 5.3 depicts the contribution of regional airports as percentages of the total regional air connectedness in 2016. Figure 5.4 presents the corresponding frequency distribution.

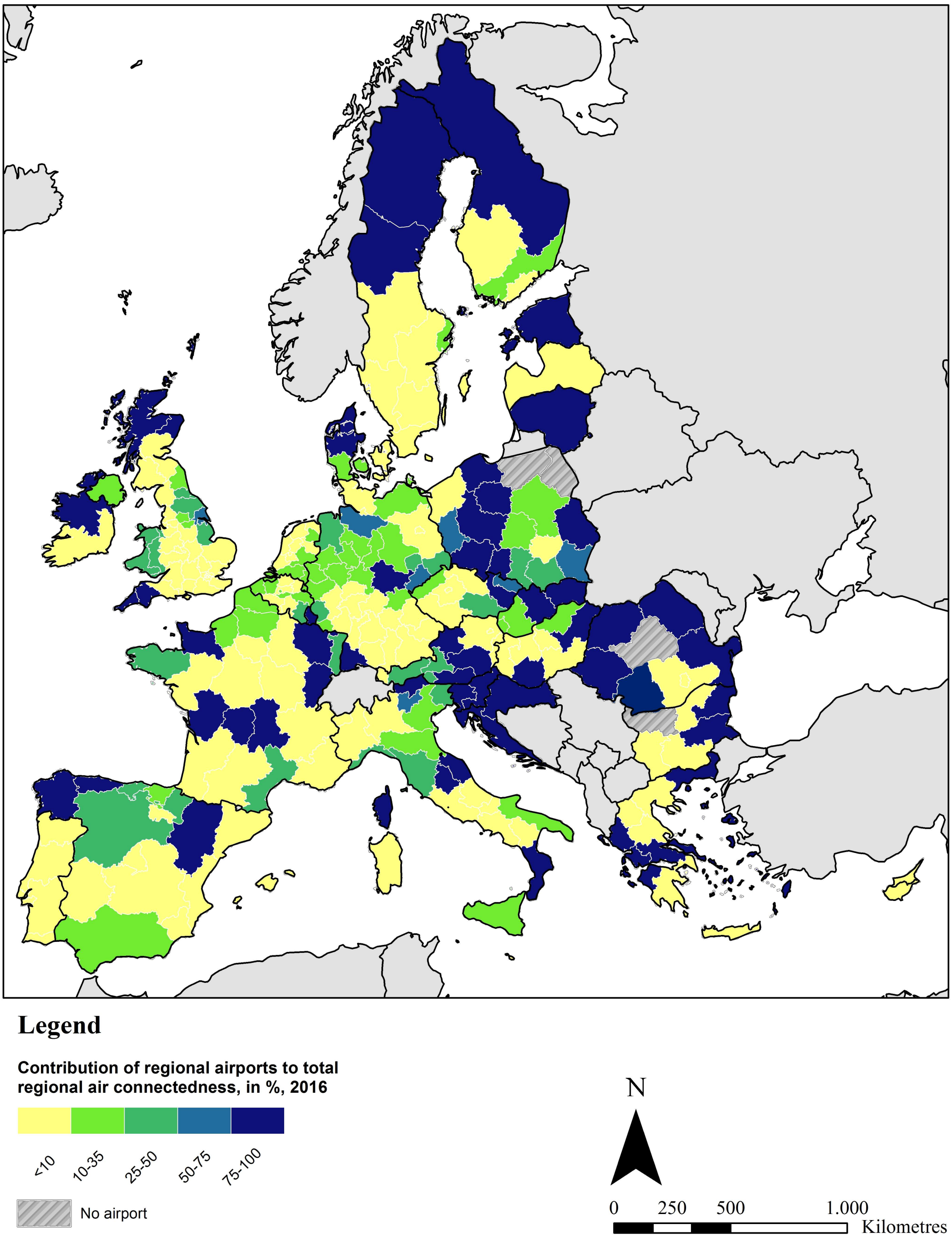


Figure 5.3: Contribution of regional airports to total regional air connectedness, 2016

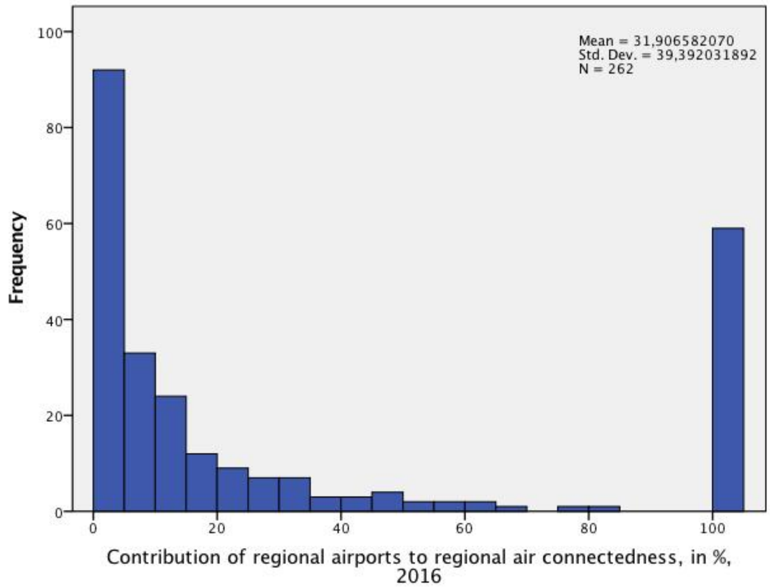


Figure 5.4: Frequency distribution of regional airports' contribution to regional air connectedness, 2016

There is great disparity across Europe with respect to the role of regional airports in contributing air connectedness. For most regions, this contribution is found to be very low. However, for 59 European regions regional air connectedness is solely provided by regional airports (see table 5.1). In total these regions inhabit almost 80 million people (Eurostat, 2018e) The entire countries of Croatia, Estonia, Lithuania and Slovenia fully depend on regional airports for their air connectedness. Furthermore, examples include the Northern parts of Scandinavia, the Northern parts Scotland, South-West England, Southern Italy and almost all of Poland's and Romania's border regions. Additionally, island groups also seem to be very dependent on regional airports for their air connectedness.

Table 5.1: Regions served by regional airports only, 2016

Country	**NUTS 2 region(s)**
Austria	Carinthia, Styria, Upper Austria
Bulgaria	North-East, South-East
Croatia	Continental Croatia, Adriatic Croatia
Czechia	Central Moravia
Denmark	Central Jutland, North Jutland
Estonia	Estonia*
Finland	Northern and Eastern Finland
France	Auvergne, Corsica, Franche-Comté, Limousin, Lorraine, Lower Normandy, Poitou-Charentes
Germany	Freiburg, Thüringen
Greece	Central Greece, Eastern Macedonia and Thrace, Epirus, Ionian Islands, North Aegean, South Aegean, Western Greece
Hungary	Great Hungarian Plains, Southern Transdanubia
Ireland	Border Midland and Western

Table 5.1 continued: Regions served by regional airports only, 2016

Country	**NUTS 2 region(s)**
Italy	Marche, South Tyrol, Umbria
Lithuania	Lithuania*
Poland	Greater Poland, Lower Silesia, Lublin, Pomerania
Romania	North-East, North-West, South-West, West
Slovakia	Central Slovakia, Eastern Slovakia
Slovenia	Eastern Slovenia, Western Slovenia
Spain	Aragón, Galicia, Principality of Asturias
Sweden	Middle Norrland, Upper Norrland
United Kingdom	Cornwall and Isles of Scilly, Devon, Highlands and Islands, North Eastern Scotland,

*Region comprises whole country

Table 5.2 presents a correlation matrix linking the contribution of regional airports to regional air connectedness to regional measures. This contribution is moderately negatively associated with the general level of regional air connectedness. Regions that highly depend on regional airports for their air connectedness are, in general, less connected than regions that inhabit major airports. Additionally, the contribution of regional airports is moderately negatively associated with GDP levels and population density. This entails that regional airports are particularly important in connecting peripheral and sparsely populated regions. One striking exception is the country of Luxembourg. While having a very high GDP, the contribution of regional airports to regional air connectedness is 81%.

Table 5.2: Correlation matrix for the contribution of regional airports to regional air connectedness

Variable	1.	2.	3.	4.
1. CON_{r2016}	1			
2. $CONT_{r2016}$	-0.467***	1		
3. GDP_{r2016}	0.397***	-0.259***	1	
4. DEN_{r2016}	0.312***	-0.224***	0.378***	1

***$p < 0.01$

5.2 Regional air connectedness and economic growth

5.2.1 OLS regression results

OLS models are performed to provide an intuition on the relationship between regional air connectedness and GDP levels for all as well as only regional airports within a single time frame. Table 5.3 presents a correlation matrix regarding the variables involved. Table 5.4 displays the OLS model results. Please note that the OLS model represents log-log formulation and therefore all coefficients should be interpreted as elasticities.

From the correlation matrix it can be distilled that the overall level of regional air connectedness is moderately positive and significantly correlated with the level of GDP in a region. However, when only considering regional airports this positive relationship is found to be weak. With respect to the control variables, population density, the percentage of population having attended higher education, the percentage of population working in knowledge intensive industries are all moderately positively correlated with GDP levels. The level of in-mural spending to R&D is strongly correlated with GDP. The total level of regional air connectedness per capita is moderately positively associated with population density, percentage of people with higher education and the percentage of people working in knowledge intensive sectors. For regional airports, these correlations are not present or negligible.

Regarding the OLS model, the first stage only connecting regional air connectedness and GDP per capita shows that a 1% increase in regional air connectedness is associated with a 0.108% higher level of GDP with an explained variance of 26%. For regional airports only a 1% rise is associated with a 0.05% higher level of GDP with only 5% of the variance in GDP levels explained. When adding control variables and regional dummies in stage 2 and 3, the level of regional air connectedness loses explanatory power. Considering the best-fit model, a 1% increase in regional air connectedness is associated with a 0.022% higher level of GDP with an explained variance of 76%. Considering only regional airports in stage 3 of the model, a 1% increase in regional air connectedness is associated with a 0.015% higher level of GDP (however with lower significance) with an explained variance of 75%. With respect to the control variables, population density, tertiary education attainment and investments in research and development are found to be linearly related with levels of GDP. Summarising, the level of regional air connectedness is positively linearly related to the level of GDP per capita when considering both all airports as well as only regional airports. In the case of regional airports, however, this relationship is found to be weaker.

Table 5.3: Correlation matrix for OLS regression model variables

	Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	GDP_{r2016}	1											
2.	CON_{r2016} (all airports)	0.397***	1										
3.	CON_{r2016} (regional airports)	0.136**	0.377***	1									
4.	DEN_{r2016}	0.378***	0.312***	-0.032	1								
5.	EDU_{r2016}	0.497***	0.335***	0.112*	0.386***	1							
6.	KI_{r2016}	0.543***	0.466***	0.175***	0.394***	0.746***	1						
7.	RD_{r2016}	0.701***	0.196***	0.070	0.123*	0.442***	0.465***	1					
8.	$BRIT$	-0.008	0.234***	-0.035	0.252***	0.483***	0.416***	0.001	1				
9.	$EAST$	-0.407***	-0.229***	-0.103	-0.109*	-0.334***	-0.515***	-0.339***	-0.221***	1			
10.	$NORTH$	0.169**	-0.051	0.005	-0.083	0.217***	0.310***	0.255***	-0.132**	-0.140**	1		
11.	$SOUTH$	-0.197***	-0.235***	-0.131**	-0.130***	-0.284***	-0.378***	-0.266***	-0.215***	-0.227***	-0.136**	1	
12.	$WEST$	0.399***	0.217***	0.212***	0.041	-0.001	0.222***	0.343***	-0.357***	-0.378***	-0.227***	-0.368***	1

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

Table 5.4: OLS regression results predicting GDP per capita in PPS, 2016

	All airports			**Regional airports**		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	10.033***	8.528***	8.202***	10.222***	8.530***	8.316***
	(0.023)	(0.206)	(0.271)	(0.024)	(0.202)	(0.288)
$\ln CON_{r2016}$	0.108***	0.022**	0.024***	0.050***	0.015*	0.015*
	(0.011)	(0.009)	(0.009)	(0.015)	(0.008)	(0.008)
$\ln DEN_{r2016}$		0.035***	0.046***		0.042***	0.060***
		(0.011)	(0.012)		(0.010)	(0.012)
$\ln EDU_{r2016}$		0.013	0.090*		0.040	0.121**
		(0.048)	(0.050)		(0.053)	(0.055)
$\ln KI_{r2016}$		0.047	0.086		0.012	0.018
		(0.078)	(0.087)		(0.082)	(0.095)
$\ln RD_{r2016}$		0.213***	0.193***		0.219***	0.193***
		(0.013)	(0.015)		(0.014)	(0.016)
$BRIT$			-0.155***			-0.145***
			(0.037)			(0.037)
$EAST$			-0.025			-0.049
			(0.044)			(0.046)
$NORTH$			0.024			0.046
			(0.035)			(0.051)
$SOUTH$			0.031			0.021
			(0.035)			(0.039)
Observations	258	258	258	231	231	231
R^2	0.26	0.73	0.76	0.05	0.73	0.75

Standard errors in parentheses.
$^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

5.2.2 Causality analysis results

While OLS estimates proves linear associations between independent and dependent variables, they do not necessarily imply causation. In the case of connecting connectedness with GDP, there are grounds to assume that causation can be two-way. In which direction causality runs is evaluated by 'Granger causality' tests by using ADL(1,1) models (see section 4.3.2).

Regional air connectedness and GDP over time

Figures 5.5 and 5.6 pictures the changes in GDP in European regions during both time frames. Regarding the first time frame, most growth in GDP is found in Eastern European regions in the Baltic, Bulgaria, Hungary, Poland, Romania and Slovakia. Regions in Central Europe and Scandinavia on average show a slight growth. However, for regions in Britain, the Iberian peninsula and particularly Greece, it is very clear that most regions have not caught up with the GDP levels from before the economic crisis by the end of time frame 1 (in 2011). Looking at time frame 2, the picture seems more stable. Most European regions, including regions that declined between 2006 and 2011, experienced a growth in GDP between 2011 and 2016. However, larger parts of Greece and Cyprus and some regions in Italy and France show some decline. The region of Groningen (NL11) in the Netherlands has seen the greatest decline. In previous years, the region's GDP was artificially high due to natural gas reserves. Between 2011 and 2016, the excavation of natural gas has declined dramatically in the region.

Regarding changes in regional air connectedness levels, figure 5.7 depicts the development between 2006 and 2011 and figure 5.8 between 2011 and 2016 with respect to all airports. During the first time frame, most continental European regions have seen air connectedness rising. Most growth is found in Eastern Europe, especially in Bulgarian, Polish and Romanian regions. Strikingly, regions on the British isles have seen the greatest declines as a result from declines in passenger numbers. Some regions in France also experienced decline, due to airport closures (see figure 2.1). Looking at the second time frame (figure 5.8), most European have grown in terms of regional air connectedness. Again, Eastern European regions do considerably well. Additionally, Portuguese regions show striking increases in regional air connectedness. Most decline is found in Spain, with exception from the Eastern coastal regions, while most of these regions actually experienced growth during the firs time frame. When looking at regional airports only, a different picture arises. Growth in regional air connectedness from regional airports during the first time frame was particularly high in Belgium, (Southern) Italy, Poland, Romania and large parts of the Netherlands. Most regions in England, Scotland and Slovakia experienced a decline. Other European countries do not show any unambiguous pattern. During the second time frame between 2011 and 2016, still, larger parts of Belgium, the Netherlands, Poland and Romania experience growth. Most decline is found in Austria, Czechia, Spain and the more densely populated regions of Finland and Sweden. Other countries, again, show rather ambiguous patterns. It should be noted that some regions have no regional airport contributing to air connectedness.

It is beyond the scope of this thesis to evaluate the regional air connectedness and GDP development of individual regions. However the correlation matrix in table 5.5 provides a general intuition on the associations between these measures. When considering associations within the same time frame, the development of regional air connectedness with respect to all airports is moderately positively correlated with the development of GDP within time frame 1 (0.332). During the second time frame, this positive association holds, however being weaker (0.220). Looking at regional airports only, a slightly positive relationship exists between the development of GDP and regional air connectedness during time frame 1 (0.283). During time frame 2, a weak negative association has been found (-0.127), however with very weak significance. Positive associations have been found for the relationship between regional air connectedness development regarding all airports and regional airports only, although this relationship has been found to be stronger for time frame 1 (0.685) than for time frame 2 (0.142). When comparing different time frames, the developments of regional GDP in both time frames are moderately positively associated (0.421), reflecting when regions have experience growth during the first time frame are moderately likely to have grown during the second time frame. Additionally, a slightly positive association is found between the development of GDP between 2006 and 2011 and the development of regional air connectedness with respect to all airports between 2011 and 2016 (0.146).

While these correlations give an intuition on how GDP and regional air connectedness measures are associated over time, no conclusions can be drawn regarding causality. This causation issue is tackled by testing for 'Granger causality' through ADL(1,1) models in the following subsections.

