Airport-airline rivalry and efficiency in the air transport industry

Tesis Doctoral

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1.1.1 Inicio de la aviación y el papel de los aeropuertos

El deseo del ser humano por volar se revela hasta en la mitología griega, con Dédalo e Ícaro, un padre y un hijo que, a pesar del trágico final, lograron construir unas alas para escapar de la isla de Creta. A partir del siglo IV a.C. ya se recogen historias donde personas, a través de diferentes artilugios, intentaban volar, hasta incluso alguno lo consiguió. Pero hay que remontarse unos cuantos siglos después para ver avances reales en este tema.

Ya en el siglo XVIII se comenzaron a fabricar los primeros prototipos de globos aerostáticos, con el principal inconveniente de que no se podían controlar, hasta que en el siglo XIX aparecieron los primeros convertibles. Estos dos siglos fueron relevantes para el desarrollo futuro, aunque aún no existía la tecnología necesaria para crear aeronaves con vuelo controlado como conocemos hoy en día.

Debido al continuo desarrollo ocurrió lo inevitable, y a principios del siglo XX se realizan los primeros vuelos controlados. Aún hoy en día existe la disputa de quién lo logró primero, si los hermanos Wright, o el que se conoce como *El padre de la aviación*, Alberto Santos Dumont. Sin duda, fuese quien fuese, este hecho marcó un nuevo rumbo dentro de la industria.

La I Guerra Mundial fue la principal propulsora del desarrollo de la aviación, aunque ya en 1908 se dieron los primeros vuelos largos. Antes de que comenzase la guerra, no se preveía, por parte de los generales, que el uso de aviones fuese a ser relevante, pero se puso énfasis en el desarrollo aeronáutico y el papel de los aviones como arma de guerra fue esencial.

Tras la guerra se comienza a desplegar la aviación comercial. Aunque el primer vuelo comercial data de 1914 en un vuelo de un solo pasajero entre San Petersburgo y Tampa en Florida. No obstante, es en los años 20 cuando aparecen aerolíneas en Europa y Estados Unidos que aprovechan el desarrollo militar previo para expandir el negocio hacia la aviación comercial.

A pesar de que en los años 30 se favoreció el crecimiento y desarrollo de la industria, no fue hasta la II Guerra Mundial cuando se produjo otro gran avance. Como se observa, las guerras han sido las principales propulsoras de la aviación. En 1940 la producción era de unos 1.200 aviones, y cuando acabó la guerra en 1945, la producción fue más de cuarenta veces más, en concreto de unos 50.500 aviones.

No solo fue relevante la producción, sino los avances en cuanto a equipamiento y tecnología. Esto provocó que tras la guerra se separase la aviación comercial de la militar.

A partir de ahí, la historia moderna de la aviación que conocemos hoy en día comenzó a escribirse.

La parte terrestre de la aviación también ha evolucionado al mismo ritmo, pasando de simples aeródromos, que servían para el aterrizaje y despegue de las aeronaves, a aeropuertos con varios edificios destinados a diferentes usos. En 1920 se abre el primer aeropuerto comercial en Sidney. Durante estos años, volar era para personas privilegiadas que tenían cierto poder adquisitivo. En cambio, el desarrollo y la movilidad internacional ha democratizado el acceso al transporte aéreo. Como prueba, en los años 70 se introdujeron los controles de seguridad para establecer un mayor control, sobre todo, en el tránsito internacional.

Desde entonces, tanto la aviación como los aeropuertos han ido evolucionando a pasos agigantados. Se ha llegado al espacio y los aeropuertos se han convertido en multiplataformas que prestan servicios a diferentes grupos de consumidores y cuya función afecta directamente a gobiernos, inversores y la economía en general.

1.1.2 Impacto del sector aéreo

Aunque la silueta de los aviones no ha cambiado de forma sustancial, sí que ha habido cambios internos notables en la electrónica, la instrumentación y la eficiencia del motor, por ejemplo. Estos cambios han sido los responsables de la rápida evolución del sector y de la eliminación de barreras para conectar el mundo.

Para reflejar el alcance, la IATA (The International Air Transport Association) indicó que en 2014 había 1.402 aerolíneas comerciales, 26.065 aeronaves que prestaron 32,8 millones de vuelos comerciales en el mundo, y 3.883 aeropuertos. En cuanto al transporte de pasajeros, en 1970 fueron 310 millones, mientras que en 2017 casi se alcanzan los 4.000 millones de pasajeros, en concreto, 3.978 millones. También destacar que la aviación ha afectado al tráfico de mercancías. En 1977 se movieron 21.333 millones de toneladas por kilómetro, cifra que se ha multiplicado por diez hasta alcanzar 213.590 millones de toneladas por kilómetro en 2017.

Estas cifras reflejan el enorme crecimiento que ha sufrido el sector. Pero lo más importante es lo que subyace debajo de estas cifras. El impacto económico que ha provocado la aviación es incalculable[1], ya que ha conectado el mundo permitiendo llegar a lugares insospechados, en un tiempo récord.

La industria aeronáutica ocupó 62,7 millones de empleos en 2014, aunque de manera directa tan solo fueron 9,9 millones. Como se puede observar, el impacto directo, que cubre las actividades de dentro de la industria, es solo una porción del impacto global. El resto se divide entre el impacto indirecto, el impacto inducido y el impacto catalítico.

El impacto indirecto, que empleó en 2014 a 11,2 millones de trabajadores, recoge las actividades de los proveedores, como por ejemplo la comida que se sirve dentro del avión, empresas constructoras, la manufactura de bienes y minoristas y servicios profesionales (abogados, software, call centers, etc.) entre otros. El impacto inducido proviene de la economía[2] que generan los empleados directos e indirectos generando un total de 5,2 millones de empleados en 2014. Por último, 36,3 millones de empleados directos e indirectos fueron creados gracias al impacto catalítico en otras industrias que tiene la aviación.

[1]El valor económico se cifra en un impacto de 2,7 trillones de dólares en 2014. En cambio, hay otros aspectos emocionales cuyo valor no se puede calcular.

[2]Gasto en comida, vivienda, ocio, transporte, ropa, etc.

El impacto catalítico es el impacto que tiene la aviación sobre el crecimiento en otros sectores. El transporte aéreo es indispensable para el turismo, que en 2017 se acercó a un consumo mundial de 5.500 millones de dólares estadounidenses. Además, la aviación facilita el comercio mundial desde diversos puntos de vista. Permite acceder al mercado a países que antes estaban excluidos y favorece la especialización. Como resultado, se impulsa la productividad mundial y mejora la eficiencia en la cadena productiva. Genera una espiral positiva que está impulsando el mundo.

También cabe destacar otro hecho relevante y es que este sector está a la cabeza en innovación a nivel mundial. Un ejemplo es Airbus, que involucra a diversos países europeos en la fabricación de aeronaves favoreciendo la colaboración entre países. Estas mejoras constantes impulsan a que existan innovaciones en otros sectores paralelos y se impulse el crecimiento en esta área. Como la inteligencia artificial que dota, cada vez más, de mayor autonomía a los aviones. Los beneficiados finales son los consumidores, los pasajeros que pueden acceder en menor tiempo y mejores condiciones a este servicio. Cada día hay más destinos y están más cerca.

Por último, destacar los beneficios sociales asociados. En ocasiones, solo se puede acceder a áreas por este medio de transporte, lo cual facilita la conexión de ciertas partes del mundo antes desconocidas, y la inclusión de los habitantes de las mismas. Quizás el mayor impacto sea a través del turismo, que permite el crecimiento económico de las áreas visitadas y el desarrollo personal de los pasajeros que viajan por ocio o para vivir nuevas experiencias culturales. Pero también tiene un papel fundamental dentro del apoyo humanitario, así como para hacer frente a emergencias. Sin duda, hay un componente económico que se puede medir, pero un gran componente inmaterial imposible de calcular.

1.1.3 Historia y labor de los aeropuertos

La historia de los aeropuertos va muy ligada al desarrollo de la aviación, puesto que son necesarios para su correcto funcionamiento. Todos los aeropuertos son aeródromos, pero no todos los aeródromos son aeropuertos. El aeropuerto más antiguo del que se tiene constancia es el de College Park Airport en Maryland, Estados Unidos en 1909. A partir de esta fecha se comenzaron a construir aeródromos, pero fueron las dos guerras mundiales las que impulsaron la construcción de aeródromos, en un principio, con un uso militar. Tras la segunda guerra mundial, se instauró una mayor sofisticación en la construcción de los aeropuertos.

Los años sesenta marcaron un punto de inflexión. El crecimiento de la aviación comercial provocó el nacimiento de las terminales modernas que conocemos hoy en día. Hubo un boom a nivel mundial en cuanto a construcción de nuevos aeropuertos y adaptación de aeródromos militares a aeropuertos comerciales.

La construcción inicial de los aeropuertos corrió a cargo de los gobiernos, por lo que tanto la titularidad como la gestión eran públicas. Hoy en día se pueden ver infinitas fórmulas que varían país a país alrededor del mundo. Una fórmula bastante utilizada ha sido la de mantener la titularidad pública y conceder la gestión a entidades privadas. El Reino Unido fue el pionero de cambios en la titularidad de los aeropuertos al privatizar varios aeropuertos en 1987. Esta tendencia se ha popularizado y extendido alrededor del mundo y favoreció el crecimiento de la regulación aeroportuaria.

Hasta entonces, dado que la titularidad de los aeropuertos era pública, no hacía falta regulación alguna. Pero tras la oleada de privatizaciones, se ha hecho efectiva la necesidad de regulación de estos entes para favorecer el crecimiento de la industria, aunque la motivación principal de la regulación reside en la posición de monopolio natural de los aeropuertos.

Por tanto, para proteger a los intereses de aerolíneas y pasajeros se han instaurado diversos sistemas de regulación en la parte aeronáutica de los aeropuertos hasta día de hoy.

El panorama actual muestra una situación en la que el capital privado ha entrado en la industria aeroportuaria de diversas formas, lo que ha forzado a establecer diversos sistemas de regulación. Los aeropuertos juegan un papel fundamental en la aviación, y a pesar de su posición dominante frente a las aerolíneas, la desregulación aérea les ha condenado a entenderse para un buen funcionamiento de la industria en general.

1.2 Relación aeropuerto-aerolíneas

1.2.1 El mercado aéreo

Las aerolíneas juegan un papel determinante en la industria aeronáutica, puesto que sin ellas no existiría. En cambio, los aeropuertos han sido más una consecuencia del impulso de esta industria. El papel de los aeropuertos ha sido pasivo, es decir, la existencia de los aeropuertos residía simplemente en dar soporte a las aerolíneas y su función comercial de mover personas de un punto a otro. No obstante, este papel ha cambiado dada la evolución y la gran relevancia a nivel mundial que tiene este sector.

Durante el boom de la aviación comercial tras la IIGM, se comenzó a construir aeropuertos más sofisticados cuyo coste de construcción iba mucho más allá que una simple pista de aterrizaje que pavimentar. Esto hizo que se crearan puentes aéreos basados en la demanda. Además, la elevada inversión que se requiere para construir nuevas infraestructuras supuso barreras de entrada en la construcción de nuevas terminales. Esto dotó a los aeropuertos de un carácter de monopolio natural, teniendo una posición de dominio y poder frente a las aerolíneas.

Sin embargo, otro hecho revolucionó la industria, y fue la desregulación aérea por parte de Estados Unidos en 1978, que fue el punto de partida del proceso de liberalización que conocemos a día de hoy. Con esta desregulación se eliminó el control gubernamental sobre las tasas aéreas, la elección de las rutas y la entrada de nuevas aerolíneas. Estos cambios introdujeron una nueva perspectiva a nivel estratégico para las compañías aéreas. Aumentó el número de aerolíneas y hubo un baile de fusiones y adquisiciones que dejó nuevas compañías en el mercado, aunque otras muchas desaparecieron. Ante el aumento y el mayor poder dotado a las aerolíneas, las tasas aéreas se redujeron, lo que tuvo un impacto en el precio de los billetes, con el consecuente aumento del número de pasajeros.

A pesar de las diferencias entre el mercado estadounidense frente al europeo, esta desregulación empujó a que en los años ochenta se siguiese esa dinámica en el viejo continente. Una de las principales diferencias se encontraba en la titularidad de las aerolíneas. En Europa, la mayoría eran aerolíneas públicas. Los puentes aéreos se resolvían con acuerdos bilaterales entre países, con el resultado de que el mercado era duopolista y existían fuertes barreras de entrada. Además, hay un fuerte componente cultural, puesto que la lengua es diferente, lo que provocaba que el tráfico intracomunitario fuese menor. A pesar de las diferencias existentes, el desarrollo de la industria en Estados Unidos hizo que, inevitablemente, se tomasen medidas muy similares en Europa y ya se esté trabajando en un mercado aéreo internacional.

Todos estos cambios, impulsados por la desregulación del mercado aéreo por parte de Estados Unidos en 1978 y seguido por la privatización de los aeropuertos por parte del Reino Unido en 1987, ha llevado a que la relación entre aeropuertos y aerolíneas evolucionase.

El ejemplo más claro es el europeo, donde tanto aeropuertos como aerolíneas eran entes públicos y han pasado a ser entidades privadas con objetivos diferentes. Tienen la ardua tarea de buscar puntos en común que permitan el desarrollo de la industria.

1.2.2 ¿Posición de poder de los aeropuertos?

Aeropuertos y aerolíneas tienen una relación vertical inevitable. Los aeropuertos ofrecen la posibilidad de volar, es decir, de desarrollar su negocio a las aerolíneas. Esta relación ha ido evolucionando con el paso de los años por las diversas circunstancias que han ocurrido dentro del sector.

El punto de partida fue una integración completa, cuando tanto aeropuerto y aerolíneas eran públicas, en el caso europeo. Los objetivos de ambos estaban integrados y todos estaban dirigidos a un fin común. Hasta que la desregulación aérea cambió el panorama. Las aerolíneas que eran públicas se privatizaron, y la relación vertical se convierte en dos entes con objetivos diferentes.

Surge el problema de que a los aeropuertos se les atribuye carácter de monopolio natural y tienen todo el poder de negociación frente a las aerolíneas. Esto obligó a que se establecieran sistemas de regulación para favorecer la integración vertical y evitar un abuso de poder por parte de los aeropuertos. Sin embargo, la propia evolución de la industria ha hecho que la balanza se iguale, es decir, que los aeropuertos han visto reducido su poder negociador frente a las aerolíneas. Tanto es así que ahora se habla de que la regulación es innecesaria.

