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A hierarchical cluster analysis of the financial performance of US hub airports in relation to lease agreement types.

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Abstract

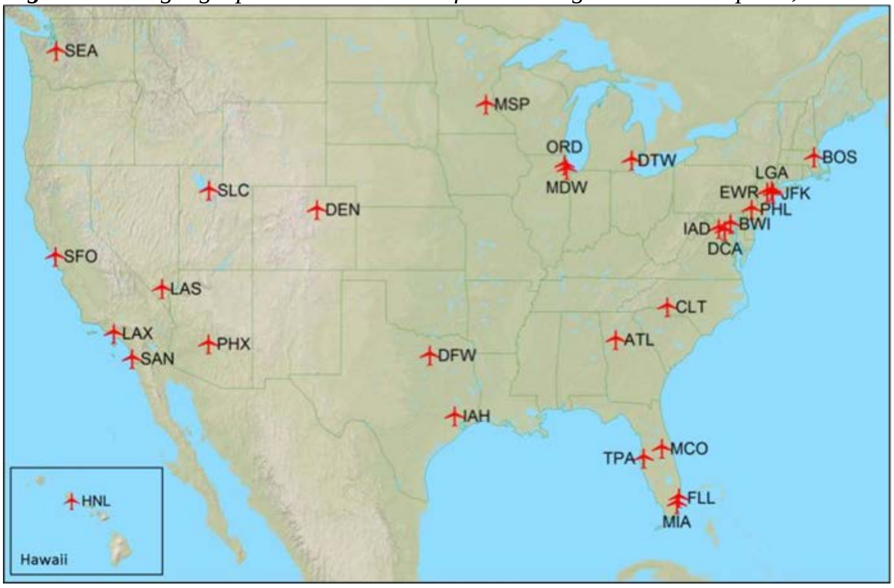
This paper performs a cluster analysis to examine the financial implications of the different types of airline lease agreements used by U.S. hub airports. Four key financial performance indicators relating to financial profitability including revenue generation, capital investment, commercial performance and cost effectiveness are analysed using 2011/12 financial data for large-hub airports. The results show that while financial performance varies according to traffic mix, airports with the same agreement types are clustered together. The paper concludes by noting that airports' control of their financial performance varies by agreement type and the identified clusters support the sub-categorisation of airport performance indicators.

1. Introduction

At most commercial airports in the United States, the conditions for utilising airport facilities are established through legally binding contracts between the airport operator and airline users (Gillen and Lall, 1997). These airport use-and-lease agreements define the financial and operational relationship that exists between an airport and its tenant airlines. Three types of agreement are used by airports in the U.S. These are Residual, Compensatory and Hybrid (Doganis, 1992). Each one of these bilateral agreements uses a different method to calculate airline charges and presents a different level of financial risk to the airport (Beckers and Fuhr, 2007).

As airline rates, fees and charges remain the largest contributor to an airport's operating revenue (Hamzaee and Vasigh, 2000), the choice of lease agreement is a fundamental part of an airport's business model and corporate strategy (TRB Report, 36, 2010). At the time of writing, thirty-five years after US airline deregulation, 83% of US airport agreements are due to expire within the next five years (ACI-NA, 2012a). Airport managers require empirical evidence of the financial implications of different types of use-and-lease agreements to inform negotiations about new agreements, which typically take one to two years (TRB Report 36, 2010). It is crucial, therefore, to establish the influence different agreements have on the financial performance of airports. The focus of our analysis is large-hub passenger airports which each account for at least 1% or more of all US passenger enplanements (FAA, 2012a). The 29 large hub airports in the U.S. are illustrated in Figure 1 and are collectively responsible for 70% of all U.S. passenger traffic.

***Figure 1**: The geographical distribution of the 29 large-hub U.S. airports, 2012.*



***Source:** FAA, 2012a.*

2. Airport Performance and Leasing Agreements

Airport use-and-lease agreements define the financial and operational relationship between an airport and its tenant airlines (Rivas, 2002). Lease agreements consist of two elements; '*leases*', which govern an airline's occupation of land and buildings, and *'use agreements'*, which define an airline's use of airport facilities (Ashford and Moore, 1992). Together, they form what is collectively known as an airport's '*use and lease agreement*'. These agreements set out the terms and conditions for the use of airport facilities and specify the method for calculating airline rates (Graham, 2008). They also specify how the risks and responsibilities of running the airport will be shared and so serve as the foundation for the financing of airport facilities (Rivas, 2002).

In a residual agreement both non-aeronautical and aeronautical revenues are considered when setting aeronautical charges (Forsyth, 2004). This enables airlines to guarantee an airport's solvency by agreeing to pay any deficit or '*residual operating costs'* not covered by non-aeronautical revenues (AAAE, 2005). By ensuring airports operate on a break-even basis the airlines assume all of an airport's financial risk (Ashford and Moore, 1992). In return, airlines receive a proportion of control and a share of non-aeronautical revenues (Oum et al, 2004). Residual agreements are therefore akin to the European 'single-till' approach in which revenues from all airport activities are taken into account when setting aeronautical charges (Forsyth, 2004). Unsurprisingly, this pricing structure encourages hubbing as airlines try to reduce their average unit costs (Doganis, 2006). In 2012, 36% of large-hub U.S. airports operated a residual agreement. Notable examples include Chicago O'Hare (ORD), Dallas-Fort Worth (DFW), Detroit Metropolitan (DTW) and San Francisco International (SFO).

Under a compensatory agreement no such cross-subsidisation exists. Airports retain all aeronautical and non-aeronautical revenues and assume all financial risk associated with the airport's operation (Ashford and Moore, 1992). This approach divides all revenues and expenses between two, financially independent, landside and airside cost centres (Rivas, 2002). Thus, contrary to a residual agreement, airlines are charged the actual cost of both the landside and the airside facilities and services they use (Graham, 2008). The compensatory approach is therefore more akin to the European 'dual-till' approach in which only aeronautical costs are considered when setting airfield charges (Forsyth, 2004). In 2012, 28% of large-hub airports used a compensatory agreement. Examples include Boston Logan (BOS), George Bush Intercontinental (IAH) and John F. Kennedy International (JFK).