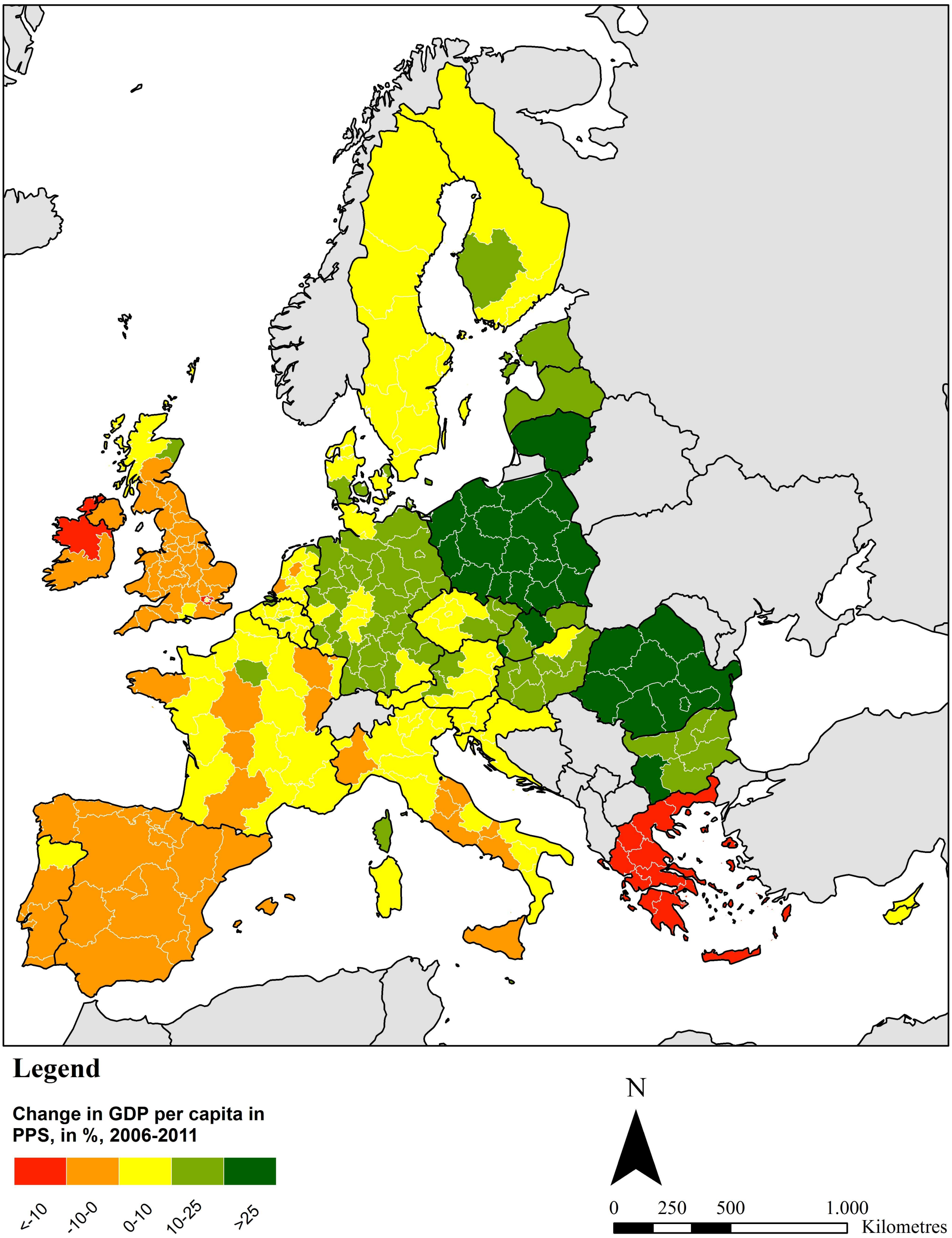


Figure 5.5: Change in GDP per capita in PPS, 2006-2011

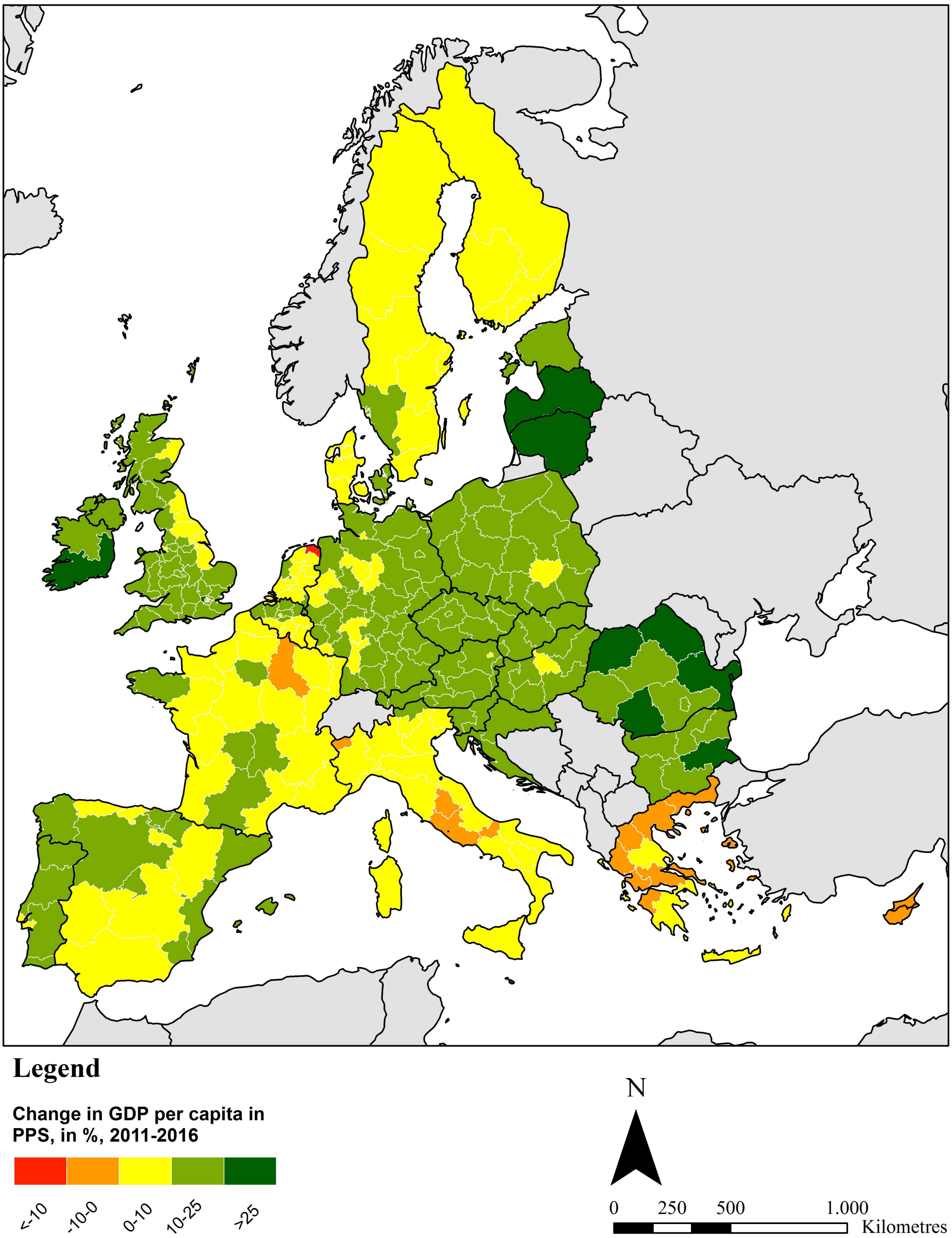


Figure 5.6: Change in GDP per capita in PPS, 2011-2016

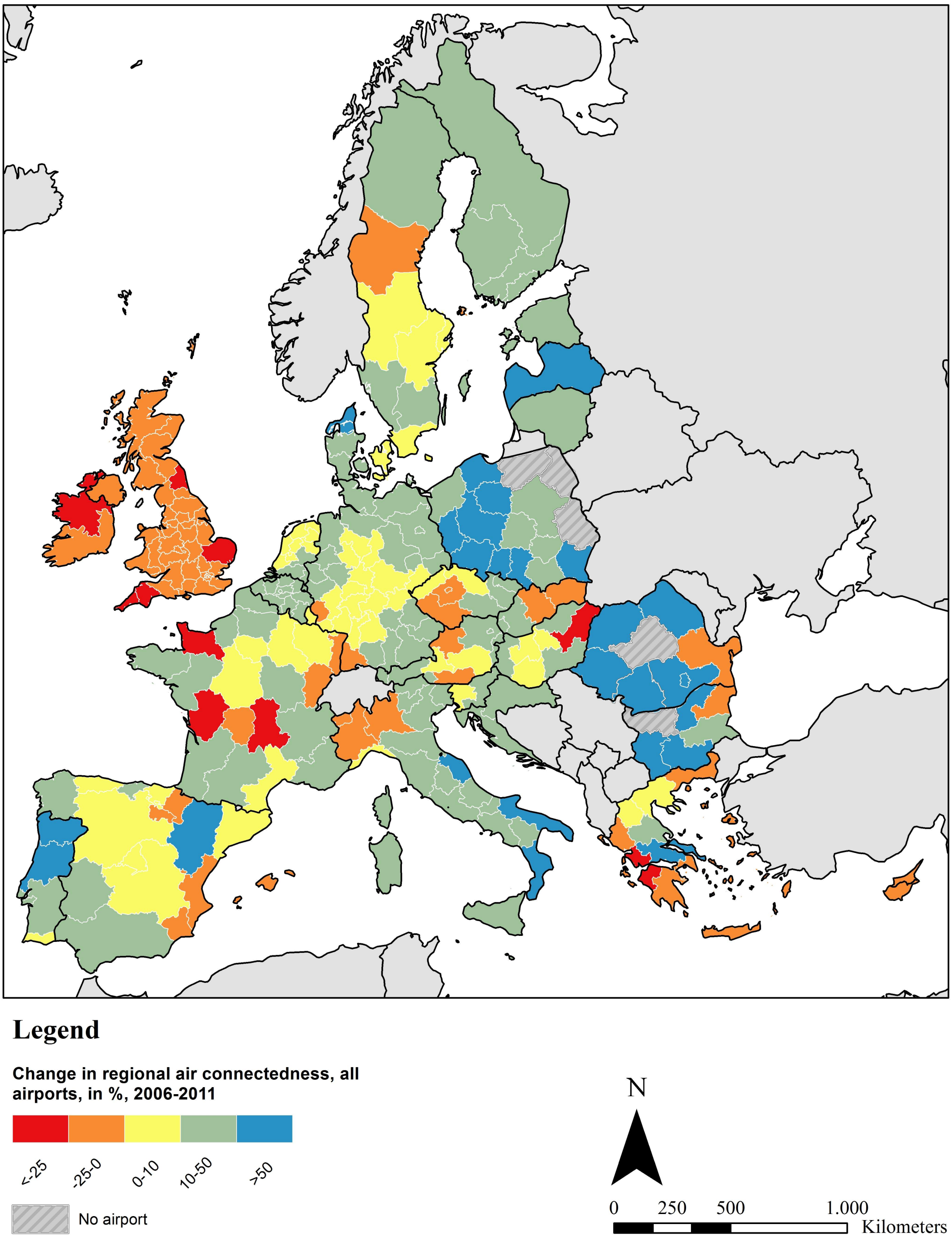


Figure 5.7: Change in regional air connectedness, all airports, 2006-2011

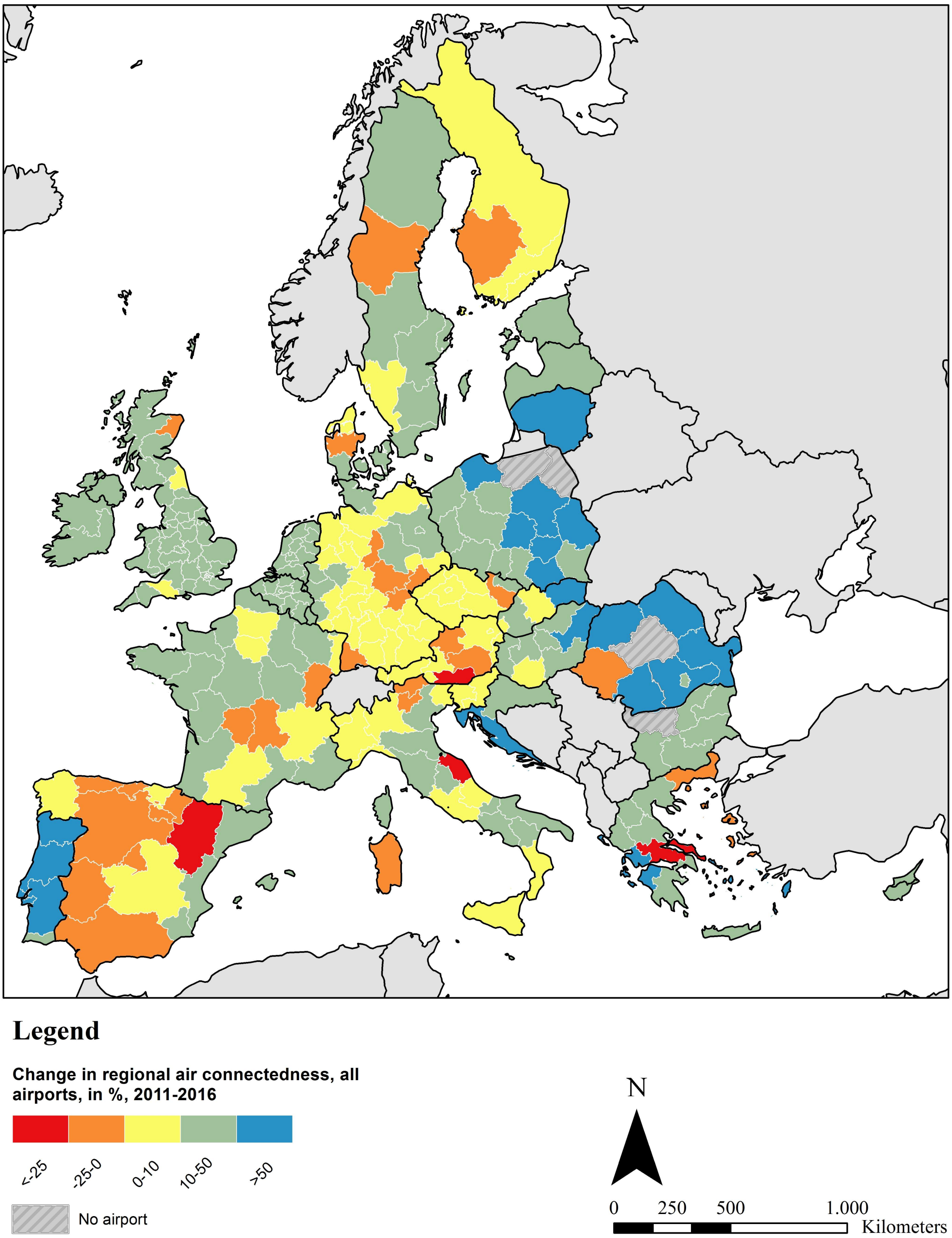


Figure 5.8: Change in regional air connectedness, all airports, 2011-2016

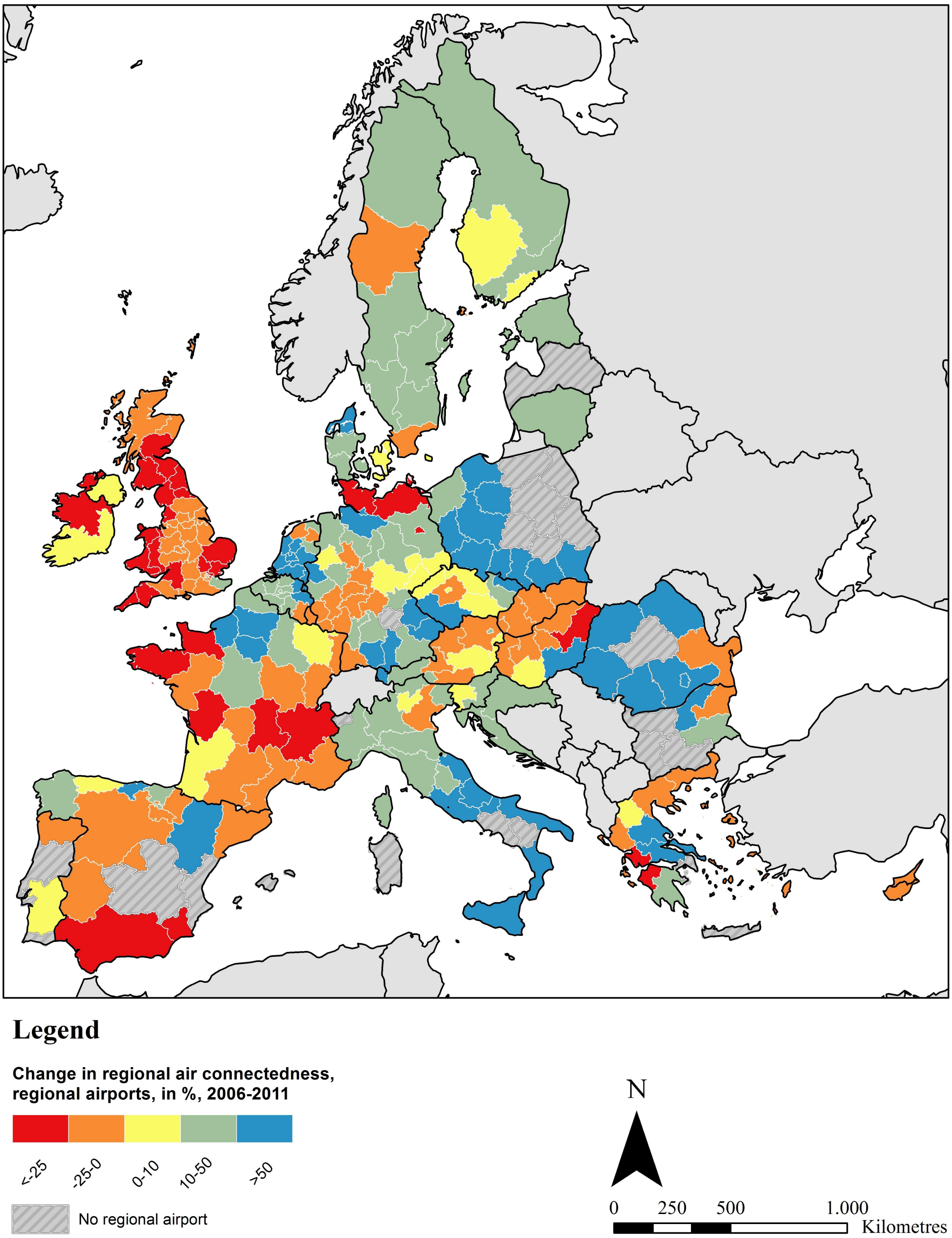


Figure 5.9: Change in regional air connectedness, regional airports, 2006-2011

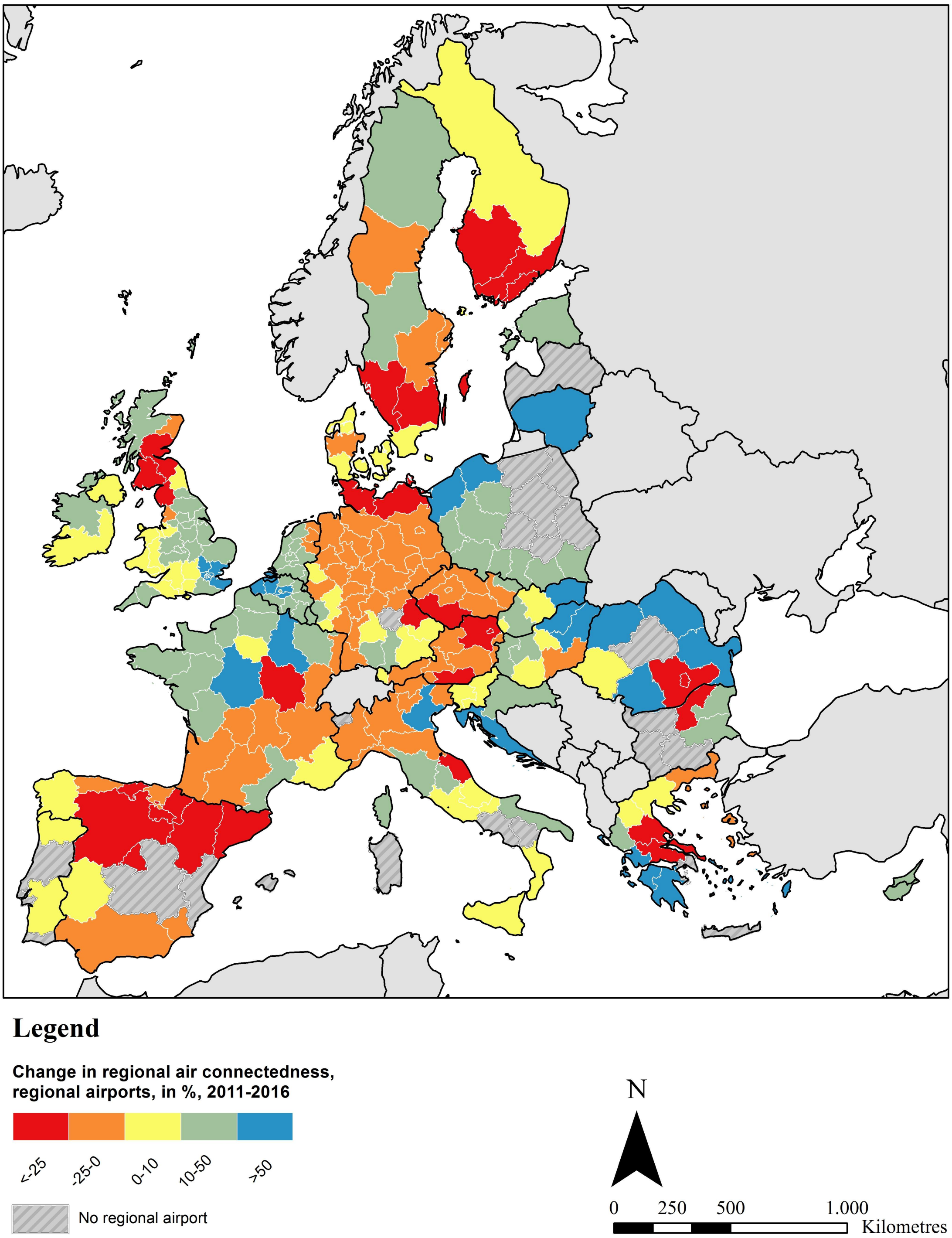


Figure 5.10: Change in regional air connectedness, regional airports, 2011-2016

Table 5.5: Correlation matrix for the development of GDP and regional air connectedness

	Variable	1.	2.	3.	4.	5.	6.
1.	$\Delta GDP_{r2006-2011}$	1					
2.	$\Delta GDP_{r2011-2016}$	0.421***	1				
3.	$\Delta CON_{r2006-2011}$ (all airports)	0.332***	0.083	1			
4.	$\Delta CON_{r2011-2016}$ (all airports)	0.146**	0.220***	-0.030	1		
5.	$\Delta CON_{r2006-2011}$ (regional airports)	0.283***	0.025	0.685***	-0.006	1	
6.	$\Delta CON_{r2011-2016}$ (regional airports)	-0.127*	0.050	-0.079	0.142**	-0.082	1

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

GDP development following regional air connectedness

This subsection evaluates whether GDP developments can be attributed to developments in regional air connectedness from both all and regional airports only through a 'Granger causality' analysis (see section 4.3.2). Table 5.6 presents the regression results regarding this analysis. When considering all airports, the lagged values of change in GDP are significantly positively predictors for change in GDP in the subsequent time frame. This entails that regions that have grown in terms of GDP per capita during time frame 1 are likely to have grown during time frame 2 as well. An 1% increase of GDP during time frame 1 is associated with 0.24% increase in GDP during time frame 2 in stage 1 of the model with 18% of the variance explained. In the best-fit stage after adding control variables and regional dummies, it is also found that regions with a higher rate of persons with tertiary education at the end of time frame 1 experience a 0.12% growth in GDP during time frame 2. The effect of a 1% growth in GDP during time frame 1 decreases to a 0.11% increase in GDP during time frame 2 with 41% of the variance explained. The level of people employed in knowledge intensive sectors at the end of time frame 1 is negatively contributing to the growth of GDP during time frame 2. Regions with high levels of employment in knowledge-intensive sectors are generally regions with already high GDP levels. Growth in terms of percentages is therefore harder to achieve, which explains these negative coefficients. For all three stages, the change in regional air connectedness during time frame 1 has not found to be a significant predictor for change in GDP during time frame 2 when incorporating the lagged values of change in GDP.

When looking at regional airports only, a similar pattern with similar coefficients arises. The growth of regional air connectedness from regional airports does not significantly contribute to the change of GDP in a subsequent time frame. It must be concluded that growth in regional air connectedness does not 'Granger-cause' growth in GDP, when considering both all and regional airports only. Therefore, no evidence of increasing traffic at (regional) airports causing growth in GDP in European regions has been found.

Table 5.6: ADL(1,1) regression results predicting change in GDP per capita in PPS, 2011-2016

	All airports			**Regional airports**		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	9.506***	14.257***	11.532***	10.314***	17.730***	21.752***
	(0.422)	(2.122)	(2.326)	(0.408)	(1.968)	(2.088)
$\Delta GDP_{r2006-2011}$	0.248***	0.259***	0.112***	0.205***	0.197***	0.081**
	(0.036)	(0.035)	(0.049)	(0.033)	(0.032)	(0.041)
$\Delta CON_{r2006-2011}$	-0.028	-0.027	0.023	-0.005	-0.007	-0.002
	(0.018)	(0.018)	(0.018)	(0.005)	(0.005)	(0.004)
DEN_{r2011}		0.001***	0.000		0.001***	0.000
		(0.000)	(0.000)		(0.000)	(0.000)
EDU_{r2011}		0.217***	0.120***		0.256***	0.174***
		(0.060)	(0.057)		(0.057)	(0.052)
GDP_{r2011}		-1.66E-4***	-4.271E-5		-0.121***	-0.006
		(0.000)	(0.0.000)		(0.043)	(0.041)
KI_{r2011}		-0.179***	-0.215***		-0.288***	-0.296***
		(0.068)	(0.076)		(0.063)	(0.069)
RD_{r2011}		-2.22E-4	0.001		0.000	0.000
		(0.001)	(0.001)		(0.001)	(0.001)
$BRIT$			1.017			-0.760
			(1.837)			(0.037)
$NORTH$			-6.276***			-6.896***
			(2.000)			(1.759)
$SOUTH$			-7.543***			8.201***
			(1.642)			(1.429)
$WEST$			-4.388***			-4.826***
			(1.356)			(1.140)
Observations	251	251	251	224	224	224
R^2	0.17	0.28	0.41	0.16	0.31	0.48

Standard errors in parentheses.
$^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Regional air connectedness following GDP development

Opposing to the previous subsection, here it is evaluated whether GDP growth causes growth in regional air connectedness. Table 5.7 presents the results of the ADL(1,1) model concerning this hypothesis. When considering all airports, the lagged values of regional air connectedness change are found to be significantly positive predictors for growth in regional air connectedness between 2011 and 2016. This entails that regions that have experienced a growth of regional air connectedness during time frame 1 also are also likely to have experienced growth in regional air connectedness during time frame 2. However, coefficients are lower in stages 2 and 3. The change in GDP during time frame 1 is positively associated with the growth of regional air connectedness during time frame 2 in all three stages considering all airports. In stage 1 and 2, a 1% rise in GDP during time frame 1 leads to around a half percent increase in regional air connectedness (0.528% and 0.482% respectively with 22% and 27% of the variance explained). When incorporating regional dummies, the effect lowers to 0.297%, however still being significant. Therefore, it can be concluded that growth in GDP 'Granger' causes growth in regional air connectedness considering all airports. When looking at regional air connectedness concerning regional airports only, a different picture arises. The first stage model needs to be rejected since neither growth in regional air connectedness from regional airports nor growth in GDP are found to be significant predictors for the growth in regional air connectedness from regional airports in the subsequent time frame. This entails that any growth of air traffic at regional airports has no implications for growth of air traffic in a subsequent time frame. Additionally, a growth of GDP does not imply growth of air traffic. Only population density measured at the end of time frame 1 has been found to be a significantly positive contributor to regional air connectedness growth in time frame 2. Only in stage two, the lagged value of change in regional air connectedness from regional airports shows a slightly significant negative coefficient. Remarkably, regions with higher GDP at the end of 2011, are associated with 5% decrease in regional air connectedness from regional airports, which may entail that regional airports lose ground in regions with high GDP. In neither of the three stages, the change in GDP was found to be a significant predictor for change in regional air connectedness from regional airports. Thus, the change in GDP does not 'Granger cause' change in regional air connectedness from regional airports.