Varios fueron los determinantes que han producido la pérdida de poder de negociación y el carácter de monopolio natural de los aeropuertos. Primero, la desregulación del sector aéreo provocó la aparición de nuevas aerolíneas dejando un mercado más fragmentado con la consiguiente reducción de tasas y el aumento en frecuencias y nuevas rutas. Las aerolíneas ganaron más movilidad y capacidad de decisión. Esto reduce el poder negociador de los aeropuertos que tienen que atraer a las aerolíneas y establecer acuerdos atractivos para evitar que se vayan o cancelen rutas.

También influye la estructura del mercado aéreo. Tras la fragmentación que se produjo justo después de la desregulación, el mercado se ha concentrado. Existen tres alianzas globales principales, Star Alliance, oneWorld y SkyTeam, que tienen más del 61 % del tráfico regular en 2015[3]. En el mercado transatlántico, su cuota de mercado llega casi al 90 % (EC & USDOT, 2010). Esta concentración del mercado, sobre todo de las principales aerolíneas, ha hecho que su poder de negociación aumente y se reduzca, por ende, la posición dominante de los aeropuertos.

Además de la influencia del mercado aéreo, también ha influido la privatización de los aeropuertos, ya que ha incrementado la competencia entre ellos. Se pueden diferenciar varios tipos de competencia. Principalmente, la competencia en el mercado internacional de los aeropuertos hub, y la competencia al compartir área de influencia entre uno o varios aeropuertos. En la escena internacional se dan casos donde hay zonas multi-aeropuerto, en la que diversos aeropuertos conviven y compiten para atraer a los pasajeros.

Por otro lado, debido al crecimiento en la demanda y a que muchos aeropuertos principales están llegando al máximo de su rendimiento, han aparecido aeropuertos satélite, también impulsados por la aparición de las aerolíneas de bajo coste, que implantan un mayor nivel competitivo en la industria. Debido al nivel competitivo al que se enfrentan los aeropuertos, su poder negociador frente a las aerolíneas disminuye, además de que pierden su

[3]World Air Transport Statistics 60th Edition, IATA.

carácter de monopolio natural.

Un último determinante que influye en el poder negociador de los aeropuertos es la competencia intermodal. El principal competidor ha sido el tren de alta velocidad que ha impactado de lleno en los puentes aéreos de corta distancia. Sobre todo en Europa, donde existen aeropuertos que tienen integrado una estación de tren de alta velocidad, como es el caso de Franckfurt.

Estos determinantes han provocado que las aerolíneas hayan ganado poder negociador frente a los aeropuertos. También abre el debate de si la regulación sigue siendo necesaria o no, y países como Australia ya han introducido una regulación blanda donde las autoridades simplemente intervienen como árbitros cuando sea necesario.

Aunque los aeropuertos tengan diversas fuentes de ingresos, lo cierto es que para que funcionen es esencial que atraigan pasajeros. Por tanto, aeropuertos y aerolíneas comparten el mismo objetivo, la de conseguir pasajeros para que la industria se mantenga y siga creciendo. En definitiva, existe una relación vertical, sea explícita o no que los une.

1.2.3 Aeropuertos-Aerolíneas, una relación para siempre.

La relación vertical entre aeropuertos y aerolíneas es evidente y ha recibido mucha atención en la literatura. Por ejemplo, algunos trabajos que tratan este tema son: Basso & Zhang (2007), Barbot (2009, 2011), Fu, Homsombat & Oum (2011), Yang, Zhang & Fu (2015) y D'Alfonso & Nastasi (2012, 2014). En cambio, debido a que desde las instituciones se busca favorecer la competencia y evitar comportamientos no competitivos, muchos de los acuerdos explícitos han sido sancionados. La IATA estableció una regla de no discriminación, por lo que los aeropuertos deben establecer una política de precios común a todas las aerolíneas que operen en el. De este modo, se hace mucho más difícil establecer acuerdos de medio y largo plazo que beneficien a ambas partes.

En Estados Unidos los acuerdos son revelados y se permiten, pero se han encontrado prácticas anticompetitivas por la aerolínea que domina el aeropuerto. En Europa no se permiten los acuerdos. Antes de los procesos de desregulación y privatización, las aerolíneas de bandera gozaban de una posición ventajosa por el carácter público que había en la industria. Tras estos procesos, para mantener ese estatus, se han establecido acuerdos con estas aerolíneas de bandera. Varios de estos casos han sido investigados y sancionados por la Comisión Europea[4], además de acuerdos entre aeropuertos satélite y compañías de bajo coste.[5]

Si existen acuerdos verticales es porque tanto aeropuertos como aerolíneas tienen incentivos. Sobre todo cuando se enfrentan a una situación competitiva, D'Alfonso & Nastasi (2012). Los aeropuertos, al establecer un acuerdo con la aerolínea dominante, se aseguran un nivel de tráfico e ingresos que le permiten acometer inversiones y mantener e incrementar el tráfico. Por otro lado, las aerolíneas consiguen, principalmente, una ventaja competitiva frente a otras aerolíneas que operan en el mismo aeropuerto, además de que se aseguran el acceso prioritario a los recursos necesarios. En definitiva, la competencia entre aeropuertos, se convierte en competencia entre estructuras verticales compuestas por un aeropuerto y su aerolínea dominante.

Fu et al. (2011) recopila los diferentes tipos de acuerdos verticales que existen alrededor del mundo. Para el propósito de esta tesis doctoral, el tipo de acuerdo que se analiza es

[4]Los casos que se han sancionado han sido en Bruselas, Finlandia y Portugal por descuentos en las tasas a las aerolíneas de bandera, Barbot (2009).

[5]Como el caso del aeropuerto de Bruselas Charleroi con Ryanair.

un acuerdo en el que los aeropuertos comparten parte de sus ingresos no aeronáuticos con las aerolíneas. Hay casos reales que se conocen como el del Aeropuerto Internacional de Tampa o The Greater Orlando Aviation Authority (2010). Este tipo de acuerdos nace por la imposibilidad de realizar convenios de precios debido a la política de antidiscriminación. Además de por la gran importancia que ha recibido esta área de negocio en la industria aeroportuaria a día de hoy.

La ACI (Airport Council International) en su Informe Económico de los Aeropuertos de 2018, cifra la industria no aeronáutica en unos 63,5 billones de dólares. Las fuentes de ingresos más importantes que suman casi un 75 % son las ventas al por menor, aparcamientos de vehículos y las rentas de espacios. La ACI también reporta que el 39,4 % de los ingresos de los aeropuertos a nivel mundial provienen del área comercial. Aunque esta cifra hay que mirarla más en detalle puesto que dependiendo de la zona geográfica que se analice es diferente. Aeropuertos como el de Hong Kong, Tampa, Keflavik o Bandaranaike superan el 70 %.[6]

A pesar de que los aeropuertos sean los que perciban este beneficio, son las aerolíneas las que, de manera indirecta, provocan que esto suceda. Por tanto, se genera una externalidad positiva, puesto que las aerolíneas transportan pasajeros al aeropuerto que les reportan beneficios tanto aeronáuticos, por las tasas que se han de cubrir, como no aeronáuticos, por el comportamiento de compra de los pasajeros. Esta es la base de la existencia de este tipo de contrato donde el aeropuerto decide compartir estos beneficios con una o más aerolíneas, debido a que son las aerolíneas las que están pidiendo apropiarse de parte de esta externalidad que ellas mismas generan.

Con este tipo de contratos se evita la política de no discriminación de precios por parte de los aeropuertos y se consigue impactar en las decisiones de las aerolíneas, ya que interiorizan

[6] Air Transport Research Sociecty (ATRS) Global Airport Performance Benchmarking (2017).

esta estrategia. Esto afecta de manera directa al precio de los billetes y, por ende, a las plazas ofertadas. Es decir, que con este tipo de acuerdos se aumenta el tráfico de los aeropuertos, lo que a su vez tiene un impacto positivo en el área comercial.

Está claro que el foco de los aeropuertos ha de estar en potenciar y obtener el máximo rendimiento de estas fuentes de ingresos, ya que la parte aeronáutica suele estar regulada y, por tanto, limitada. Por otro lado, conviene mantener la vista en la evolución de este tipo de contratos que permite a las aerolíneas participar del sector aeroportuario.

1.3 El transporte aéreo en España

1.3.1 Historia del transporte aéreo en España

La aviación llegó a España de la mano de Alfonso XII en el siglo XIX. Como en el resto del mundo, el primer uso que se dio a la aviación en España fue militar. Fue en la Guerra de Marruecos a principios del siglo XX. El desarrollo de la aviación nacional estuvo delimitado por su evolución en el ámbito internacional. Así que las dos grandes guerras supusieron un periodo de barbecho en el desarrollo aéreo de España.

El primer aeródromo, que hoy todavía sigue vigente, se situó en Cuatro Vientos, Madrid. España fue aumentando su red de aeródromos para uso militar, hasta que comenzó a explotar el uso comercial y la construcción de aeropuertos. Ya a principios de los años 80, se separa la aviación civil de la militar, tomando caminos diferentes. En el 1991, debido al proceso de liberalización del sector aéreo, se crea AENA como un ente público que gestiona el transporte aéreo en España y que poco a poco va cogiendo más competencias.

En 1998 AENA crea una subdivisión, AENA Internacional, donde engloba la parte del negocio dirigida, sobre todo, a la expansión en Latinoamérica. Otro hecho relevante ha sido la privatización de AENA, que llega en 2011, más de veinte años después de que el Reino Unido iniciase el proceso de privatización de algunos de sus aeropuertos que supuso un punto de inflexión en la industria. AENA, en 2014 y 2015, fue parcialmente privatizada, 49 %, en un proceso de adquisición preferencial[7] del 21 % y el resto en bolsa.

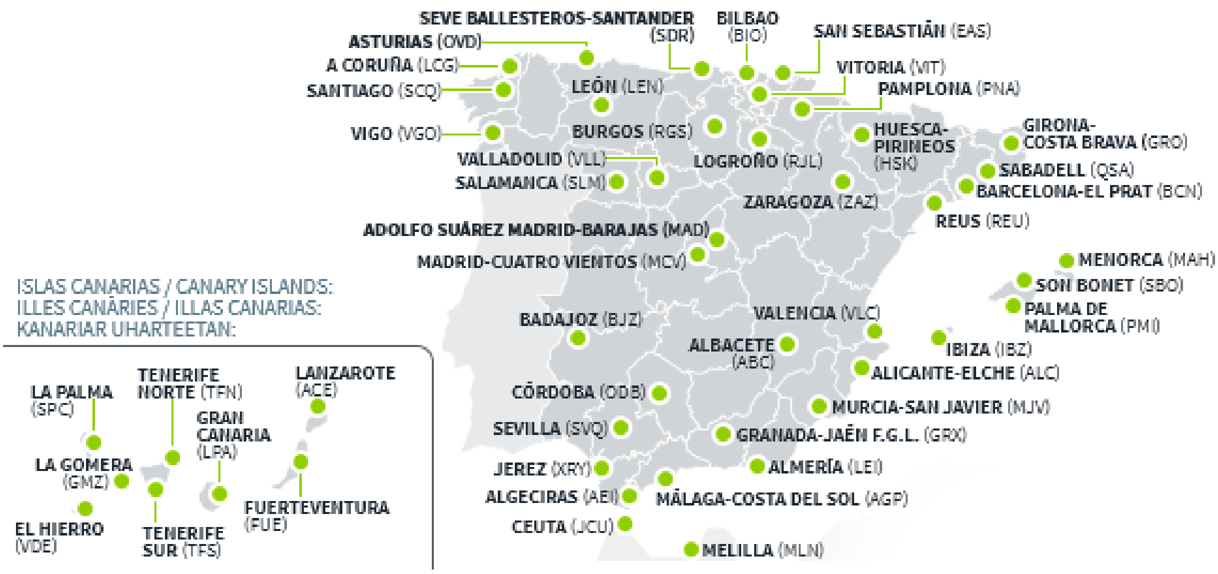
AENA gestiona hoy en día una red de 46 aeropuertos y 2 helipuertos (Ceuta y Algeciras) como se observa en la Figura 1.1.[8] Además de la red de AENA, en España hay seis aeropuertos más que son de propiedad privada o autonómica[9], veinte bases de uso militar y más de sesenta aeródromos. Hay que destacar que el peso del transporte aéreo comercial en España recae en AENA, mientras que el resto del transporte suele ser de uso privado o militar, puesto que el resto de aeropuertos que no son gestionados por AENA apenas tienen tráfico.

[7]Los socios de referencia que adquirieron parte de AENA en 2014 debido al proceso de privatización fueron: Corporación Financiera Alba con un 8 %, TCI con un 6,5 % y Ferrovial con un 6,5 %.

[8]Fuente: Wikimedia Commons.

[9]Aeropuerto de Andorra-La Seo, Aeropuerto de Castellón-Costa Azahar, Aeropuerto Central Ciudad Real, Aeropuerto de Lérida-Alguaire, Aeropuerto Internacional de Teruel y Aeropuerto Internacional de la Región de Murcia-Juan de la Cierva Codorníu.

Fig. 1.1 Red de aeropuertos españoles de AENA.



El mayor impacto en el transporte aéreo en España proviene de AENA, que en 2017 movió a casi 250 millones de pasajeros en más de dos millones de vuelos. AENA clasifica sus 46 aeropuertos en tres categorías: hub, turísticos y regionales, y establece políticas comunes por tipología.

Pero la gestión de AENA va mucho más allá de las fronteras de España, puesto que gestiona 16 aeropuertos en América (12 en Méjico, 2 en Colombia y 2 en Jamaica) y posee el 51 % del capital de la sociedad concesionaria que gestiona el aeropuerto de Londres-Luton.

1.3.2 Modelo de gestión de AENA

El modelo de gestión de la red aeroportuaria en España se ha forjado con las decisiones en el pasado y tiene sus particularidades. Desde las instituciones se ha favorecido la unidad en la gestión de los aeropuertos. Hecho que contrasta con la realidad internacional, donde se aboga por la gestión individual para favorecer la competencia y acceder de forma más sencilla a capital privado. Como resultado, España es el único gran país en Europa que mantiene la gestión global de todos los aeropuertos por una única gestora, AENA.