Hybrid agreements combine elements of both residual and compensatory agreements to suit the needs of a particular airport (Graham, 2008). Hybrid agreements typically combine residual principles to airside facilities, such as runways, and compensatory elements to landside faculties, including car parks (Ashford and Moore, 1992). Here, the relationship falls in the middle of the risk/reward spectrum. However, most hybrid airports negotiate non-aeronautical revenue sharing clauses into their agreements. Currently, 36% of large-hub airports employ a hybrid agreement. Examples include Denver International Airport (DEN), , Los Angeles International (LAX) and Seattle-Tacoma International (SEA).

Interestingly, there is no legal requirement to enter into an agreement, and they are not required to finance improvements (Ashford and Moore, 1992). Indeed, 10% of U.S. airports have no formal agreement (ACI-NA, 2012a). Establishing a business arrangement without an agreement is generally referred to as an *'Ordinance'* approach (TRB Report 36, 2010). In the absence of a negotiated contract, local governments or authorities periodically enact legislation to set an airport's rates and charges using local ordinances or resolutions (Rivas, 2002). However, the 1996 DOT/FAA Federal Policy Regarding Airline Rates and Charges legislated that such charges must be "*fair*", "*reasonable*" and "*non-discriminatory*" (TRB Report 36, 2010; Forsyth, 2004). In this scenario, airports have the greatest flexibility and control over capital investment programmes, but they also have to assume all associated financial risk. Consequently, this unilateral relationship is only successful if an airport has a strong local market and traffic demand (Rivas, 2002). Examples of airports adopting this approach include Gerald R. Ford International (GRR), Phoenix Sky Harbour (PHX) and Sacramento International Airport (SMF).

3. Data

In order to identify the performance metrics which are most appropriate for measuring airport financial performance, a series of in-depth interviews were conducted with leading airport and airline trade associations in the U.S. Quantitative financial data relating to revenue generation, where non-aeronautical revenues such as car parking and hotels are included, capital investment, commercial performance relating to concessionary services and associated revenues such as from shops, food and beverages etc., cost effectiveness and financial profitability was then collected for a carefully selected sub-sample of 23 large hub airports that represented each type of agreement. Collectively, these 23 airports represent 57.4% of all US passenger enplanements. Only airports which have operated a single type of agreement for more than three years were selected for analysis. This avoids airports experiencing high sunk and transition costs associated with newly changed agreements from distorting the dataset (TRB Report 36, 2010). As a result, Las Vegas McCarran International (LAS), and Orlando International (MCO) were excluded. Charlotte Douglas International (CLT), Honolulu International (HNL) and Chicago Midway International (MDW) were excluded from the analysis as data availability was an issue. Phoenix (PHX) was excluded as it has no formal agreement. Four further airports[1] assumed zero debt and would have biased the results if included. This leaves 19 airports in the sample which is still a large enough sample of large hubs to draw conclusions from and represents 49% of enplanements.

Cross-sectional financial airport data for the 2011/12 financial year was collected from three independent sources; the FAA airport financial statement database, Compliance Activity Tracking System (CATS), (FAA, 2012b); the ACI-NA, 2012 Benchmarking Survey, and the ACI-NA, 2012 Airport/Airline Use & Lease Agreement Survey. Using FAA and ACI-NA data ensures comparability as both organisations use identical and certified financial data reporting techniques (TRB Report 19a, 2010).

The FAA CATS database collects and disseminates congressionally mandated airport financial information from 520 commercial service airports for the purpose of evaluating compliance with revenue-use requirements (FAA, 2012b). The database details 52 financial characteristics covering revenues, expenses, debts and assets (ACI, 2006). The ACI-NA 2012 Benchmarking Survey is

[1] John F Kennedy- New York (JFK), La Guardia New York (LGA), Newark (EWR), Salt Lake City (SLC).

consistent with the FAA's 5100-127 form[2]. However, the survey examines revenues, costs and debt in greater detail to provide a comprehensive analysis of 75 key economic indicators (TRB Report 19a, 2010). For comparability ACI-NA data has been pre-adjusted to include relevant airline data for airports which lease entire terminals to their airlines, including JFK and Atlanta (ACI, 2006; Graham, 2013; Doganis, 2010). The 2012 annual survey captured 90% of large-hubs in North America (ACI-NA, 2012b). ACI-NA's Airport/Airline Use & Lease Agreement Survey is conducted every 10 years. Its purpose is to assess the level of airline market power during lease agreement negotiations. In 2012 the survey represented 62% of large-hub airports and was completed by airport finance personnel.

The resulting data was converted into a series of industry recognised Airport Performance Indicators (API). These were selected as ACI and TRB recommend them. ACI lists indicators by functionality, whilst TRB lists by importance. A cross-compilation of the two provides the most important APIs. By standardising financial inputs as a measure per output, the comparison of different sized airports was enabled. Airports were then categorised according to their agreement type and benchmarked against each other and the industry mean. The results of the analysis identified performance trends that related to particular agreement types. Finally, a hierarchical cluster analysis of airport performance metrics was performed. This was supplemented by an analysis of covariance (ANCOVA) to evaluate the statistical and financial significance of an airport's type of agreement on its financial performance.