Table 5.7: ADL(1,1) regression results predicting change in regional air connectedness, 2011-2016

	All airports			**Regional airports**		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	10.141***	19.773***	15.367***	10.314	125.105***	112.056***
	(1.914)	(3.970)	(4.421)	(17.476)	(31.656)	(35.502)
$\Delta CON_{r2006-2011}$	0.261***	0.097***	0.094***	-0.261	-0.302*	-0.002
	(0.035)	(0.035)	(0.035)	(0.192)	(0.170)	(0.172)
$\Delta GDP_{r2006-2011}$	0.528***	0.482***	0.297*	1.312	0.791	0.504
	(0.140)	(0.139)	(0.173)	(1.317)	(1.194)	(1.452)
CON_{r2011}		8,344E-8	1,544E-7		1,470E-6	1,563E-6
		(0.000)	(0.000)		(0.000)	(0.000)
DEN_{r2011}		0.003**	0.002		0.065***	0.057***
		(0.001)	(0.001)		(0.010)	(0.011)
GDP_{r2011}		-0.127***	-0.015		-5,245***	-5,090***
		(0.044)	(0.043)		(1,044)	(1.138)
$BRIT$			3.397			122.480*
			(8.611)			(68.478)
$EAST$			10.039***			25.346
			(1.192)			(33.255)
$NORTH$			4.086			17.468
			(3.339)			(34.404)
$SOUTH$			2.261			20.286
			(1.445)			(40.044)
Observations	173	173	173	163	163	163
R^2	0.22	0.27	0.30	0.01	0.26	0.28

Standard errors in parentheses.
$^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Chapter 6

Discussion and conclusions

This chapter discusses the results presented in chapter 5 and provides final answers to the research questions. First, the role of regional airports in providing air connectedness to European regions is addressed. Afterwards, the relationship between regional air connectedness and economic development is evaluated. The results are reflected upon with respect to the existing literature and recent policy debates on state aid to regional airports.

6.1 Regional airports' role in connecting European regions by air

The core function of airports is connecting regions with the global air network. The highest levels of regional air connectedness are found in regions along the 'Blue Banana' corridor. High levels of regional air connectedness are reflected in the high number of airports in these areas (see figure 2.2). Lieshout et al. (2016) also found, by using the NetScan connectivity index to measure airport connectivity, that competition among European airports is strongest in these regions. This is no coincidence, as population density and GDP levels are particularly high in these regions (see table 5.2). This increases options for LCCs to easily switch airports and involves risks for regional airports in particularly these regions that depend on LCCs for their traffic (see De Wit and Zuidberg, 2016; Maertens, 2012; Malighetti et al., 2016; Thelle and La Cour Sonne, 2017).

In most regions in Europe, the contribution of regional airports to regional air connectedness is low (see figure 5.3). This is particularly evident in regions with high levels of air connectedness resulting from many competing airports. In the case that regional airports fail to survive without state aid, LCCs may easily relocate to other airports or cease operations and implications for regional air connectedness would be very low. However, for 59 European regions inhabiting almost 80 million people, regional airports are essential in providing regional air connectedness (see table 5.1). These regions are in general more sparsely populated and peripheral areas with lower levels of GDP (see table 5.2) that are not able to upkeep bigger airports. When airports would close in these regions, losses in air connectedness can be dramatic. This is particularly the case for Eastern European regions in countries such as Bulgaria, Hungary, Poland and Romania. These are still emerging economies with low connectivity. Statements made regarding the essential role regional airports have in connecting regions (see ACI Europe, 2013; AER, 2013) may therefore be justified in these cases and for reasons of social equity, funding regional airports may be essential in these regions to guarantee some minimum level of air connectedness and promote EU wide cohesion (see Annema, 2013).

6.2 Regional airports' role in economic growth

6.2.1 Initial relationship

Regional stakeholders often consider airports as 'engines' for local economic development (see Brueckner, 2003; Button and Taylor, 2000; Graham and Guyer, 2000; Rasker et al., 2009; Sheard, 2014). Through OLS models an initial relationship between regional air connectedness and GDP on a regional level has been established (see table 5.4). It has been found that the level of regional air connectedness is positively linearly related to the level of GDP per capita. This is in line with the findings of ACI Europe (2014), reporting a strong linear relationship regarding how well a country is connected through the air and its level of GDP per capita with an explained variance of 71%. The estimates in this thesis report a weaker connection (26% of the variance is explained when no control variables are included). This is mainly due to differences in scale. On a regional level, differences in GDP can be substantial (see figure 3.2), while airport connectivity is dispersed more evenly and gradually over space. Next to that, regional boundaries are determined arbitrarily and are not equally sized. This leads to cases where regions with lower levels of GDP per capita actually have very high levels of air connectedness due to their location near an economic centre. This is particularly present around capital regions that have high values of GDP and exhibit large airports, while surrounding areas that are more peripheral still benefit from the connectivity provided from the main airport serving the core region. It can therefore be concluded that the link between air connectivity and GDP is positive however weaker on a regional scale compared to the national scale.

