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Public Service Obligations for Air Transport in the United States and Europe: Connectivity Effects and Value for Money

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Abstract

Public service obligations (PSOs) are used by governments in many countries, including the United States and 11 countries in Europe, to mandate a minimum level of commercial air transportation service, especially for small or rural communities. This paper analyzes PSOs in these 12 countries for the year 2010 using the recently proposed Global Connectivity Index to measure direct and indirect market access and a novel subsidy database covering 90% of PSO movements in these countries to assess value-for-money.

We show that PSO services represent about 2.5% of all commercial movements in the 12 countries analyzed, generating about 1% of these countries' total air transport connectivity. Over all routes for which data was available, approximately USD$ 900 million was earmarked for PSO and air service discount provision in 2010, with average subsidies per movement ranging from about $700 to $3,500. PSO market access and efficiency outcomes vary across the countries analyzed. Some countries, such as Germany and the United States, focus on providing network access for smaller communities, thereby creating not only point-to-point, but also onward connectivity, while others such as Norway, Sweden, and Ireland, predominantly aim at providing "lifeline services" that connect remote regions to a nearby economic center without providing onward connections.

Keywords: public service obligations, air transport subsidies, Essential Air Service, small community air service, connectivity

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1. Introduction

Communities throughout the world rely on local airports to connect their residents and businesses to economic and social opportunities across the globe. However, for many small communities, demand for air transportation is often not sufficient to support commercial flights from local airports (Bråthen, 2011). If, however, air services to a community are deemed important to the social good of the community, e.g. because the community lacks other connections to economic centers, governments may choose to subsidize such services. These subsidies can take a number of forms, including subsidies paid directly to an air carrier to provide services (Calzada and Fageda, 2014), subsidies paid to airports to support infrastructure for service to local communities (Merkert and O'Fee, 2013; Wittman, 2014), and price caps or discount programs that limit maximum fares on publicly-supported routes (Di Francesco and Pagliari, 2012).

This paper focuses on public service obligations (PSOs) - a widely-used means for establishing and maintaining air services to communities through route subsidies paid to airlines. While the details of PSOs vary by country, PSOs are generally defined as air transportation routes for which a minimum level of service is mandated by the government (Santana, 2009). Airlines usually operate PSO routes in return for a subsidy while fulfilling pre-defined mandates on, for example, frequencies, aircraft size, or airfares (Reynolds-Feighan, 1999; Williams, 2010). PSO programs are relatively widespread internationally with eleven European countries and the United States having such programs in place in 2014 (European Commission, 2014; U.S. Department of Transportation 2014).

While the detailed goals of public service obligations differ by program, country, and community (Di Francesco and Pagliari, 2012; Merkert and O'Fee, 2013), many PSO-issuing authorities place a high priority on "access" for and to communities (Merkert and O'Fee 2013). Access *to* communities often focuses on promoting incoming trade and tourism, whereas access *for* small communities can entail providing "lifeline" services to economic and social infrastructure. Access is enhanced by air service to communities, which - given the network character of aviation - does not only create point-to-point connectivity, but can also create indirect connectivity if the air services involves a hub airport.

Given the different nature of PSO programs, this paper aims at providing the first quantitative assessment of (i) the prevalence and nature of PSOs by country, (ii) the contribution of PSOs to connecting communities by means of air services, and (iii) the subsidies paid for creating or maintaining connectivity through PSOs. For this purpose, we analyze network-wide contributions of PSOs in creating and maintaining access for and to communities across 11 European countries and the United States, for the year 2010 as the most recent year for which a complete dataset could be obtained. Through this approach, the paper provides a multifaceted assessment of PSO outcomes. This assessment can serve as an input to prescriptive analyses on the societal necessity of PSO routes based on "minimum" or "optimal" levels of connectivity for individual airports or regions.

In order to analyze the different nature and impacts of PSOs, this paper sets out to assess the connectivity impacts of PSOs in the United States and in all 11 European countries with designated PSO routes in 2010. Analyses of the connectivity and market access provided by air transportation have grown in number in recent years as researchers aim to describe the societal and economic benefits of access to aviation (Matisziw and Grubesic, 2010; Burghouwt and Redondi, 2013; O'Kelly, 2016). We regard this perspective as particularly insightful for two reasons. First, increased access is a core goal of many PSO programs and therefore should be a key metric for their analysis (Merkert and O'Fee, 2013). Second, improving market access has been identified as the fundamental mechanism by which air transport drives regional economic development (Brueckner, 2003; Lakshmanan, 2011; Allroggen and Malina, 2014). In turn, connectivity analyses, particularly those that acknowledge the heterogeneities across different regions, align with recent work in the New Economic Geography literature that has introduced an increasingly regional perspective to aviation activity (Dobruszkes et al. 2011; Allroggen and Malina, 2014; Gillen and Hazledine, 2015).

To assess PSO route connectivity, we apply the Global Connectivity Index (GCI) proposed by Allroggen et al. (2015). The GCI quantifies the 'connectivity value' of direct and indirect air services which are available to passengers at a specific airport during a defined time period by considering not only the frequency of connections, but also the link quality and destination quality of each itinerary. By using the GCI, this paper provides the first quantification of the degree to which PSOs contribute to market access for local communities. We note that the causal interpretation of our results might be limited since there is no observation of the 'counterfactual' network in a (hypothetical) world without PSOs. However, for European PSOs, subsidies are only paid if no carrier has offered to serve the route without subsidies (Williams and Pagliari, 2004), and the U.S. Essential Air Service Program is designed to serve communities that otherwise would not receive commercial airline service without a subsidy (Grubesic and Matisziw, 2011).

In addition, this paper is the first to link the connectivity outcomes of PSOs to subsidy levels. For this purpose, we introduce a novel dataset on PSO subsidies covering more than 90% of U.S. and European PSO movements in the year 2010.

Although the subsidy dataset covers only a single year due to a lack of consistently collected data in some countries, it improves upon the current state of the literature by providing the most complete and up-to-date summary of PSO subsidy values in nearly a decade.

Combined with the connectivity analysis, the subsidy data allows for a unique perspective on the performance of PSO programs—including movements per subsidy dollar, seats per subsidy dollar, and connectivity per subsidy dollar—to present a multi-metric assessment of the relative value provided by PSOs across geographies that has so far been absent in the literature. The degree to which PSOs provide small communities with access to the air transportation network and the costs of this access has been scarcely examined in the existing PSO literature. Most analyses of public service obligations rather focus on assessing PSO outcomes as parameterized through movements created (Pagliari, 2010; Di Francesco and Pagliari, 2012; Calzada and Fageda, 2014), seats offered or passengers transported (Pagliari, 2010; Silveira, 2010; Di Francesco and Pagliari, 2012), or metrics of system or carrier efficiency (Santana, 2009; Grubesic and Matisziw, 2011; Bubalo, 2012; Merkert and Williams, 2013). While these metrics provide useful insights into the outcomes of PSOs, they do not fully capture the aviation network, in which access can be generated through both direct and indirect connections.

Additionally, while many past evaluations of PSOs explore outcomes or network structures in individual countries (e.g. Lian and Rønnevik, 2011; Silveira, 2012; Pita et al., 2013; Grubesic et al., 2014; Núñez-Sánchez et al., 2015), relatively few studies compare or benchmark PSO programs *across* countries. Exceptions include Williams and Pagliari (2004), who provide the most recent comprehensive collection of European subsidy data in the literature (based on year-2000 data and covering seven countries), and Williams (2012), who reviews the characteristics of PSOs in 10 European countries, including information about average stage length, aircraft size, and average fares. Merkert and O'Fee (2013); Merkert and Williams (2013); Calzada and Fageda (2014); and Merkert and O'Fee (2016) also conduct reviews of European PSO programs in multiple countries, but focus mostly on managerial or competitive outcomes of these programs.

Reynolds-Feighan (1999) and Santana (2009) are among the few studies that extend beyond Europe to provide a descriptive comparison of both European and North American PSOs. Reynolds-Feighan (1999) finds that significant differences exist in competition, carrier business models, traffic feed, and aircraft size across countries in Europe and the United States. Santana (2009) considers airline costs in relation to PSO operations to assess whether operating PSO routes makes airlines more or less efficient. She finds that airlines that operate PSO routes in Europe generally have higher costs, whereas Essential Air Service airlines do not display this pattern. However, no subsidy data is compared across countries in these papers, thereby limiting the scope of their findings to a descriptive discussion of general characteristics of these subsidy programs and the airlines that operate these routes. Thus, our paper also adds to the literature through comparing PSOs impacts in Europe and the United States.

The remainder of the paper is structured as follows: Section 2 provides an overview of PSO programs in the U.S. and Europe. Section 3 describes the computation of the GCI metric and discusses the connectivity impacts of PSOs. Section 4 presents the methodology for collecting the subsidy data and analyzes PSO performance with regard to the subsidy data. Section 5 concludes by discussing possible uses of these PSO evaluation metrics for academic and policy purposes.