4. Cluster Analysis

Cluster analysis is a form of numerical taxonomy. Its objective is to identify homogeneus groups within a dataset using multivariate data for each case in the dataset, that is, airports. For more information on the technique see Everett et al, (2011). Previous examples of the use of cluster analysis to analyse airport performance include Rodriguez-Deniz and Voltes-Dorta (2010) examination of 106 world airports. In 2013, Vogel and Graham also used cluster analysis to identify homogeneous

[2] http://www.faa.gov/forms/index.cfm/go/document.information/documentID/185626

airports for future comparative financial performance studies. Using nine financial indicators from 73 world airports, this research identified three distinct clusters, one being entirely dominated by North American airports. The research concluded that U.S. airports should be analysed separately from their global counterparts. In evaluating the operational efficiencies of 44 U.S. airports, Sarkis and Talluri (2004) used nine variables to identify 13 airport groups. The research concluded that cold weather negatively affects performance whilst airline hubbing increases operational efficiency. The analysis here builds on these analyses.

The derived API data is analysed. It is posited that the inherent characteristics[3] associated with the types of lease agreement affects an airport's overall financial performance. All applicable data (except percentage ratios) were normalised into US dollars. Squared Euclidean Distance (SED) was used on the continuous data as the measure of separation. This sums all variable scores to obtain one index. However, SED only considers the absolute value of the squared difference between the variables, causing some variables in large, widely distributed datasets, to be disproportionally influential (Everitt et al, 2011). To overcome this difficulty, the variables were standardised using 'autoscaling' or 'z-scoring', thereby giving the variables a mean of zero and a standard deviation of one. However, because this corrective method reduces the variability of the original data (Jajuga et al, 2002), both standardised and unstandardised analyses were undertaken. The analysis is performed using the agglomerative clustering method in conjunction with the single-linkage "nearest neighbour" algorithm. This classifies variables based on the smallest distance between them (Everitt et al, 2011). The analysis was designed to identify several clusters relating to the key determinants of airport financial performance, including; agreement type, traffic mix and market orientation. Individual airports and their respective types of agreements are ranked on the y-axis of the subsequent dendrograms using their three letter FAA identifier codes. The accompanying letter 'R', 'H' or 'C' signifies their agreement as 'Residual', "Hybrid' or 'Compensatory' respectively.

[3] The different characteristics can restrict an airport's revenues, debts, control, x-inefficiency, development and borrowing all resulting in differences in financial performance

The agglomeration schedule shown in Table 1 table ranks the distance coefficients to identify similarity between the variables. This provides a measure of how dissimilar the clusters are. A visual analysis of the coefficients in Table 1 identifies five clusters. The first is from stage 1 to 8, the second from stage 9-13 inclusive and the third is from 14-16 inclusive. Stage 17 and 18 form two distinct groups. This finding partially supports the a priori expectations that the three types of agreement affect financial performance.

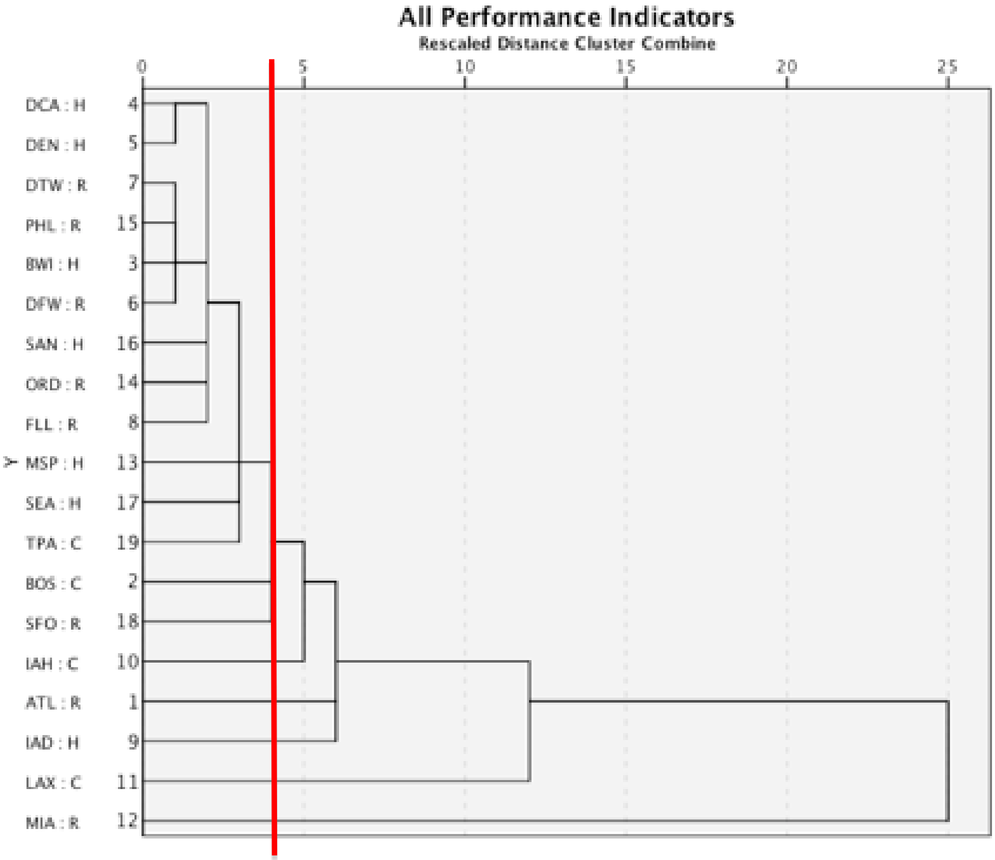
Table 1*: Agglomeration Schedule of All Performance Indicators.*

All Performance Indicators

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	4	5	5.089	0	0	7
2	7	15	5.501	0	0	3
3	3	7	6.032	0	2	4
4	3	6	6.927	3	0	5
5	3	16	7.582	4	0	6
6	3	14	7.612	5	0	7
7	3	4	7.722	6	1	8
8	3	8	8.644	7	0	9
9	3	13	10.648	8	0	10
10	3	17	10.956	9	0	11
11	3	19	11.113	10	0	12
12	2	3	12.177	0	11	13
13	2	18	12.695	12	0	14
14	2	10	15.218	13	0	15
15	1	2	17.418	0	14	16
16	1	9	17.650	15	0	17
17	1	11	30.814	16	0	18
18	1	12	58.992	17	0	0

The dendrogram (Figure 2) displays the airport coefficients in the agglomeration schedule on a standardised scale of 0-25 to visually identify the clusters. We cut off the clustering at the fourth 'degree of distance'. This intentionally excludes stages 14 to 18. The dendrogram partially supports the a priori expectations as pairs of hybrid, residual and compensatory airports are frequently clustered together. Interestingly, an airport's proportion of domestic traffic increases up the y-axis, with five hub airports, DEN, DTW, DCA, PHL and DFW, placed together. Equally, the dissimilar international gateways of LAX, MIA, IAD ATL and SFO, are placed towards the bottom. This supports the work of Fu and Zhang (2010) and Oum et al (2004) which suggests that market orientation affects an airport's financial performance.