La decisión de mantener una gestión global de la red de aeropuertos estuvo respaldada para mantener la competitividad de los aeropuertos españoles frente a otros aeropuertos extranjeros.

Los aeropuertos españoles se enfrentan, principalmente, a tres tipos de competencia. La principal es la competencia por tráfico de conexión. Este tipo de competencia afecta a los aeropuertos hub de Madrid y Barcelona. El Aeropuerto Madrid/Barajas es una de las principales puertas a nivel mundial para entrar en América, sobre todo, América Latina. Además, AENA Internacional favorece esta posición dominante con respecto a nuestros vecinos europeos. Por tanto, se creyó que individualizar la gestión iba a imponer una tensión competitiva mayor entre los hubs españoles que iba a favorecer la pérdida de dicha ventaja competitiva en el mercado internacional.

El segundo tipo de competencia es la competencia por destino turístico. España es un país receptor de turismo y, obviamente, el transporte aéreo favorece la llegada de turistas. España ha tenido que competir con otros países que ofrecían destinos turísticos similares, aunque la inestabilidad política de esos países ha favorecido la adquisición de turistas internacionales en estos últimos años. Eso ha favorecido el desarrollo y la evolución de los destinos turísticos españoles, pero establecer una estrategia de gestión individualizada añadiría más presión competitiva dentro de la red española de aeropuertos.

Por último, y me parece la más relevante, está la competencia por área de influencia. De los 42 aeropuertos que forman parte de la red, 26 aeropuertos tienen, al menos, un aeropuerto a menos de 130 km. de distancia. En la Figura 1.1 se observa la cercanía entre los aeropuertos de la red. Debido a este factor, existen varios aeropuertos regionales sobre los que se plantea el debate de si deben permanecer abiertos o no debido a que su nivel operativo es muy reducido. El hecho de establecer un sistema de gestión global de la red ha favorecido que dichos aeropuertos sigan operativos a pesar de que no sufraguen sus costes.

Esta decisión también ha influido en el proceso de privatización. Privatizar la red, se planteaba más fácil si la gestión era individual, pero existía el riesgo de que los aeropuertos menos rentables no fuesen privatizados. Existían otras alternativas como la de privatizar los aeropuertos por lotes, para evitar este problema. Finalmente se decide ir al mercado financiero para realizar una privatización minoritaria del 49 %.

No obstante, el 51 % de AENA, que es la empresa que gestiona la red de aeropuertos españoles, permanece perteneciendo a una compañía pública. Entonces, las decisiones que se toman están enfocadas a mejorar el bienestar de los ciudadanos. Por ello se sostiene la decisión de mantener una gestión global y el control de la compañía que gestiona la red aeroportuaria.

1.4 Objetivos de la Tesis

El objetivo principal de esta tesis doctoral es analizar la relación vertical existente entre aeropuertos y aerolíneas y cómo afecta a los diferentes agentes involucrados en la economía. Estos acuerdos causan impacto en la competitividad de los mercados y en el desempeño de aerolíneas y aeropuertos. Los pasajeros también se ven afectados debido a que se pueden producir cambios en las frecuencias o en los precios de los vuelos, así como abrirse nuevos mercados.

El transporte aéreo ha sufrido una constante y rápida evolución desde comienzos del siglo XX. El panorama actual es que se tiene un mercado aéreo desregulado y se están buscando nuevas fórmulas para una desregulación global. Y, por otro lado, se tiende a la privatización del mercado aeroportuario. Estos cambios han llevado a que sea un sector mucho más competitivo y los agentes principales busquen nuevas fórmulas que les permitan estar dentro del mercado y adaptarse a su crecimiento natural. Lo que pretenden las aerolíneas es establecer acuerdos para garantizar una posición de ventaja competitiva en mercados determinados que les permitan ser líderes y obtener una rentabilidad real. Por otro lado, los aeropuertos pretenden asegurarse un cierto nivel de operatividad que les de estabilidad y liquidez para acometer inversiones de ampliación y mejora de los recursos para que puedan absorber el crecimiento de la demanda.

Bajo el pretexto de esta tesis doctoral se analizan los acuerdos en los que los aeropuertos comparten con las aerolíneas parte de sus ingresos comerciales. Esto permite a las aerolíneas interiorizar estos ingresos en sus decisiones reduciendo los precios de los vuelos. Este hecho es posible por el cambio que han sufrido los aeropuertos, que han pasado de ser meros edificios que hacían de conexión entre pasajeros y aerolíneas a transformarse en multiplataformas que recogen diversas líneas de negocio. Tanto es así que aproximadamente el 50 % de los ingresos de los aeropuertos a nivel mundial provienen de otras áreas que no son las estrictamente aéreas.

En definitiva, esta tesis tiene tres líneas de investigación que tratan lo anteriormente comentado. En primer lugar se estudia bajo qué contextos un aeropuerto decide ofrecer un contrato donde reparte sus ingresos comerciales con aerolíneas que operan en él, y si este contrato es exclusivo o no. En segundo lugar, se analiza cómo los aeropuertos pueden modificar este contrato para competir con otros aeropuertos con los que comparten su área de influencia. Los aeropuertos compiten a través de las aerolíneas, así que con estos contratos pueden incidir en la decisión de ellas para atraer al tráfico de sus competidores. Por último, se investiga el nivel de eficiencia técnica de los aeropuertos españoles que forman la red de AENA. Es un análisis empírico del que también se extraen conclusiones de la parte comercial de los aeropuertos. De todos y cada uno de ellos se extraen conclusiones y líneas de actuación que optimicen el desempeño en el sector del transporte aéreo.

1.4.1 Resumen de los capítulos

En el **primer capítulo** analizo bajo qué condiciones un aeropuerto decide formar una alianza vertical con una o varias de las aerolíneas que operan en él. Estas alianzas se forman bajo un tipo de contrato específico en el que los aeropuertos comparten parte de sus ingresos comerciales con las aerolíneas a cambio de un compromiso por parte de ellas. La industria aeronáutica es cada vez más competitiva, lo que obliga a aeropuertos y aerolíneas a establecer relaciones verticales para lograr sinergias y reducir costes. Las aerolíneas son las encargadas de llevar a los pasajeros de un aeropuerto a otro y son esos pasajeros los que permiten a los aeropuertos percibir ingresos comerciales además de los operativos. Como consecuencia, se genera una externalidad positiva en la que los aeropuertos se ven beneficiados y, desde este punto de vista, las aerolíneas pretenden participar de estas ganancias a través de este tipo de contratos. Desde la literatura se entiende que los aeropuertos tienen poder negociador frente a las aerolíneas, aunque este hecho ha cambiado en estos últimos años, y es quien decide si ofrecer o no este tipo de contratos. El escenario para analizar la decisión consta de un aeropuerto con dos aerolíneas que operan en él. El aeropuerto se enfrenta a la decisión de ofrecer el contrato para compartir sus ingresos comerciales, además de decidir si lo hace de manera exclusiva, es decir, a solo una aerolínea, o no exclusiva. Para encontrar el equilibrio se crea un juego en tres etapas que se resuelve por inducción hacia atrás. En la primera etapa el aeropuerto decide si ofrecer o no el contrato vertical y si lo hace de forma exclusiva o no exclusiva. Por último, en la segunda etapa, las aerolíneas compiten a la Cournot donde eligen el número de pasajeros que ofrecen.

El **segundo capítulo** analiza la competencia entre estructuras verticales formadas por un aeropuerto y la aerolínea que opera en él. Estas estructuras verticales existen debido a que aeropuertos y aerolíneas establecen un contrato o acuerdo bajo el cual se reparten los ingresos comerciales como se analiza en el primer capítulo. En cambio, el enfoque en este capítulo está en la competencia entre aeropuertos. El rápido crecimiento en la industria ha dejado un panorama en el cual muchos aeropuertos comparten área de influencia y, por tanto, compiten para atraer a los mismos pasajeros. Pero en realidad, son las aerolíneas las que compiten entre sí, ya que los aeropuertos son edificios que no tienen movilidad ni capacidad de atracción por sí mismos. Por ello es necesario establecer estructuras verticales para analizar la competencia aeroportuaria. Para obtener conclusiones se construye un juego en el que hay dos aeropuertos que comparten área de influencia y tienen una aerolínea operando en cada uno de ellos. Estas aerolíneas ofrecen servicios sustitutivos, por lo que los pasajeros se enfrentan ante la elección de un par aerolínea-aeropuerto para comprar su vuelo. Para resolver el juego se obtiene el equilibrio de Nash perfecto en subjuegos y consta de dos etapas. En la primera etapa, cada par aeropuerto-aerolínea decide las variables del contrato donde se reparten los ingresos comerciales. En la segunda etapa, las aerolíneas compiten a la Cournot y deciden el número de pasajeros que van a transportar.

Este segundo capítulo consta de una segunda parte. En esta segunda parte se analizan, bajo el mismo escenario que la primera, las alianzas entre las aerolíneas y cómo afecta a la competencia aeroportuaria. Desde que comenzó la desregulación del mercado aéreo, es común encontrar alianzas entre aerolíneas. Se pueden encontrar dos tipos de alianzas. Las alianzas complementarias, en las que una aerolínea alimenta a otra aerolínea de pasajeros en vuelos de conexión. Por ejemplo, al volar de Valencia a Boston haciendo escala en Madrid. Es un solo itinerario formado por dos vuelos que, normalmente, están operados por compañías diferentes. En el caso de que sean aerolíneas aliadas, esto supone ciertas ventajas para el pasajero, como que el equipaje va directo al destino. El otro tipo de alianzas, son las alianzas paralelas en las que dos aerolíneas competidoras forman una alianza. Este tipo de alianza ha sido menos estudiado en la literatura porque tiene efectos adversos en la competencia y no han sido tan permitidas por las autoridades. En este caso, analizo las alianzas paralelas para ver cómo afecta al comportamiento estratégico de los aeropuertos.

Por último, en el **tercer capítulo** uso una metodología diferente ya que aplico técnicas econométricas para realizar un análisis empírico. En concreto, analizo la evolución de la eficiencia técnica de los aeropuertos de la red de AENA en España, así como sus determinantes. La composición de la industria aeronáutica en España es particular, ya que es el único país grande que mantiene una gestión global de casi todos sus aeropuertos a través de una entidad pública, AENA. A finales de los ochenta se comenzó a privatizar los aeropuertos para acceder a nuevas fuentes de financiación que no fuesen públicas. Desde entonces, se produjo la desfragmentación de las redes de aeropuertos y existen muchos sistemas actualmente en los que hay desde aeropuertos totalmente privatizados hasta aeropuertos totalmente públicos. Entre estos dos extremos existen tantos casos como aeropuertos. La literatura analiza tanto la privatización como la gestión aeroportuaria y cómo afecta al desempeño de los aeropuertos, y a la sociedad en general. En este capítulo se realiza un análisis de la eficiencia técnica de los aeropuertos entre los años 2011-2014 para analizar su evolución y sus determinantes. Se usan dos metodologías diferentes. Una metodología paramétrica, Análisis de Frontera Estocástico

(SFA), y una metodología no paramétrica, el Análisis Envolvente de Datos (DEA). Luego, en una segunda etapa se analizan los determinantes de esa eficiencia, puesto que hay diferentes parámetros ambientales que afectan al desarrollo aeronáutico de los aeropuertos españoles.

Para realizar el análisis dentro de cada capítulo se ha usado como base la organización industrial, que parte del campo de la teoría de juegos. Estos mecanismos los he usado para analizar problemas específicos de la Economía del Transporte. En concreto, en los dos primeros capítulos se realiza un análisis teórico y formal del que se extraen proposiciones. Mientras que en el último capítulo, se realiza un análisis empírico con datos reales de aeropuertos para contrastar las hipótesis planteadas.

1.5 Conclusiones

Los resultados que se extraen son de gran relevancia debido al gran número de agentes que existen en la industria aeronáutica. Los actores principales son aeropuertos y aerolíneas cuya relación y decisiones son clave a nivel estratégico y operativo para que la industria siga evolucionando. Pero además, también hay un compendio de empresas que prestan servicios secundarios y que generan un impacto en la sociedad. En última instancia son los gobiernos los que determinan la regulación de los mercados para asegurar una situación lo más competitiva posible y evitar posibles posiciones de poder de algún agente. En definitiva, lo que se pretende es democratizar y hacer más accesible esta industria a los pasajeros y los consumidores finales que adquieren bienes transportados por este canal. El impacto, directo e indirecto, del transporte aéreo es global y por ello cualquier matiz genera un impacto a gran escala.

Conclusiones del Capítulo 1 Este capítulo analiza si un aeropuerto está dispuesto a compartir sus ingresos comerciales con las aerolíneas que operan en él o no. Tanto en este capítulo como en el capítulo dos y otros artículos en la literatura como Zhang et al. (2010), se constata que establecer este tipo de contratos aumenta el tráfico de pasajeros. Por lo tanto, bajo ciertas condiciones que dotan de simplicidad al problema para poder extraer conclusiones claras, se constata este hecho, que los aeropuertos siempre van a preferir firmar un acuerdo vertical con las aerolíneas. Por otro lado, dependerá de los ingresos comerciales por pasajero que un aeropuerto decida si ofrecer un contrato exclusivo o, por el contrario, no exclusivo. Esta decisión depende de los ingresos comerciales por pasajero y de las tasas aeronáuticas impuestas. A grandes rasgos se puede decir que el aeropuerto prefiere establecer un contrato exclusivo en el caso de que los ingresos comerciales por pasajero sean bajos. De este modo puede influir de manera más directa en el mercado, ya que repartir esos bajos ingresos entre más compañías reduciría el impacto en cada una de ellas.

A su vez, las autoridades a través de la regulación pueden modificar el comportamiento de los aeropuertos. En el sector aéreo la regulación aeroportuaria está muy extendida, por tanto, y debido a las complementariedades existentes entre las dos áreas de negocio de las que dispone un aeropuerto, la aeronáutica y la comercial, las decisiones sobre regulación afectan a las decisiones comerciales de los aeropuertos. En concreto, se encuentra que hay casos donde el nivel de la tasa aeronáutica determina el tipo de contrato que ofrece el aeropuerto, exclusivo o no exclusivo. Las autoridades tienen un papel clave dentro de la industria, ya que son capaces de influir en la relación entre aeropuertos y aerolíneas.

Conclusiones del Capítulo 2 Este capítulo es una extensión natural del capítulo anterior, donde bajo la existencia de estructuras verticales bajo contratos que comparten ingresos comerciales, hay aeropuertos que compiten porque comparten la misma área de influencia.