2. Public service obligations for air transport in Europe and the United States

In Europe, PSO contracts are typically issued as part of a two-phase tendering process. First, governments define a minimum level of service and/or a maximum fare on a given route. Carriers are offered the option to accept these conditions and operate the route without a direct subsidy (Santana, 2009). These routes are referred to as "open" PSO routes. In the case that no carriers are willing to operate the route without a direct subsidy, a second round of tendering commences in which a subsidy is provided to the winning carrier to operate the so-called "restricted" route (Di Francesco and Pagliari, 2012).

The United States also maintains a public service obligation program, called the Essential Air Service (EAS) program, for a pre-defined list of small and rural communities (U.S. Department of Transportation, 2016). EAS contracts are awarded following a tendering process. Airlines submit proposals for EAS service to the U.S. Department of Transportation, including the subsidy required, the aircraft type of operation, and the target airport for service. After soliciting responses from the community, the Department of Transportation issues a contract to a selected airline, which is obligated to run the service during the contract period (Matisziw et al. 2012). EAS services must connect the small airport they serve to a larger community, unlike European PSO programs, which have no such mandate (Matisziw and Wei, 2012).

Routes covered by public service obligations are inventoried by governments in both regions. In Europe, the European Commission maintains a database of routes on which public service obligations have been imposed, and the United States Department of Transportation maintains a route database for its Essential Air Service program (European Commission, 2009; U.S. Department of Transportation, 2010). In 2010, 11 European countries had designated PSO routes listed in the European Commission's database. The PSO routes in Europe and the U.S. in the year 2010 are shown in the maps in Figure 1.

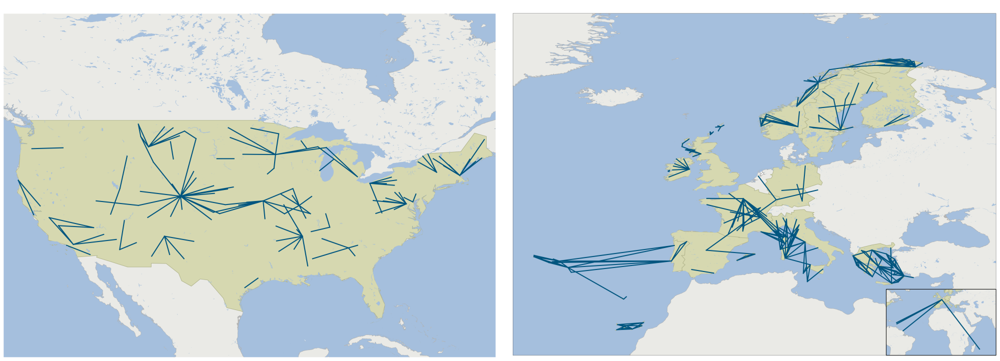

Figure 1: European and U.S. PSOs and countries included in dataset, year 2010
Sources: European Commission (2009); U.S. Department of Transportation (2010)

Table 1 provides summary statistics for the public service obligation routes included in our dataset. In 2010[1], PSOs covered over 450,000 aircraft movements in Europe and the mainland United States, with over 28 million scheduled yearly seats, representing about 2.5% of the scheduled commercial flights and 1.3% of the scheduled seats for the 12 countries assessed.

Country	Airports w/ PSO Flights	Thousands of Scheduled Movements (2010)			Millions of Scheduled Seats (2010)			Seats per PSO movement	Avg. Stage Length (km)*
		PSO	Total	PSO % of Total	PSO	Total	PSO % of Total		
Finland	4	2	181	0.9%	0.1	20	0.4%	53.0	250.1
France	38	43	1,074	4.0%	6.7	155	4.3%	155.1	1624.3
Germany	5	3	1,583	0.2%	0.1	226	<0.1%	39.2	283.9
Greece	31	15	256	5.9%	0.8	34	2.5%	55.1	222.3
Ireland	11	10	194	5.1%	0.8	31	2.6%	81.4	203.7
Italy	13	32	1,018	3.1%	5.6	153	3.7%	175.9	444.6
Norway	37	58	392	14.8%	2.2	44	5.0%	37.9	186.1
Portugal	15	21	234	8.8%	1.9	33	5.8%	92.7	552.5
Spain	14	90	1,231	7.3%	6.4	191	3.3%	70.9	217.5
Sweden	13	7	304	2.3%	0.3	34	1.0%	50.4	303.5
U.K.	27	9	1,662	0.5%	0.1	252	0.1%	15.8	76.5
U.S. (mainland)	135	164	10,073	1.6%	3.1	1,041	0.3%	18.6	282.8
Total	343	453	18,202	2.5%	28.2	2,214	1.3%	62.2	401.0

Table 1: PSO program airports, movements, seats, and stage length in the U.S. and Europe, 2010
Sources: European Commission (2009); U.S. Department of Transportation (2010); analysis of OAG schedule data; analysis of Innovata SRS schedule data via Diio Mi portal
* Weighted by number of movements

Figure 1 and Table 1 also display the variation in PSO route networks across countries. For instance, in the United States, Greece, and the United Kingdom, PSO routes are mostly short-haul, with average stage lengths of less than 300 kilometers. In contrast, Portugal and France support longer-haul routes with PSOs that connect outermost territories with the mainland.[2] As a result, average stage lengths for PSO programs in France and Portugal are two to eight times larger than those of other countries. Table 1 also reveals significant heterogeneity in average seats per PSO movement, ranging from 16 seats to 176 seats. To some extent, the variation is a consequence of differences in average stage length with France's long-haul flights to outermost territories requiring wide-body aircraft, for example.

Significant heterogeneity also exists in terms of the percentage of movements and

[1] The year 2010 was selected for all quantitative analyses in this paper due to availability of cross-country PSO subsidy data, which could not be obtained with sufficient coverage for more recent periods. More details about the subsidy data collection process are discussed in Section 4.

[2] Portugal uses PSOs to support routes from the mainland to the Azores, and France supports a number of long-haul PSO routes to territories like Guadeloupe, French Guyana, and Reunion Island. French routes to long-haul territories are examples of "open" routes, which airlines are willing to operate without requiring a direct subsidy.

seats in each country that are covered by PSOs, with countries having territories outside of the mainland such as Spain and Portugal, and countries with remote regions far away from economic centers (such as Norway), having among the highest percentage of movements that were covered by PSO's in 2010.

While a number of PSO routes are point-to-point services, an analysis of the PSO route maps in Figure 1 also reveals the presence of several "central" airports that are the destinations of many PSO flights. These airports, like Denver, Minneapolis-St. Paul, Paris Orly, and Stockholm Arlanda, may offer the possibility of indirect connectivity to residents of small communities through onward connecting service if such onward services exist. The regulatory focus of the EAS clearly supports such structures for the U.S., thereby explaining the largely hub-and-spoke appearance of the EAS network in the United States. The extent to which PSOs in various countries actually provide feasible connections to the rest of the air transportation network is explored in detail in Section 3.

The differences in PSO network structures can be explained partly by geography as outlined above, but also by their emergence and governance structures. For instance, as European air transport liberalization increased commercial pressure on airlines, they were less capable of providing access for remote communities (Calzada and Fageda, 2014), which necessitated the introduction of a policy measure to re-introduce air transport network coverage in remote regions. As such, European PSOs were mostly designed to enhance access for remote populations to nearby centers. Examples of such routes are PSOs to/from the Canary Islands (Santana, 2009), the Azores (Silveira, 2012), the Shetland Islands, the Outer Hebrides, and the Aran Islands (Ernst and Young, 2014). This helps explain both the relatively short stage lengths of most PSO programs in Europe, as well as the extent to which domestic commercial air transport in some countries with highly remote regions or territories, such as Portugal or Norway, relies on PSOs.

In addition to subsidizing airlines to provide service on such routes, PSOs to remote or distant territories are often designed to include discounts for residents of those regions. SATA Air Azores, for example, provides discounts for residents of the Azores traveling between the islands and to the Portuguese mainland, and a "Social Mobility Aid" program supports Azorean residents with reimbursements for travel that exceeds a maximum fare set by the government (Santana, 2009). Similarly, the Scottish government offers an Air Discount Scheme for residents of the Scottish Highlands and Islands (Williams and Bråthen, 2012).

3. Connectivity effects of public service obligations

In this section, we propose a method for assessing the degree to which PSO routes provide airports and communities with access to economic markets and the air transportation network. To this end, we first describe a connectivity metric (the

Global Connectivity Index) that has been developed to quantify market access generated by scheduled air transportation (Allroggen et al, 2015). Then, we apply this metric to PSO routes in the year 2010, aggregated at a country level, to explore the differences in outcomes between PSOs in different geographies.