Figure 2: *All Performance Indicators.*



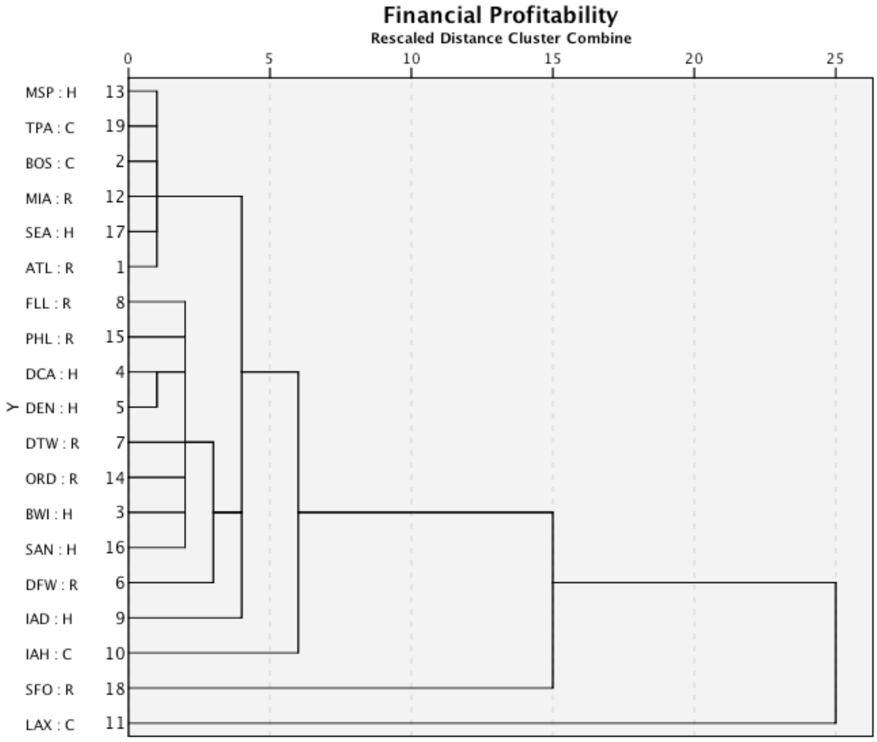
Note: *C = Compensatory; H = Hybrid; R=Residual.*

The results were even more conclusive when the analysis focused on the four sub-functional performance areas of revenue generation, capital investment, commercial performance, cost effectiveness and liquidity.

4.1 Financial Profitability

The airports are relatively homogeneous in terms of financial profitability. This is evident from the low coefficients in the agglomeration schedule. At a similarity measure of 4, two distinct groupings were identified (Figure 3). One was dominated by domestic airports while the second, including LAX, SFO, IAH, IAD, and DFW, supported largely international origin and destination traffic.

Figure 3: *Financial Profitability Ratios.*



This trend, while evident in the unstandardised analysis of revenue generation indicators (see Figure 4), was most apparent in the standardised analysis (Figure 5). At a distance measure of 8, two cluster ‘leafs’ and two sub-group ‘sub-leafs’ were identified (Figure 4). The sub-group, containing hybrid airports DEN, SEA and DCA supports the a priori expectations. The hierarchical clustering and segregation of the domestic airports (FLL, MSP, DFW, DTW, SAN, IAH, PHL, and BWI) from all remaining international gateways, supports Oum et al’s (2003) assertion that traffic mix affects revenue generation. Meanwhile the less significant grouping of prominent American Airlines hubs, DTW, MSP, DFW and FLL, partially supports Fu and Zhang (2010) and Oum et al (2004) in that hubbing both positively impacts operating revenues[4] and is a characteristic of residual airports (Doganis, 2006).

Figures 4: *Unstandardised Revenue Generation Indicators.*

[4] Hubbing increases revenues due to economies of scale and longer dwell times in terminals boosting concession revenue. Hubbing is encouraged by residual airports as airlines try to lower their average unit cost by routing through these cross-subsidised facilities.

