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Comparing spatial concentration and assessing relative market structure in air traffic

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A B S T R A C T

Traffic distributions of air traffic and their concentration have been measured through Gini, an index that contrasts in many ways with other more established ones, such as Herfindahl's. This research is extended in the sense that it perceives spatial concentration in air transport as an aggregate of complex networks that are subject to multiple constraints, such as geopolitics or technology. We propose a multi-layered analytic approach where network operators are economic agents that behave in strategic ways. It allows for comparing air traffic between airports in Europe with that of the US and, in particular, introduces a normative component by isolating patterns in airlines' strategies that coincide with more or less welfare-oriented degrees of spatial concentration in light of the above constraints.

1. Introduction

Leading to our research problem, the first part of this paper presents the classic economic measures for concentration and discusses their application to air traffic (Fig. 1).

The Lorenz curve is a graphical representation of the cumulative distribution function of a probability distribution; it is a graph showing the proportion of the distribution assumed by the bottom *y%* of the values. It is often used to represent income distribution, where it shows for the bottom *x%* of households, what percentage *y%* of the total income they have. The percentage of households is plotted on the *x*-axis, the percentage of income on the *y*-axis. The Lorenz curve can be seen as a graphical depiction of the Gini index that is commonly used as a measure of concentration.

1.1. Measuring concentration in air traffic: Gini index or Herfindahl?

The most common measures for economic concentration include the coefficient of variance, the Herfindahl-index, Theil's entropy measure, the C-4 firm concentration ratio, and the Gini index. Reynolds-Feighan recommends the Gini index as the most appropriate concentration measure for airline networks (Reynolds-Feighan, 2001) or airline traffic distributions at airports (Reynolds-Feighan, 1998). Allison (1978) and Sen (1976) examined the properties of income inequality measures and proposed a series of characteristics that indices should possess. The C-4 index only reacts to changes in the traffic distribution in an airport population when the 4 biggest airports are involved. Moreover, the Herfindahl-index is only sensitive to changes in the extremes of the population. The coefficient of variance, on the other hand, reacts well to changes in the population, but is extremely sensitive to the underlying distribution.

The Gini index was the only index to satisfy all the criteria (see Burghouwt, 2006, pp. 65–66). The Gini index is not sensitive to the distribution of the population and reacts quite well to changes in all parts of a given population (see Reynolds-Feighan, 1998; Sen, 1976), i.e. it is sensitive to inequalities at medium and smaller sized airports as well. Another critical advantage of Gini is its scale independence (Reynolds-Feighan, 2001, p. 265). Burghouwt (2006) puts forward these properties of Gini in terms of spatial concentration, rather than economic concentration, and applies them with regards to airports and airlines. The following presents a definition of Gini and its application to air traffic (see Burghouwt, 2006).

Definition:

$$G = \frac{1}{2n^2\overline{y}}\sum_i \sum_j \left|y_i - y_j\right|$$

where y is the air traffic at airport i or j, defined as the total number of supplied seats per week, and n is the number of airports in the airline network. The Gini index is based on the absolute difference in seat capacity between every possible airport pair in the airline network scaled to the number of airports in that network and the average seat capacity per airport. If the airport share is always equal to a share in overall traffic (seat capacity), then there is a situation of perfect equality (Gini = 0), fitting a 45° line on a Lorenz curve. On the other hand, if all seat capacity (for outgoing traffic, for example)

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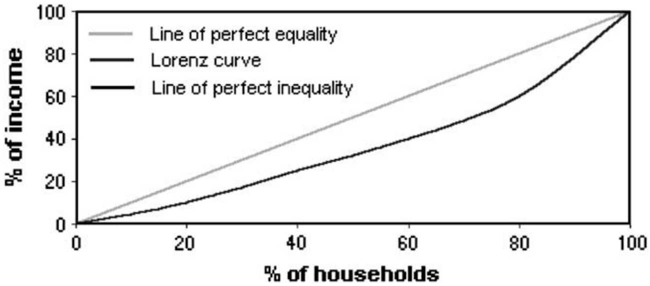

Fig. 1. Lorenz curve.

would be concentrated at one airport only, with no traffic leaving from the remaining airports, a Gini score of 1 would be the result.