3.1 The Global Connectivity Index

The Global Connectivity Index (GCI) is a metric of air transport connectivity that assesses both the quantity and quality of commercial air service. Allroggen et al. (2015) computed air transport connectivity scores using the GCI for 5,000+ airports worldwide. An airport *a's* GCI score in year *t* is computed as follows:

$$GCI_{a,t} = \sum_{r \in \mathcal{R}_{nonstop,a,t}} f_{r,t} w_{d_r,t} + \sum_{r \in \mathcal{R}_{onestop,a,t}} \alpha_{r,t} f_{r,t} w_{d_r,t} \qquad (1)$$

where $\mathcal{R}_{nonstop,a,t}$ is the set of all available nonstop routings from airport a in year t, $\mathcal{R}_{onestop,a,t}$ is the set of all available one-stop routings from airport a in year t, $\alpha_{r,t}$ is a measure of "link quality" for one-stop routing r, $f_{r,t}$ describes how many flights are operated in year t on routing r, and $w_{d_r,t}$ is the "destination quality" of route r's destination airport d_r in year t. These dimensions are parameterized as follows:

- The set of available routings $\mathcal{R}_{onestop,a,t}$ considers onestop routings in which both flights are operated by a single airline selling connecting tickets.[3] Routings operated under code-share agreements are also regarded as feasible routings. Furthermore, a minimum connecting time requirement must be met in order to consider a routing as a feasible routing. Given this structure, both direct and indirect connectivity scores can be calculated. Direct scores represent the contribution to an airport's total connectivity through its nonstop service, whereas indirect scores represent the contribution of one-stop connecting flights to the airport's total connectivity score. Summed together, the direct and indirect scores yield the total connectivity for an airport.
- "Link quality" $\alpha_{r,t}$ describes the quality of the itinerary from airport a to destination airport d_r on routing r. For nonstop routes, $\alpha_{r,t}$ is equal to 1 and has been omitted from expression (1); for connecting routes, $\alpha_{r,t}$ becomes closer to one as the routing approaches a hypothetical nonstop routing in terms of travel time.[4] In contrast, $\alpha_{r,t}$ equals 0 if a "maximum acceptable detour" in terms of travel time is reached from the passenger's perspective.[5]

[3] In turn, self-help hubbing (Malighetti et al., 2008) is not accounted for. A year-specific list of airlines which do not offer connecting flights is compiled through desktop research. We use a heuristic approach so that all airlines which offer code-shares are assumed to sell transfer connections.
[4] We consider both flight times of each leg and flight-time-equivalent layover time.
[5] Allroggen et al. (2015) derive maximum acceptable detour from observed passenger behavior.

- Frequency $f_{r,t}$ describes the number of times a given routing r is operated in a year t. Higher frequency implies more opportunities to take advantage of a given routing, and therefore higher connectivity.
- "Destination quality" refers to the economic market potential of the destination airport on a given route. In the GCI, it is computed as a function of wealth-adjusted population in the airport's surrounding region, subject to a decay function. This feature is unique to the GCI model and is particularly important in the evaluation of PSO route performance. Specifically, the inclusion of the destination quality parameter means that a PSO route that connects two small communities will contribute less to an airport's direct connectivity than a route that connects a small community with a large economic center. Note that without the destination quality weight, both of these routes would contribute identical levels of direct connectivity. The inclusion of destination quality thereby creates a more nuanced assessment of the heterogeneity among different routes.

As an example of the calculation of the GCI, consider a stylized example of a small airport with one daily flight to a large airport with a destination quality of $w_{d_r,t} = 0.5$. From this large airport, one daily flight is available to five different destinations, each of which with a destination quality of $w_{d_r,t} = 0.3$. From this perspective of the smaller airport, suppose that each of these five one-stop connection routings via the large airport possesses a link quality of one fifth of a direct flight ($\alpha_{r,t} = 0.2$). Using the GCI, the small airport's direct connectivity would be (1 * 365) * 0.5 = 182.5, and the airport's indirect connectivity would be 5 * [0.2 * (1 * 365) * 0.3] = 109.5. The airport's total GCI score would be 182.5 + 109.5 = 292.

To compute the GCI impact of a PSO route for an airport a, with-without comparisons are conducted. For that purpose, the GCI model is run twice. In the baseline run, the set $\mathcal{R}_{a,t}$ includes all routings. In the PSO run, the routing set $\mathcal{R}'_{a,t}$ is used. It is compiled by removing the PSO route in question from $\mathcal{R}_{a,t}$. In cases in which the PSO tender covered several routes (for instance, in a so-called "triangle pattern"), all routes were removed from the routing set $\mathcal{R}_{a,t}$. The impact of PSO routes on an airport a's GCI score $\Delta_{a,r}$ is identified as the difference between the GCI score in both scenarios:

$$\Delta_{a,r} = \sum_{r \in \mathcal{R}_{a,t}} \alpha_{r,t} f_{r,t} w_{d_r,t} - \sum_{r \in \mathcal{R}'_{a,t}} \alpha_{r,t} f_{r,t} w_{d_r,t} \quad (2)$$

This approach can be generalized to multiple routes by deleting a set of PSO routes from $\mathcal{R}_{a,t}$ while compiling $\mathcal{R}'_{a,t}$. Country-level impacts are computed by summing contributions for each airport within the country.

Since available subsidy data covers the year 2010, the connectivity impact is computed for PSO routes using the year 2010 schedule base file supplied from the Official Airline Guide (OAG). For metrics involving scheduled seats, seat data from Innovata's Schedule Reference Service (SRS) was used for the year 2010.

3.2 Connectivity impacts of PSO services

The total GCI connectivity scores associated with PSO routes in the year 2010 are shown in Table 2 on a country-by-country level. The table depicts the direct, indirect, and total connectivity scores $\Delta_{a,r}$ associated with from PSO routes for each country. A route-by-route analysis of connectivity impacts is provided in Appendix B. We note that we cannot consider whether the routes covered by PSOs in 2010 would have been operated without support; in this section, rather we assess the scope and scale of the PSO route network as it existed in 2010.

As Table 2 shows, the total connectivity scores associated with PSO routes varied significantly by country in 2010. The total GCI scores associated with PSO routes ranged from about 50 points for Finland to over 52,000 points for the U.S. Essential Air Service program, which covers over one hundred routes. For context, the total GCI connectivity score in 2010 for the most connected airport in the GCI model—Los Angeles International Airport—was about 152,000. As a result, the U.S. Essential Air Service program generated about the same amount of cumulative connectivity as a well-connected mid-sized U.S. airport, such as Salt Lake City, Utah or Kansas City, Missouri.

Country	*GCI Scores*			*% of Total PSO GCI*		*GCI Per PSO Movement*	*Total GCI (All Routes)*	*PSO % of Total GCI*
	Direct	*Indirect*	*Total*	*Direct*	*Indirect*			
Finland	46	4	50	92%	8%	0.03	40,714	0.1%
France	5,170	5,416	10,586	49%	51%	0.25	257,152	4.1%
Germany	334	1,294	1,628	21%	79%	0.63	428,358	0.4%
Greece	340	363	703	48%	52%	0.05	46,395	1.5%
Ireland	436	70	506	86%	14%	0.05	52,432	1.0%
Italy	2,156	1,110	3,266	66%	34%	0.10	276,493	1.2%
Norway	778	96	874	89%	11%	0.02	57,777	1.5%
Portugal	218	748	966	23%	77%	0.05	38,165	2.5%
Spain	1,218	1,082	2,300	53%	47%	0.03	217,884	1.0%
Sweden	118	0	118	100%	0%	0.02	58,169	0.2%
U.K.	108	143	251	43%	57%	0.01	299,390	0.1%
U.S.	11,336	41,448	52,785	21%	79%	0.32	5,504,769	1.0%
Total	22,212	51,770	73,983	30%	70%	0.16	7,236,984	1.0%

Table 2: Total GCI connectivity for PSO routes in Europe and the U.S. in 2010
Sources: Movement data collected via an analysis of OAG schedule data; seat data collected via an analysis of Innovata SRS schedule data via Diio Mi

The differences in GCI scores partly stem from the scope of PSO programs in each country. For instance, since Finland has only 3 PSO routes, the larger number of PSO routes in the U.S. leads to a higher total connectivity contribution. However, even on a per-movement-basis, there is still significant variation across countries, ranging from 0.01 to 0.63. In part, these variations can be explained through different PSO network configurations, leading to heterogeneity in the contribution of indirect connectivity in the total GCI score. In some countries, such as Ireland, Norway, and Sweden, PSO programs were associated with mostly direct connectivity. This is because PSO routes in these countries serve to connect remote regions to nearby communities, with no or few connections available to onward destinations via a hub. These PSO flights serve primarily as lifelines to the regions they serve, connecting, for instance, small communities in northern Norway to the larger cities of Tromsø or Bodø. In turn, GCI per PSO movement is small and the PSO contribution through indirect connectivity is negligible.