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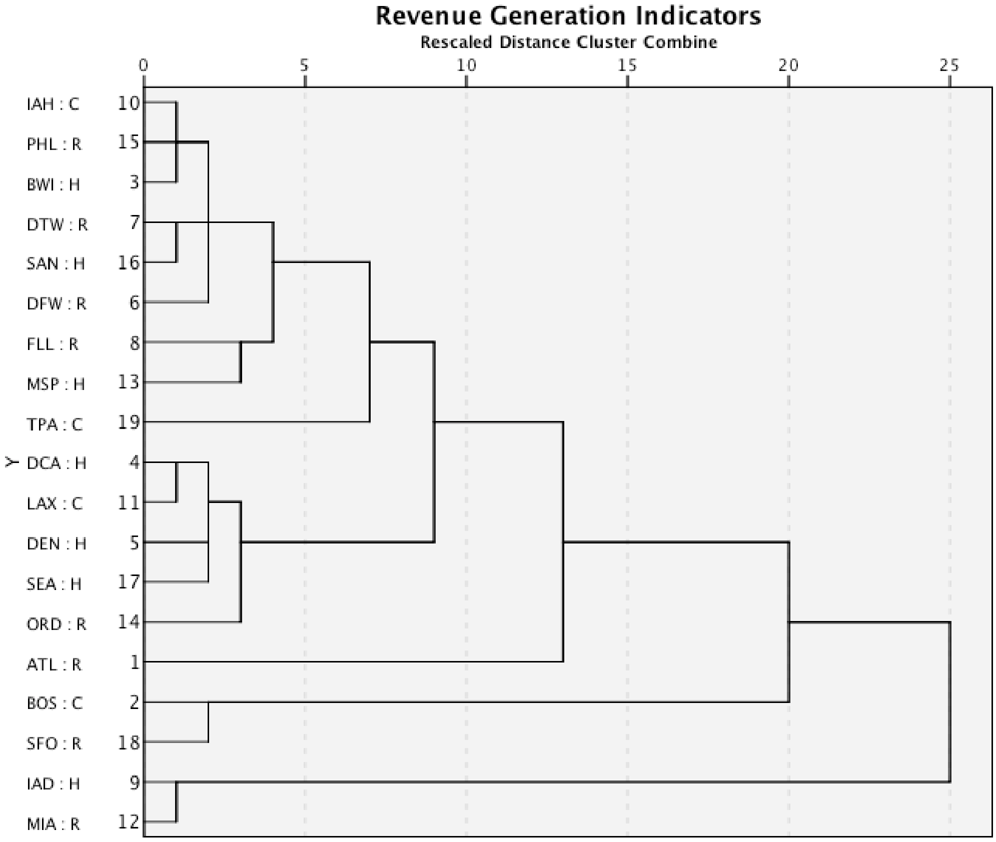
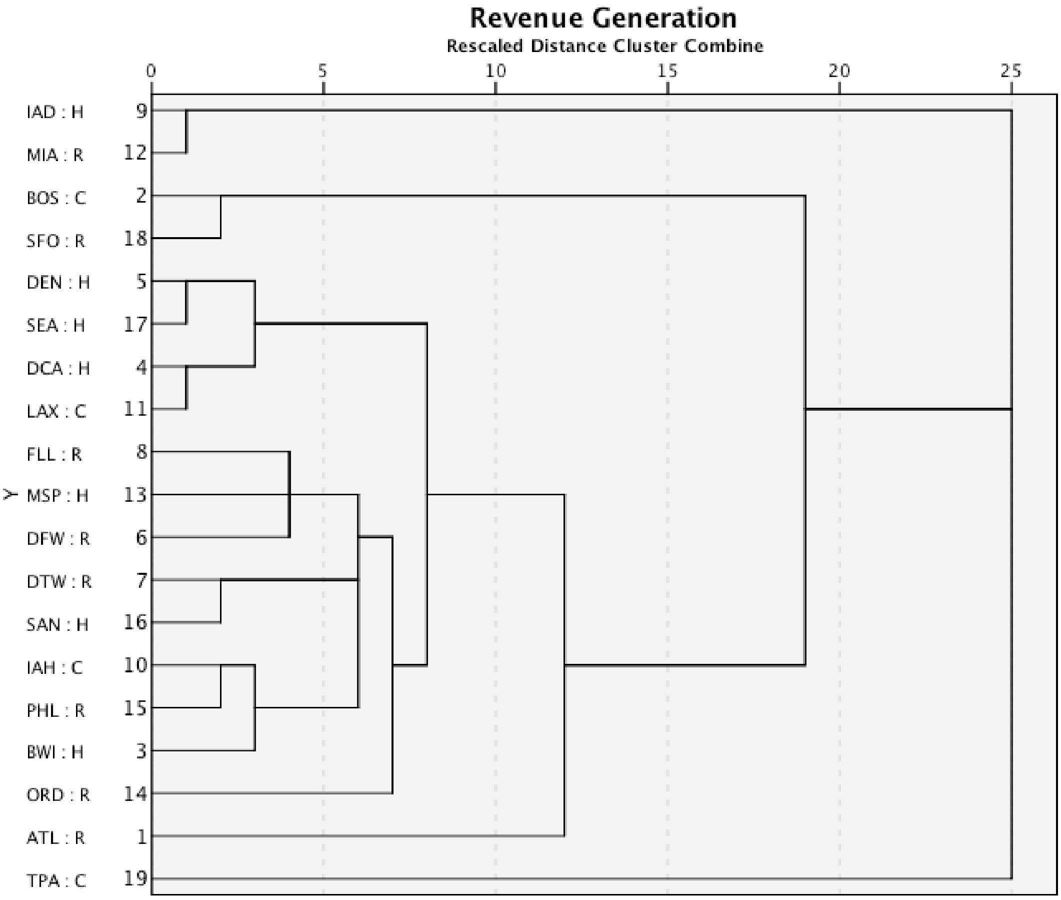