In the following, we shall use the advantageous properties of Gini to move our analysis from spatial concentration to economic concentration in a more normative sense to assist policy makers in their assessment of market structure and effective competition policy in air traffic. In order to do so, different layers for analysis will be used: first, the distribution of traffic (in units of available seats; available seat miles) between airports will be measured with Gini and these Gini indices will be compared on similar, geopolitically determined routes between Western Europe and the US. Secondly, all airlines that operate scheduled flights within the described zones (and have their home base within) shall be classified in clusters along critical multi-dimensional scales that relate to their network features, such as: number of airports being served by the given airline, number of links per airport for each airline, maximum frequency of flights at airline's main airport, and number of intercontinental links for each airline. Since the later analysis also takes account of a ranked order distribution of flight frequencies among all airports that an airline serves, this too could be interpreted as a form of concentration or equality measure. However, we did not choose to employ Gini for the clustering of airline networks at this point. The results of the first analysis that employed the measure for traffic concentration at airports can then be decomposed along the identified clusters of airline networks. This third layer of analysis will allow providing a summary description on how different types of airlines' network structures allocate capacity (in terms of available seats and available seat miles) between the airports that they serve. This summary description at the last stage of our analysis will allow for making inferences as to which airlines networks shape market structure in distinctive manners and thus determine economic concentration, not only spatial concentration.

1.2. Towards a more normative approach

It is our intention to evolve from graph theory and its idiosyncratic typologies for network structures, and to help develop a practical tool for policy makers. There are many legitimate caveats when applying measures for spatial concentration to policy making. In order to highlight potential problems of such a graph based approach, it is useful to go back to the article of Reynolds-Feighan (2001). For measuring the distribution for air traffic inside the US with Gini, Reynolds-Feighan used a comprehensive measure for air traffic that was composed of passengers and/or number of movements, which may appear close to the measure for seat capacity as presented by Burghouwt in the above, but risk to obscure other fundamental dimensions that matter in this respect: for example, distance. In order to describe available capacity in air traffic, the unit of analysis of available seat miles (ASM) is at least as important as seat capacity (AS). Indeed, the economies for airline operators that can be gained through the utilization of aircraft on appropriate distances go beyond spatial concentration measures and relate directly to the notion of efficiency.

Reynolds-Feighan's approach was non-exhaustive in its selection of airlines (7 major ones and 11 low-cost ones, following the official classification of the Department of Transportation (DoT)). Although instructive in terms of understanding capacity allocation inside the operating agent's network, it does not allow to draw a comprehensive picture of market structure or to compare between distinct geopolitical constituencies, such as Europe and the US. In its conclusion, Reynolds-Feighan stresses frequent difficulties to distinguish hub-and-spoke structures from point-to-point ones. Among a wave of new entrants to the industry, the Gini index often suggested little homogeneity within the same strategic group of "low-cost airlines": some carriers showed Gini values of <0.5, suggesting point-to-point traffic. Another group of "low-cost" carriers showed Gini indices of at least 0.6, which was interpreted as an increased propensity towards hubbing. Apparently, the dependency on airline classifications from a regulating body (the DoT in occurrence) apparently did not fully match the paper's research purpose. This motivated us to classify economic agents along their intrinsic network characteristics, before assessing their respective impact on overall market structure at a later stage of our analysis.

Finally, Lijesen (2004) addresses two weaknesses of Herfindahl, which we cannot ignore when looking for a normative validity in terms of Gini: (a) its robustness with respect to the definition of the market and (b) the questioning of the relationship between concentration and market power. When comparing concentration between Europe and the US, we would expect to find important structural differences, rather than perfect symmetry: the different geopolitical environments in which airlines have evolved and are operating can be considered an important factor that helps define the boundaries for both markets. In particular, the domestic market inside EU member states may be more effectively compared to that inside states of the US, rather than the total US-domestic market. In turn, intra-European traffic, i.e. between member states, may be compared with US-domestic traffic that crosses state borders, but not with intercontinental traffic, etc. Measuring traffic concentration on the most appropriate geopolitical scale is likely to provide adequate definitions for the limits of a common market.

The historical dimension must also enter into a valid and nuanced assessment of concentration and its likely dynamics in the future: if one were to consider, for example, all European airlines and airports that served as the relevant actors defining our market, a strong bias due to domestic traffic would enter into Gini, but its influence on concentration over the long run may be questioned due to the advancing integration of European air traffic and a possible reallocation of routes towards trans-European connections over time. As of today, such trans-European routes are still under-developed: airlines that would enable such new linkages, including low-cost carriers, have not attained their full potential before many years. Similarly, intercontinental traffic is concentrated at major airport hubs that are dominated by legacy carriers. The alliances that have been formed among these industry incumbents may tend to re-allocate these intercontinental routes on to even less mega-hubs in Europe. In comparison to the US, European air traffic is still at an early stage of liberalization and its degree of concentration risks to be subjected to significant changes in the foreseeable future.

1.3. On the relationship between network concentration and market power

Applying a Gini measure for approximating market power in air traffic is problematic, although establishing such a relationship through Herfindahl is not obvious neither (see Lijesen, 2004). In