In other countries, however, PSO routes were associated with a significant amount of indirect connectivity. These countries include Germany, Portugal, France, and the United States. In contrast to lifeline services, these PSO routes served to generate onward connections to other points in the air transportation network. For instance, many of the routes from the Azores to Portugal were operated by TAP Portugal, allowing for onward connections in Lisbon or Porto. Similarly, many large network carriers in the United States provided services from Essential Air Service communities to their large hubs, allowing for onward connections to other points in these carriers' networks.[6]

The route-level analysis in Figures 2(a) – 2(d) provides further support for this interpretation by underlining the high indirect connectivity scores for hub connections. For instance, the Essential Air Service routes from Escanaba, Michigan, to Detroit and from Meridian, Mississippi, to Atlanta provided among the highest connectivity per PSO route among the routes in our sample, due to the onward connections available on Delta Air Lines. Each of these routes supplied over 1.0 GCI point per movement. In contrast, for the Swedish route from Torsby to Stockholm Arlanda, from which no onward connections were available from operating carrier NextJet, the number of GCI points generated per PSO movement was about 40 times less than the most connected U.S. PSO route.

This demonstrates that the operating airline of a PSO service can also significantly influence the connectivity score of a PSO route. For instance, operating airlines with codeshares or interline connections with major carriers are able to provide seamless single-ticket one-stop connectivity on flights to large hub airports. When PSOs were operated by specialty carriers like NextJet in Sweden, these interline

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[6] In fact, Essential Air Service routes are required to serve a nearby Large Hub or Medium Hub airport (Matisziw and Wei 2012), underscoring the focus of this program on indirect connectivity.

connections may not have been available even though the route provided service to a large hub airport. That is, connectivity as computed by the GCI is not only a function of the destination, frequency, and quality of service, but also on the carrier operating the service and the agreements it has with other airlines.

Following the heterogeneity in network structures, we also observe notable differences in PSO-established access from the community perspective. Where available, indirect connectivity may significantly drive PSOs' GCI contributions. For instance, indirect connectivity on the Meridian, Mississippi, to Atlanta, Georgia, service in the United States and the Hof to Frankfurt service in Germany contributed 95% and 84% to total route connectivity, respectively. In contrast, for routes without feasible onward connections available, such as those from Kerry to Dublin in Ireland, or from Olbia to Verona in Italy, 100% of the route's connectivity impact was due to direct connectivity. This reinforces the argument that PSOs can either serve to provide indirect connectivity to small communities or be focused on connecting remote or small communities, often without onward connections.

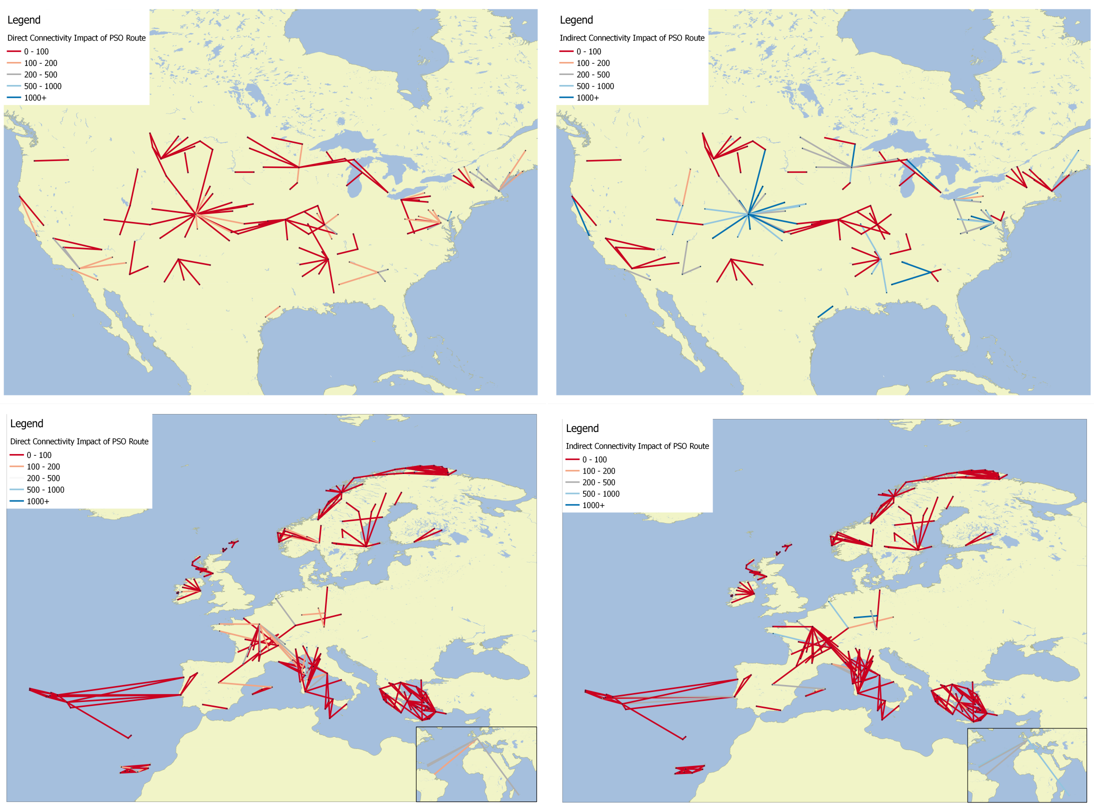
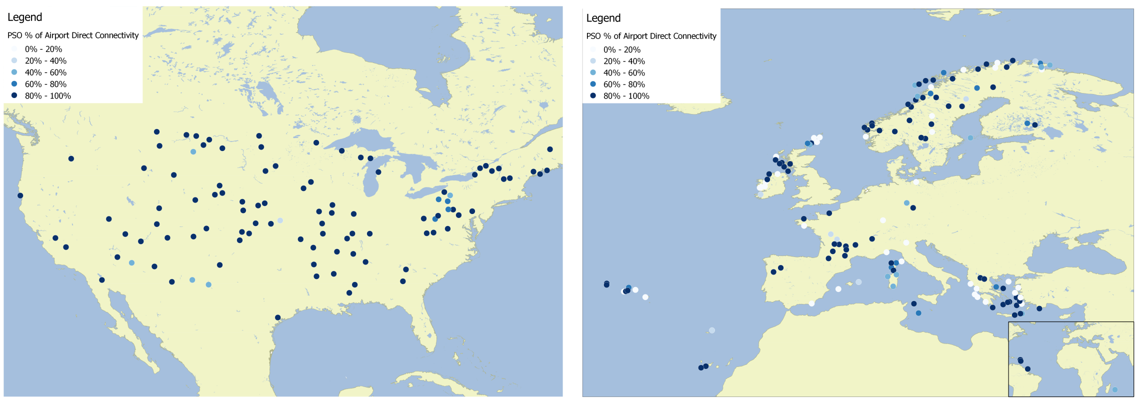


Figure 2(a) – 2(d): Direct and indirect connectivity impacts (GCI points) of PSO routes in the United States and Europe, 2010

While the latter "lifeline routes" do not provide a large amount of indirect access to the global air transportation network as measured by the Global Connectivity

Index, they often serve as their communities' fastest access to the mainland or to a large economic center. In fact, in many communities, PSO routes provide the only air connectivity, and removing the service mandate might lead to the airport receiving no service at all. The reliance of smaller airports on PSO routes for most or all of their direct connectivity is shown in the maps in Figures 3(a) and 3(b). Out of the over 340 airports that received PSO service in 2010, 142 airports relied on PSO routes for more than 90% of their direct connectivity. This suggests that even if the amount of connectivity that PSO programs provide may be small in absolute terms, these programs still serve as vital lifelines to many communities.



Figures 3(a) and 3(b): PSO route share of total airport direct connectivity for smaller U.S. and European airports[7] receiving PSO service, 2010

The connectivity analysis of the PSO route network in 2010 reveals significant heterogeneity in the goals and outcomes of PSO programs in various countries. By examining the extent to which PSO routes provide direct and/or indirect connectivity to the communities they serve, we can start to classify PSO programs into connectivity-focused and lifeline-focused programs. These archetypes are expanded in Section 4 with the addition of subsidy data for 90% of the PSO routes in our dataset.

4. Performance of public service obligation programs

4.1. PSO subsidy data

To fully compare the performance of PSO programs in various countries, we analyze the amount that the government makes available to pay to an airline in exchange for operating a PSO route. The availability of this information varies by country. The United States, for instance, publishes Essential Air Service subsidy data on a regular basis (U.S. Department of Transportation, 2014). However, while the European Commission provides a full inventory of PSO routes, it does not publish the subsidy values for tendered routes. In fact, a survey of 16 PSO-

[7] In Figures 3(a) and (b), the airports with the highest amount of base connectivity in each PSO route are excluded to focus on the remote regions which are the targets of the PSOs.

procuring authorities[8] by Merkert and O'Fee (2013) reveals that in five cases, commercial confidentiality requirements restrict the availability of subsidy data for PSO routes, and such information is only available via a freedom-of-information request in an additional four cases.