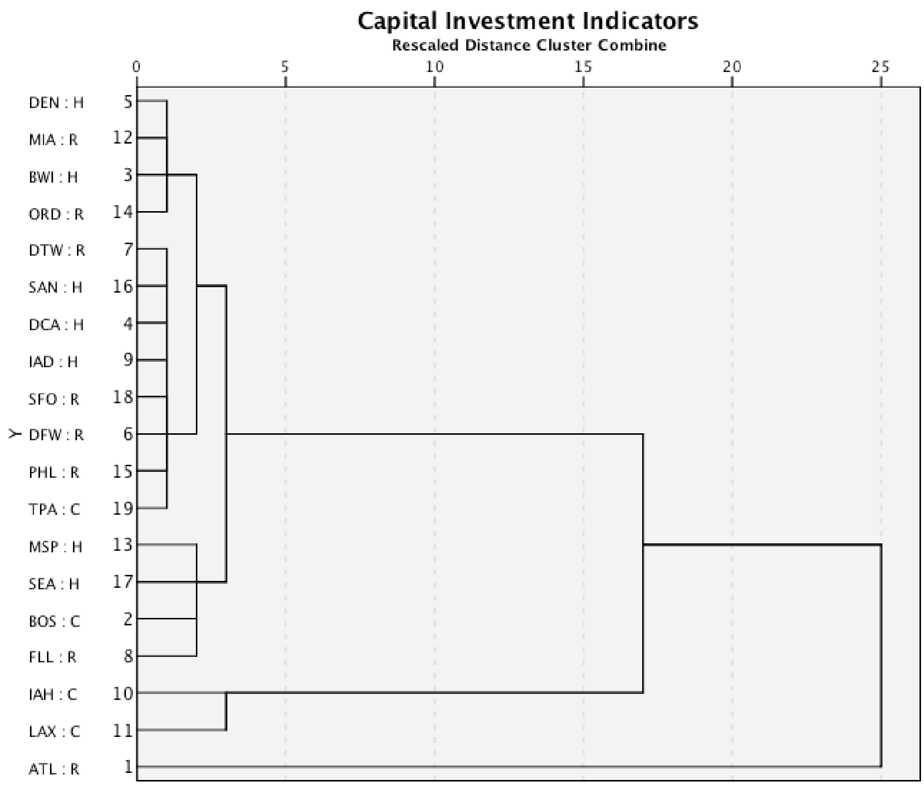
Figure 5: *Standardised Revenue Generation Indicators.*



4.2 Capital Investment

The consistent and low coefficients identified a very homogeneous sample. This is to be expected given that the sample consisted entirely of large-hub airports. Both the unstandardised and standardised analysis identified two distinct groups with one almost entirely dominated by compensatory airports and the other by residual and hybrid airports. This suggests their interrelationship is a function of their residual airfield's and airline presence, which partially supports Oum and Fu's (2009) findings that airline involvement positively affects an airport's ability to invest. This involvement enables such airports to more easily and cheaply invest in large scale projects such as runways. This cost is shared by residual and hybrid airports and assumed by compensatory.

Figure 6: *Capital Investment indicators.*



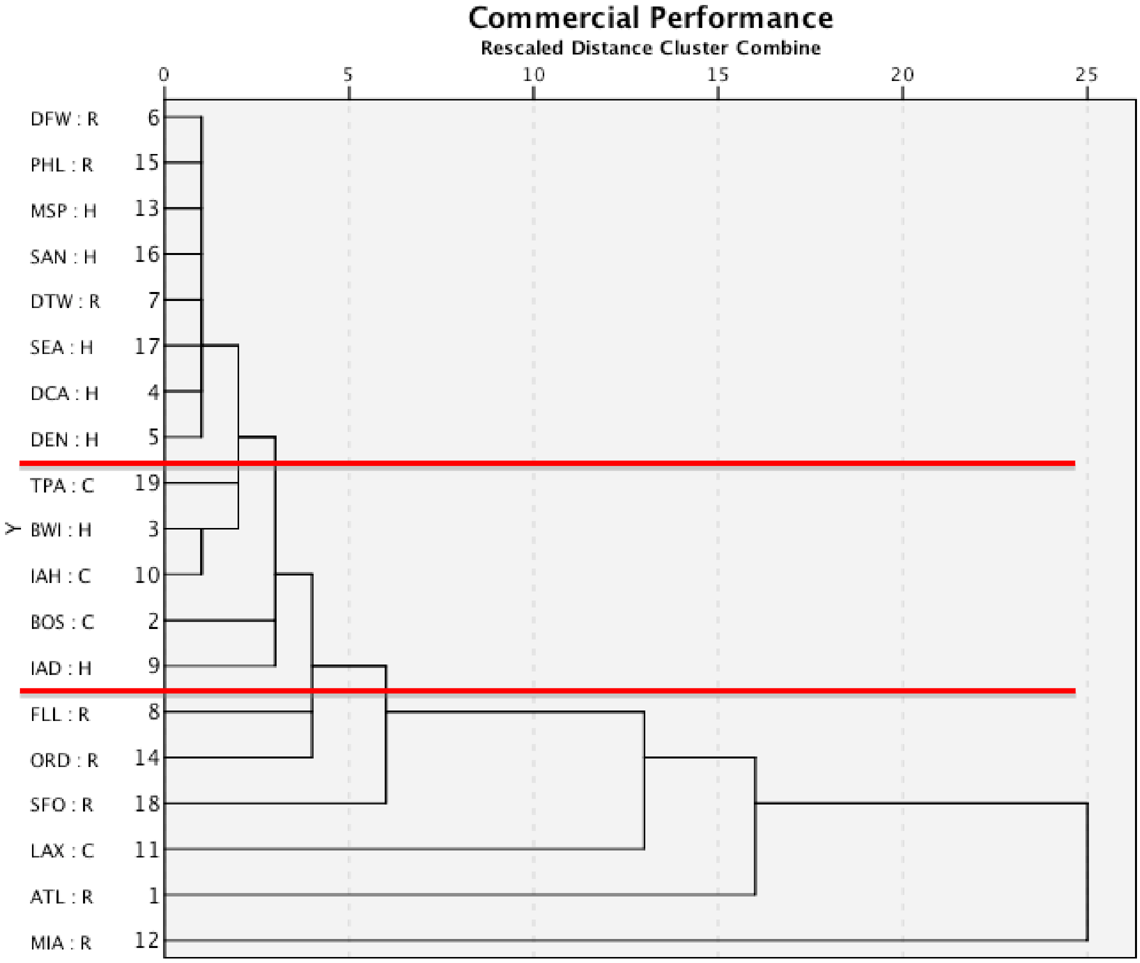
Interestingly, the standardised dendrogram in Figure 6 also identified three low scoring groups directly related to agreements. At a similarity score of 4, the grouping of compensatory airports, IAH and LAX, residual airports SFO, DFW and PHL and hybrid airports SAN, DCA and IAD becomes apparent.