Una de las principales conclusiones es que los aeropuertos pueden usar los contratos como mecanismos para competir y arrebatar tráfico a sus competidores. Esto ocurre porque las aerolíneas que perciben estos ingresos extra se encuentran con una ventaja competitiva que pueden trasladar a las tarifas aéreas.

También se analiza la propiedad de los aeropuertos y cómo influye en el equilibrio del mercado. Se encuentra que los aeropuertos públicos tienden a compartir un mayor porcentaje de sus ingresos comerciales. Esto ocurre porque los objetivos de aeropuertos públicos y privados son diferentes y, donde unos buscan el bienestar común, los otros buscan su rentabilidad. Como consecuencia el tráfico disminuye en el caso de que se produzca la privatización de los aeropuertos.

Por último, en la segunda parte del capítulo, se analizan las alianzas paralelas entre las aerolíneas y su impacto en la relación estratégica entre los aeropuertos. Siguiendo los resultados encontrados en la literatura, las alianzas paralelas reducen el tráfico, puesto que el mercado se concentra. Esto provoca que los aeropuertos, como respuesta, aumenten el porcentaje de ingresos comerciales que comparten para contrarrestar este efecto negativo en el tráfico que afecta tanto a los ingresos comerciales como a los aeronáuticos. Finalmente, se encuentra que en el caso de que en el juego haya algún aeropuerto privado, el bienestar social se incrementa, siempre y cuando los aeropuertos no compartan la totalidad de sus ingresos comerciales.

Conclusiones del Capítulo 3 En el último capítulo realizo un análisis empírico de la red aeroportuaria de AENA en España. A pesar de que he usado dos técnicas distintas para analizar la eficiencia técnica de los aeropuertos, ambas arrojan resultados muy similares. En concreto, la eficiencia técnica de la red de AENA se sitúa en torno al 80 % de media, y ha ido descendiendo durante los años analizados. Esto se debe a la pérdida de pasajeros durante el periodo de análisis.

También se analizan los determinantes de esa eficiencia. Por ejemplo, los aeropuertos situados en las islas son menos eficientes que los situados en la península. El motivo es que en las islas hay una demanda limitada, mientras que el área de influencia de los aeropuertos en la península es mayor. Por otro lado, analizando la competencia dentro de la red, se obtiene que hay un efecto negativo en la eficiencia cuando existen aeropuertos que comparten la misma área de influencia. Al ser una misma compañía, y además de componente público, la que gestiona todos los aeropuertos, no se aprovechan los efectos positivos en la demanda que ofrece la competencia. Por ello aparece un efecto negativo, porque los aeropuertos en teoría competidores tienen que compartir los mismos pasajeros sin ver aumentada su demanda potencial.

Estas son las principales conclusiones que se han obtenido en cada uno de los capítulos. No obstante, en la lectura de los mismos podrá encontrar más conclusiones y resultados, y un análisis más detallado de cada aspecto.

Chapter 2

Exclusivity in concession revenue sharing contracts

2.1 Introduction

Airports have played a fundamental role in the air industry as public infrastructures serving the needs of airlines and passengers. However, in recent times airports have been under pressure to become more financially self-sufficient and leave off relying on public funds. There has been a considerable evolution in the regulatory policies and management structures of airports, which mark new challenges within this industry.

Nowadays, airports are usually seen as two-sided platforms and have to meet the demands of passengers and airlines simultaneously by offering enough incentives to keep them, both sides, as customers; they do so by enhancing complementarities between airlines and passengers, D'Alfonso & Nastasi (2014). Airlines are better off if there are more passengers and passengers are better off if there are more airlines, more destinations and more flights. Rochet & Tirole (2006) characterized two-sided markets considering airports as one of the examples. This implies that they have two main sources of income. On the one hand, there are revenues that are derived from aeronautical services such as landing fees, passenger charges, airport air traffic control charges, aircraft parking, hangarage and picketing, etc., and the revenues that come from non-aeronautical activities such as concessions and other services, commercial, car parking, rents or lease incomes, etc., (Doganis, 2006b).

Since aeronautical charges are usually regulated, airports are leading their efforts increasing non-aeronautical revenues to achieve greater self-financing. Worldwide, 39.4 % of airport revenues are non-aeronautical according to ACI Airport Economics Report 2018, although there are airports such as Hong Kong (HKG) or Tampa (TPA) that obtain more than 70 % of their revenues through non-aeronautical activities.[1] These data reflect the growing importance of non-commercial activities within airports. Furthermore, Zhang & Zhang (1997) formally found that social welfare can be higher when an airport is allowed to make profits in concession operations.

The regulation of the aeronautical part of airport business has been preceded from the consideration of airports as natural monopolies. However, several features such as the airline market structure, the level of competition between airports or the vertical relationship between airports and airlines affect airports decisions, and there are studies that support the theory that the presence of non-aeronautical income prevents airports from increasing their aeronautical charges (Starkie, 2001, Zhang & Zhang, 2003). Therefore, it can be concluded that the positive externality of the demand for aviation services on the demand for commercial services reduces an airport's incentive to exploit its market power, and to set higher aeronautical charges (Oum & Fu, 2008).

This situation provides both airports and airlines with incentives to establish agreements between them. When establishing a vertical relationship, airports ensure a portion of future

[1] Air Transport Research Sociecty (ATRS) Global Airport Performance Benchmarking (2017).

traffic and benefits, that give them greater security in order to face competition and any financial challenge. On the other hand, airlines face two types of competition, the competition of the airlines that operate in the same airport and competition from other airports. By allying with an airport, they have a preferential treatment that allows them to establish a dominant position within the airport and gain a competitive advantage over other airlines.

Vertical agreements between airport-airline pairs can have positive efficiency effects such as the removal of double-marginalization (Tirole 1988). Several types of vertical agreements can be found in the literature. For example, Fu et al. (2011) points out five types: signatory airlines of airports, airline ownership or control of airport facilities, long-term use contracts, airport issuance of revenue bonds to airlines, and concession revenue sharing between airports and airlines. Barbot (2011) and D'Alfonso & Nastasi (2012) analyzed three types of vertical agreements in a situation with and without competition. Their results mainly point out anti-competitive concerns about vertical agreements, since signatory airlines benefit from their position inside the airport. Furthermore, Barbot & D'Alfonso (2014) find that price rebate contracts, where airports ensure a level of traffic in exchange for a discount in airlines charges, are not sustainable.

However, they do not analyze concession revenue sharing between airports and airlines which is our objective in this Chapter. Because these operations depend greatly on the passenger throughput of an airport, there are complementarities between the demand for aviation services and the demand for concession services.[2] However, if airlines were unable to benefit from concession sale activities at airports, they would ignore such a demand externality in making their decisions. Thus, airlines are asking airports to participate in concession revenues because they are a positive externality airlines generate. Then, an increasing number

[2]For a more deep insight on the complementarity between the aeronautical and commercial part of airports see D'Alfonso & Bracaglia (2017).

of airports have started to share their concession revenues with airlines and that inducing them to bring in more passengers.

For example, Tampa International Airport has been sharing revenue with airlines since 2000. In 2006, it shared 20 % of its net revenue with its signatory airlines. The Greater Orlando Aviation Authority (2010) is also implementing similar revenue sharing arrangements covering the 2009 to 2013 fiscal years. The revenue remaining after satisfying all requirements is between the parties, with 30 % allocated to signatory airlines and 70 % allocated to the airport authority in the 2009 and 2010 fiscal years, and respective shares of 25 % and 75 % applying in 2011-2013. The signatory airline share is distributed among the airlines based on each airline's share of enplaned passengers. In 2002, the Frankfurt Airport signed a five-year agreement with Lufthansa and other airlines showing a non-exclusive concession behavior.

In the literature, Zhang & Zhang (1997) were the first to introduce this kind of contracts following a traditional approach. Later on, several studies have been carried out under the vertical structure approach, where the downstream market is modeled and airports and airlines are vertically related. Among the most relevant is Fu and Zhang (2010), which focused on the effects of this type of contract. They found that revenue sharing increases welfare, but it can have negative effects on competition among airlines, due to the fact that it increases the market power of signatory airlines. Moreover, Zhang et al. (2010) analyzes how the sharing varies depending on the structure of the downstream market. Typically, the literature assumed the existence of these contracts. In contrast, our analysis focuses on determining the conditions under which an airport decides to offer concession revenue sharing contracts to the airlines that operate in it. In addition, in the event that the airport prefers concession revenue sharing, we examine under what conditions the contract is exclusive or non-exclusive. We consider an airport with two competing airlines. The airport decides whether or not to offer a concession revenue sharing contract and if it does, airlines decide whether to accept it. The contract can be exclusive, so only one airline signs it, or non-exclusive, where both sign the contract.

We show that the airport always prefers to offer a contract. Although the airport gives away part of its non-aeronautical revenues, it can positively influence the downstream market by increasing traffic, which also raises revenues. The choice of contract type will depend on net concession revenue per passenger. If it is large enough, the airport prefers to make a non-exclusive sharing. On the other hand, with relatively small values of net concession revenue per passenger, the airport prefers to make an exclusive sharing offer to generate a greater impact through a single airline. The role played by institutions is also important. The aeronautical part of the airport business is regulated, therefore, under this regulation they can influence the decision of the airport to opt for a certain type of contract. Then, under the conjecture that vertical contracts may affect competition in the downstream market, institutions can choose an aeronautical charge that results in non-exclusive contracts. In this way, all airlines are allowed to appropriate the positive externality they generate, in addition to taking advantage of the benefits for society that this type of contract has. As will be seen in Chapter 2 and in line with the papers mentioned above, concession revenue sharing contracts increase traffic and social welfare.

The next Section sets out the model. First, equilibrium values are obtained in the downstream market to later determine the different equilibrium contracts. With all the information, the airport chooses the kind of contract it is going to offer. Finally, Section 2.3 establishes the conclusions of the analysis.

2.2 The Model

Consider a single airport with two different airlines operating a given origin-destination route. Both airlines compete by providing differentiated services considered as substitutes by passengers. Passenger preferences are described by the following representative consumer utility function:

$$U(q_1,q_2) = a(q_1+q_2) - \frac{b}{2}q_1^2 - \frac{b}{2}q_2^2 - dq_1q_2 + y \tag{2.1}$$

For a,b and d positive constants. The q_i's denote the number of passengers served by each airline. Parameter a denotes the maximum willingness to pay for traveling. Parameter d, which is assumed to be smaller than b, measures the degree of substitutability between airline services, so that a higher d implies less differentiated services, while $d = 0$ corresponds to the case of independent services. After utility maximization subject to the budget constraint (defined as $M = y + p_1q_1 + p_2q_2$ with M denoting the representative consumer‘s income), the following inverse demand system for services is obtained:[3]

$$p_i = a - bq_i - dq_j \quad \forall \quad i,j = 1,2, \quad i \neq j \tag{2.2}$$

in the region of quantity space where airfares become positive, where p_i is the airfare paid for traveling with airline i.

Airline i's profit function, π_i, is composed of two terms, the standard operating profits term and profits derived from concessions, in the case that airline i signs a concession revenue sharing contract (CRSc). Operating profits are $(p_i - c - w)q_i$, where w denotes aeronautical

[3]The inverse demand system satisfies the usual properties: (i) downward-sloping demand $\frac{\partial p_i}{\partial q_i} = -b < 0$; (ii) own effects dominate cross effects $\frac{\partial p_1}{\partial q_1}\frac{\partial p_2}{\partial q_2} - \frac{\partial p_1}{\partial q_2}\frac{\partial p_2}{\partial q_1} = b^2 - d^2 > 0$.

charges per passenger paid by airlines to airports and c is the marginal cost per passenger. On the other hand, passengers spend money on non-aeronautical services at the airport, which generates additional revenue, denoted by hQ, where h is the per passenger net surplus generated and $Q = q_1 + q_2$. Concession profits are, precisely given by $hQr_i - f_i$, where r_i is the proportion (share) of concession revenues that go to airline i, with $0 \leq r_i \leq 1$, and f_i is the fixed payment made by the airline to the airport in exchange.[4]

The airport also has two sources of revenue. It obtains wQ from aeronautical activities; whereas, non-aeronautical activities yield the airport concession revenues from commercial activities equal to hQ in case no concession is given to airlines.[5] The airport may decide to share concession revenues either with one airline or with both or none of them. If the airport opts for exclusive concession revenue sharing, the airport keeps $(1 - r_i)hQ$ of concession revenues, and receives f_i. However, if the revenue sharing is non-exclusive, the airport keeps $(1 - r_1 - r_2)hQ$, receiving the fixed payment from each airline, $f_1 + f_2$. Finally, τ is the marginal aeronautical cost, while fixed costs are normalized to zero. Therefore, the airport profits denoted by Υ, are equal to $(w - \tau)Q + (1 - r_i)hQ + f_i$, when airline i obtains exclusive concession revenue sharing; and $(w - \tau)Q + (1 - r_1 - r_2)hQ + f_1 + f_2$ in the case of non-exclusive concession revenue sharing.[6]

Agents make decisions in two stages. In the first stage, for any given aeronautical charge per passenger, the airport decides whether to share, and if so the sharing is exclusive or not,

[4]The revenue sharing contract considered has been employed before by Fu & Zhang (2010), and contains two variables, (r, f). The sharing proportion, r, displays the effort of airports to pursue more passengers. In exchange, airports ask airlines for a fixed payment which can be seen, for example, as a compromise to make any investment or to be attached to that airport for several years. We assume the two variable contract because it is consistent with situations in which airports and airlines can commit to medium-/long-term cooperation. Furthermore, Zhang et al. (2010) stated that this contract "gets more traffic volume and social welfare" than the contract with just one variable.

[5]This simple representation where net concession revenue is strictly complementary to passenger volume has been used by Zhang et al. (2010), Fu & Zhang (2010), and Yang et al. (2015), among others.

[6]For the sake of simplicity, it is assumed that the airport aeronautical activities margin is non-negative, $w \geq \tau$.

and then it sets the concession revenue sharing contract. In the second stage, airlines compete for the number of passengers served, given the sharing proportion. To solve the model the subgame perfect Nash equilibrium is obtained.