To generate a dataset on route subsidies for European PSOs, subsidy data were collected on a route- or region-specific level for ten European countries and the United States. Data were collected from a variety of sources, including academic papers, consultant reports, news articles, and government documents, through an internet search and review of relevant documents mentioning specific PSO routes or the phrase "public service obligation" (or the equivalent phrase in the country's official language). Unlike the United States' standardized form of reporting subsidy data, European PSO subsidy data was often fragmented or not reported on a route-by-route basis. In these cases, PSO route information was aggregated to the geographical level at which subsidy data was available.

In some cases, we have observed that governments provide a subsidy to both airports and airlines, such that the airport can expand operations to accommodate the increase in traffic from the PSO flight.[9] In the interest of consistency, these airport subsidies have been removed whenever possible. Therefore, subsidy values refer to subsidies paid directly to airlines only, except when otherwise noted.

There was no single year for which data was available for all regions; therefore, a cross-sectional dataset for the year 2010 was generated, since the year 2010 overlapped with most programs for which financial subsidy data was available.[10] Subsidy amounts were converted from local currencies to 2010 U.S. dollars based on the World Bank's Purchasing Power Parity index. A full list and description of subsidy data sources is available in Appendix A.

Table 3 summarizes the PSOs programs in the eleven European countries included in the dataset, as well as the United States. As the table shows, our dataset covers 100% of PSO movements in nine countries and approximately 50% and 90% of PSO movements in a further two countries. Subsidy data for Italian PSO movements were not available. Overall, the subsidy data covers 90% of PSO movements in the U.S. and Europe in 2010, and shows that over $900 million was earmarked to provide publicly supported commercial air service and air service discounts to small communities in that year.

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[8] Merkert and O'Fee (2013)'s sample includes PSO-procuring authorities from Finland, France, Germany, Iceland, Italy, Norway, Portugal, Scotland, Sweden, and Wales.
[9] For example, Calzada and Fageda (2012) mention that subsidies of airport fees are offered along with airline subsidies to PSO routes that link the Spanish mainland and the Canary and Balearic islands.
[10] Subsidy values may change from year-to-year, whereas the list of PSO routes was unlikely to change substantially from year to year unless a tendering process was underway. 2010 was also selected because it fell in the middle of the PSO contract period for many countries for which data was available.

Country	Total Annual Subsidy (Millions of USD, 2010 PPP)	Thousands of PSO Movements (2010)		% of PSO Movements Covered by Subsidy Data
		Subsidy data available	All PSO movements	
Finland	$2.3	2	2	100%
France*	$19.6	22	43	51%
Germany	$8.3	3	3	100%
Greece*	$49.8	14	15	92%
Ireland	$19.1	10	10	100%
Italy	Not Available	0	32	0%
Norway	$73.3	58	58	100%
Portugal	$64.7	21	21	100%
Spain**	$495.2	206	206	100%
Sweden	$9.1	7	7	100%
U.K.	$6.2	9	9	100%
United States	$155.6	164	164	100%
Total	**$903.2**	**515**	**569**	**90%**

Table 3: Summary data for PSO subsidies in the U.S. and Europe, 2010
Sources: See Appendix A for subsidy data sources; movement data collected via an analysis of OAG schedule data
* Only routes with subsidy data available are included
** In this table, Spain data includes air discount scheme routes between the mainland and the Canary and Balearic Islands. Caution should be used when comparing Spanish results to other countries, in which air discount schemes are not included.

Note that the Spanish data in Table 3 also includes flights between the Spanish mainland and the Canary and Balearic Islands. While these routes are not strictly PSO routes, they are supported under a subsidized Air Discount Scheme program that subsidizes up to 50% of ticket prices for island residents. Furthermore, while many Spanish PSO routes *within* the Balearic and Canary Islands are designated as "open" routes for which no airline subsidy is provided, these routes are also indirectly subsidized through significant air discount scheme programs that provide discounts to passengers on these routes. As such, these Spanish air discount scheme routes and subsidy values have also been included as part of the subsidy dataset in Table 3. In all other European countries, the PSO movements included were those listed on the European Commission's list of PSO routes published in late 2009 (European Commission, 2009).

4.2 Performance of public service obligation programs

The PSO subsidy data allows for "value for money"-comparisons across PSO programs. For this purpose, we compute three subsidy metrics—subsidies per PSO movement, subsidies per PSO seat, and subsidies per GCI point resulting from PSO service. These metrics are computed on the country level and tabulated in Table 4. As mentioned before, the lack of a counterfactual does not allow for a causal analysis of PSO impacts. However, we note that PSOs in Europe pass through a two-stage tendering process in which carriers are offered the choice to operate the route without a subsidy first, that all routes under the Essential Air Service routes in the U.S. need to be additional routes that must not have been operated before without incentives.

Country	Total Annual Subsidy (Millions of USD, PPP)	PSO Operations (2010)		Average Subsidy Per:		
		Movements (Thousands)	Seats (Millions)	Movement	Seat	GCI Point
Finland	$2.3	2	0.1	$1,419	$27	$46,936
France*	$19.6	22	3.0	$902	$7	$4,734
Germany	$8.3	3	0.1	$3,241	$83	$5,120
Greece*	$49.8	14	0.7	$3,549	$72	$76,589
Ireland	$19.1	10	0.8	$1,935	$24	$37,811
Norway	$73.3	58	2.2	$1,261	$33	$83,756
Portugal	$64.7	21	1.9	$3,127	$34	$66,940
Spain**	$495.2	206	27.2	$2,404	$18	$21,726
Sweden	$9.1	7	0.3	$1,335	$26	$77,688
U.K.	$6.2	9	0.1	$724	$46	$24,748
U.S.	$155.6	164	3.1	$946	$51	$2,949
Cross-Country Mean				$1,756	$23	$10,657

Table 4: Subsidy amounts per movement, seat, and connectivity point for PSO routes in Europe and the U.S., 2010

Sources: See Appendix A for subsidy data sources; movement data collected via an analysis of OAG schedule data; seat data collected via an analysis of Innovata SRS schedule data via Diio Mi

* Only routes with subsidy data available are included; see Table 3 for more information about the coverage of subsidy data in these countries

** In this table, Spanish data also includes air discount scheme discounts between the mainland and the Canary and Balearic Islands, and within these islands. Caution should be used when comparing Spanish results to other countries, in which air discount schemes are not included.

We find significant heterogeneity in results within all performance metrics. The cross-country mean subsidy per movement amounts to approximately $1,800, with a range from approximately $700 to approximately $3,500. Per seat subsidies vary between $7 and $83 with a mean of $23. The mean subsidy paid per connectivity point is $10,700, with individual country values ranging from approx. $3,000 to $84,000.

It is important to note that it would be spurious to compare the efficiency of various PSO programs solely through these metrics, as this would ignore the disparate goals of PSOs in different countries, as well as the dissimilar PSO networks discussed in Section 3. Taken together with the previous analysis, these metrics reveal differences in program goals leading to three country archetypes:

- The United States and Germany serve as examples of countries with a focus on creating access to the global air transportation network, with a number of PSO flights connecting small communities to hubs like Frankfurt, Denver, and Washington Dulles on air carriers that provide onward connections. Consequently, costs per GCI unit are low. For the US, many EAS services are provided with smaller aircraft, leading to relatively high costs per seat (Table 4). However, the cost per movement is relatively low, which might be partially explained by prevalent high aircraft utilization within the highly optimized hub and spoke networks in the U.S. (Allroggen et al., 2015).

- In the U.K., Norway, Finland, Sweden, Greece, and Ireland, PSOs focus on "lifeline services" which connect remote regions and islands to the nearest centers in order to provide access to important economic and societal infrastructure. For Norway, Sweden, and Ireland, such services do not aim primarily at providing access to the global air transport network, so that indirect connectivity contributions are low (Table 2) and an above-average subsidy level per unit GCI is observed (Table 4). In contrast, the PSO routes from the outer Scottish Isles to Glasgow also create considerable onward connectivity for Scottish communities, decreasing the cost per GCI point for the U.K. relative to the other lifeline service countries.

- In Spain, Portugal, and France, both network access PSOs and lifeline services exist, as PSOs connect remote territories to each other and to mainland hubs. In particular, some Spanish PSOs are operated by large aircraft leading to lower costs per seat, but increased cost per movement. In contrast, Portuguese PSOs cover longer routes (the second-longest on average across all countries in our dataset), thereby resulting in higher costs per movement and seat. Note that France's cost per PSO movement, seat, and connectivity point are all among the lowest of the countries assessed, as many French PSOs provide onward connectivity through Paris Orly. This suggests that France's PSO program could be seen as a hybrid between remote territory-focused programs like Spain and Portugal and onward connectivity-focused programs like Germany and the U.S. In all three cases, PSO-established GCI contributions for remote territory-focused programs are significantly driven by onward connectivity (Table 2).

Finally, we quantify the degree of correlation between the subsidy per unit of connectivity metric and the subsidy per seat and subsidy per movement metrics, respectively. The computed correlations between subsidies per GCI and subsidies per movements and seats are weak, with correlation coefficients at 0.23 and -0.04, respectively. This indicates that seats and movements are insufficient proxies for connectivity impacts by PSOs.