4.3 Commercial Performance

The unstandardised analysis identified a very homogenous sample containing two distinct clusters and one sub-cluster of commercial performance. One was dominated by residual hub airports, which reinforces Fu and Zhang (2010) and Oum et al's (2004) research that hubbing positively affects commercial revenues. This suggests residual airports are unique in terms of their commercial performance as these hubs have higher traffic volumes with longer dwell times and share concessionary investment. The involvement of commercially driven airlines enhances commercial acumen and results in joint investment, shared knowledge, newer facilities and lower brand fatigue.

Upon standardisation, three additional clusters were identified within the hierarchical distribution of the coefficients. At a similarity distance of 6, three agreement-related clusters were identified (Figure 7). One group of nine facilities (from DFW to TPA on the y-axis) is dominated by hybrid airports. This is followed by a cluster containing most of the population of compensatory airports and a third cluster in which 83% of airports use residual agreements. Interestingly, this contradicts several industry publications and Lewis (1988) who suggested that the commercial performance of compensatory airports with their in-built incentives would result in higher performance . It seems they are less willing to take risks than residuals

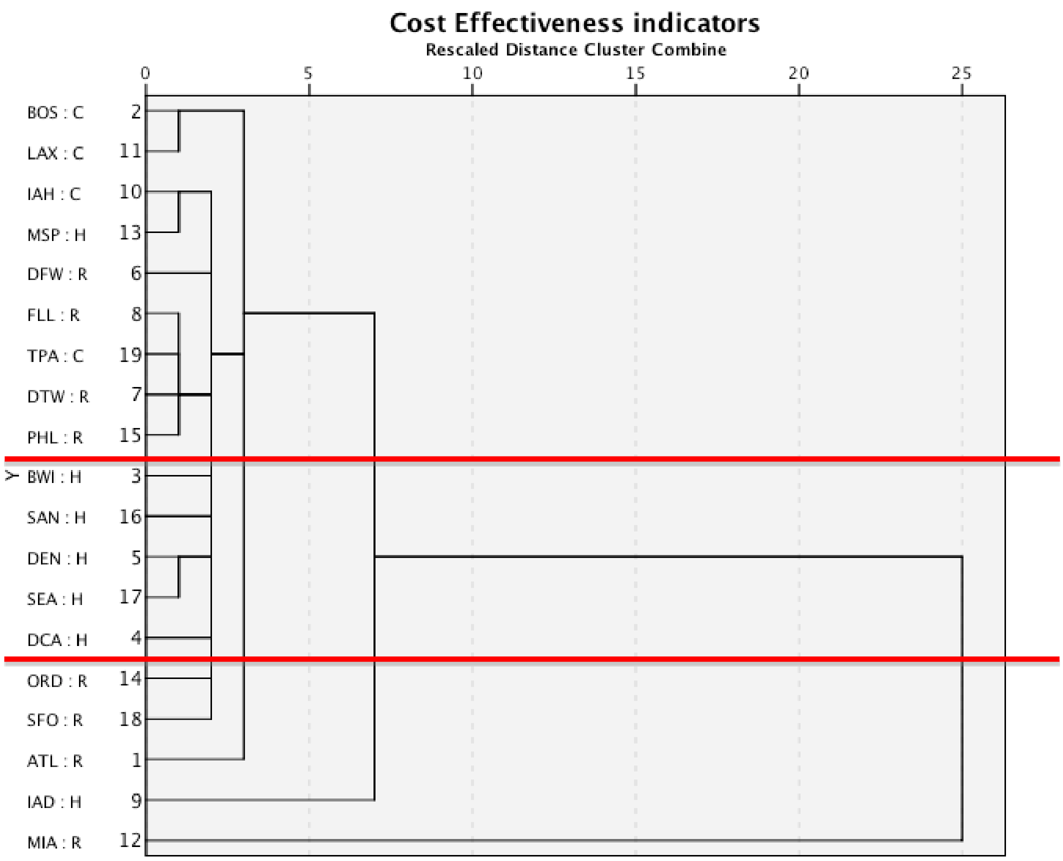
Figure 7: *Standardised Commercial Performance Indicators.*



4.4 Cost Effectiveness

The unstandardised analysis of cost effectiveness indicators, showing how an airport has the ability to control and keep down its costs relative to the output it produces, identified two clusters with one dominated by hybrid and compensatory airports. This was not surprising given the similarities between the two agreements. This trend was amplified in the standardised analysis, shown in Figure 8, whereby the relatively homogeneous population of compensatory airports rank in close proximity between BOS and PHL on the y-axis. This is followed by both a cluster of five entirely hybrid airports representing 71% of their population and a subsequent cluster dominated by residual airports. This suggests that systematic differences in cost effectiveness result from varying types of lease agreement. This agrees withGillen and Lall (1997) and Oum et al (2004) that through their unique cost efficiencies, the three agreements typesare fundamentally different in terms of their impact on financial performance. Cost effectiveness improves as airline involvement grows.