2.2.1 Second stage: airline competition

There are three qualitatively different subgames that can be reached at the second stage depending on the concession revenue sharing decision taken by the airport in the first stage. The first one, the *no-sharing case*, corresponds to the case where the airport does not offer a concession revenue sharing contract. The second one, the *non-exclusive sharing case*, is the case where both airlines are offered a non-discriminatory concession revenue sharing contract. Finally, the third subgame corresponds to the case where only one airline, say airline i, is offered a concession revenue sharing contract, while the other, say airline j, the non-signatory airline is not. This subgame is the *exclusive sharing case*.

The no-sharing case

Each airline i, $i = 1,2$ chooses q_i to maximize its profits[7] defined by $\pi_i = (p_i - c - w)q_i$. The equilibrium quantities are the solution of the following system of two first order conditions, i.e. $\frac{\partial \pi_i}{\partial q_i} = 0, \frac{\partial \pi_j}{\partial q_j} = 0$ and reads as follows:[8]

$$q^0 = q_1^0 = q_2^0 = \frac{a-c-w}{2b+d}. \tag{2.3}$$

The superscript *0* denotes the no-sharing case. In order to ensure a positive equilibrium output, it is assumed that $w < a - c$. Plugging the above expressions in the corresponding

[7] Empirical evidence from Brander & Zhang (1990, 1993) states that the model which best fits with airline market competition is Cournot; moreover, it is widely used in the literature.

[8] Both the second-order conditions for a maximum ($\frac{\partial^2 \pi_i}{\partial q_i^2} = -2b < 0$) and the stability conditions are satisfied ($\frac{\partial^2 \pi_i}{\partial q_i^2}\frac{\partial^2 \pi_j}{\partial q_j^2} - \frac{\partial^2 \pi_i}{\partial q_i \partial q_j}\frac{\partial^2 \pi_j}{\partial q_j \partial q_i} = 4b^2 - d^2 > 0$). Also, there is strategic substitution between services ($\frac{\partial^2 \pi_i}{\partial q_i \partial q_j} = -d < 0$).

inverse demand functions in (2.2) yields the following equilibrium airfares and profits,

$$p^0 = p_1^0 = p_2^0 = \frac{ab + (b+d)(c+w)}{2b+d}; \pi^0 = \pi_1^0 = \pi_2^0 = b(q^0)^2. \quad (2.4)$$

The non-exclusive sharing case

In this subgame, the airport and each airline have agreed on the concession revenue sharing contracts defined by $\{r_1, f_1\}$ and $\{r_2, f_2\}$, which imply the following airline profits,

$$\pi_1 = (p_1 - c - w)q_1 + hQr_1 - f_1, \ \pi_2 = (p_2 - c - w)q_2 + hQr_2 - f_2. \quad (2.5)$$

Similarly as above, the equilibrium quantities are the solution to the system of two first order conditions that follows,

$$\frac{\partial \pi_1}{\partial q_1} = p_1 - c - w + \frac{\partial p_1}{\partial q_1} q_1 + hr_1 = 0, \quad (2.6)$$

$$\frac{\partial \pi_2}{\partial q_2} = p_2 - c - w + \frac{\partial p_2}{\partial q_2} q_2 + hr_2 = 0. \quad (2.7)$$

It is important to note that, with respect to the no-sharing case, there is a new and positive term, which is proportional to the share in revenues. This new term will imply an outward shift in the reaction function of each airline, leading to an equilibrium with more airline services and lower airfares at equilibrium provided that $0 \leq r_i \leq 1$. The equilibrium quantities, aggregate quantity, prices and profits are respectively,

$$q_i^{ne}(r_i, r_j) = q^0 + \frac{(2br_i - dr_j)h}{4b^2 - d^2} \quad \forall i, j = 1,2 \quad i \neq j, \quad (2.8)$$

$$p_i^{ne}(r_i, r_j) = p^0 - \frac{((2b^2 - d^2)r_i + bdr_j))h}{4b^2 - d^2} \quad \forall i, j = 1,2 \quad i \neq j, \quad (2.9)$$

$$Q^{ne}(r_1, r_2) = Q^0 + \frac{h(r_1 + r_2)}{2b + d} \quad (2.10)$$

$$\pi_i^{ne}(r_i, r_j) = b(q_i^{ne})^2 + hr_i q_j^{ne} - f_i \quad \forall i, j = 1,2 \quad i \neq j, \quad (2.11)$$

where superscript *ne* denotes non-exclusive.

The exclusive sharing case

In this subgame, only the signatory airline i receives concession revenues according to the terms of the concession revenue contract, $\{r_i, f_i\}$. Airline profits are,

$$\begin{aligned} \pi_i &= (p_i - c - w)q_i + hQr_i - f_i && (2.12) \\ \pi_j &= (p_j - c - w)q_j && (2.13) \end{aligned}$$

Note that the asymmetry in profits carries over to the first order conditions implying that the reaction function of the signatory airline shifts outwards provided that $0 \leq r_i \leq 1$, while that of the non-signatory one does not. Since quantities are behaving as strategic substitutes, this shift leads to both an increase in the equilibrium quantity of the signatory airline and a reduction in the equilibrium quantity of the non-signatory one. Solving the two first-order conditions we obtain the equilibrium quantities, prices and profits as follows, where superscript *ex* denotes the exclusive sharing case,

$$\begin{aligned} q_i^{ex}(r_i) &= q^0 + \frac{2bhr_i}{4b^2 - d^2}, && (2.14) \\ q_j^{ex}(r_i) &= q^0 - \frac{dhr_i}{4b^2 - d^2}, && (2.15) \\ p_i^{ex}(r_i) &= p^0 - \frac{(2b^2 - d^2)hr_i}{4b^2 - d^2}, && (2.16) \\ p_j^{ex}(r_i) &= p^0 - \frac{bdhr_i}{4b^2 - d^2}, && (2.17) \end{aligned}$$

$$Q^{ex}(r_i) = Q^0 + \frac{hr_i}{2b+d}, \quad (2.18)$$

$$\pi_i^{ex}(r_i) = b(q_i^{ex})^2 + hr_i q_j^{ex} - f_i, \quad (2.19)$$

$$\pi_j^{ex}(r_i) = b(q_j^{ex})^2. \quad (2.20)$$

In order to ensure positive equilibrium outputs for the non-signatory firm and then to keep the same market structure downstream, it is assumed that the per passenger net surplus generated at the airport, h, is not too large for the most demanding situation, i.e. for $r_i = 1$. In particular, it is assumed throughout the paper that $h < \bar{h} = (\frac{4b^2-d^2}{d})q^0$.

Proposition 1 *Concession revenues, whether exclusive or non-exclusive, increase the number of passengers and reduce airfares, that is,* $\frac{\partial Q^{ne}}{\partial r_j} = \frac{\partial Q^{ne}}{\partial r_i} = \frac{\partial Q^{ex}}{\partial r_i} > 0$, $\frac{\partial p_i^{ne}}{\partial r_i} = \frac{\partial p_j^{ne}}{\partial r_j} < 0$, $\frac{\partial p_i^{ne}}{\partial r_j} = \frac{\partial p_j^{ne}}{\partial r_i} < 0$ *and* $\frac{\partial p_i^{ex}}{\partial r_i} < 0$, $\frac{\partial p_j^{ex}}{\partial r_i} < 0$. *Finally, exclusive sharing introduces a competitive advantage on the signatory airline that entails a reduction in profits on the non-signatory one as compared to the no-sharing case, since* $q_j^{ex} < q^0$.

The above result shows the way the airport can attract passengers through airlines using the sharing proportion. Further, it highlights the strategic effect on the non-signatory airline in case the airport employs an exclusive concession revenue contract, which can be exploited by the airport when setting the terms of the contract.

2.2.2 First Stage: the revenue sharing contract

In the first stage, the airport decides on the terms of the concession revenue sharing contract, that is $\{r, f\}$, and announces whether it offers the contract to one or both airlines or none. Then, and given the terms of the contract, the airline or airlines, depending on whether the contract is exclusive or not, unilaterally and independently accept or not the deal. This implies that all the bargaining power is assigned to the airport. The contract terms are obtained as follows. The sharing proportions are computed as those that maximize joint profits of the vertical structure, that is, the sum of the airport and the corresponding signatory airline. Finally, the airport chooses the maximum fixed fee that satisfies the participation constraint of the corresponding signatory airline.

Sharing proportion

With respect to the sharing proportions, r_i, the airport does not share more than the whole concession revenues. Under the exclusive contract, the maximum the airport shares is $r_i = 1$, whereas, in the non-exclusive case, since the airport does not discriminate between airlines, the maximum sharing is $r_1 = r_2 = 1/2$, which makes $r_1 + r_2 = 1$. Notice that for the no-sharing case this stage of the game is empty and therefore, $r_i = f_i = 0$, for $i = 1, 2$.

The non-exclusive case

Consider first the case when the airport announces non-exclusive contracts. In this case, the airport chooses the pair of sharing proportions, r_1 and r_2, that will maximize each of the vertical airport-airline pair aggregate profits, i. e. $\Upsilon + \pi_1$ and $\Upsilon + \pi_2$, respectively. In particular,

$$\begin{aligned}
\Upsilon + \pi_1^{ne} &= (w-\tau)Q^{ne} + (1-r_1-r_2)hQ^{ne} + f_1 + f_2 + (p_1^{ne} - c - w)q_1^{ne} + r_1 hQ^{ne} - f_1 \\
&= (w - \tau + h(1-r_2))Q^{ne} + f_2 + (p_1^{ne} - c - w)q_1^{ne} \qquad (2.21) \\
\Upsilon + \pi_2^{ne} &= (w-\tau)Q^{ne} + (1-r_1-r_2)hQ^{ne} + f_1 + f_2 + (p_2^{ne} - c - w)q_2^{ne} + r_2 hQ^{ne} - f_2 \\
&= (w - \tau + h(1-r_1))Q^{ne} + f_1 + (p_2^{ne} - c - w)q_2^{ne} \qquad (2.22)
\end{aligned}$$

The equilibrium sharing proportions are, therefore, obtained by solving the following system of first-order conditions: $\frac{\partial(\Upsilon+\pi_i)}{\partial r_i}=0$, $\frac{\partial(\Upsilon+\pi_i)}{\partial r_j}=0$. Since both airlines are symmetric and making use of (2.3) above, the symmetric equilibrium reads as follows,[9]

$$r^{ne}=r_1^{ne}=r_2^{ne}=\begin{cases}\frac{(2b+d)(d^2q^0+(2b-d)(h+w-\tau))}{2h(4b^2+bd-d^2)} & \text{if } h>h^{ne}=\frac{(2b+d)(d^2q^0+(2b-d)(w-\tau))}{bd}\\ 1/2 & \text{otherwise}\end{cases} \tag{2.23}$$

From the upper branch term in expression (2.23), it is clear that the equilibrium sharing proportions are decreasing in h, which implies that r^{ne} is set to $\frac{1}{2}$ for all h below the threshold h^{ne}.

The exclusive case

In this case, the airport chooses the sharing proportion r_i that will maximize the vertical airport-airline aggregate profits with the signatory airline i,

$$\begin{aligned}\Upsilon+\pi_i^{ex} &= (w-\tau)Q^{ex}+(1-r_i)hQ^{ex}+f_i+(p_i^{ex}-c-w)q_i^{ex}+r_ihQ^{ex}-f_i\\ &= (w-\tau+h)Q^{ex}+(p_i^{ex}-c-w)q_i^{ex}\end{aligned} \tag{2.24}$$

Before obtaining the equilibrium it is interesting to compare the first order conditions for airline i under the two cases,

$$\left.\frac{\partial(\Upsilon+\pi_i)}{\partial r_i}\right|_{ne} = (w-\tau+h(1-r_j))\frac{\partial Q^{ne}}{\partial r_i}+(b\frac{\partial q_i^{ne}}{\partial r_i}+\frac{\partial p_i^{ne}}{\partial r_i})q_i^{ne}-hr_i\frac{\partial q_i^{ne}}{\partial r_i}=0 \tag{2.25}$$

$$\left.\frac{\partial(\Upsilon+\pi_i)}{\partial r_i}\right|_{ex} = (w-\tau+h)\frac{\partial Q^{ex}}{\partial r_i}+(b\frac{\partial q_i^{ex}}{\partial r_i}+\frac{\partial p_i^{ex}}{\partial r_i})q_i^{ex}-hr_i\frac{\partial q_i^{ex}}{\partial r_i}=0 \tag{2.26}$$

[9]Note that second order conditions are satisfied.