When only considering regional airports, this positive relationship is found to be weaker (only 5% of the variance in GDP is explained when control variables are left out). There may be several reasons why connectedness from regional airports is less linked to GDP figures than when considering airports in general. Regional airports are located more randomly across space and are not necessarily linked to major economic centres. Many regional airports served as military airfields before commercialising (Barbot, 2006). Next to that, commercialised secondary airfields are located outside metropolitan areas, where land prices are lower, resulting in lower construction and operating costs (Barbot, 2006). As consumers are more price- than time-sensitive, remotely located airports can still benefit from large customer pools (Copenhagen Economics, 2012). Finally, regional airports are considerably smaller than their major airport counterparts. Smaller airports are associated with lower levels of connectivity (see figures 4.1 and 4.2) due to their point-to-point network structures than their major airport counterparts that service hub-and-spoke networks (see Belobaba et al., 2015), making regional airports less able to facilitate multinational or internationally oriented firms' global interactions, which are said to be essential in the modern globalized economy where face-to-face contact has a premium (see Glaeser and Kohlhase, 2004; McCann, 2008; McCann and Acs, 2011; Rietveld and Vickerman, 2004; Storper and Venables, 2004). Therefore, the link between air traffic at regional airports and economic output may be weaker than when considering airports in general.

6.2.2 Causality

To evaluate in which direction causality runs considering the positive relationship between regional air connectedness and GDP, a 'Granger' causality analysis is conducted through the use of ADL(1,1) models. Regarding the causality analysis, two subsequent time frames of five years are established to allow for catalytic economic effects to settle in. It should be noted that the financial crisis of 2007–2008 is part of the first time frame. This could have flawed the outcomes, as GDP may not be generated in the same way as in periods of stable development. Next to that, the financial crisis has had different impacts across regions. Regional dummies are incorporated to correct for spatially uneven effects related to this crisis.

The estimates in table 5.6 show that there is no evidence that growth in regional air connectedness causes growth in GDP, for both considering all airports as well as regional airports only. The change in regional air connectedness has not found to be a significant predictor for change in GDP during a subsequent time frame when incorporating the lagged values (initial trend) of change in GDP. These findings somewhat contradict studies that do find positive spillovers from air traffic (e.g. Bel and Fageda, 2008; Brueckner, 2003; Cooper and Smith, 2005; Doeringer et al., 2014; InterVISTAS, 2015; Strauss-Kahn and Vives, 2005). However, these studies have predominantly focused on very specific impacts such as (foreign) business investments and location behaviour of corporate headquarters (see table 3.1). Additionally, these studies have been mostly executed with a focus on major hub airports operating intercontinental hub-and-spoke networks and serving metropolitan areas. In this thesis, a rather 'bird eye' approach is taken, considering all airports and regions across Europe. It should be stressed that these major hub airports only account for a small share of all airports in Europe (Eurostat 2018a). Most airports are rather small and do not operate a dense hub-and-spoke network. Apparently, positive economic spillovers associated with air traffic at major hub airports are not generalisable for all regions and all airports in the long term. It can be concluded that airports, and especially regional airports servicing point-to-point networks (Belobaba et al., 2015), in general do not promote economic growth in the long term. Therefore, the alleged role of airports in facilitating internationally oriented businesses that drive local economies (see McCann, 2013; Porter, 1990) while coping with increasing spatial transaction costs (see McCann, 2007, 2008) and in promoting spatial concentration resulting from lower transportation costs (see Brakman et al., 2009), may be limited to major hub airports (e.g. Bel and Fageda, 2008; Brueckner, 2003; Strauss-Kahn and Vives, 2005). Again, the observation that smaller airports are less connected to the global air network than major hub airports (see figures 4.1 and 4.2) due to differences in network structures may explain that only major hub airports facilitate economic growth. Further research specifying different potential economic benefits at different airport sizes and types may be beneficial in clarifying this relationship.

In contrast, the estimates in table 5.7 do provide evidence of causality running from growth in GDP to growth in regional air connectedness. A 1% rise in GDP in a time frame of 5 years is associated with around half percent increase of regional air connectedness in a subsequent time frame. It makes sense that air traffic follows GDP developments as GDP developments are essential in airline planning strategies (Belobaba et al., 2015). When incomes rise, more people will be able to afford flying and route frequencies will be increased. Next to a causal relationship, evidence is found on a simultaneous development of air connectedness and GDP (see table 5.5). This reflects the flexibility of airlines to adjust routes to market developments on relatively short notice. With respect to only considering regional airports, no evidence on GDP growth causing growth in air traffic at regional airports had been found. Also, only limited evidence is found on a simultaneous development (only during the first time frame). Explanations may lie in the footloose business strategies of LCCs that dominate traffic at regional airports. LCCs are known for high flexibility in route switching (De Wit and Zuidberg, 2016; Thelle and La Cour Sonne, 2017). Route choices by LCCs are based on cost-minimising strategies concerning network efficiency optimisation and negotiations with regional airports to achieve lower operating fees. Airlines usually have greater negotiating power as regional airports are looking for all kinds of ways to increase traffic in a highly competitive market (Barbot, 2006; Gillen and Lall, 2004; Lei and Papatheodorou, 2010; Malighetti et al., 2016). For regional airports, therefore, favourable conditions such as subsidies and low aeronautical charges at the airport are more important determinants for the development in regional air connectedness than macroeconomic developments such as GDP figures. The OLS-estimates also confirm this, as regional airports are found to be less linked to GDP than airports in general (see table 5.4). Therefore, any connection between GDP developments and air traffic at regional airports in the long term is not likely.

6.3 Concluding remarks

Relating to the policy debate on funding regional airports, criticisms on the new restrictive EC guidelines on state aid to airports can only be partly justified. Airports are often considered by local stakeholders to be 'engines' for local economic development through vast catalytic impacts (see Brueckner, 2003; Button and Taylor, 2000; Graham and Guyer, 2000; Rasker et al., 2009; Sheard, 2014). It is found very unlikely that regional airports function as such. The initial link between air connectedness and GDP is weaker for regional airports than for airports in general, due to more random spatial dispersion and lack of traffic. Additionally, no causal relationship regarding air traffic at regional airports and GDP has been found either way. The fickle competitive environment regional airports operate in results in a weak connection between economic development and incoming airlines (LCCs). Arguments regarding economic development to upkeep regional airports by state therefore likely to be too optimistic (as with many infrastructure related debates (see Flyvbjerg, 2003)). Changes are high that investments in regional airports to maximise welfare will fail ultimately. Therefore, one should be very careful when promoting state aid to regional airports for reasons regarding economic growth.

However, for almost 80 million European citizens in predominantly peripheral regions, regional air connectedness is solely provided by regional airports (see table 5.1). When airports in these regions fail to survive when state aid has been clamped down, problems may arise for regional accessibility and the connectivity of the overall EU network. This is an example how a space-blind policy could have different spatial outcomes for different regions. Since transportation services are predominantly provided by governments for societal equity reasons (Annema, 2013), it could be argued that peripheral regions should have a certain level of air connectedness, even if the costs of building and maintaining infrastructures do not outweigh the monetary benefits. With the current space-blind approach of the EC, regions that depend on regional airports are at risk of losing all air connectivity when these airports fail to survive. Following this line of reasoning, a more place-based approach relaxing state aid restrictions to airports in regions that depend on regional airports could be beneficial for ensuring a fair distribution of air connectedness across Europe. It may be that regional airports are accountable for other positive, rather qualitative, effects which may not resound in GDP growth in the long term. Regional airports could serve as marketing tool to drive up regional profiles (Kramer, 1990). This may lead to firms that are not functionally related to the airport starting to locate in the region because of an improved regional image. Other positive spillovers may be found in consumer surplus for citizens in the region benefiting from the convenience of (multiple) regional airports (see Lueg-Arndt et al., 2010). However insights in the qualitative role of regional airports are to date limited and should be evaluated in further research.

In conclusion it can be stated that the role regional airports in generating economic growth is in most cases very limited or non-existent. Regarding the policy debate on justifying state aid to unprofitable regional airports, arguments concerning their supposed role as regional economic catalysts should be dismissed. However, many predominantly peripheral regions are found to be fully dependent on regional airports for their air connectedness. Therefore, for reasons regarding social equity, state aid to regional airports may be justified for the sake of connecting regions. Additionally regional airports may play a role as regional marketing tools and in generating traveller's consumer surplus. When these considerations are brought at the forefront of the debate, very different trade-offs with respect to the (societal) costs and benefits related to air traffic at regional airports will arise and the policy debate on state aid to regional airports will be more balanced.

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Appendices

Appendix A

European airport data

List of European airports

ICAO	Name	*pax* (2006)	*pax* (2011)	*pax* (2016)	Regional (Yes/No)
AT_LOWG	GRAZ	947820	1001431	990208	Yes
AT_LOWI	INNSBRUCK	823745	1008576	1013641	Yes
AT_LOWK	KLAGENFURT	411320	378480	196036	Yes
AT_LOWL	LINZ	800930	703846	443273	Yes
AT_LOWS	SALZBURG	1908025	1725536	1753698	Yes
AT_LOWW	WIEN-SCHWECHAT	16856511	21188400	23504647	No
BE_EBAW	ANTWERPEN/DEURNE	120567	115339	258062	Yes
BE_EBBR	BRUSSELS	16735657	18901917	21857625	No
BE_EBCI	CHARLEROI/BRUSSELS SOUTH	2154583	5883173	7291395	No
BE_EBLG	LIEGE	297728	302979	378146	Yes
BE_EBOS	OOSTENDE/BRUGGE	146355	215852	424660	Yes
BG_LBBG	BURGAS	1708199	2243108	2872719	Yes
BG_LBSF	SOFIA	2209350	3469633	4979041	No
BG_LBWN	VARNA	1522658	1181313	1701025	Yes
CH_LSGG	GENEVA	9926721	13048960	16458924	No
CH_LSZA	LUGANO	186294	165054	167686	Yes
CH_LSZB	BERN-BELP	107720	169765	167596	Yes
CH_LSZH	ZURICH	19558040	24376142	27662527	No
CH_LSZM	BASEL	3024581	4347853	6741605	No
CH_LSZR	ST. GALLEN-ALTENRHEIN	98039	94834	98979	Yes
CY_LCLK	LARNAKA/INTL	5098487	5431272	6770897	No
CY_LCPH	PAFOS/INTL	2026363	1797136	2340322	Yes
CZ_LKKV	KARLOVY VARY	34963	98517	25153	Yes
CZ_LKMT	OSTRAVA/MOSNOV	325451	294981	275656	Yes
CZ_LKPD	PARDUBICE	71500	63320	30002	Yes
CZ_LKPR	PRAHA/RUZYNE	11540273	11780323	13066750	No
CZ_LKTB	BRNO/TURANY	428688	587754	432566	Yes
DE_EDDB	BERLIN-SCHOENEFELD	6091966	7127188	11656313	No
DE_EDDC	DRESDEN	1874990	1931846	1669583	Yes
DE_EDDE	ERFURT-WEIMAR	361913	285666	237999	Yes
DE_EDDF	FRANKFURT/MAIN	53126476	56561629	60869747	No
DE_EDDG	MUENSTER/OSNABRUECK	1545867	1316089	776416	Yes
DE_EDDH	HAMBURG	12014704	13574939	16250085	No
DE_EDDI	BERLIN/TEMPELHOF	635005	0	0	Yes
DE_EDDK	KOELN/BONN	9977206	9642378	11906846	No
DE_EDDL	DUESSELDORF	16619841	20343771	23518735	No
DE_EDDM	MUENCHEN	30796867	37851113	42332604	No
DE_EDDN	NUERNBERG	4100519	3979304	3481129	No
DE_EDDP	LEIPZIG/HALLE	2509431	2691923	2201424	Yes
DE_EDDR	SAARBRUECKEN	459589	490875	452184	Yes
DE_EDDS	STUTTGART	10159529	9616798	10643313	No
DE_EDDT	BERLIN-TEGEL	11836750	16934834	21250678	No
DE_EDDV	HANNOVER	5734653	5372145	5412064	No
DE_EDDW	BREMEN	1709005	2568230	2576175	Yes
DE_EDFH	FRANKFURT-HAHN	3690913	2945599	2703591	Yes

ICAO	Name	*pax* (2006)	*pax* (2011)	*pax* (2016)	Regional (Yes/No)
DE_EDFM	MANNHEIM CITY	69923	45800	44600	Yes
DE_EDHL	LUEBECK-BLANKENSEE	659255	329185	0	Yes
DE_EDJA	MEMMINGEN	4715	756016	993832	Yes
DE_EDLP	PADERBORN/LIPPSTADT	1274750	976119	701653	Yes
DE_EDLV	NIEDERRHEIN	584043	2415450	1854110	Yes
DE_EDLW	DORTMUND	1980668	1825580	1915947	Yes
DE_EDNY	FRIEDRICHSHAFEN	632540	539376	467448	Yes
DE_EDRZ	ZWEIBRUECKEN	0	215286	0	Yes
DE_EDSB	KARLSRUHE/BADEN-BADEN	829204	1119643	1107811	Yes
DE_EDVK	KASSEL-CALDEN	0	0	129562	Yes
DE_EDXW	SYLT	82702	195438	129562	Yes
DE_ETNL	LAAGE	167851	174334	218821	Yes
DK_EKAH	AARHUS	550503	588698	380533	Yes
DK_EKBI	BILLUND	1868515	2695433	3085297	Yes
DK_EKCH	KOBENHAVN/KASTRUP	20862815	22707908	29016548	No
DK_EKEB	ESBJERG	198133	87318	108601	Yes
DK_EKKA	KARUP	211175	292972	154732	Yes
DK_EKOD	ODENSE	0	23183	23183	Yes
DK_EKRK	KOBENHAVN/ROSKILDE	15021	19063	10085	Yes
DK_EKRN	BORNHOLM/RONNE	220600	233806	268481	Yes
DK_EKSB	SONDERBORG	64295	71802	57449	Yes
DK_EKYT	AALBORG	780548	1378767	1501813	Yes
EE_EETN	LENNART MERI TALLINN	1533706	1908202	2215875	Yes
EL_LGAL	ALEXANDROUPOLIS/DIMOKRITOS	277919	238265	161635	Yes
EL_LGAV	ATHINAI/ELEFTHERIOS VENIZELOS	15073202	14422831	20008914	No
EL_LGAV	ALMIROS/NEA ANCHIALOS	18120	101806	26435	Yes
EL_LGHI	CHIOS/OMIROS	232341	233927	200628	Yes
EL_LGIK	IKARIA/IKAROS	24642	37535	41254	Yes
EL_LGIO	IOANNINA/KING PYRROS	126239	88597	97123	Yes
EL_LGIR	IRAKLION/NIKOS KAZANTZAKIS	5345652	5294085	6761284	No
EL_LGKA	KASTORIA/ARISTOTELIS	8021	8021	8021	Yes
EL_LGKC	KITHIRA	27913	28811	37139	Yes
EL_LGKF	KEFALLINIA/ANNA POLLATOU	372973	355524	546816	Yes
EL_LGKJ	KASTELORIZO	6907	6907	6907	Yes
EL_LGKL	KALAMATA	93991	106503	231839	Yes
EL_LGKO	KOS/IPPOKRATIS	1573117	1958709	1922401	Yes
EL_LGKP	KARPATHOS	161186	195312	229660	Yes
EL_LGKR	KERKIRA/IOANNIS KAPODISTRIAS	1997776	1862208	2774960	Yes
EL_LGKS	KASSOS	7233	7233	7233	Yes
EL_LGKV	KAVALA/MEGAS ALEXANDROS	320165	266550	275102	Yes
EL_LGKY	KALYMNOS	6484	24249	20213	Yes
EL_LGKZ	KOZANI/FILIPPOS	5851	5851	5851	Yes
EL_LGLE	LEROS	28851	32541	26715	Yes
EL_LGLM	LIMNOS/IFAISTOS	129567	100323	95759	Yes
EL_LGMK	MIKONOS	396262	497091	1017182	Yes
EL_LGML	MILOS	32092	30352	48701	Yes
EL_LGMT	MITILINI/ODYSSEAS ELYTIS	489688	481869	419790	Yes
EL_LGNX	NAXOS	28633	25793	35135	Yes
EL_LGPA	PAROS	37339	36282	74294	Yes
EL_LGPL	ASTYPALAIA	19563	13350	12014	Yes
EL_LGPZ	PREVEZA/AKTION	288555	305636	482116	Yes
EL_LGRP	RODOS/DIAGORAS	3491522	4190216	4971297	No
EL_LGRX	ARAXOS	111864	81854	129599	Yes
EL_LGSA	CHANIA/IOANNIS DASKALOGIANNIS	1760959	1784831	2966556	Yes
EL_LGSK	SKIATHOS/ALEXANDROS PAPADIAMANDIS	248661	259641	404111	Yes
EL_LGSM	SAMOS/ARISTARCHOS OF SAMOS	450918	423503	363284	Yes
EL_LGSO	SYROS/DIMITRIOS VIKELAS	11264	9881	17892	Yes
EL_LGSR	SANTORINI	678250	809876	1706678	Yes
EL_LGST	SITIA/VITSENTZOS KORNAROS	22902	39630	21246	Yes
EL_LGSY	SKIROS	8934	4533	16154	Yes
EL_LGTS	THESSALONIKI/MAKEDONIA	3802854	4008104	5735482	No
EL_LGZA	ZAKINTHOS/DIONISIOS SOLOMOS	1000635	929893	1419585	Yes
ES_GCFV	FUERTEVENTURA	4158197	4940641	5663494	No
ES_GCHI	HIERRO	168397	169314	0	Yes
ES_GCLA	LA PALMA	1147655	1068252	1114596	Yes
ES_GCLP	GRAN CANARIA	9848057	10436261	11972530	No
ES_GCRR	LANZAROTE	5345923	5535851	6681379	No
ES_GCTS	TENERIFE SUR/REINA SOFIA	8364819	8598533	10388512	No