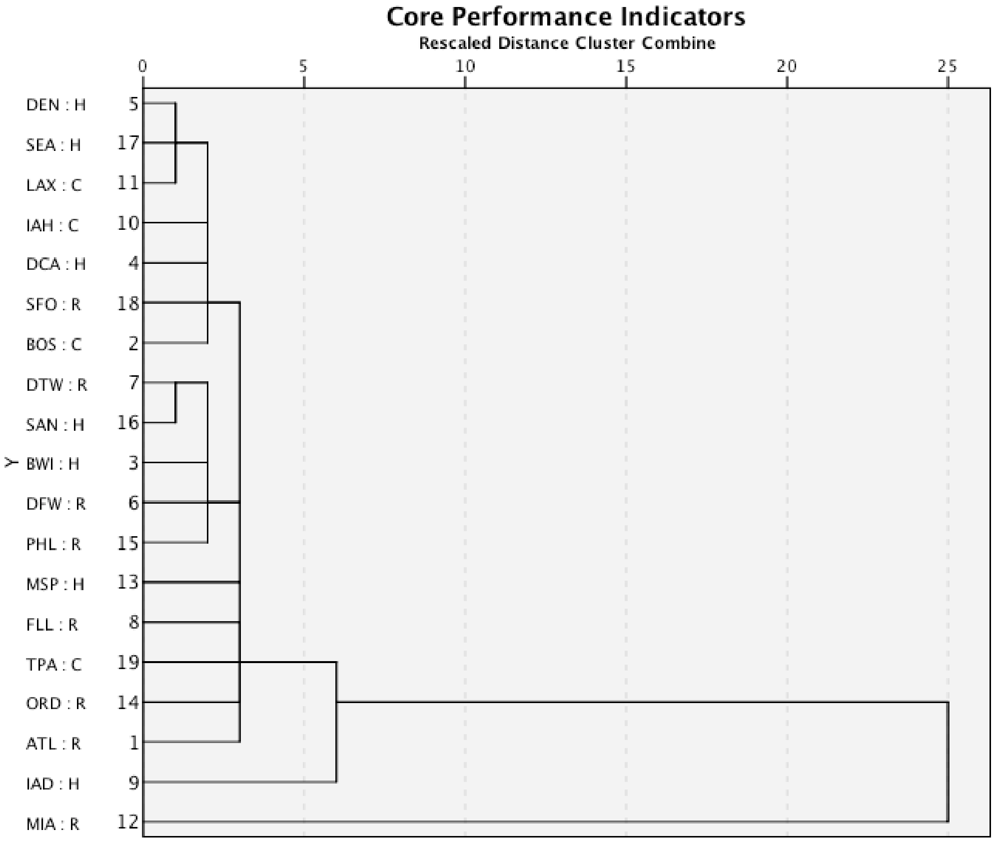
Figure 8: *Cost Effectiveness Performance Indicators.*



4.5 Relative Importance

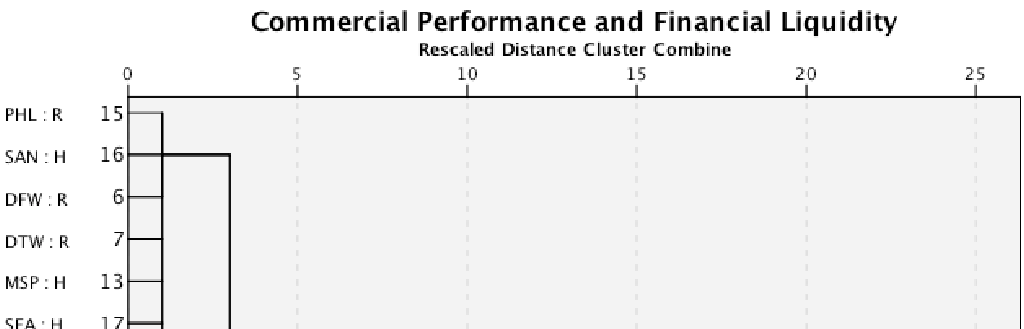
The non-functional variation in the ‘core’ and ‘key’ performance indicators resulted in a relatively non-homogeneous sample in which only a selection of agreement pairs could be identified (Figure 9). These include residual airports ORD, ATL, DFW and PHL, hybrid airports DEN, SAN and BWI and a concentration of compensatory airports between LAX and BOS.

Figure 9: *Core Performance Indicators.*



This highlights that the functional categorisation of API's by Doganis and Graham (1987) provides a more accurate model of airport performance than that suggested in TRB Report 19a (2010), which is categorised by relative importance. This trend was amplified in a multi-variable analysis of both the financial performance and the liquidity indicators in which trios of common airports were identified. In order to provide an additional level of exploration, 56 iterations were performed. Interestingly, when the commercial and liquidity indicators were combined, two distinct clusters were identified. One of these was dominated by hybrid airports at a similarity scale of 3.

Figure 10: *Commercial Performance and Financial Liquidity.*



This finding reflects the fact that hybrid airports are uniquely cash liquid to satisfy rating agencies and improve bond ratings while compensatory airports are significantly less so by comparison. Bond ratings are important when financial risk is assumed.

5. Conclusion

The result of our analysis reveal that the statistical clustering of multiple airports takes place at significant, low coefficient similarity distances. Pairs of common agreement airports were grouped through the analysis and confirm the unique contextual characteristics of U.S. airports. The segregation of hub airports from the otherwise heterogeneous airports at such low coefficients, exemplifies the uniquefeatures of residual and hybrid airports. The analysis proved they are unique in their relative positive or negative performance. Similarly two traffic-mix related clusters were identified in the airports' financial profitability, revealing a distinct positive correlation between the proportion of connecting traffic and financial similarity. This trend was divided further in the revenue generation analysis to identify distinct international and domestic market orientation differentials.

Although these characteristics are not pertinent to particular agreements, agreements were most prevalent amongst the areas most affected by airline involvement. Indeed the three agreements became progressively defined within the airports' capital investment, commercial performance and cost effectiveness, exemplifying the diminishing control an airline is able to enforce upon an airport's cost, commercial and capital activities.

The analysis culminated with an examination of eight cost effectiveness API's, in which three and near perfectly defined clusters were identified, which directly corresponded with the three known types of lease agreement. This statistically confirms that airport lease agreements systematically affect financial performance, with specific impacts upon cost effectiveness and commercial performance. The analysis of relative importance served to validate the systematic analytical method that was applied by confirming that the sub-functional categorisation of API's by Doganis and Graham (1987) provides a substantially superior model of financial performance over those recommended in the industry published and federally sponsored API manual (TRB Report 19 2010). Airports with above average concessionary revenues, domestic traffic or dominant carrier presence, are likely to adopt a residual agreement.

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