Noting that, i) the marginal effects on outputs and prices are the same under the two cases, that ii) the terms $(b\frac{\partial q_i^{ex}}{\partial r_i}+\frac{\partial p_i^{ex}}{\partial r_i})=(b\frac{\partial q_i^{en}}{\partial r_i}+\frac{\partial p_i^{en}}{\partial r_i})$ are positive and that iii) q_i^{ex} is larger than q_i^{ne}, the difference $\frac{\partial(\Upsilon+\pi_i)}{\partial r_i}\Big|_{ex}-\frac{\partial(\Upsilon+\pi_i)}{\partial r_i}\Big|_{ne}$ is proven to be positive. This implies that the marginal effect of an increase in sharing generates a larger increase in aggregate profits when there is exclusive sharing. Therefore, the trade-off that arises between the exclusive or non-exclusive sharing cases, is between offering two contracts at a lower fee or one including a larger fee. By solving the expression in (2.26) for r_i, we obtain the equilibrium sharing proportion r^{ex} as follows,[10]

$$r^{ex}=r_i^{ex}=\begin{cases}\frac{(4b^2-d^2)(d^2q^0+(2b-d)(h+w-\tau))}{4bh(2b^2-d^2)} & \text{if } h>h^{ex}=\frac{(4b^2-d^2)(d^2q^0+(2b-d)(w-\tau))}{d(4b^2-2bd-d^2)}\\ 1 & \text{otherwise}\end{cases} \tag{2.27}$$

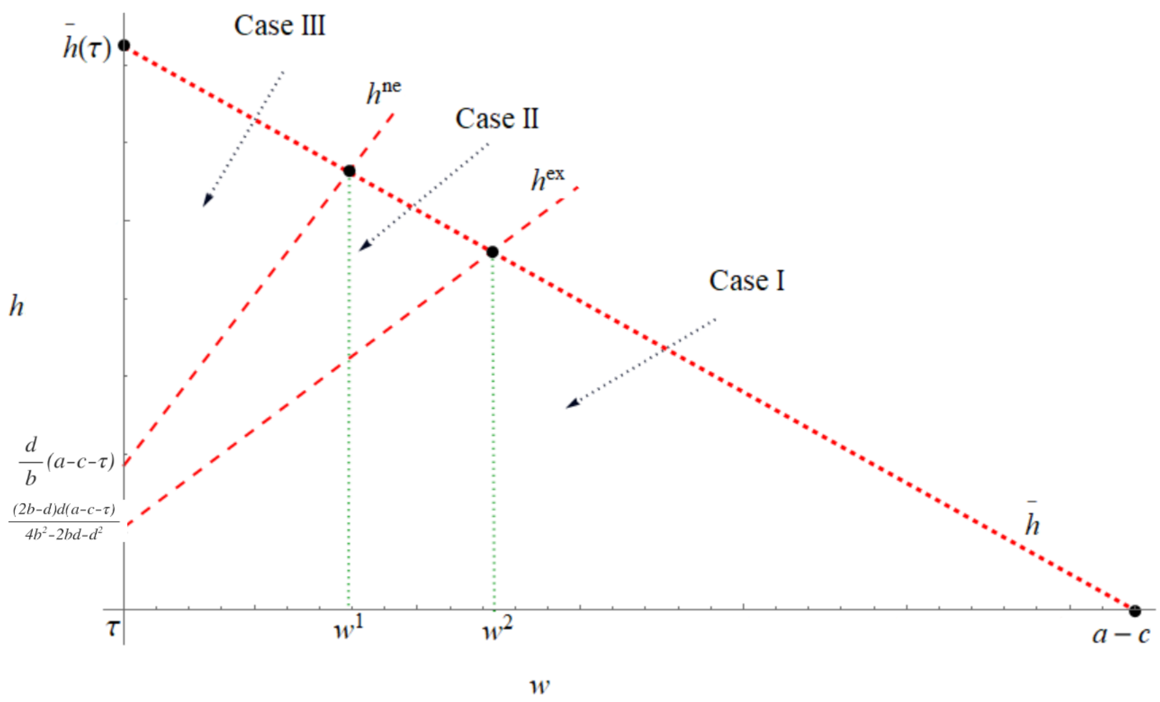
Similarly as above, from the inspection of the upper branch term in expression (27), it happens that the equilibrium sharing proportion is decreasing in h, which implies that r^{ex} is set to 1 for all h below the threshold h^{ex}.

Furthermore, and by comparing both h^{ne} and h^{ex}, it turns out that $h^{ex}<h^{ne}$ for all given w. This result defines three possible situations depending on whether the equilibrium sharing proportions are interior or corner solutions for the exclusive and non-exclusive cases. Figure 2.1 displays these three situations. In particular, we will denote by *case I*, the case when for any given w then $0<h<h^{ex}$. That is, when the corner solutions are applied in either sharing contract, $r^{ex}=1$ and $r^{ne}=\frac{1}{2}$. Both, exclusivity and non-exclusivity imply full concession. *Case II* happens for $h^{ex}<h<h^{ne}$. This will correspond to the case where the corner solution applies when non-exclusive sharing is offered to the airlines while for the exclusive sharing case it is the interior situation the one that applies, that is $r^{ex}<1$ and $r^{ne}=\frac{1}{2}$. Finally, *case III*

[10] Note that second order condition is satisfied since $b\frac{\partial q_i^{ex}}{\partial r_i}+\frac{\partial p_i^{ex}}{\partial r_i}-h<0$.

denotes the case for $h^{ex} < h < \bar{h}$, which corresponds to the situation where none of the sharing agreement types implies fully sharing of the concession revenues obtained by the airport, that is, $r^{ex} < 1$ and $r^{ne} < \frac{1}{2}$. Thus, it is easy to prove that $0 < r^{ne} \leq r^{ex} \leq 2r^{ne}$, implying that with the non-exclusive sharing contract the airport is sharing no less concession revenues as compared to the exclusive contract. In the next subsection we will obtain the fixed payment that corresponds to each particular sharing contract and for the three cases just defined.

Fig. 2.1 Cases for the equilibrium sharing proportions



In Figure 2.1 we can see the different cases proposed. The vertical axis represents the value of the net concession revenue per passenger, h, which ranges between zero and $\bar{h}(\tau)$; while the horizontal axis shows the aeronautical charge per passenger which is regulated and it ranges between τ and $(a-c)$. The increasing lines correspond to the different threshold values of h that shape the model and suggest policy implications for decision-making. The decreasing dotted line in Figure 2.1 corresponds to $\bar{h}$. It is assumed that $h \in \left(0, \bar{h}\right]$ to ensure positive equilibrium outputs, and therefore, to maintain the market structure in the downstream industry. As a consequence only the region below $\bar{h}$ is relevant for our analysis. From the intersection between $\bar{h}$ and h^{ex}, h^{ne}, two values of the aeronautical charge arise, $w^1 = \frac{(b-d)(2b+d)q^0}{2b-d} + \tau$ and $w^2 = \frac{2(b-d)(2b+d)q^0}{2b-d} + \tau$. If the institutions choose an aeronautical charge such that $w^2 < w < a-c$, the only possible case is Case I, so there would be full sharing by the airport for any $h \in (0, \bar{h}]$. If, instead, they choose an aeronautical charge such that $w^1 < w < w^2$, Cases I and II would be possible depending on the value of h. Finally, if $\tau < w < w^1$, any of the three cases are possible depending on the value of h.

The fixed payment in the concession revenue sharing contract

Consider first the case of non-exclusive contracts. The airport chooses a fixed payment such that the airline is indifferent between accepting or not, that is, the airport will set the largest payment that will ensure airlines acceptance. In this case, since the contract is non-exclusive, the airport announces the offer of two contracts. The fixed payment is calculated as the difference between the airlines profits if both of them participate in the non-exclusive contract and the profits one airline will have if she does not accept the contract while the other is accepting it. Take for instance airline i, its profits if both accept the non-exclusive contract will be:

$$\pi_i^{ne}(r_1^{ne}, r_2^{ne}) = bq_i^{ne}(r_1^{ne}, r_2^{ne})^2 + r_i^{ne} h q_j^{ne}(r_1^{ne}, r_2^{ne}) - f_i^{ne}. \tag{2.28}$$

Whereas, if airline i decides not to accept, knowing the other is going to do it, will get:

$$\pi_0^{ne}(r_i = 0, r^{ne}) = bq_0^{ne}(r_i = 0, r^{ne})^2, \tag{2.29}$$

where $q_0^{ne}(r_i = 0, r^{ne}) = \frac{(a-c-w)(2b-d) - \frac{1}{2}dh}{4b^2 - d^2} = q^0 - \frac{dh}{2(4b^2 - d^2)}$

Thus, the equilibrium fixed payment value is defined as f_i^{ne} such that, $\pi_i^{ne} = \pi_0^{ne}$. That is,

$$f_i^{ne} = \begin{cases} b((q_i^{ne})^2 - (q_0^{ne})^2) + r^{ne} h q_j^{ne} & \text{if } h > h^{ne} \\ b((q_i^{ne})^2 - (q_0^{ne})^2) + \frac{1}{2} h q_j^{ne} & \text{otherwise} \end{cases} \tag{2.30}$$

Notice that for $h < h^{ne}$ the corner solution in expression (2.23) applies, i.e. r^{ne} equals $\frac{1}{2}$. Also, note that the symmetry in the airlines implies that both are offered the same contracts terms, then, $f_i^{ne} = f_j^{ne}$.

Consider now the exclusive contract where airline i is the signatory one. Then, the airport sets the fixed payment such as the profits of the signatory airline are the same that the profits of the non-signatory one. The reason is that the airport has announced that one contract will be awarded and then, in case airline i declines the offer, it is the airline j the one that will be offered an exclusive contract. In case airline i accepts, it will obtain,

$$\pi_i^{ex}(r^{ex}) = b(q_i^{ex}(r^{ex}))^2 + r^{ex} h q_j^{ex}(r^{ex}) - f_i^{ex}. \tag{2.31}$$

While, if it does not accept, it gets,

$$\pi_j^{ex}(r^{ex}) = b(q_j^{ex}(r^{ex}))^2 \tag{2.32}$$

Then, f_i^{ex} is defined as the one satisfying $\pi_i^{ex} = \pi_j^{ex}$, that is,

$$f_i^{ex} = \begin{cases} b((q_i^{ex})^2 - (q_j^{ex})^2) + r^{ex} h q_j^{ex} & \text{if } h > h^{ex} \\ b((q_i^{ex})^2 - (q_j^{ex})^2) + h q_j^{ex} & \text{otherwise} \end{cases} \tag{2.33}$$

Airport's contract choice

Once the terms of the concession revenue sharing contracts are defined, the airport decides the profit maximizing type of contract that it is going to offer. First note, that the no-sharing case is giving the airport the following profits $\Upsilon^0(w) = (w - \tau + h)Q^0$, which correspond to the opportunity cost of entering into agreements with airlines to share concession revenues. For the sake of the presentation we first consider the decision about the type of contract and then whether the airport always signs concession revenue sharing contracts.

Consider first the airport profits for the three cases defined in subsection 2.2.2 as a function of (r^{ex}, r^{ne}) and for the type of concession contract, whether exclusive or non-exclusive, respectively.

$$\Upsilon^{ne}(w) = (w-\tau)Q^{ne} + h(1-2r^{ne})Q^{ne} + 2f^{ne} \quad (2.34)$$

$$\Upsilon^{ex}(w) = (w-\tau)Q^{ex} + h(1-r^{ex})Q^{ex} + f_i^{ex} \quad (2.35)$$

The first term in expressions (2.34) and (2.35) corresponds to the stream of profits that are derived from the aeronautical activities, the second term is the share of non-aeronautical revenues that is kept by the airport and finally, the third term is the income derived from concession contracts. In *Case I*, that is for $0 < h < h^{ex}$ the equilibrium shares are $r^{ex} = 1$ for the exclusive and $r^{ne} = \frac{1}{2}$ for the non-exclusive contract, which implies full sharing under both types of contracts. Besides and given that $Q^{ne} = Q^0 + \frac{2r^{ne}h}{2b+d}$ and $Q^{ex} = Q^0 + \frac{r^{ex}h}{2b+d}$, airport profits are given by,

$$\Upsilon^{ne}(w) = (w-\tau)(Q^0 + \frac{h}{2b+d}) + 2f^{ne} \quad (2.36)$$

$$\Upsilon^{ex}(w) = (w-\tau)(Q^0 + \frac{h}{2b+d}) + f_i^{ex} \quad (2.37)$$

Since the two types of contracts imply full sharing, the first term is the same (that is, $Q^{ne} = Q^{ex}$), the second term vanishes and then, the decision on whether the non-exclusive contract is chosen only relies on the difference between the fixed payments that correspond to each type of contract. In particular, the non-exclusive contract is chosen if and only if

$2f^{ne} \geq f_i^{ex}$, or equivalently for $h \geq h_I$.[11] The threshold h_I is decreasing in w, which implies that lower per passenger net surplus is required in order to choose a non-exclusive contract the larger aeronautical charges per passenger paid by airlines to airports are.

Consider now *Case II* which corresponds to $h^{ex} < h < h^{ne}$ implying $r^{ex} < 1$, $r^{ne} = \frac{1}{2}$. Therefore, only the non-exclusive contract implies full sharing. The airport profits are in this case the following.

$$\Upsilon^{ne}(w) = (w-\tau)(Q^0 + \frac{h}{2b+d}) + 2f^{ne} \tag{2.38}$$

$$\Upsilon^{ex}(w) = (w-\tau)(Q^0 + \frac{r^{ex}h}{2b+d}) + h(1-r^{ex})(Q^0 + \frac{r^{ex}h}{2b+d}) + f_i^{ex} \tag{2.39}$$

As only the non-exclusive contract implies full sharing, this implies a positive first term in the difference between airport profits since the number of passengers that non-exclusive contracts attract is larger than under exclusive ones, but also a negative second term since the non-exclusive type of contract implies no revenue coming from non-aeronautical activities. In particular, $\Upsilon^{ne} - \Upsilon^{ex} = \frac{(w-\tau)h(1-r^{ex})}{2b+d} - h(1-r^{ex})(Q^0 + \frac{r^{ex}h}{2b+d}) + 2f^{ne} - f_i^{ex}$, where this difference is larger than or equal to zero for $h \geq h_{II}$.[12]

Finally, consider *Case III* (i.e. $h^{ne} < h < \bar{h}$) implying that $r^{ex} < 1$ and that $r^{ne} < \frac{1}{2}$, so that full sharing is never implemented. This leads to the following airport profits,

$$\Upsilon^{ne}(w) = (w-\tau)(Q^0 + \frac{2r^{ne}h}{2b+d}) + h(1-2r^{ne})(Q^0 + \frac{2r^{ne}h}{2b+d}) + 2f^{ne} \tag{2.40}$$

$$\Upsilon^{ex}(w) = (w-\tau)(Q^0 + \frac{r^{ex}h}{2b+d}) + h(1-r^{ex})(Q^0 + \frac{r^{ex}h}{2b+d}) + f_i^{ex} \tag{2.41}$$

As happens in *Case II*, the difference in airport profits also includes a first positive term (since $2r^{ne} > r^{ex}$) that captures the fact the non-exclusive contracts imply a larger revenue

[11] The precise expressions for the thresholds h_I, h_{II} and h_{III} are in the Appendix.
[12] It is also shown in the Appendix that h_{II} is decreasing with w for $\frac{d}{b}\varepsilon\,[0.382, 1]$.

sharing and a second negative term. The difference in airport profits is larger than or equal to zero for $h \geq h_{III}$. Similarly to *Case I* above, h_{III} is decreasing in w thus meaning that the larger the relevance of per passenger aeronautical revenues the lower the per passenger net surplus is required to choose a non-exclusive contract. The next Proposition presents the most interesting conclusions from the above discussion.