ICAO	**Name**	*pax* (2006)	*pax* (2011)	*pax* (2016)	Regional (Yes/No)
ES_GCXO	TENERIFE NORTE	4013139	4119242	4111669	No
ES_GEML	MELILLA	302972	278586	323800	Yes
ES_LEAL	ALICANTE	8786738	9898074	12310252	No
ES_LEAM	ALMERIA	1038318	768346	909208	Yes
ES_LEAS	ASTURIAS	1337118	1333589	1280953	Yes
ES_LEBA	CORDOBA	6555	6555	6555	Yes
ES_LEBB	BILBAO	3837661	4037846	4578161	No
ES_LEBL	BARCELONA/EL PRAT	29689092	34339549	43756712	No
ES_LEBZ	BADAJOZ	32963	32963	32963	Yes
ES_LECO	A CORUNA	995188	1006724	1064244	Yes
ES_LEGE	GIRONA	3580140	2995707	1646765	Yes
ES_LEGR	GRANADA	1059742	861343	750490	Yes
ES_LEIB	IBIZA	4371597	5626908	7404152	No
ES_LEJR	JEREZ	1295588	962638	908067	Yes
ES_LELC	MURCIA/SAN JAVIER	1639337	1262370	1095517	Yes
ES_LELN	ES_LELN	126650	75000	40000	Yes
ES_LEMD	ADOLFO SUAREZ MADRID-BARAJAS	44931236	49574061	49222080	No
ES_LEMG	MALAGA/COSTA DEL SOL	12899630	12781898	16631294	No
ES_LEMH	MENORCA	2621291	2570734	3174968	Yes
ES_LEPA	PALMA DE MALLORCA	21781925	22711035	26234588	No
ES_LEPP	PAMPLONA	364450	229925	0	Yes
ES_LERS	REUS	1352204	1351904	808276	Yes
ES_LESO	SAN SEBASTIAN	361792	240762	263510	Yes
ES_LEST	SANTIAGO	1939114	2447523	2497380	Yes
ES_LEVC	VALENCIA	4938526	4969983	5780638	No
ES_LEVD	VALLADOLID	445104	452958	225628	Yes
ES_LEVT	VITORIA	165052	23300	35304	Yes
ES_LEVX	VIGO	1179788	975642	955260	Yes
ES_LEXJ	SEVE BALLESTEROS-SANTANDER	646576	1115106	777387	Yes
ES_LEZG	ZARAGOZA	426634	750532	418841	Yes
ES_LEZL	SEVILLA	3825330	4944093	4610487	No
FI_EFET	ENONTEKIO	17413	18238	22275	Yes
FI_EFHK	HELSINKI-VANTAA	12013557	14891185	17180936	No
FI_EFIV	IVALO	154759	135962	179592	Yes
FI_EFJO	JOENSUU	146145	117109	122538	Yes
FI_EFJY	JYVASKYLA	149183	88823	62379	Yes
FI_EFKE	KEMI-TORNIO	85275	93796	61311	Yes
FI_EFKI	KAJAANI	92024	78071	85766	Yes
FI_EFKK	KOKKOLA-PIETARSAARI	95806	98517	88659	Yes
FI_EFKS	KUUSAMO	108383	91883	76835	Yes
FI_EFKT	KITTILA	245212	253734	257220	Yes
FI_EFKU	KUOPIO	331902	284104	226872	Yes
FI_EFLP	LAPPEENRANTA	49170	116942	35776	Yes
FI_EFMA	MARIEHAMN	63708	53662	59524	Yes
FI_EFOU	OULU	858803	973936	1027376	Yes
FI_EFPO	PORI	63991	53712	9581	Yes
FI_EFRO	ROVANIEMI	428743	396052	487806	Yes
FI_EFSA	SAVONLINNA	24521	21037	11601	Yes
FI_EFTP	TAMPERE-PIRKKALA	633514	660044	208663	Yes
FI_EFTU	TURKU	339343	403880	323847	Yes
FI_EFVA	VAASA	305854	349998	288384	Yes
FR_FMCZ	DZAOUDZI	320178	320178	320178	Yes
FR_FMEE	LA REUNION-ROLAND GARROS	1308700	2179078	2122837	Yes
FR_FMEP	SAINT PIERRE PIERREFONDS	116029	0	0	Yes
FR_LFBD	BORDEAUX-MERIGNAC	3225846	4114817	5798282	No
FR_LFBE	BERGERAC-ROUMANIERE	269620	290008	303897	Yes
FR_LFBH	LA ROCHELLE-ILE DE RE	179821	228425	219810	Yes
FR_LFBI	POITIERS-BIARD	119218	0	0	Yes
FR_LFBL	LIMOGES-BELLEGARDE	375242	339798	291735	Yes
FR_LFBO	TOULOUSE/BLAGNAC	5899070	7075078	8137808	No
FR_LFBP	PAU-PYRENEES	762874	640682	606276	Yes
FR_LFBT	TARBES LOURDES PYRENEES	449047	446023	380401	Yes
FR_LFBZ	BIARRITZ-PAYS BASQUE	864792	1032051	1135312	Yes
FR_LFCR	RODEZ-AVEYRON	148154	0	0	Yes
FR_LFJL	METZ NANCY-LORRAINE	319086	278356	223129	Yes
FR_LFKB	BASTIA-PORETTA	820804	1027064	1287612	Yes
FR_LFKC	CALVI-SAINTE-CATHERINE	267620	294381	321283	Yes
FR_LFKF	FIGARI-SUD-CORSE	312822	445927	631390	Yes

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FR_LFKJ	AJACCIO-NAPOLEON-BONAPARTE	984677	1180321	1424292	Yes
FR_LFLB	CHAMBERY-AIX-LES-BAINS	194460	233478	208993	Yes
FR_LFLC	CLERMONT-FERRAND-AUVERGNE	552800	406129	402107	Yes
FR_LFLL	LYON SAINT-EXUPERY	6661182	8557353	9583837	No
FR_LFLP	ANNECY-MEYTHET	65016	0	0	Yes
FR_LFLS	GRENOBLE-ISERE	430419	335637	304571	Yes
FR_LFLW	AURILLAC	19234	0	0	Yes
FR_LFMD	CANNES-MANDELIEU	16536	0	0	Yes
FR_LFMH	SAINT-ETIENNE-LOIRE	39347	0	0	Yes
FR_LFMK	CARCASSONNE-SALVAZA	427547	368011	392089	Yes
FR_LFML	MARSEILLE-PROVENCE	5958171	7502312	8552617	No
FR_LFMN	NICE-COTE D AZUR	9926252	10436303	12428186	No
FR_LFMP	PERPIGNAN RIVESALTES	447203	367720	376609	Yes
FR_LFMT	MONTPELLIER MEDITERRANEE	1322966	1317484	1666795	Yes
FR_LFMU	BEZIERS-VIAS	46440	193702	243321	Yes
FR_LFMV	AVIGNON-CAUMONT	81852	0	0	Yes
FR_LFOB	BEAUVAIS-TILLE	1887858	3677236	3997670	Yes
FR_LFOH	LE HAVRE-OCTEVILLE	45535	0	0	Yes
FR_LFOK	CHALONS-VATRY	8448	50789	132772	Yes
FR_LFOP	ROUEN-VALLEE DE SEINE	21576	0	0	Yes
FR_LFOT	TOURS VAL DE LOIRE	82296	121014	199936	Yes
FR_LFPG	PARIS-CHARLES DE GAULLE	56448699	60871751	65978836	No
FR_LFPO	PARIS-ORLY	25603532	27103533	31241339	No
FR_LFQQ	LILLE-LESQUIN	925488	1178030	1788375	Yes
FR_LFRB	BREST-BRETAGNE	795301	997711	1023492	Yes
FR_LFRC	CHERBOURG-MAUPERTUS	13064	0	0	Yes
FR_LFRD	DINARD PLEURTUIT SAINT MALO	163687	0	0	Yes
FR_LFRG	DEAUVILLE-NORMANDIE	54524	0	0	Yes
FR_LFRH	LORIENT-LANN-BIHOUE	225025	181516	121567	Yes
FR_LFRK	CAEN-CARPIQUET	105881	0	0	Yes
FR_LFRM	LE MANS-ARNAGE	11504	0	0	Yes
FR_LFRN	RENNES SAINT JACQUES	460392	432772	641414	Yes
FR_LFRO	LANNION	45704	0	0	Yes
FR_LFRQ	QUIMPER-PLUGUFFAN	139356	0	0	Yes
FR_LFRS	NANTES ATLANTIQUE	2332414	3331822	4844273	No
FR_LFRZ	SAINT-NAZAIRE-MONTOIR	1002736	647425	563561	Yes
FR_LFSB	BALE-MULHOUSE	556743	556743	556743	Yes
FR_LFSD	DIJON-LONGVIC	11397	0	0	Yes
FR_LFSR	REIMS/CHAMPAGNE	24660	0	0	Yes
FR_LFST	STRASBOURG-ENTZHEIM	2001491	1090992	1060805	Yes
FR_LFTH	HYERES-LE PALYVESTRE	635522	573788	498088	Yes
FR_LFTW	NIMES-GARONS	226664	192791	212902	Yes
FR_SOCA	CAYENNE-FELIX-EBOUE	367535	438004	530486	Yes
FR_TFFF	AIME CESAIRE/MARTINIQUE	1541109	1804407	1926406	Yes
HR_LDDU	DUBROVNIK/CILIPI	1120453	1356036	2002861	Yes
HR_LDOS	OSIJEK	28651	28651	28651	Yes
HR_LDPL	PULA	295342	351394	436238	Yes
HR_LDRI	RIJEKA/KRK	139718	139718	139718	Yes
HR_LDSB	BRAC	8809	8809	8809	Yes
HR_LDSP	SPLIT/KASTELA	1095852	1302084	2297326	Yes
HR_LDZA	ZAGREB/PLESO	1728414	2269191	2762234	Yes
HR_LDZD	ZADAR/ZEMUNIK	65423	298366	532022	Yes
HU_LHBP	LISZT FERENC INTERNATIONAL	8245920	8884837	11409543	No
HU_LHDC	DEBRECEN	36939	19135	284965	Yes
HU_LHSM	HEVIZ-BALATON	63627	18191	17663	Yes
IE_EICK	CORK	3023527	2358904	2226231	Yes
IE_EICM	GALWAY	245918	67134	0	Yes
IE_EIDL	DONEGAL	245918	67134	0	Yes
IE_EIDW	DUBLIN	21265834	18758105	27778845	No
IE_EIKN	IRELAND WEST	608296	614172	735869	Yes
IE_EIKY	KERRY	392576	292353	325670	Yes
IE_EINN	SHANNON	3690889	1364955	1674567	Yes
IT_LIBD	BARI/PALESE	2018084	3724058	4330428	No
IT_LIBP	PESCARA	332923	546399	570825	Yes
IT_LIBR	BRINDISI/CASALE	826874	2062026	2332702	Yes
IT_LICA	LAMEZIA TERME	1368486	2307380	2544195	Yes
IT_LICB	COMISO	0	0	459460	Yes
IT_LICC	CATANIA/FONTANAROSSA	5419974	6807964	7828178	No

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IT_LICD	LAMPEDUSA	196604	161291	222996	Yes
IT_LICG	PANTELLERIA	0	132487	0	Yes
IT_LICJ	PALERMO/PUNTA RAISI	4246555	5013524	5278285	No
IT_LICR	REGGIO CALABRIA	569454	597426	483921	Yes
IT_LICT	TRAPANI/BIRGI	314057	1469955	1499208	Yes
IT_LIEA	ALGHERO/FERTILIA	1059988	1515595	1348303	Yes
IT_LIEE	CAGLIARI/ELMAS	2519014	3706020	3712830	No
IT_LIEO	OLBIA/COSTA SMERALDA	1802334	1876242	2528117	Yes
IT_LIMC	MILANO/MALPENSA	21902192	19495756	19510383	No
IT_LIME	BERGAMO/ORIO AL SERIO	5209902	8423238	11160024	No
IT_LIMF	TORINO/CASELLE	3288744	3707862	3959872	No
IT_LIMJ	GENOVA/SESTRI	1072146	1399949	1285299	Yes
IT_LIML	MILANO/LINATE	9699054	9065905	9640771	No
IT_LIMP	PARMA	123755	268783	188063	Yes
IT_LIMZ	CUNEO/LEVALDIGI	182699	223614	135955	Yes
IT_LIPB	BOLZANO	68550	59373	35141	Yes
IT_LIPE	BOLOGNA/BORGO PANIGALE	4072310	5943835	7683095	No
IT_LIPH	TREVISO/S.ANGELO	1328832	1075509	2630870	Yes
IT_LIPK	FORLI	625320	347258	0	Yes
IT_LIPO	BRESCIA/MONTICHIARI	229373	31880	0	Yes
IT_LIPQ	TRIESTE/RONCHI DEI LEGIONARI	679731	857134	725398	Yes
IT_LIPR	RIMINI/MIRAMARE	322252	918863	240907	Yes
IT_LIPX	VERONA/VILLAFRANCA	3011683	3408516	2827601	Yes
IT_LIPY	ANCONA/FALCONARA	481549	606591	484054	Yes
IT_LIPZ	VENEZIA/TESSERA	6303082	8572909	9618083	No
IT_LIRA	ROMA/CIAMPINO	4919865	4741305	5366837	No
IT_LIRF	ROMA/FIUMICINO	30329679	37897931	41907338	No
IT_LIRN	NAPOLI/CAPODICHINO	5111305	5784798	6772130	No
IT_LIRP	PISA/S. GIUSTO	3012224	4528675	4984187	No
IT_LIRQ	FIRENZE/PERETOLA	1543283	1893306	2503381	Yes
IT_LIRZ	PERUGIA/S. FRANCESCO	97027	171975	218364	Yes
LT_EYKA	KAUNAS INTL	245203	870817	740499	Yes
LT_EYPA	PALANGA/INTERNATIONAL	116797	111980	236616	Yes
LT_EYVI	VILNIUS/INTERNATIONAL	1447071	1718418	3816288	Yes
LU_ELLX	LUXEMBOURG	1597404	1836920	2984242	Yes
LV_EVRA	RIGA	2502295	5114658	5411781	No
MT_LMML	LUQA	2699870	3506691	5080446	No
NL_EHAM	AMSTERDAM/SCHIPHOL	46128748	49838392	63732670	No
NL_EHBK	MAASTRICHT/AACHEN	330056	367643	184926	Yes
NL_EHEH	EINDHOVEN	1177383	2670269	4826667	Yes
NL_EHGG	GRONINGEN/EELDE	195896	180387	203707	Yes
NL_EHRD	ROTTERDAM	1124622	1149906	1677578	Yes
NO_ENAL	ALESUND/VIGRA	707825	892080	1053615	Yes
NO_ENAN	ANDOYA/ANDENES	35519	0	0	Yes
NO_ENAT	ALTA	418742	346366	364356	Yes
NO_ENBL	FORDE/BRINGELAND	70186	0	0	Yes
NO_ENBN	BRONNOYSUND/BRONNOY	99604	94272	94272	Yes
NO_ENBO	BODO	1443137	1544353	1678871	Yes
NO_ENBR	BERGEN/FLESLAND	4094234	5184549	5682751	No
NO_ENBS	BATSFJORD	23213	0	0	Yes
NO_ENBV	BERLEVAG	13421	0	0	Yes
NO_ENCN	KRISTIANSAND/KJEVIK	790221	945316	1017476	Yes
NO_ENDU	BARDUFOSS	168688	196980	244923	Yes
NO_ENEV	HARSTAD/NARVIK/EVENES	459246	582338	700497	Yes
NO_ENFL	FLORO	93041	122030	106157	Yes
NO_ENGM	OSLO/GARDERMOEN	16271576	21102984	25663538	No
NO_ENHD	HAUGESUND/KARMOY	417869	597053	624443	Yes
NO_ENHF	HAMMERFEST	151982	122770	122770	Yes
NO_ENHK	HASVIK	11142	0	0	Yes
NO_ENHV	HONNINGSVAG/VALAN	23075	0	0	Yes
NO_ENKB	KRISTIANSUND/KVERNBERGET	243897	283591	250328	Yes
NO_ENKR	KIRKENES/HOYBUKTMOEN	239318	295214	306031	Yes
NO_ENLK	LEKNES	90056	110085	110085	Yes
NO_ENMH	MEHAMN	22894	0	0	Yes
NO_ENML	MOLDE/ARO	418171	434844	502821	Yes
NO_ENMS	MOSJOEN/KJAERSTAD	75888	61094	61094	Yes
NO_ENNA	LAKSELV/BANAK	56704	0	0	Yes
NO_ENNK	NARVIK/FRAMNES	27186	0	0	Yes