This archetypical framework generated through the connectivity and value-for-money analyses in Sections 3 and 4 more clearly identifies the qualitative similarities and differences in the way various countries approach PSO provision. The framework suggests that PSO-granting authorities that value the generation of indirect connectivity through PSOs should review the practices of countries like the U.S. and Germany, while those focused more on lifeline services should consider countries like Sweden and Norway when assessing PSO performance.

The analysis in this section also highlights the need for multifaceted evaluations of PSO programs using metrics like connectivity and value-for-money, as opposed to focusing purely on seats or movements provided. PSO routes provide a diverse range of services to the communities they serve, and a single PSO movement in a lifeline-focused region could result in different outcomes for a community than a PSO movement that provides onward connections. As governmental budgets continue to be squeezed and PSO programs find themselves up for renewal and review, more nuanced analyses of PSO performance could provide policymakers with a more complete picture of the effects of PSOs on small community air travel.

5. Conclusions

While public service obligations have often been the focus of academic and governmental reviews regarding quantity, quality, and efficiency (e.g. Santana, 2009; Matisziw et al., 2012; Merkert and Williams, 2013), none of these reviews has quantified the outcomes that PSOs provide to their communities in terms of market access. This paper attempts to remedy this gap in the literature by using the recently proposed Global Connectivity Index (Allroggen et al., 2015) to measure the connectivity contributions of PSO routes to small and remote airports in the year 2010.

The paper found that PSOs covered about 2.5% of total movements in the 12 countries surveyed, providing about 1% of these countries' total air transport connectivity. Furthermore, by using a novel subsidy dataset covering 90% of PSO movements in 2010 across eleven countries, we calculated different PSO outcome metrics to provide additional insight into the value for money that PSO programs provide across countries. We found that USD$900 million was earmarked for PSO and air discount scheme provision in 2010, leading to an average subsidy of about $1,800 per movement and $10,700 per GCI connectivity point with significant variability in both metrics across countries.

Through this approach, we are the first to conduct a multi-dimensional analysis of PSO routes including connectivity impacts. On the basis of these results, we classify routes according to their goals and network structures. The resulting continuum is bounded by PSOs focused on providing network access and those focused on creating "lifeline" access. The latter PSOs are vital links for remote regions and serve to connect residents of small communities to crucial medical, educational, and economic opportunities in their local geographies. The former PSO routes serve a second purpose of providing onward connections for residents in remote regions and connect inhabitants to a larger range of places and economic opportunities. We found that analyzing PSO routes on a per-movement or per-seat basis only (Williams and Pagliari, 2004; Bråthen, 2011; Núñez-Sánchez et al., 2015) does not fully capture the range of outcomes that PSO routes bring to their communities as it omits the role of PSO in providing market access, which – as our data shows - is very weakly correlated with PSO movement and seats offered.

We regard our results as useful for policymakers and planners since they can inform a strategic approach towards designing PSOs. The proposed "connectivity-per-dollar" metric is a natural addition to the policy analysis toolbox, particularly for governmental agencies that are trying to decide between multiple airline tenders to provide a PSO service.

For instance, in the United States, while connectivity is an explicit goal of PSO programs, it is currently not directly evaluated in the tendering or proposal process. In the United States' PSO program, airlines submit bids that include a proposed subsidy amount, a nearby hub to serve (which could vary across tenders), and a sample schedule (U.S. Department of Transportation, 2016). If onward connections are a targeted goal of the PSO program, the government agency or airport could use a GCI-based analysis when evaluating these bids to identify which airline provides the best value for money while considering onward connections. This would directly incorporate connectivity provision into the basket of criteria that are used to award PSO services.

Using a connectivity-centric value for money metric will also be instructive for evaluating non-PSO air services that are incentivized through public funds. For example, through air carrier incentive programs, airports can offer discounts on certain fees or bonus payments to airlines for a limited period of time in exchange for new routes or guaranteed growth in passengers transported. Existing analyses show significant involvement of public airports in providing monetary incentives through these programs (Malina et al., 2012; Allroggen et al., 2013; Wittman, 2014), but neither the effects of these programs on airport connectivity nor the efficiency of connectivity provision have been quantified and compared to date.

We close by outlining several avenues for future research. First, while our analysis was descriptive in nature it could be extended to a quantitative assessment of the "social need" for specific PSO routes. In order to so one would need to define and operationalize minimum connectivity levels for communities or regions, to assess the degree to which those are already satisfied by other modes of transportation, and to quantify the contribution of PSO air services in closing connectivity gaps. This social need metric could then be contrasted with the route subsidy data to provide another perspective on which PSOs provide good value for money relative to the unique access they provide to the communities they serve.

Second, the analysis of PSO subsidy levels in this paper was limited to the year 2010 due to lack of completeness of more recent data. Significant additional effort will be required – including freedom of information requests – to construct a comprehensive time-series of subsidy data. Once this has been accomplished, PSO outcomes could also be assessed in the temporal dimension, allowing for a quantification of marginal impacts.

Finally, the GCI metric employed here could also be used for PSO efficiency analyses. This paper has provided data that shows how different countries aim at various PSO outcomes and how measurement of PSO performance can change depending on the metric employed. Given this heterogeneity, future efficiency analyses of PSO programs should consider the varied goals of PSO programs worldwide and assess multiple performance metrics including connectivity impacts at once, instead of focusing only on a single metric.

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Appendix A. Sources of PSO data

Table A1 shows the sources used to collect PSO subsidy data for each of the countries covered in this study. Data was collected on a route level whenever possible; only three countries (Spain, Portugal, and some Norwegian routes) aggregated large numbers of routes together in a single subsidy figure. Data was collected for the year 2010 whenever available; when data was presented in multi-year periods (often from 2009-2012, which was a common tender period among European PSOs), subsidy amounts were divided to generate a yearly amount. Additionally, although some subsidy values were given for other nearby years, PSO routes and schedules remain often largely unchanged throughout the length of a tender period (from 2009-2012); therefore, to retain analytical consistency, these values were treated as if they were 2010 for data consistency purposes.

Country	Data Source	Description	Years
Finland	Markkinaoikeus (2008)	Government report	2010-2011
	Yle.fi (2010)	News report	2009-2012
France	Assemblee de Corse (2008)	Budget document	2008-2011
	Constant (2013)	News report	2011-2013
Germany	Die Welt (2007)	News report	2007-2009
	Przybilla and Symanski (2010)	News report	2010
	Mitteldeutsche Zeitung (2011)	News report	2010
Greece	Angelopoulos et al. (2011)	Academic study	2011
Ireland	Department of Transport (2010)	Government study	2008-2011
Norway	Lian et al. (2010)	Academic study	2009-2012
Portugal	Governo de Portugal (2010)	Budget document	2010
Spain	Gobierno de España (2011)	Budget document	2010
	Ministerio de Fomento (2009)	Govt. document	2009
Sweden	Anger et al. (2012)	Academic study	2002-2012
U.K.	Brown (2011)	Government study	2009-2010
	Reference Econ. Consultants et al. (2012)	Consultant report	2009-2012
	Argyll & Bute Council (2013)	Government report	2011-2012
	Orkney Islands Council (2013)*	Budget document	2013-2016
	Ernst and Young (2014)	Consultant report	2010
	Wales Audit Office (2014)	Consultant report	2010
United States	U.S. Department of Transportation (2010)	Government data	1998-2015

Table A1: Subsidy data sources used for PSO routes

*Subsidy information for the 2009-2013 tender period for this route was redacted

Appendix B: GCI Connectivity Impacts of PSO Routes, 2010

The following tables display the GCI direct and indirect connectivity scores associated with each U.S. and European PSO route in 2010, as well as the percentage of the total GCI score resulting from direct connectivity. For PSOs that include multiple origin-destination pairs, only one origin-destination is displayed in the tables. Routes are listed in alphabetical order by PSO-issuing country, and then in descending order by total connectivity impact.