Proposition 2 *The airport prefers a non-exclusive concession revenue sharing contract rather than an exclusive one if the per passenger net surplus, h, is large enough. The level of h required is decreasing with per passenger aeronautical revenues, w.*

Fig. 2.2 Exclusive vs. non-exclusive concession sharing contract choice

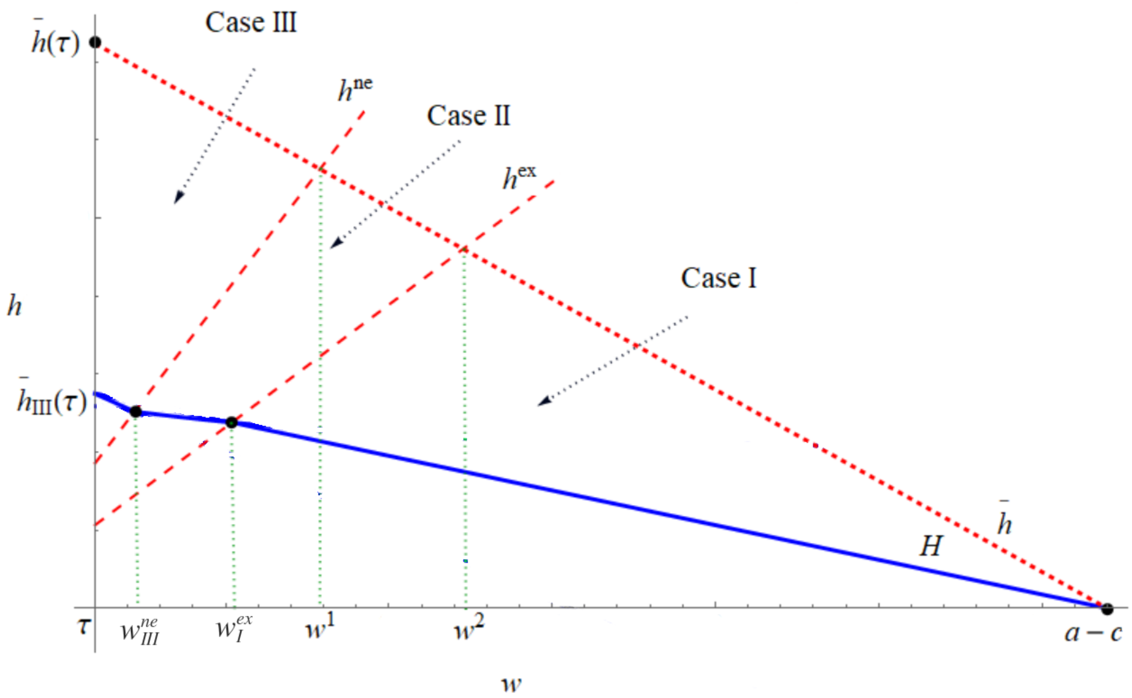


Figure 2.2 illustrates this Proposition, where H is constructed by the threshold h_{III} for $w \in [\tau, w_{III}^{ne})$, the threshold h_{II} for $w \in [w_{III}^{ne}, w_I^{ex})$ and by the threshold h_I for $w \in [w_I^{ex}, a-c]$. This function H defines the election of the type of contract by the airport, that is, in each case (Cases I, II or III) what does the airport prefer, to offer exclusive or non-exclusive contracts. Also note that H is decreasing in w. In addition, alluding to Proposition 2, the airport prefers

non-exclusive versus exclusive for all values above H. Therefore, it can be observed that depending on the value of h, the institutions that choose aeronautical charges are able to influence the airport's concession revenue sharing strategy and, therefore, how this affects the downstream market.

In the above Proposition, the conditions for a non-exclusive concession revenue contract to be chosen vis a vis the exclusive one are presented. It remains to check whether the no-sharing case is an option that arises in equilibrium. To do so, notice that the difference in airport profits is the result of three terms, a positive one that incorporates the difference in aeronautical profits, which is positive for a positive r^{ne}, i.e. $(w-\tau)(Q^{ne}-Q^{0})>0$. A second negative term that measures the difference in non-aeronautical revenues, in particular $(1-2r^{ne})hQ^{ne}-hQ^{0}>0$. The third term is the payments the airport receives for the concession revenue contract which is obviously positive. The next Proposition shows the sign of the above comparison.

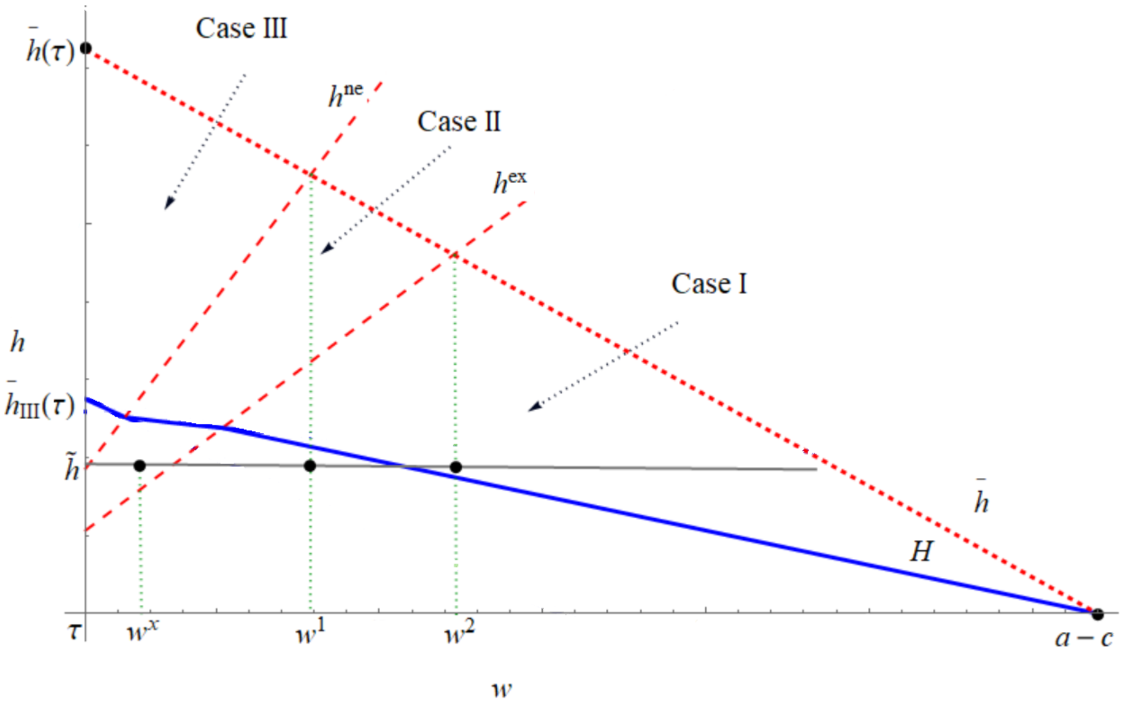
Proposition 3 *The airport always shares its non-aeronautical revenues with airlines.*

It is therefore proved that the airport is better off by giving up a portion, eventually the full share, of its non-aeronautical revenues in exchange for more passengers and rents obtained from airlines through concession revenue sharing contracts.

Propositions 2 and 3 reveal the airport equilibrium strategy in terms of concession revenue and it is obtained for any given per passenger aeronautical revenue, w. In some sense it is assumed that this parameter is set by a regulatory authority with a given objective. It is out of the scope of this paper to set the specific w but it is important to highlight that under particular values of the parameters in the model, a change in w will imply a change in the airport strategy about concession sharing.

Result 1 *For any $h \in (0, h_{III}(\tau)]$ a sufficiently large increase in w will imply a change in the type of concession revenue contract offered by the airport from exclusive to non-exclusive.*

Fig. 2.3 Implications of changes in *w*



For example, in Figure 2.3 and for a given value of h represented by the horizontal line,$\tilde{h}$, the possible values of w will lead to different choices by the airport in terms of concession revenues proportions and type of contract. If the institutions choose w^x, we will be in Case II, and since h is below H, there will be an exclusive contract where the sharing proportion is less than one, that is, $r^{ex} < 1$. If the institutions decide to increase the aeronautical charge up to w^1, the contract would remain exclusive because h is still below H, but now we would have full sharing, $r^{ex} = 1$ since this area corresponds to Case I. Finally, if the institutions decide to further increase the aeronautical charge a little more up to w^2, the result is that the airport would now offer non-exclusive contracts with full sharing such that $r_1^{ne} = r_2^{ne} = 1/2$. This example shows the intuition of Result 1, where you can see how the choice of w does affect the airport decision on exclusive or non-exclusive sharing. Then, institutions by modifying w

are not only affecting airport aeronautical revenues, but also affecting the way airports and airlines share non-aeronautical revenues, which in turn modifies traffic levels and airfares.

2.3 Conclusions

As the literature points out, airports and airlines have incentives to establish mutually beneficial agreements. Vertical agreements between airports and airlines have their pros and cons, so it is necessary to analyze their suitability depending on the specific situation that is faced. In this Chapter, we analyze a specific vertical contract type, which is concession revenue sharing contract. The effects of this type of contracts have already been analyzed in the literature. In general, they allow to increase traffic because airlines appropriate a part of the positive externality generated at airports. It has also been proven how they positively affect consumer surplus and social welfare. However, there are cases in which an airport decides to only establish vertical agreements with one or a few airlines thus introducing asymmetries in downstream competition. These signatory airlines have a competitive edge and better conditions than their competitors that affecting the industry performance. In turn, there are cases in which the airport decides not to discriminate and shares its concession revenue with all its airlines, eliminating such asymmetry in the downstream industry. This Chapter focuses on this point. In particular, the conditions under which an airport decides to offer an exclusive or non-exclusive agreement are analyzed. The literature has focused on analyzing the effects of this type of contract assuming that airports and airlines sign it. Instead, the focus of this chapter is on seeing what are the necessary conditions for the agreements to be signed. It is found that, effectively, airports will always prefer to sign a vertical agreement. In addition, if the concession revenue per passenger is sufficiently high, the airport offers a non-exclusive contract. On the other hand, if the concession revenue per passenger is relatively low, the airport offers an exclusive contract. In this way the airport can create a greater impact on traffic. What is relevant is that the authorities, through regulation, can influence the type of contract and make it non-exclusive. This would eliminate the signatory airline competitive advantage, and extend the benefits of this type of contract as the increase in traffic and welfare.

In a way, vertical contracts have been carefully scrutinized because of potential anti-competitive effects. In practice, most airports have only a few airlines that move the majority of passengers. So, what is the real impact of exclusive contracts on the rest of the airlines? They may lose market share, but the positive impact is greater than that loss. From another point of view, both airports and airlines seek stability in order to grow, and this is offered by this type of agreement. In addition, we must not forget that airlines seek to appropriate part of a positive externality they generate, since they are the ones who take passengers from one airport to another. In the end, institutions through regulation also participate in the industry, therefore, the focus must go on understanding how it works to favor a better development that benefits all parties. As we have seen in this chapter, the institutions can, from their field of action, influence the decisions of the airports, which, in turn, influence the decisions of the airlines.

Implications for future research can be drawn from this Chapter. It has been seen that the decision of an airport on the type of contract is limited to certain parameters and how the institutions can influence that choice. The next step would be to verify these implications with different structures in the downstream market and in the upstream market with airport competition. In addition, it would be interesting to analyze in this context the different regulations to assess their influence and the real power that institutions have depending on the type of regulation chosen. The analysis in this chapter has been from the theoretical point of view, the next step would be to contrast these results with real data that endorse and shed more light on these conclusions.

2.4 Appendix

Proof of Proposition 1

By inspection, it is easy to check that :

1. Number of passengers are increased with concession revenues sharing contracts.
   $\frac{\partial Q^{ne}}{\partial r_i} = \frac{\partial Q^{ne}}{\partial r_j} = \frac{\partial Q^{ex}}{\partial r_i} = \frac{h}{2b+d} > 0.$

2. Airfares are reduced with concession revenues sharing contracts.
   $\frac{\partial p_i^{ne}}{\partial r_i} = \frac{\partial p_j^{ne}}{\partial r_j} = \frac{\partial p_i^{ex}}{\partial r_i} = -\frac{h(2b^2-d^2)}{4b^2-d^2} < 0,$
   $\frac{\partial p_i^{ne}}{\partial r_j} = \frac{\partial p_j^{ne}}{\partial r_i} = \frac{\partial p_j^{ex}}{\partial r_i} = -\frac{bdh}{4b^2-d^2} < 0.$

3. Exclusive sharing introduces a competitive advantage on the signatory airline.

   The signatory airline i receives more passengers than the non-signatory one j since $q_j^{ex} < q^0 < q_i^{ex}$.

Proof of Proposition 2

Proposition 2 analyzes under which conditions the airport prefers exclusive or non-exclusive concession revenue sharing contracts. The airport profits for each type of contract are,

$$\begin{aligned}
\Upsilon^{ne}(w) &= (w-\tau)(Q^0 + \frac{2r^{ne}h}{2b+d}) + h(1-2r^{ne})(Q^0 + \frac{2r^{ne}h}{2b+d}) + f_i^{ne} + f_j^{ne}, \\
\Upsilon^{ex}(w) &= (w-\tau)(Q^0 + \frac{r^{ex}h}{2b+d}) + h(1-r^{ex})(Q^0 + \frac{r^{ex}h}{2b+d}) + f_i^{ex}.
\end{aligned}$$

If the difference in profits showed below is positive, the airport prefers to offer non-exclusive contracts upon an exclusive one,

$$\Upsilon^{ne}(w) - \Upsilon^{ex}(w) = (w-\tau)(Q^{ne} - Q^{ex}) + \tag{2.42}$$

$$+ \; h((1-2r^{ne})Q^{ne} - (1-r^{ex})Q^{ex}) \tag{2.43}$$

$$+ \; 2f_i^{ne} - f_i^{ex} \tag{2.44}$$

Further, note that the first and the second terms above can be written as,

$$\begin{aligned}(w-\tau)(Q^{ne}-Q^{ex}) &= \frac{h(w-\tau)(2r^{ne}-r^{ex})}{2b+d},\\ h((1-2r^{ne})Q^{ne}-(1-r^{ex})Q^{ex}) &= -\frac{h((2b+d)Q^0+h(2r^{ne}+r^{ex}-1))(2r^{ne}-r^{ex})}{2b+d}.\end{aligned}$$

While the third one equals,

$$2f_i^{ne}-f_i^{ex} = \frac{h\left((4b^2-d^2)q^0(2(8b^2-d^2)r^{ne}-(4b-d)(2b+d)r^{ex})-h\left((b-d)(4b^2-d^2)(r^{ex})^2-2(12b^3-8b^2d-2bd^2+d^3)(r^{ne})^2)\right)\right)}{(4b^2-d^2)^2}.$$

We are considering three cases depending on whether full sharing is offered in each type of contract.