ICAO	Name	*pax* (2006)	*pax* (2011)	*pax* (2016)	Regional (Yes/No)
NO_ENNM	NAMSOS	34518	0	0	Yes
NO_ENOV	ORSTA-VOLDA/HOVDEN	60377	102859	102859	Yes
NO_ENRA	MO I RANA/ROSSVOLL	104104	110799	110799	Yes
NO_ENRM	RORVIK/RYUM	30957	0	0	Yes
NO_ENRY	MOSS/RYGGE	0	1666446	1175434	Yes
NO_ENSB	SVALBARD/LONGYEAR	112941	169799	169799	Yes
NO_ENSD	SANDANE/ANDA	40092	0	0	Yes
NO_ENSG	SOGNDAL/HAUKASEN	94781	70947	70947	Yes
NO_ENSH	SVOLVAER/HELLE	67889	0	0	Yes
NO_ENSK	STOKMARKNES/SKAGEN	100407	94333	94333	Yes
NO_ENSN	SKIEN/GEITERYGGEN	11577	0	0	Yes
NO_ENSO	STORD/SORSTOKKEN	56649	0	0	Yes
NO_ENSR	SORKJOSEN	18659	0	0	Yes
NO_ENSS	VARDO/SVARTNES	23006	0	0	Yes
NO_ENST	SANDNESSJOEN/STOKKA	86843	75975	75975	Yes
NO_ENTC	TROMSO/LANGNES	1596893	1698357	1987518	Yes
NO_ENTO	SANDEFJORD/TORP	1147604	1338616	1437054	Yes
NO_ENVA	TRONDHEIM/VAERNES	3227756	3901645	4398497	No
NO_ENVD	VADSO	99546	73762	73762	Yes
NO_ENZV	STAVANGER/SOLA	3082615	3881453	3967725	No
PL_EPBY	BYDGOSZCZ/SZWEDEROWO	133009	276705	366813	Yes
PL_EPGD	GDANSK IM LECHA WALESY	1249753	2456078	3994012	Yes
PL_EPKK	KRAKOW/BALICE	2367257	3006503	4976919	No
PL_EPKT	KATOWICE/PYRZOWICE	1357914	2542249	3238088	Yes
PL_EPLB	LUBLIN	0	0	376823	Yes
PL_EPLL	LODZ/LUBLINEK	204718	384071	241138	Yes
PL_EPMO	WARSZAWA/MODLIN	0	0	2859191	Yes
PL_EPPO	POZNAN/LAWICA	643855	1416685	1689412	Yes
PL_EPRZ	RZESZOW/JASIONKA	0	491173	662121	Yes
PL_EPSC	SZCZECIN/GOLENIOW	182523	244433	459142	Yes
PL_EPWA	WARSZAWIA/CHOPINA	8116876	9352979	12848326	No
PL_EPWR	WROCLAW/STRACHOWICE	460518	1626037	2391685	Yes
PT_LPFL	FLORES	27446	35797	37396	Yes
PT_LPFR	FARO	4956527	5599944	7618129	No
PT_LPHR	PLUGUFFAN	177899	177012	200464	Yes
PT_LPLA	LAJES	347434	480656	480656	Yes
PT_LPMA	MADEIRA	1989618	2237336	2814555	Yes
PT_LPPD	PONTA DELGADA	851778	840975	1371404	Yes
PT_LPPO	SANTA MARIA OAC/FIC	82164	86784	99643	Yes
PT_LPPR	PORTO	3194348	5977972	9364890	No
PT_LPPS	PORTO SANTO	149545	103785	157065	Yes
PT_LPPT	LISBOA	12127959	14609500	22288272	No
RO_LRBC	BACAU/GEORGE ENESCU	40601	293965	414744	Yes
RO_LRBS	BUCURESTI/BANEASA-AUREL VLAICU	675159	2390857	0	Yes
RO_LRCL	CLUJ NAPOCA/AVRAM IANCU	256483	1045570	1888595	Yes
RO_LRCV	CRAIOVA	0	32006	222320	Yes
RO_LRIA	IASI	70592	184311	879981	Yes
RO_LROP	BUCURESTI/HENRI COANDA	3514209	5049443	10982444	No
RO_LRSB	SIBIU	63618	202300	415538	Yes
RO_LRTM	TARGU MURES/TRANSILVANIA	46882	257303	287486	Yes
RO_LRTR	TIMISOARA/TRAIAN VUIA	763361	1230329	1161869	Yes
SE_ESDF	RONNEBY	209990	227497	232000	Yes
SE_ESGG	GOTEBORG/LANDVETTER	4362095	4981906	6408406	No
SE_ESGJ	JONKOPING	128432	112506	112506	Yes
SE_ESGP	GOTEBORG/SAVE	536349	772924	1236	Yes
SE_ESKN	STOCKHOLM/SKAVSTA	1773635	2581495	2025569	Yes
SE_ESMQ	KALMAR	157733	177906	241608	Yes
SE_ESMS	MALMO	1993237	2041810	2273457	Yes
SE_ESMT	HALMSTAD	119959	119959	119959	Yes
SE_ESMX	VAXJO/KRONOBERG	160482	180805	173072	Yes
SE_ESNN	SUNDSVALL-TIMRA	339094	290697	282517	Yes
SE_ESNO	ORNSKOLDSVIK	0	0	76178	Yes
SE_ESNQ	KIRUNA	172080	164773	260964	Yes
SE_ESNS	SKELLEFTEA	221303	277998	282397	Yes
SE_ESNU	UMEA	853378	979484	1086983	Yes
SE_ESNZ	ARE OSTERSUND	389521	378677	497420	Yes
SE_ESOE	OREBRO	85158	62514	118721	Yes
SE_ESOK	KARLSTAD	119443	108776	93517	Yes

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SE_ESOW	STOCKHOLM/VASTERAS	190111	144520	143553	Yes
SE_ESPA	LULEA/KALLAX	924273	1101716	1199919	Yes
SE_ESPC	OESTERSUND	459796	464816	464816	Yes
SE_ESSA	STOCKHOLM/ARLANDA	17795221	19097851	24738363	No
SE_ESSB	STOCKHOLM/BROMMA	1695695	2238965	2510643	Yes
SE_ESSD	BORLANGE	26804	26804	26804	Yes
SE_ESSL	LINKOPING/SAAB	157346	157346	157346	Yes
SE_ESSP	NORRKOPING/KUNGSANGEN	82580	114088	99609	Yes
SE_ESSV	VISBY	290420	339072	463972	Yes
SE_ESTA	ANGELHOLM	363157	396847	419518	Yes
SI_LJLB	MARIBOR	12452	6000	24886	Yes
SI_LJLJ	LJUBLJANA/BRNIK	1330016	1359646	1405510	Yes
SK_LZIB	BRATISLAVA/M.R.STEFANIK	1932447	1580642	1765382	Yes
SK_LZKZ	KOSICE	336184	265726	461412	Yes
UK_EGAA	BELFAST/ALDERGROVE	5061410	4105320	5147693	No
UK_EGAC	BELFAST/CITY	2105952	2395702	2665139	Yes
UK_EGAE	LONDONDERRY/EGLINTON	341752	405835	290671	Yes
UK_EGBB	BIRMINGHAM	9238416	8622832	11650938	No
UK_EGBJ	GLOUCESTERSHIRE	166	14762	12417	Yes
UK_EGCC	MANCHESTER	22751301	18975025	25675202	No
UK_EGCN	DONCASTER SHEFFIELD	900827	824215	1256182	Yes
UK_EGEC	CAMPBELTOWN	8472	8472	8472	Yes
UK_EGET	LERWICK/TINGWALL	4438	4438	4438	Yes
UK_EGFF	CARDIFF	2055595	1237006	1350738	Yes
UK_EGGD	BRISTOL	5804474	5793996	7617616	No
UK_EGGP	LIVERPOOL	4965237	5253911	4780798	No
UK_EGGW	LONDON LUTON	9437625	9517478	14648956	No
UK_EGHH	BOURNEMOUTH	967457	614915	669940	Yes
UK_EGHI	SOUTHAMPTON	1913256	1762185	1947139	Yes
UK_EGHQ	NEWQUAY	386870	215991	372826	Yes
UK_EGKK	LONDON GATWICK	34246209	33698225	43124169	No
UK_EGLC	LONDON/CITY	2358209	2941864	4538813	No
UK_EGLL	LONDON HEATHROW	67716534	69475746	75750160	No
UK_EGMC	SOUTHEND	30366	42439	874631	Yes
UK_EGNH	BLACKPOOL	552807	235671	36269	Yes
UK_EGNJ	HUMBERSIDE	525744	276122	202023	Yes
UK_EGNM	LEEDS BRADFORD	2798155	2988803	3612791	Yes
UK_EGNT	NEWCASTLE	5456555	4356293	4810767	No
UK_EGNV	DURHAM TEES VALLEY	919158	193872	133042	Yes
UK_EGNX	EAST MIDLANDS	4733038	4221953	4656775	No
UK_EGPA	KIRKWALL	140814	157973	173622	Yes
UK_EGPB	SUMBURGH	140257	145705	252093	Yes
UK_EGPC	WICK	38642	25673	20310	Yes
UK_EGPD	ABERDEEN/DYCE	3165527	3083141	2945927	Yes
UK_EGPE	INVERNESS	713555	583174	783149	Yes
UK_EGPF	GLASGOW	8877297	6902162	9330291	No
UK_EGPH	EDINBURGH	8615981	9386342	12349195	No
UK_EGPI	ISLAY	26600	26138	28704	Yes
UK_EGPK	PRESTWICK	2399887	1298726	674803	Yes
UK_EGPL	BENBECULA	34511	35124	32519	Yes
UK_EGPM	SCATSTA	255164	288314	162100	Yes
UK_EGPN	DUNDEE	51538	61700	37647	Yes
UK_EGPO	STORNOWAY	122753	128716	128710	Yes
UK_EGPR	BARRA	9808	10490	12832	Yes
UK_EGPU	TIREE	7051	8661	12056	Yes
UK_EGSH	NORWICH	748214	413955	506007	Yes
UK_EGSS	LONDON STANSTED	23692664	18054377	24320636	No
UK_EGTE	EXETER	994794	724153	847612	Yes

Source: Eurostat (2018a).

Appendix B

European regional data

European regional statistics

NUTS	**Regional centre**	*pop* (2016)	*GDP* (2016)	ΔGDP (2006-2011)	ΔGDP (2011-2016)	*DEN* (2016)	*EDU* (2016)	*RD* (2016)	*KI* (2016)
AT11	Eisenstadt	291011	25700	10	15	77	28	277	38
AT12	Sankt Poelten	1653691	30400	8	11	88	30	572	38
AT13	Wien	1840226	44700	4	4	4682	40	1764	47
AT21	Klagenfurt	560482	31600	9	10	60	29	1051	36
AT22	Graz	1232012	33000	9	11	76	27	1831	31
AT31	Linz	1453948	37800	10	12	125	29	1286	31
AT32	Salzburg	545815	44800	11	14	78	32	715	33
AT33	Innsbrueck	739139	40200	6	17	59	28	1325	33
AT34	Bregenz	384147	41100	8	18	153	28	797	31
BE10	Brussels	1201285	58400	1	3	7409	44	1130	48
BE21	Antwerp	1828927	40500	5	11	654	35	1363	41
BE22	Hasselt	866970	28300	7	10	363	33	408	40
BE23	Gent	1489084	31900	10	13	503	40	847	46
BE24	Leuven	1122600	37000	7	13	533	47	1687	52
BE25	Brugge	1184418	33700	7	13	377	35	400	42
BE31	Wavre	397745	38700	11	15	364	52	2614	56
BE32	Mons	1341267	22100	7	8	353	30	380	49
BE33	Luik	1103490	24700	8	7	288	33	547	48
BE34	Arlon	283257	21800	2	5	64	35	188	46
BE35	Namur	492074	23800	8	8	135	35	316	54
BG31	Pleven	783909	8600	14	16	41	20	21	29
BG32	Ruse	815441	9800	16	23	55	24	23	27
BG33	Varna	944458	11400	17	19	65	26	19	30
BG34	Burgas	1052575	12500	16	32	54	22	18	25
BG41	Sofia	2121185	22800	34	16	105	39	155	36
BG42	Plovdiv	1436216	9900	19	19	65	22	23	24
CY00	Nicosia	848319	24100	1	-4	92	42	101	36
CZ01	Prague	1267449	53100	9	16	2627	43	961	49
CZ02	Prague	1326876	23500	6	20	124	21	278	31
CZ03	Plzen	1214450	22500	5	18	71	19	220	27
CZ04	Usti nad Labem	1120654	18400	7	10	132	14	42	28
CZ05	Liberec	1507209	21100	9	18	123	19	174	28
CZ06	Brno	1684500	23600	15	20	123	26	419	32
CZ07	Olomouc	1219394	20800	15	19	134	19	166	27
CZ08	Ostrava	1213311	21800	16	17	228	20	156	29
DE11	Stuttgart	4069533	47200	12	14	387	33	3044	37
DE12	Karlsruhe	2761977	39900	10	8	404	32	1896	41
DE13	Freiburg	2224535	34500	11	11	241	29	950	36
DE14	Ulm	1823573	38700	15	12	211	31	1826	36
DE21	Munich	4588944	51500	10	12	268	38	2334	45
DE22	Landshut	1212119	35100	20	11	119	22	458	32
DE23	Regensburg	1092339	37600	20	15	114	25	780	35
DE24	Bayreuth	1059358	33400	16	15	147	23	665	35
DE25	Nuremberg	1738686	39100	15	12	242	29	1533	38
DE26	Wuertsburg	1306048	35800	14	10	154	27	776	36

NUTS	Regional centre	*pop* (2016)	*GDP* (2016)	ΔGDP (2006-2011)	ΔGDP (2011-2016)	*DEN* (2016)	*EDU* (2016)	*RD* (2016)	*KI* (2016)
DE27	Augsburg	1846020	35700	13	13	187	24	582	35
DE30	Berlin	3520031	34500	15	10	4193	39	1267	53
DE40	Potsdam	2484826	26100	14	16	86	27	443	41
DE50	Bremen	671489	45200	4	11	1727	28	1308	42
DE60	Hamburg	1787408	58300	4	9	2534	36	1372	47
DE71	Frankfurt am Main	3922369	46600	4	8	532	33	1530	46
DE72	Giessen	1040091	30800	8	12	194	28	806	42
DE73	Kassel	1213712	33000	10	13	147	24	544	40
DE80	Rostock	1612362	24400	17	13	71	26	470	38
DE91	Braunschweig	1598164	34800	20	4	198	25	3737	39
DE92	Hannover	2132290	33500	11	6	238	25	843	43
DE93	Cuxhaven	1699969	25700	13	16	111	23	255	40
DE94	Oldenburg	2496176	31500	16	10	168	20	306	36
DEA1	Duesseldorf	5173623	38100	11	9	1002	27	694	40
DEA2	Koeln	4422371	39000	9	12	608	30	1136	46
DEA3	Muenster	2614229	30300	12	9	379	25	352	40
DEA4	Bielefeld	2057996	34400	13	13	316	23	663	37
DEA5	Dortmund	3597297	31700	14	10	450	23	541	37
DEB1	Koblenz	1488308	31100	13	14	186	23	225	40
DEB2	Trier	532715	28600	13	15	108	26	868	38
DEB3	Mainz	2031780	34500	15	12	300	28	1192	40
DEC0	Saarbruecken	995597	33300	9	9	388	23	540	40
DED2	Dresden	1602754	28100	11	20	206	31	1135	40
DED4	Chemnitz	1465612	25800	15	17	224	24	462	34
DED5	Leipzig	1016485	29000	17	14	262	31	612	41
DEE0	Magdeburg	2245470	25100	13	15	111	23	361	36
DEF0	Kiel	2858714	29400	7	12	186	24	451	43
DEG0	Erfurt	2170714	26700	17	20	134	27	547	38
DK01	Copenhagen	1789174	46300	11	13	739	50	2847	59
DK02	Roskilde	827499	25300	3	11	117	29	341	46
DK03	Odense	1211770	32800	11	8	101	31	817	43
DK04	Aarhus	1293309	32400	7	7	102	36	1087	45
DK05	Aalborg	585499	30200	6	7	76	31	597	45
EE00	Tallinn	1315944	21900	16	18	30	39	230	34
EL30	Athens	3781274	26900	-14	0	993	38	253	43
EL41	Chios	196654	14700	-15	-5	52	26	95	40
EL42	Ermoupoli	334791	21300	-21	2	64	17	34	31
EL43	Heraklion	631812	16700	-22	2	76	27	213	27
EL51	Alexandroupoli	604504	13500	-13	-4	43	25	78	31
EL52	Thessaloniki	1883339	15400	-17	0	100	31	106	33
EL53	Kozani	273843	17200	-13	-4	30	22	73	27
EL54	Ioannina	336834	13900	-16	-1	37	28	140	31
EL61	Larissa	729442	15100	-22	7	52	26	82	29
EL62	Zakynthos	206141	18100	-24	3	90	21	76	29
EL63	Patras	668258	14300	-20	-3	60	23	159	30
EL64	Lamia	555830	17400	-20	-1	36	21	76	25
EL65	Tripoli	581026	16100	-15	2	38	21	53	25
ES11	A Coruna	2720102	23900	0	12	92	36	182	32
ES12	Oviedo	1040925	23200	-3	5	98	41	151	34
ES13	Santander	582504	24000	-5	7	111	39	176	33
ES21	Bilbao	2164066	35300	-2	12	301	49	586	36
ES22	Pamplona	637486	33300	-5	11	62	45	471	32
ES23	Logrono	312810	28100	-5	8	62	37	226	28
ES24	Zaragoza	1318571	29000	-3	9	28	36	228	34
ES30	Madrid	6424275	36400	-3	11	809	47	545	47
ES41	Valladolid	2454454	25200	-2	10	26	34	216	35
ES42	Toledo	2048900	20900	-5	7	26	27	98	34
ES43	Merida	1084969	18400	-1	10	26	25	107	38
ES51	Barcelona	7408290	32000	-6	13	232	39	420	34
ES52	Valencia	4932347	23600	-9	11	213	33	205	30
ES53	Palma	1135527	27800	-10	11	230	29	79	32
ES61	Sevilla	8403774	19800	-7	8	97	29	176	35
ES62	Murcia	1466474	22100	-8	12	130	28	167	29
ES70	Las Palmas	2135209	22000	-9	5	289	29	95	32
FI19	Tampere	1379116	28300	12	1	24	41	976	41
FI1B	Helsinki	1620261	41900	6	3	179	52	1824	51
FI1C	Turku	1160491	28200	4	4	37	39	671	40
FI1D	Oulou	1298457	26300	8	5	6	38	783	42