PSO-Issuing Country	Origin-Destination	GCI Connectivity from PSO Route (2010)			
		Direct	Indirect	Total	% Direct
Finland	Helsinki-Savonlinna-Varkaus	38.0	3.6	41.6	91%
Finland	Mariehamn-Stockholm	8.1	0.0	8.1	100%
France	Guadeloupe-Paris Orly	424.7	500.3	925.0	46%
France	Reunion Island-Paris Orly	205.3	558.4	763.7	27%
France	Martinique-Paris Orly	419.2	332.7	751.9	56%
France	Strasbourg-Amsterdam	217.2	511.3	728.5	30%
France	Lorient-Lyon	104.6	504.9	609.5	17%
France	Ajaccio-Paris Orly	459.2	73.4	532.7	86%
France	Guyane-Paris Orly	170.8	331.2	502.0	34%
France	Bastia-Paris Orly	395.4	70.8	466.2	85%
France	Annecy-Paris Orly	401.3	47.2	448.6	89%
France	Ajaccio-Marseille	97.3	319.2	416.4	23%
France	Le Havre-Lyon	75.0	339.8	414.8	18%
France	Bastia-Marseille	96.6	307.3	403.9	24%
France	Ajaccio-Nice	61.3	307.0	368.3	17%
France	Rodez-Paris Orly	274.4	77.4	351.8	78%
France	Lourdes/Tarbes-Paris Orly	291.1	53.7	344.7	84%
France	Figari-Marseille	72.9	231.0	303.9	24%
France	Strasbourg-Prague	89.2	156.0	245.2	36%
France	Bastia-Nice	57.5	184.0	241.5	24%
France	Lannion-Paris Orly	189.8	3.8	193.7	98%
France	Figari-Paris Orly	153.4	40.0	193.4	79%
France	Calvi-Marseille	51.1	140.0	191.2	27%
France	Calvi-Paris Orly	135.9	35.8	171.7	79%
France	Figari-Nice	28.2	115.4	143.6	20%
France	Le Puy-Paris Orly	143.4	0.0	143.4	100%
France	Strasbourg-Madrid	70.0	57.7	127.7	55%
France	Limoges-Paris Orly	87.0	35.2	122.2	71%
France	Calvi-Nice	23.7	79.6	103.3	23%
France	Castres-Lyon	76.5	0.0	76.5	100%
France	Castres-Paris Orly	71.3	1.2	72.5	98%
France	Agen-Paris Orly	70.1	0.6	70.7	99%
France	Brive-La-Gaillarde-Paris Orly	47.0	0.8	47.7	98%

Appendix B (con't): GCI Connectivity Impacts of PSO Routes, 2010

PSO-Issuing Country	Origin-Destination	GCI Connectivity from PSO Route (2010)			
		Direct	Indirect	Total	% Direct
France	Aurillac-Paris Orly	46.4	0.9	47.3	98%
France	Perigueux-Paris Orly	43.4	0.0	43.4	100%
France	Poitiers-Lyon	19.8	0.0	19.8	100%
Germany	Hof-Frankfurt	193.4	1037.3	1230.8	16%
Germany	Erfurt-Munich	130.0	220.2	350.2	37%
Germany	Rostock-Munich	10.8	36.6	47.4	23%
Greece	Athens-Paros	48.8	102.2	151.0	32%
Greece	Athens-Milos	35.6	76.1	111.7	32%
Greece	Athens-Kythira	14.7	43.9	58.6	25%
Greece	Athens-Kozani	46.8	10.5	57.3	82%
Greece	Athens-Leros	22.9	16.2	39.1	59%
Greece	Athens-Kalimnos	23.5	12.5	36.0	65%
Greece	Athens-Ikaria	13.6	17.8	31.4	43%
Greece	Athens-Karpathos	14.4	16.2	30.6	47%
Greece	Athens-Skyros	6.8	23.8	30.6	22%
Greece	Athens-Sitia	8.5	21.2	29.7	29%
Greece	Athens-Naxos	22.0	2.1	24.1	91%
Greece	Athens-Astypalea	13.7	7.1	20.8	66%
Greece	Athens-Skiathos	16.9	0.6	17.5	97%
Greece	Thessaloniki-Kerkyra	6.8	4.7	11.5	59%
Greece	Thessaloniki-Lemnos	7.6	0.8	8.5	90%
Greece	Lemnos-Mytilini	7.6	0.0	7.6	100%
Greece	Kerkyra-Preveza/Lefkas(Aktion)	4.3	2.4	6.7	64%
Greece	Thessaloniki-Chios	3.7	0.8	4.4	83%
Greece	Thessaloniki-Samos	4.1	0.2	4.3	95%
Greece	Rhodes-Kos	2.9	1.1	4.0	73%
Greece	Thessaloniki-Kalamata	3.4	0.5	4.0	86%
Greece	Rhodes-Kastelorizo	1.7	2.1	3.8	45%
Greece	Thessaloniki-Skiros	3.4	0.0	3.4	99%
Greece	Rhodes-Karpathos	2.9	0.4	3.3	89%
Greece	Rhodes-Karpathos	1.5	0.1	1.6	95%
Greece	Aktio-Sitia	1.1	0.0	1.1	100%
Greece	Alexandroupolis-Sitia	0.9	0.0	0.9	100%
Ireland	Dublin-Galway	125.2	48.0	173.2	72%
Ireland	Dublin-Donegal	118.4	12.4	130.9	90%
Ireland	Dublin-Derry	99.7	9.6	109.2	91%
Ireland	Dublin-Kerry County	92.8	0.0	92.8	100%
Ireland	Connemara-Inis Mor	NO GCI			
Italy	Cagliari-Rome Fiumicino	410.1	773.6	1183.7	35%
Italy	Cagliari-Milan Linate	562.6	94.1	656.7	86%
Italy	Olbia-Bologna	286.2	10.7	296.9	96%

Appendix B (con't): GCI Connectivity Impacts of PSO Routes, 2010

PSO-Issuing Country	Origin-Destination	GCI Connectivity from PSO Route (2010)			
		Direct	Indirect	Total	% Direct
Italy	Alghero-Milan Linate	187.7	9.7	197.4	95%
Italy	Alghero-Rome Fiumicino	141.1	49.3	190.4	74%
Italy	Olbia-Rome Fiumicino	126.7	34.6	161.3	79%
Italy	Pantelleria-Rome Fiumicino	3.5	54.5	58.0	6%
Italy	Cagliari-Bologna	48.6	3.5	52.0	93%
Italy	Olbia-Bologna	44.7	5.0	49.7	90%
Italy	Cagliari-Verona	48.8	0.4	49.3	99%
Italy	Alghero-Bologna	41.9	5.7	47.7	88%
Italy	Cagliari-Napoli	38.8	6.2	45.0	86%
Italy	Lampedusa-Palermo	20.3	24.2	44.5	46%
Italy	Alghero-Torino	39.3	1.3	40.6	97%
Italy	Cagliari-Firenze	28.6	6.1	34.7	82%
Italy	Cagliari-Turin	31.7	0.3	31.9	99%
Italy	Olbia-Verona	27.2	0.0	27.2	100%
Italy	Pantelleria-Palermo	21.8	5.4	27.2	80%
Italy	Cagliari-Palermo	14.7	11.2	25.9	57%
Italy	Pantelleria-Trapani	19.8	0.0	19.8	100%
Italy	Lampedusa-Rome Fiumicino	3.4	13.3	16.7	20%
Italy	Lampedusa-Catania	8.9	1.3	10.2	87%
Norway	Førde-Oslo	141.9	9.7	151.7	94%
Norway	Sandane-Oslo	132.9	2.8	135.7	98%
Norway	Florø-Oslo	122.7	0.0	122.7	100%
Norway	Sogndal-Oslo	92.1	3.3	95.4	97%
Norway	Mo i Rana-Bodø	47.4	16.9	64.3	74%
Norway	Namsos-Trondheim	31.1	28.6	59.7	52%
Norway	Brønnøysund-Bodø	28.9	24.6	53.5	54%
Norway	Fagernes-Oslo	48.1	0.0	48.1	100%
Norway	Roros-Oslo	44.8	0.0	44.8	100%
Norway	Alta-Kirkenes	18.4	2.1	20.5	90%
Norway	Svolvær-Bodø	15.1	1.0	16.1	94%
Norway	Leknes-Bodø	12.8	1.9	14.7	87%
Norway	Sandnessjøen-Bodø	13.0	1.5	14.5	90%
Norway	Narvik-Bodø	8.6	0.9	9.5	90%
Norway	Andenes-Bodø	8.0	1.0	9.0	89%
Norway	Lakselv-Tromsø	7.5	1.3	8.8	86%
Norway	Værøy-Bodø	3.4	0.0	3.4	100%
Norway	Røst-Bodø	1.6	0.8	2.4	67%
Portugal	Azores to Mainland Routes	198.7	737.9	936.7	21%
Portugal	Inter-Azores Routes	12.1	4.7	16.8	72%
Portugal	Funchal-Porto Santo	7.4	5.5	12.9	57%
Spain	Routes within Balearic Islands	263.3	857.3	1120.6	23%