NUTS	Regional centre	*pop* (2016)	*GDP* (2016)	ΔGDP (2006-2011)	ΔGDP (2011-2016)	*DEN* (2016)	*EDU* (2016)	*RD* (2016)	*KI* (2016)
FI20	Aland	28983	38200	2	7	19	29	125	54
FR10	Paris	12138930	51100	13	10	1018	47	1552	52
FR21	Chalons en Champagne	1336535	24500	3	-3	52	23	208	39
FR22	Amiens	1933719	22900	2	6	100	23	300	40
FR23	Rouen	1862637	26100	2	6	152	27	351	39
FR24	Orleans	2580581	25100	0	6	66	29	424	41
FR25	Caen	1478803	24100	2	5	83	25	317	40
FR26	Dijon	1639637	24600	1	4	52	28	269	38
FR30	Lille	4083273	24300	5	6	329	29	207	43
FR41	Metz	2336356	23600	-3	9	99	30	297	42
FR42	Strasbourg	1884204	27700	4	5	228	34	508	41
FR43	Besancon	1179998	23800	-1	7	73	30	712	37
FR51	Nantes	3742638	27000	4	7	117	32	317	42
FR52	Rennes	3309220	26000	-2	10	121	34	495	43
FR53	Poitiers	1807170	23900	2	5	70	27	209	40
FR61	Bordeaux	3396364	27000	3	7	83	32	412	43
FR62	Toulouse	3024327	27900	0	12	67	39	1352	48
FR63	Limoges	736983	24600	-5	17	43	32	217	41
FR71	Lyon	6569276	30000	4	5	149	38	883	41
FR72	Clermont-Ferrand	1363924	25800	1	12	52	31	571	41
FR81	Montpellier	2794804	22300	3	2	103	31	548	43
FR82	Marseille	5028341	28100	4	6	161	36	596	46
FR83	Ajaccio	330752	25000	11	7	38	38	94	49
HR03	Split	1394290	16700	8	12	57	23	34	32
HR04	Zagreb	2796379	17900	9	12	89	23	116	28
HU10	Budapest	2993948	29800	12	7	441	36	323	42
HU21	Szekesfehervar	1060703	18600	11	22	99	19	100	27
HU22	Gyor	983933	21500	14	23	88	19	71	27
HU23	Pecs	900868	12900	14	11	65	19	31	34
HU31	Miskolc	1153714	13000	6	25	86	17	36	32
HU32	Debrecen	1474383	12500	17	12	85	17	78	35
HU33	Szeged	1262936	14000	13	22	69	20	132	31
IE01	Galway	1259673	25000	-13	11	39	38	488	40
IE02	Dublin	3466613	63400	-5	66	96	46	745	47
ITC1	Turin	4404246	30000	-1	4	175	17	622	32
ITC2	Aosta	127329	35600	4	0	39	16	235	39
ITC3	Genova	1571053	31400	2	6	290	20	437	37
ITC4	Milan	10008349	37300	5	4	435	19	454	33
ITF1	L'Aquila	1326513	24600	6	3	123	17	225	32
ITF2	Campobasso	312027	20400	-1	-1	70	18	91	33
ITF3	Napoli	5850850	18600	-2	8	429	15	219	37
ITF4	Bari	4077166	18100	1	5	211	13	175	34
ITF5	Potenza	573694	21000	1	10	57	16	132	33
ITF6	Catanzaro	1970521	17100	2	2	130	15	116	37
ITG1	Palermo	5074261	17500	-2	1	197	13	169	41
ITG2	Cagliari	1658138	20600	2	3	70	15	166	39
ITH1	Bolzano	520891	43400	8	12	71	17	311	33
ITH2	Trento	538223	35600	4	5	88	19	623	39
ITH3	Venice	4915123	32300	1	7	283	16	340	28
ITH4	Trieste	1221218	30900	1	6	161	17	462	33
ITH5	Bolonga	4448146	35300	2	8	201	21	603	30
ITI1	Firenze	3744398	30500	2	6	164	20	387	32
ITI2	Perugia	891181	24400	-4	-1	107	21	215	30
ITI3	Ancona	1543752	27100	-1	4	164	19	221	28
ITI4	Roma	5888472	32100	-1	-4	348	23	495	43
LT00	Vilnius	2888558	22000	26	28	46	40	133	34
LU00	Luxembourg	576249	75100	7	8	225	43	1177	56
LV00	Riga	1968957	18800	15	26	31	33	77	35
MT00	Valetta	450415	27800	12	29	1450	20	167	42
NL11	Groningen	583721	37200	12	-19	247	36	928	49
NL12	Leeuwarden	646040	25900	8	3	190	27	238	45
NL13	Assen	488629	26000	0	7	184	29	228	43
NL21	Zwolle	1144280	30700	8	7	341	32	609	42
NL22	Arnhem	2035351	31300	5	6	408	33	727	44
NL23	Almere	404068	28800	-2	7	283	30	461	47
NL31	Utrecht	1273613	43300	4	5	910	47	1049	52
NL32	Amsterdam	2784854	47800	2	13	1016	43	882	49
NL33	Rotterdam	3622303	37400	0	7	1261	37	880	47

NUTS	**Regional centre**	*pop* (2016)	*GDP* (2016)	ΔGDP (2006-2011)	ΔGDP (2011-2016)	*DEN* (2016)	*EDU* (2016)	*RD* (2016)	*KI* (2016)
NL34	Middelburg	381252	29000	11	7	212	26	185	41
NL41	Eindhoven	2498749	38800	5	10	505	34	1140	40
NL42	Maastricht	1116260	31700	5	11	518	29	626	40
PL11	Lodz	2479350	18600	36	18	137	27	71	28
PL12	Warsaw	5323267	31700	39	17	151	38	313	38
PL21	Krakow	3330031	18100	34	20	222	31	152	29
PL22	Katowice	4520567	20700	38	13	372	27	71	29
PL31	Lublin	2118528	13700	36	16	85	27	83	27
PL32	Rzeszow	2083496	14000	33	17	118	28	104	25
PL33	Kielce	1241895	14300	33	10	107	27	50	24
PL34	Bialystok	1158945	14100	36	14	58	29	62	29
PL41	Poznan	3450966	21700	35	21	117	26	91	25
PL42	Szczecin	1684025	16700	27	17	77	26	32	33
PL43	Gorzow	1005159	16700	26	18	73	23	21	28
PL51	Wroclaw	2864624	22100	45	14	145	29	107	32
PL52	Opole	952557	15900	36	14	102	25	30	27
PL61	Bydgoszcz	2062006	16300	29	17	117	23	42	29
PL62	Olsztyn	1414734	14200	32	15	62	23	26	31
PL63	Gdansk	2277059	19300	32	18	129	31	122	34
PT11	Porto	3603778	19000	2	16	170	20	197	26
PT15	Faro	441929	23700	-9	20	90	21	66	33
PT16	Torre	2256364	19700	-2	15	80	23	184	27
PT17	Lisboa	2812678	29700	-3	5	1003	32	351	43
PT18	Evora	724391	21200	-4	15	23	19	83	33
RO11	Cluj	2576777	14900	29	27	76	17	29	18
RO12	Brasov	2341749	15800	35	23	69	18	25	21
RO21	Iasi	3256282	10400	30	32	89	12	22	15
RO22	Constanta	2469801	14500	37	27	73	13	6	20
RO31	Lloiesti	3031386	13400	46	15	89	13	22	19
RO32	Bucharest	2288538	40400	53	20	1304	35	177	41
RO41	Craiova	1993741	12400	32	25	69	17	12	15
RO42	Timisoara	1802040	17600	39	17	56	16	36	18
SE11	Stockholm	2231439	50400	9	9	345	50	2465	60
SE12	Uppsala	1638825	31100	7	8	43	38	1537	50
SE21	Jonkoping	834276	30600	4	9	25	34	594	44
SE22	Malm	1459880	30200	2	9	106	43	1280	51
SE23	Gteborg	1963466	35300	5	12	68	40	1706	49
SE31	Gvle	838747	28800	2	7	13	33	475	45
SE32	Sundsvall	371273	30200	8	3	5	33	294	52
SE33	Umea	513111	32500	10	1	3	38	1113	52
SI03	Maribor	1092193	19900	3	11	89	27	253	30
SI04	Ljubljana	971995	28800	0	10	125	35	595	40
SK01	Bratislava	633288	53700	33	11	316	39	653	50
SK02	Nitra	1832159	20900	21	12	123	20	118	28
SK03	Zilina	1343458	17900	26	17	83	20	134	31
SK04	Kosice	1617347	15600	22	18	103	19	76	31
UKC1	Middlesbrough	1190295	21100	-4	9	395	33	266	44
UKC2	Newcastle	1441996	23900	-5	8	260	38	386	48
UKD1	Carlisle	497677	28000	-2	21	74	36	432	34
UKD3	Manchester	2765142	27000	-6	14	2174	39	325	48
UKD4	Preston	1479227	24500	-5	15	482	37	286	45
UKD6	Warrington	919043	37500	-2	18	407	47	1876	48
UKD7	Liverpool	1526142	23700	-2	8	2111	36	485	49
UKE1	Lincoln	927490	23300	-7	7	264	34	237	42
UKE2	York	811004	26500	-5	7	98	42	548	44
UKE3	Sheffield	1378722	21100	-5	10	891	34	340	43
UKE4	Leeds	2289330	26000	-5	11	1132	35	351	47
UKF1	Derby	2168542	24600	-2	12	455	37	855	44
UKF2	Leiceter	1785506	27100	-5	14	366	37	409	44
UKF3	Lincoln	739568	21000	-4	10	125	32	101	42
UKG1	Hereford	1324254	29900	-4	23	225	43	1228	43
UKG2	Shrewsbury	1600427	23400	-3	13	259	34	195	42
UKG3	Birmingham	2847401	25100	-6	14	3170	33	607	48
UKH1	Norwich	2477141	27800	-6	14	198	38	1729	46
UKH2	Bedford	1832858	32300	-9	18	640	45	1335	51
UKH3	Essex	1795481	25000	-6	14	491	34	513	50
UKI3	City of London	1154723	178200	8	21	10647	75	3688	71
UKI4	Newham	2351077	48700	4	9	11290	60	346	63

NUTS	**Regional centre**	pop (2016)	GDP (2016)	ΔGDP (2006-2011)	ΔGDP (2011-2016)	DEN (2016)	EDU (2016)	RD (2016)	KI (2016)
UKI5	Romford	1881234	22300	-12	15	4383	46	98	49
UKI6	Croydon	1293591	27800	-12	12	3661	54	148	61
UKI7	Hendon	2078783	39300	-12	27	4494	55	482	55
UKJ1	Oxford	2371762	43900	-1	16	415	52	2010	53
UKJ2	Brighton	2848968	32500	-5	14	525	47	659	53
UKJ3	Southampton	1961234	31400	0	12	474	40	876	52
UKJ4	Dover	1810607	25300	-3	11	487	39	409	48
UKK1	Bristol	2450153	32300	0	14	329	46	853	51
UKK2	Bournemouth	1316014	24200	-6	11	216	41	270	43
UKK3	Truro	554342	20100	-6	13	156	35	101	42
UKK4	Plymouth	1171817	23300	-5	11	175	40	332	44
UKL1	Swansea	1954116	19900	-4	14	149	35	199	47
UKL2	Cardiff	1151742	27100	-4	13	151	44	401	48
UKM2	Edinburgh	2071557	29800	-6	16	116	51	796	50
UKM3	Glasow	2341746	26500	-6	16	180	46	374	48
UKM5	Aberdeen	494758	42000	10	4	76	49	785	39
UKM6	Iverness	468546	26800	1	12	12	44	180	46
UKN0	Belfast	1858540	23600	-9	12	138	34	486	45

Sources: Eurostat (2018b, 2018f, 2018g, 2018h, 2018i).

Appendix C

Regional air connectedness data

Regional air connectedness statistics

NUTS	Regional centre	CON (2016) All	CON (2016) Regional	ΔCON (2006-2011) All	ΔCON (2011-2016) All	ΔCON (2006-2011) Regional	ΔCON (2011-2016) Regional	$CONT$ (2016)
AT11	Eisenstadt	55	0.66	23	11	4	-3	1.2
AT12	Sankt Poelten	8	0.09	22	10	-14	-39	1.2
AT13	Wien	11	0.04	22	11	29	-29	0.4
AT21	Klagenfurt	1	0.89	-1	-26	-1	-27	100
AT22	Graz	1	0.71	4	-5	4	-7	100
AT31	Linz	1	0.63	-12	-19	-12	-21	100
AT32	Salzburg	8	3.1	6	5	-10	-7	38.4
AT33	Innsbrueck	4	1.21	20	8	19	-4	33.6
AT34	Bregenz	25	2.49	26	13	64	6	9.9
BE10	Brussels	22	2.58	14	21	30	48	11.8
BE21	Antwerp	11	0.36	18	17	48	31	3.3
BE22	Hasselt	32	1.42	17	17	54	19	4.5
BE23	Gent	13	1.95	22	22	38	59	14.8
BE24	Leuven	25	2.1	20	20	37	51	8.5
BE25	Brugge	11	1.11	21	20	24	62	10
BE31	Wavre	65	6.52	23	20	31	50	10.1
BE32	Mons	16	1.01	28	19	18	44	6.5
BE33	Luik	23	2.56	26	18	64	29	10.9
BE34	Arlon	21	10.35	16	27	-3	31	49.1
BE35	Namur	47	3.67	27	19	15	40	7.8
BG31	Pleven	0	0	0	0	0	-100	0
BG32	Ruse	3	0	95	40	279	-100	0
BG33	Varna	2	1.75	-18	43	-18	46	100
BG34	Burgas	2	2.46	36	28	36	31	100
BG41	Sofia	2	0	56	44	0	-100	0
BG42	Plovdiv	1	0	63	43	0	-100	0
CY00	Nicosia	5	0.46	-7	25	-21	29	8.4
CZ01	Prague	9	0.22	-3	10	1	-19	2.5
CZ02	Prague	8	0.21	-6	10	-3	-21	2.5
CZ03	Plzen	6	0.01	0	10	175	-75	0.2
CZ04	Usti nad Labem	6	0.97	2	6	3	-14	16.7
CZ05	Liberec	3	0.19	0	9	1	-14	6.9
CZ06	Brno	2	0.52	15	4	2	-10	30.9
CZ07	Olomouc	0	0.31	17	-20	17	-19	100
CZ08	Ostrava	2	1.36	45	34	56	20	57
DE11	Stuttgart	8	0.16	6	8	36	1	2
DE12	Karlsruhe	11	0.41	7	8	18	-12	3.7
DE13	Freiburg	1	0.61	-17	-1	-17	-5	100
DE14	Ulm	10	0.52	18	12	159	13	4.9
DE21	Munich	7	0.21	21	11	38	5	2.9
DE22	Landshut	27	0.25	25	11	54	10	0.9
DE23	Regensburg	19	0	22	9	189	-75	0
DE24	Bayreuth	2	0.4	2	-14	11	-20	17.9
DE25	Nuremberg	8	0	17	5	0	-100	0

NUTS	**Regional centre**	CON (2016) All	CON (2016) Regional	ΔCON (2006-2011) All	ΔCON (2011-2016) All	ΔCON (2006-2011) Regional	ΔCON (2011-2016) Regional	$CONT$ (2016)
DE26	Wuertsburg	21	0.03	8	7	-22	-14	0.1
DE27	Augsburg	15	0.33	21	12	385	19	2.2
DE30	Berlin	8	0.13	33	35	-48	-19	1.7
DE40	Potsdam	10	0.36	38	33	11	-18	3.4
DE50	Bremen	16	3.88	14	8	35	-9	24.6
DE60	Hamburg	9	0.51	14	16	53	-4	5.8
DE71	Frankfurt am Main	14	0.28	7	8	-13	-13	2
DE72	Giessen	41	0.73	9	8	-14	-1	1.8
DE73	Kassel	5	0.92	5	6	-13	-3	17.8
DE80	Rostock	1	0.1	11	9	-30	-40	11.1
DE91	Braunschweig	3	0.56	4	-1	35	-6	20.1
DE92	Hannover	4	0.59	5	3	20	-12	15.7
DE93	Cuxhaven	1	0.76	25	4	53	-1	51.4
DE94	Oldenburg	2	0.87	22	6	30	-10	44.5
DEA1	Duesseldorf	6	0.9	22	16	56	7	14
DEA2	Koeln	7	0.73	16	16	32	-4	11.2
DEA3	Muenster	6	1.16	14	8	7	-18	19.2
DEA4	Bielefeld	4	0.93	2	4	-12	-16	22
DEA5	Dortmund	7	1.09	20	13	20	-7	15.8
DEB1	Koblenz	29	1.62	8	11	-11	6	5.6
DEB2	Trier	18	7.6	0	14	-4	15	42.6
DEB3	Mainz	26	0.88	7	8	-11	-11	3.3
DEC0	Saarbruecken	19	3.4	9	7	-2	8	17.7
DED2	Dresden	4	1.48	13	11	9	-16	33.8
DED4	Chemnitz	2	1.31	4	-6	5	-14	54.1
DED5	Leipzig	7	2.87	19	9	7	-20	40.1
DEE0	Magdeburg	3	0.66	13	18	14	-15	23
DEF0	Kiel	3	0	11	17	-49	-100	0
DEG0	Erfurt	0	0.44	6	-17	6	-17	100
DK01	Copenhagen	15	0.83	8	27	3	5	5.4
DK02	Roskilde	28	1.4	8	27	3	10	5
DK03	Odense	6	1.1	13	24	35	9	17.4
DK04	Aarhus	2	1.76	37	0	37	-2	100
DK05	Aalborg	3	2.52	63	3	63	2	100
EE00	Tallinn	2	1.52	26	16	26	17	100
EL30	Athens	4	0	-5	39	0	-100	0
EL41	Chios	1	0.94	0	-14	0	-12	100
EL42	Ermoupoli	0	0.05	-14	80	-14	79	100
EL43	Heraklion	10	0	-5	28	0	-100	0
EL51	Alexandroupoli	0	0.39	-17	-22	-17	-21	100
EL52	Thessaloniki	2	0.02	3	42	-18	5	1.1
EL53	Kozani	4	0.02	6	43	2	3	0.4
EL54	Ioannina	1	0.66	-16	34	-16	37	100
EL61	Larissa	0	0.02	25	20	428	-72	4.5
EL62	Zakynthos	6	6.37	-8	53	-8	55	100
EL63	Patras	0	0.13	-26	58	-26	63	100
EL64	Lamia	0	0.02	456	-74	456	-74	100
EL65	Tripoli	3	0.24	-4	42	13	121	7
ES11	A Coruna	1	0.95	10	3	10	5	100
ES12	Oviedo	1	1	0	-7	0	-4	100
ES13	Santander	4	1.21	17	-3	64	-29	27.4
ES21	Bilbao	2	0.3	7	8	31	-15	14.5
ES22	Pamplona	2	0.73	-12	-12	-18	-30	46.5
ES23	Logrono	4	0.34	-3	-5	-10	-64	8.7
ES24	Zaragoza	0	0.27	54	-47	54	-46	100
ES30	Madrid	7	0	3	-1	-3	-52	0
ES41	Valladolid	0	0.08	4	-25	0	-48	32.3
ES42	Toledo	12	0	1	-1	0	-100	0
ES43	Merida	0	0.02	24	-6	-2	1	7.1
ES51	Barcelona	5	0.15	6	23	-18	-43	2.9
ES52	Valencia	1	0	-3	18	0	-100	0
ES53	Palma	21	0	-7	16	0	-100	0
ES61	Sevilla	1	0.05	14	-7	-30	-6	10.1
ES62	Murcia	6	0.53	-1	20	-29	-14	9.2
ES70	Las Palmas	5	0	-3	15	0	-100	0
FI19	Tampere	2	0.16	17	-2	2	-66	7.8
FI1B	Helsinki	9	0.03	17	15	8	-38	0.3

NUTS	Regional centre	CON (2016) All	CON (2016) Regional	ΔCON (2006-2011) All	ΔCON (2011-2016) All	ΔCON (2006-2011) Regional	ΔCON (2011-2016) Regional	$CONT$ (2016)
FI1C	Turku	3	0.26	21	9	15	-26	10.1
FI1D	Oulou	1	0.68	13	4	13	4	100
FI20	Aland	2	1.57	-19	11	-19	7	100
FR10	Paris	6	0.13	5	11	87	6	2
FR21	Chalons en Champagne	9	0.19	8	11	37	72	2.1
FR22	Amiens	15	1.57	11	10	79	14	10.3
FR23	Rouen	4	0.95	14	15	62	14	24.5
FR24	Orleans	5	0.15	5	16	29	53	3.2
FR25	Caen	0	0.04	-66	48	-66	47	100
FR26	Dijon	0	0	27	11	-17	-100	0
FR30	Lille	4	0.48	21	17	33	49	10.9
FR41	Metz	1	1.06	6	30	6	31	100
FR42	Strasbourg	3	1.07	-11	4	-21	-8	32.1
FR43	Besancon	0	0.1	-2	-2	-2	-2	100
FR51	Nantes	1	0.08	32	45	-7	29	7
FR52	Rennes	1	0.18	11	45	-27	39	26.4
FR53	Poitiers	0	0.1	-38	13	-38	11	100
FR61	Bordeaux	1	0.03	22	40	7	-1	2.2
FR62	Toulouse	2	0.09	13	14	-15	-5	4
FR63	Limoges	0	0.35	-11	-14	-11	-14	100
FR71	Lyon	2	0.01	23	15	-44	-6	0.6
FR72	Clermont-Ferrand	0	0.26	-29	-1	-29	-2	100
FR81	Montpellier	1	0.71	6	18	-5	17	48.9
FR82	Marseille	2	0.11	18	14	-16	3	6.9
FR83	Ajaccio	4	4	12	21	12	15	100
HR03	Split	1	1.37	24	77	24	79	100
HR04	Zagreb	1	0.84	32	21	32	25	100
HU10	Budapest	3	0	3	28	-21	10	0.2
HU21	Szekesfehervar	6	0.06	9	28	-17	15	1
HU22	Gyor	15	0.93	19	14	-18	13	6.2
HU23	Pecs	0	0.01	5	-2	5	2	100
HU31	Miskolc	2	0.26	10	38	-19	166	13.8
HU32	Debrecen	0	0.18	-46	1377*	-46	1384*	100
HU33	Szeged	2	0.08	13	27	66	-2	3.9
IE01	Galway	1	0.83	-59	22	-59	20	100
IE02	Dublin	7	0.08	-18	47	5	7	1.2
ITC1	Turin	2	0.05	-6	2	25	-21	2.1
ITC2	Aosta	41	0	-2	6	0	-100	0
ITC3	Genova	3	0.75	9	2	30	-9	28.3
ITC4	Milan	3	0.09	-2	8	15	-18	3
ITF1	L'Aquila	10	0.16	17	11	58	1	1.5
ITF2	Campobasso	3	0.15	17	16	67	5	5.7
ITF3	Napoli	1	0	13	17	0	-100	0
ITF4	Bari	1	0.21	93	16	148	12	18.7
ITF5	Potenza	3	0	36	17	0	-100	0
ITF6	Catanzaro	1	1.05	64	8	64	8	100
ITG1	Palermo	1	0.11	30	5	365	1	12.7
ITG2	Cagliari	2	0	46	0	0	-100	0
ITH1	Bolzano	2	1.83	10	-12	10	-16	100
ITH2	Trento	5	3.2	16	3	6	-11	64.9
ITH3	Venice	1	0.31	23	21	-9	70	21.3
ITH4	Trieste	3	0.93	25	6	13	-5	34.5
ITH5	Bolonga	2	0.5	34	19	23	-2	20.7
ITI1	Firenze	2	0.61	37	23	20	29	27.6
ITI2	Perugia	1	0.65	31	12	31	11	100
ITI3	Ancona	0	0.42	63	-37	63	-37	100
ITI4	Roma	6	0	16	11	90	6	0
LT00	Vilnius	1	1.3	48	94	48	105	100
LU00	Luxembourg	8	6.51	6	30	-7	16	81.5
LV00	Riga	2	0	120	6	0	-100	0
MT00	Valetta	10	0	27	45	0	-100	0
NL11	Groningen	16	1.01	8	25	18	-2	6.5
NL12	Leeuwarden	26	0.18	7	28	-8	13	0.7
NL13	Assen	6	0.72	5	22	-4	-10	11.6
NL21	Zwolle	26	0.95	9	25	47	-7	3.7
NL22	Arnhem	19	2.32	15	24	74	21	12
NL23	Almere	120	6.08	4	29	61	42	5

NUTS	Regional centre	CON (2016) All	CON (2016) Regional	ΔCON (2006-2011) All	ΔCON (2011-2016) All	ΔCON (2006-2011) Regional	ΔCON (2011-2016) Regional	$CONT$ (2016)
NL31	Utrecht	40	3.08	8	27	75	39	7.6
NL32	Amsterdam	20	0.92	6	29	55	47	4.6
NL33	Rotterdam	15	1.05	9	28	53	46	7.2
NL34	Middelburg	48	4.96	12	25	43	67	10.4
NL41	Eindhoven	17	2.48	17	26	89	37	15
NL42	Maastricht	27	2.78	26	20	119	39	10.1
PL11	Lodz	2	0.2	17	53	0	100	10
PL12	Warsaw	2	0.39	13	63	0	100	16
PL21	Krakow	2	0.47	47	54	124	27	27.1
PL22	Katowice	1	0.61	55	45	86	29	46.4
PL31	Lublin	0	0.18	0	100	0	100	100
PL32	Rzeszow	1	0.54	222	47	0	35	55.2
PL33	Kielce	0	0	29	65	0	-100	0
PL34	Bialystok	0	0	0	0	0	0	0
PL41	Poznan	0	0.43	116	20	116	19	100
PL42	Szczecin	2	0.18	36	37	34	89	7.6
PL43	Gorzow	1	0.51	59	44	93	35	63.6
PL51	Wroclaw	1	0.69	254	47	254	48	100
PL52	Opole	3	2.02	120	41	153	39	79.4
PL61	Bydgoszcz	0	0.3	106	39	106	40	100
PL62	Olsztyn	0	0	0	0	0	0	0
PL63	Gdansk	1	1.45	93	62	93	60	100
PT11	Porto	2	0.09	75	53	-17	0	3.7
PT15	Faro	15	0	6	36	0	-100	0
PT16	Torre	2	0	55	55	0	-100	0
PT17	Lisboa	7	0	17	53	0	-100	0
PT18	Evora	11	0.02	22	52	3	3	0.2
RO11	Cluj	1	0.56	312	79	312	89	100
RO12	Brasov	0	0	0	0	0	0	0
RO21	Iasi	0	0.25	164	377	164	442	100
RO22	Constanta	0	0.01	-20	41	-20	60	100
RO31	Lloiesti	2	0	79	52	262	-100	0
RO32	Bucharest	4	0	76	44	246	-100	0
RO41	Craiova	0	0.10	100	100	590	590	100
RO42	Timisoara	1	0.54	62	-6	62	0	100
SE11	Stockholm	10	1.79	4	22	26	-13	17.7
SE12	Uppsala	13	1.27	6	26	27	-1	9.7
SE21	Jonkoping	3	0.15	13	21	20	-45	5.2
SE22	Malm	17	1.35	2	26	-2	6	8.1
SE23	Gteborg	3	0.03	13	12	32	-91	1.2
SE31	Gvle	10	0.56	8	28	29	10	5.4
SE32	Sundsvall	1	0.62	-14	-3	-14	-3	100
SE33	Umea	2	2.20	16	14	16	13	100
SI03	Maribor	2	1.52	10	7	10	7	100
SI04	Ljubljana	2	2.03	5	4	5	2	100
SK01	Bratislava	27	2.75	18	10	-15	1	10
SK02	Nitra	4	0.55	17	11	-18	12	14.5
SK03	Zilina	0	0.2	-16	8	-16	8	100
SK04	Kosice	0	0.25	-22	73	-22	72	100
UKC1	Middlesbrough	4	1.69	-23	16	-27	17	37.7
UKC2	Newcastle	3	0.34	-25	10	-47	7	10.5
UKD1	Carlisle	10	0.12	-21	21	-68	-57	1.2
UKD3	Manchester	10	0.65	-16	26	-12	11	6.4
UKD4	Preston	9	0.48	-15	24	-31	-6	5.1
UKD6	Warrington	32	1.55	-14	25	-11	10	4.8
UKD7	Liverpool	13	0.46	-13	23	-14	3	3.5
UKE1	Lincoln	3	2.18	-15	21	-15	21	65.1
UKE2	York	12	3.55	-18	26	-17	19	30.6
UKE3	Sheffield	14	1.76	-15	28	-13	22	12.6
UKE4	Leeds	8	1.61	-16	26	-13	17	20.9
UKF1	Derby	8	0.46	-14	28	-10	29	5.5
UKF2	Leiceter	11	0.21	-10	29	-20	35	2
UKF3	Lincoln	7	1.94	-14	23	-17	21	26.1
UKG1	Hereford	31	0.18	-6	23	-8	47	0.6
UKG2	Shrewsbury	17	0.24	-14	27	-4	35	1.4
UKG3	Birmingham	12	0.07	-9	24	-8	43	0.6
UKH1	Norwich	3	0.19	-25	37	-47	19	6.3

NUTS	Regional centre	*CON* (2016) All	*CON* (2016) Regional	Δ*CON* (2006-2011) All	Δ*CON* (2011-2016) All	Δ*CON* (2006-2011) Regional	Δ*CON* (2011-2016) Regional	*CONT* (2016)
UKH2	Bedford	43	0.13	-7	21	-42	298	0.3
UKH3	Essex	44	0.42	-8	24	-33	657	0.9
UKI3	City of London	88	0.64	-3	20	-8	112	0.7
UKI4	Newham	38	0.21	-13	23	-20	1109*	0.6
UKI5	Romford	50	0.32	-10	23	-27	922	0.6
UKI6	Croydon	59	0.51	-3	20	-8	211	0.9
UKI7	Hendon	52	0.38	-9	20	-14	79	0.7
UKJ1	Oxford	33	0.42	-5	18	-16	5	1.3
UKJ2	Brighton	25	0.31	-4	20	-13	29	1.2
UKJ3	Southampton	26	1.13	-3	15	-19	6	4.3
UKJ4	Dover	35	0.18	-7	20	33	1861*	0.5
UKK1	Bristol	11	0.54	-5	16	-32	6	4.7
UKK2	Bournemouth	18	1.62	-3	9	-23	7	9
UKK3	Truro	1	0.84	-39	46	-39	41	100
UKK4	Plymouth	0	0.49	-33	30	-33	25	100
UKL1	Swansea	1	0.37	-22	23	-41	8	35.1
UKL2	Cardiff	4	1.01	-19	25	-41	7	26.1
UKM2	Edinburgh	7	0.08	-8	30	-48	-49	1.2
UKM3	Glasow	7	0.2	-15	28	-47	-48	2.8
UKM5	Aberdeen	5	5.11	-8	-4	-8	-9	100
UKM6	Iverness	1	1.42	-21	34	-21	34	100
UKN0	Belfast	7	1.39	-13	31	9	6	20.1

*Extreme values of air connectedness change are often caused by opening and closures of airports. These cases are left out of the analysis as they would undermine the model's performance.