Appendix B (con't): GCI Connectivity Impacts of PSO Routes, 2010

PSO-Issuing Country	Origin-Destination	GCI Connectivity from PSO Route (2010)			
		Direct	Indirect	Total	% Direct
Spain	Routes within Canary Islands	922.1	177.9	1099.9	84%
Spain	Almeria -Seville	32.4	47.0	79.4	41%
Sweden	Arvidsjaur-Lycksele	38.4	0.0	38.4	100%
Sweden	Torsby-Stockholm Arlanda	37.1	0.0	37.1	100%
Sweden	Vilhelmina-Stockholm Arlanda	27.7	0.0	27.7	100%
Sweden	Gallivare-Stockholm Arlanda	6.8	0.0	6.8	100%
Sweden	Ostersund-Umea	3.5	0.0	3.5	100%
Sweden	Sveg-Stockholm Arlanda	3.4	0.0	3.4	100%
Sweden	Pajala-Lulea	0.6	0.0	0.6	100%
United Kingdom	Argyll & Bute/Outer Hebrides - Glasgow	93.2	142.2	235.4	40%
United Kingdom	Inner Hebrides Routes	10.0	0.0	10.0	100%
United Kingdom	Kirkwall Islands Routes	4.4	0.0	4.4	100%
United Kingdom	Benbecula-Barra	0.7	0.9	1.6	42%
United Kingdom	Tingwall-Fair Isle	NO GCI			
United Kingdom	Tingwall-Foula	NO GCI			
United Kingdom	Tingwall-Out Skerries	NO GCI			
United Kingdom	Tingwall-Papa Stour	NO GCI			
United States	Staunton-Washington Dulles	219.0	1765.0	1983.9	11%
United States	Meridian-Atlanta	114.5	1763.1	1877.6	6%
United States	Scottsbluff-Denver	132.2	1598.9	1731.1	8%
United States	Chisholm/Hibbing-Minneapolis	114.3	1560.8	1675.1	7%
United States	Muscle Shoals-Atlanta	132.5	1463.5	1595.9	8%
United States	Victoria-Houston	121.8	1318.3	1440.0	8%
United States	Hays-Denver	132.1	1293.5	1425.6	9%
United States	Laramie-Denver	100.1	1305.6	1405.7	7%
United States	Dickinson-Denver	99.9	1262.9	1362.8	7%
United States	Morgantown-Washington Dulles	151.7	1149.6	1301.3	12%
United States	Escanaba-Detroit	64.4	1194.0	1258.4	5%
United States	Pueblo-Denver	113.3	1121.7	1235.0	9%
United States	Crescent City-San Francisco	147.0	1060.2	1207.2	12%
United States	Garden City-Denver	127.2	1071.0	1198.2	11%
United States	North Platte-Denver	95.7	1075.3	1171.0	8%
United States	Cortez-Denver	97.6	1039.1	1136.7	9%
United States	Chadron-Denver	70.0	1060.4	1130.4	6%
United States	Parkersburg-Washington Dulles	143.8	975.9	1119.7	13%
United States	Liberal/Guymon-Denver	96.3	984.1	1080.4	9%
United States	Kearney-Denver	99.2	919.2	1018.4	10%
United States	Mason City-Minneapolis	112.9	903.4	1016.3	11%
United States	Alamosa-Denver	90.9	909.2	1000.1	9%
United States	Columbia/Jefferson-Memphis	69.7	836.5	906.3	8%
United States	Altoona-Washington Dulles	132.3	705.4	837.7	16%

Appendix B (con't): GCI Connectivity Impacts of PSO Routes, 2010

PSO-Issuing Country	Origin-Destination	GCI Connectivity from PSO Route (2010)			
		Direct	Indirect	Total	% Direct
United States	Moab-Denver	59.9	775.3	835.3	7%
United States	Greenville-Memphis	41.5	742.8	784.3	5%
United States	Laurel/Hattiesburg-Memphis	47.5	701.1	748.6	6%
United States	Lancaster-Baltimore	726.2	17.9	744.1	98%
United States	Presque Isle-Boston	194.9	536.4	731.3	27%
United States	Augusta/Waterville-Boston	210.5	482.5	693.0	30%
United States	Jamestown-Cleveland	100.5	574.5	674.9	15%
United States	Vernal-Denver	60.4	605.6	666.0	9%
United States	Grand Island-Denver	95.2	519.5	614.7	15%
United States	Oil City/Franklin-Cleveland	98.8	506.7	605.6	16%
United States	Cedar City-Salt Lake City	46.3	553.9	600.2	8%
United States	Clarksburg-Washington Dulles	80.3	474.9	555.2	14%
United States	Lewisburg-Cleveland	86.7	458.6	545.2	16%
United States	Lebanon-Boston	487.2	55.6	542.7	90%
United States	Bar Harbor-Boston	125.3	381.4	506.7	25%
United States	Jamestown-Minneapolis	41.2	460.3	501.5	8%
United States	Hagerstown-Baltimore	483.9	8.2	492.1	98%
United States	Johnstown-Washington Dulles	101.9	380.1	481.9	21%
United States	DuBois-Cleveland	86.1	384.7	470.8	18%
United States	Watertown-Minneapolis	82.4	386.2	468.6	18%
United States	Dodge City-Denver	75.7	381.0	456.7	17%
United States	El Centro-Los Angeles	157.6	296.8	454.4	35%
United States	Page-Phoenix	83.9	348.8	432.8	19%
United States	Worland-Denver	26.6	393.8	420.4	6%
United States	McCook-Denver	60.2	345.7	405.9	15%
United States	Macon-Atlanta	396.5	0.0	396.5	100%
United States	Devils Lake-Minneapolis	39.9	337.4	377.3	11%
United States	Show Low-Phoenix	85.3	268.3	353.5	24%
United States	Beckley-Washington Dulles	59.1	279.2	338.2	17%
United States	Rockland-Boston	308.3	26.4	334.7	92%
United States	Visalia-Las Vegas	319.3	13.6	332.8	96%
United States	Iron Mountain-Detroit	41.9	286.9	328.8	13%
United States	Plattsburgh-Boston	263.4	31.5	294.9	89%
United States	Alliance-Denver	24.7	260.0	284.6	9%
United States	Merced-Las Vegas	277.6	4.8	282.4	98%
United States	Rutland-Boston	238.5	14.4	252.9	94%
United States	Saranac Lake-Boston	233.7	12.5	246.2	95%
United States	Ponce-San Juan	149.1	95.0	244.1	61%
United States	Athens-Atlanta	228.7	0.0	228.7	100%
United States	Marion/Herrin-Kansas City	201.8	3.0	204.8	99%
United States	West Yellowstone-Salt Lake City	16.7	186.9	203.6	8%

Appendix B (con't): GCI Connectivity Impacts of PSO Routes, 2010

PSO-Issuing Country	Origin-Destination	GCI Connectivity from PSO Route (2010)			
		Direct	Indirect	Total	% Direct
United States	Quincy-St. Louis	188.1	6.4	194.5	97%
United States	Mayaguez-San Juan	105.7	79.9	185.6	57%
United States	Bradford-Cleveland	32.8	145.5	178.3	18%
United States	Joplin-Kansas City	84.4	73.2	157.7	54%
United States	Manhattan-Kansas City	76.1	69.2	145.3	52%
United States	Prescott-Ontario	128.2	14.2	142.3	90%
United States	Cape Girardeau-St. Louis	130.0	1.4	131.5	99%
United States	Decatur-St. Louis	130.4	0.0	130.4	100%
United States	Kingman-Las Vegas	125.0	4.3	129.3	97%
United States	Massena-Albany	107.1	0.7	107.8	99%
United States	Fort Leonard Wood-St. Louis	73.6	22.8	96.5	76%
United States	Jackson-Nashville	85.7	8.2	93.9	91%
United States	Manistee-Milwaukee	91.6	1.0	92.6	99%
United States	Salina-Kansas City	50.4	41.6	92.0	55%
United States	Ogdensburg-Albany	91.3	0.0	91.3	100%
United States	Burlington-Kansas City	76.5	13.9	90.4	85%
United States	Owensboro-Nashville	85.5	0.0	85.5	100%
United States	Watertown-Albany	80.7	0.0	80.7	100%
United States	Kirksville-St. Louis	54.2	0.0	54.2	100%
United States	Silver City-Albuquerque	20.4	20.6	41.0	50%
United States	Clovis-Albuquerque	21.6	5.3	26.9	80%
United States	Pendleton-Portland	23.9	1.7	25.5	93%
United States	Alamogordo/Holloman-Albuquerque	23.3	0.0	23.3	100%
United States	Fort Dodge-Mason City	20.7	0.0	20.7	100%
United States	Carlsbad-Albuquerque	20.4	0.0	20.4	100%
United States	Jonesboro-Memphis	15.6	0.0	15.6	100%
United States	Hot Springs-Memphis	15.4	0.0	15.4	100%
United States	Harrison-Memphis	14.7	0.0	14.7	100%
United States	Sidney-Dickinson	4.3	9.5	13.9	31%
United States	El Dorado-Memphis	13.5	0.0	13.5	100%
United States	Ironwood/Ashland-Rhinelander	7.0	0.0	7.0	100%
United States	Billings - Lewiston	3.2	0.1	3.3	97%
United States	Wolf Point-Billings	2.5	0.0	2.5	100%
United States	Huron-Pierre	2.1	0.0	2.1	100%
United States	Glendive-Dickinson	1.9	0.0	1.9	100%
United States	Havre-Billings	1.8	0.0	1.8	98%
United States	Glasgow (MT) -Billings	1.4	0.1	1.5	92%
United States	Miles City-Gilette	0.9	0.0	0.9	100%
United States	Ely-Grand County	0.6	0.0	0.6	100%

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