Case I

In *case I*, that is for $0<h<h^{ex}$, both types of contracts offer full sharing, which implies $r^{ne}=\frac{1}{2}$ and $r^{ex}=1$. Therefore, the third term above is the only non-zero term remaining. This term is positive as long as

$$\left(4b^3-d^3\right)h-4bd(4b^2-d^2)q^0>0.$$

Then for $h \geq h_I \equiv \frac{4bd(4b^2-d^2)q^0}{4b^3-d^3}$, it happens that $\Upsilon^{ne}(w)-\Upsilon^{ex}(w)>0$. Note that h_I is a decreasing function in w since q^0 decreases in w. Further, note that it is relevant to check whether h_I is larger than the upper bound in h for *case I*. It is easy to find that $h_I<h^{ex}$ iff $w>w_I^{ex}$, where

$$w_I^{ex} = \frac{d^2(a-c)(12b^3-8b^2d-4bd^2+d^3)+\tau(4b^2-d^2)(4b^3-d^3)}{2(8b^5+4b^3d^2-6b^2d^3-2bd^4+d^5)}.$$

Case III

Consider now *case III*, (i.e. $h^{ne}<h<\bar{h}$) implying that $r^{ex}<1$ and that $r^{ne}<\frac{1}{2}$, so that full sharing is never implemented. It is important to check first that a non-exclusive type of contracts supposes a larger level of sharing than am exclusive one, that is,

$$2r^{ne} - r^{ex} \quad = \quad \frac{d(b-d)(2b+d)^2(d^2q^0 + (2b-d)(w-\tau+h))}{4bh\left(2b^2-d^2\right)\left(4b^2+bd-d^2\right)} > 0.$$

Which it is true since we are assuming $w > \tau$. Further, note that $2r^{ne} + r^{ex} > 1$, since,

$$2r^{ne} + r^{ex} - 1 \quad = \quad \frac{(2b+d)\left(16b^3-2b^2d-7bd^2+d^3\right)(d^2q^0+(2b-d)(w-\tau))+h\left(32b^5-16b^4d-20b^3d^2+10b^2d^3+3bd^4-d^5\right)}{4bh\left(2b^2-d^2\right)\left(4b^2+bd-d^2\right)} > 0.$$

The above inequalities imply that the first and third terms in $\Upsilon^{ne}(w) - \Upsilon^{ex}(w)$ above, that is expressions (2.42) and (2.44), are positive, while the second one, expression (2.43) is negative. After substituting back in (2.42) to (2.44) we conclude that $\Upsilon^{ne}(w) - \Upsilon^{ex}(w) > 0$ iff $h \geq h_{III}$. Where,

$$h_{III} = \frac{dN_{III}(b,d)}{(2b-d)D_{III}(b,d)} q^0 - (w-\tau),$$

with

$$N_{III}(b,d) \quad = \quad 1024b^9 - 640b^8d - 1216b^7d^2 + 848b^6d^3 + 480b^5d^4 - 392b^4d^5 - 68b^3d^6 + 69b^2d^7 + 2bd^8 - 3d^9.$$

$$D_{III}(b,d) \quad = \quad 128b^8 - 144b^6d^2 - 48b^5d^3 + 72b^4d^4 + 44b^3d^5 - 21b^2d^6 - 10bd^7 + 3d^8.$$

Note that h_{III} is decreasing in w since q^0 is decreasing in w. Next we provide the condition for h_{III} be greater than h^{ne}. If $w < w^{ne}_{III}$ then $h^{ne} < h_{III}$, where,

$$w^{ne}_{III} = \frac{d^2 N^{ne}_{ac}(a-c) + \tau N_{III}(4b^2-d^2)}{2\left(2b^2-d^2\right) D^{ne}_{w}},$$

with

$N^{ne}_{ac} = 128b^8 - 192b^7d - 48b^6d^2 + 224b^5d^3 - 56b^4d^4 - 84b^3d^5 + 29b^2d^6 + 10bd^7 - 3d^8$,

$D^{ne}_{w} = 128b^8 - 80b^6d^2 - 96b^5d^3 + 56b^4d^4 + 64b^3d^5 - 25b^2d^6 - 10bd^7 + 3d^8$.

Case II

Finally consider *case II*, which corresponds to $h^{ex} < h < h^{ne}$ implying $r^{ex} < 1$, $r^{ne} = \frac{1}{2}$. Only the non-exclusive contract implies full sharing. As happens in *case II*, expressions (2.42) and (2.44) are positive whereas expression (2.43) is negative. By substituting back $r^{ne} = \frac{1}{2}$ and $r^{ex} = \frac{(4b^2-d^2)(d^2q^0+(2b-d)(h+w-\tau))}{4bh(2b^2-d^2)}$ in the difference $\Upsilon^{ne}(w) - \Upsilon^{ex}(w)$ and solving for h the equation, $\Upsilon^{ne}(w) - \Upsilon^{ex}(w) = 0$, it is easy to check that $\Upsilon^{ne}(w) \geq \Upsilon^{ex}(w)$ iff $h \geq h_{II}$, where,

$$h_{II} = \frac{(4b^2-d^2)(N_1(b,d)q^0 + N_2(b,d)(w-\tau) + 2(2b^2-d^2)\sqrt{A})}{D_{II}(b,d))}.$$

with,

$$A = 2b((2b^2-d^2)N_3(b,d)(w-\tau)^2 + 2d(2b-d)N_4(b,d)q^0(w-\tau) + d^2N_5(b,d)(q^0)^2,$$

$$N_1(b,d) = \left(4b^2-2bd-d^2\right)\left(16b^4-12b^2d^2+3d^4\right),$$

$$N_2(b,d) = -d(2b-d)\left(16b^4-16b^2d^2+2bd^3+3d^4\right),$$

$$N_3(b,d) = 16b^5-12b^3d^2-4b^2d^3+2bd^4+3d^5,$$

$$N_4(b,d) = 32b^6-16b^5d-16b^4d^2+4b^3d^3-4b^2d^4+2bd^5+3d^6,$$

$$N_5(b,d) = 128b^7-64b^6d-80b^5d^2+32b^4d^3+12b^3d^4-12b^2d^5+4bd^6+3d^7,$$

$$D_{II}(b,d) = 128b^8-192b^6d^2-32b^5d^3+128b^4d^4+16b^3d^5-32b^2d^6-4bd^7+3d^8.$$

Finally, we provide the condition for h_{II} to decrease with w in the interval $[h^{ex}, h^{ne}]$. First note that $w^{ne}_{III} < w^{ex}_{I}$ as long as $128b^8+32b^7d-176b^6d^2-80b^5d^3+104b^4d^4+48b^3d^5-28b^2d^6-9bd^7+3d^8 > 0$, which is the case. Further, note that, $h^{ex} < h_{II} < h^{ne}$ iff $w^{ne}_{III} < w < w^{ex}_{I}$. Finally, we compute $h^{ne}(w^{ne}_{III})$ and $h^{ex}(w^{ex}_{I})$ and find the condition for the former to be larger than the latter. In particular,

$$h^{ne}(w^{ne}_{III}) = \frac{4bd(2b-d)^3(2b+d)\left(4b^2+bd-d^2\right)(a-c-\tau)}{128b^8-80b^6d^2-96b^5d^3+56b^4d^4+64b^3d^5-25b^2d^6-10bd^7+3d^8},$$

and

$$h^{ex}(w_I^{ex}) = \frac{2bd(2b-d)^2(2b+d)(a-c-\tau)}{8b^5+4b^3d^2-6b^2d^3-2bd^4+d^5}.$$

Where,

$$sign[h^{ne}(w_{III}^{ne}) - h^{ex}(w_I^{ex})] = -sign[32b^7 - 96b^6d + 88b^4d^3 - 4b^3d^4 - 21b^2d^5 + d^7],$$

which is positive for $\frac{d}{b} \in [0.382, 1]$. Therefore, we conclude that h_{II} is decreasing in w as log as $\frac{d}{b} \in [0.382, 1]$.

Proof of Proposition 3

This Proposition shows that the airport prefers to share concession revenues with airlines. We will prove that the non-exclusive contract always dominates no sharing. This happens if the following difference in airport profits is positive,

$$\Upsilon^{ne} - \Upsilon^0 = (w-\tau)Q^{ne} + (1-2r^{ne})hQ^{ne} + f_i^{ne} + f_j^{ne} - (w-\tau+h)Q^0.$$

where $Q^{ne} = Q^0 + \frac{2hr^{ne}}{2b+d}$ and $f_i^{ne} = f_j^{ne} = \frac{hr^{ne}\left(q^0\left(32b^4-12b^2d^2+d^4\right)+hr^{ne}\left(12b^3-8b^2d-2bd^2+d^3\right)\right)}{\left(4b^2-d^2\right)^2}$.
Taking the derivative of the above expression with respect to r^{ne}, we obtain,

$$\frac{\partial(\Upsilon^{ne}-\Upsilon^0)}{\partial r^{ne}} = \frac{2h(w-\tau)+2h^2}{2b+d} + \frac{2d^2hq^0}{4b^2-d^2} - \frac{4h^2\left(4b^3-2bd^2+d^3\right)r^{ne}}{\left(4b^2-d^2\right)^2},$$

where the above expression is decreasing in r^{ne} and positive for $r^{ne} = \frac{1}{2}$. Therefore, we conclude that the difference $(\Upsilon^{ne} - \Upsilon^0)$ is increasing in r^{ne} which in turn implies that $(\Upsilon^{ne} - \Upsilon^0) > 0$ for any $r^{ne} > 0$ (note that $(\Upsilon^{ne} - \Upsilon^0) = 0$ if $r^{ne} = 0$) .

Chapter 3

The effects of concession revenue sharing contracts and airline alliances in airport competition

3.1 Introduction

Concession revenues turned decisive after governments around the world began to privatize airports. Airports cannot rely on public financing, so they had to look for alternative sources of income other than the usual aeronautical charges. In fact, the Air Transport Research Society, ATRS, (2017) found that non-aeronautical revenue in major airports reached over 70 % of their total revenue. Moreover, ACI through its Airport Economics Report 2018 that worldwide the average of concession revenues remained 39.4 %. Nevertheless, it is airlines that generate those revenues, which airports earn as a positive externality. That is why airports containing large potential over concession revenues have incentives to share them in order to attract more passengers (Gillen & Mantin 2014). Over time, concession revenue sharing contracts have become increasingly common.[1] Thus, airports may affect the downstream market making airlines more competitive, and encouraging passenger welfare.

At the same time, rivalry between airports has intensified for several reasons. However, the most important stance of rivalry occurs when they share the same catchment area. An airport catchment area is the area surrounding the airport from which it attracts its passengers. Due to the growth in the number of airports around the world, many situations arise where two or more airports compete for attracting the same passengers, that is, they share the same catchment area.[2] The simplest way to measure the catchment area has been by drawing concentric circles around airports. However, in the case of competing airports other parameters influence its measurement. For example, Lieshout (2012) listed, as parameters of the catchment area measurement, the accessibility and the service level offered by the airport in terms of fares and frequencies of the compilation of airports that share the same catchment area. Thus, nowadays passengers face the decision among airport-airline pairs, instead of an airline within a single airport context; for example, a passenger traveling from London to Alicante could fly with either Ryanair from Stansted or with EasyJet from Gatwick. Hence, airports and airlines share a common purpose, that is, to attract more passengers.

In recent years, the vertical relationship between airports and airlines is a matter of increasing attention among scholars (see D'Alfonso & Nastasi 2014). Basso & Zhang (2007)

[1] For example, Tampa International Airport has been sharing revenue with airlines since 2000. In 2006, it shared 20 % of its net revenue with its signatory airlines. The Greater Orlando Aviation Authority (2010) is also implementing similar revenue sharing arrangements covering the 2009 to 2013 fiscal years. The revenue remaining after satisfying all requirements is divided between the parties, with 30 % allocated to signatory airlines and 70% allocated to the airport authority in the 2009 and 2010 fiscal years, and respective shares of 25 % and 75 % applying in 2011-2013. The signatory airline share is distributed among the airlines based on each airline's share of enplaned passengers. In 2002, the Frankfurt Airport signed a five-year agreement with Lufthansa and other airlines.

[2] Evidence of airports sharing catchment areas are London, Paris, Rome and Milan in Europe, or San Francisco, Chicago, New York, Washington, Dallas, Detroit, Houston, and Los Angeles in the US. Alternatively, other ways of airport competition appear in international markets such as Fiumicino in Rome and Malpensa in Milan, Barcelona and Madrid in Spain, Brussels and Amsterdam, Brussels and Paris in Europe.

review the evolution that the vertical relationship of airports and airlines has had in the literature. They differentiate between the traditional approach, in which airlines are taken as price takers, that is, the decisions on the level of traffic fall directly to the airport, and the vertical structure approach, with airports supplying an input to airlines (Basso & Zhang, 2008). In the vertical structure approach, airlines behave strategically, and given the vertical relationship, airports, which are located in the upstream market, can influence the decisions of airlines and the equilibrium in the downstream market. Barbot (2009), in a context where two vertical structures compete with each other, determined that there are incentives to establish vertical agreements. Later, Barbot (2011) analyzed the effects of three different types of agreements on the economy,[3] and D'Alfonso & Nastasi (2012) made the same analysis, although with two vertical structures competing. Then, there are incentives for signing vertical agreements between airports and airlines, which is supported by Barbot et al. (2013) who found evidence for vertical collusion in two scenarios, when there is a main national carriers in a small airport, or in the case of low cost carriers in secondary airports. However, there is a trade-off between competition and welfare. Signing vertical agreements solves the problem of double marginalization because of the integration between an upstream and a downstream firm, but in turn, they surface anti-competitive issues in the downstream market. Specifically, this occurs when an airport offers exclusive agreements where only a few airlines benefit, altering the competition between the airlines operating at the airport. Nevertheless, these papers do not consider concession revenue sharing contracts.

Concession revenue sharing contracts are agreements where airports share their revenues from commercial operations with airlines, inducing them to bring in more passengers. This kind of agreements allow airlines to take part in the positive externality they generate. Zhang

[3]Barbot (2011) collects the agreements from Starkie (2008). The types of agreements that are the most common are: (1) the European case, in which companies negotiate rates with the airport, therefore, end up paying a lower price than the rest of the airlines that do not sign any agreement ; (2) the Australian case, where airlines sign long-term terminal leases and its management; and (3) the case of US, in which airlines pay the airport the variable costs of its facilities plus a part of the fixed costs.

& Zhang (1997) were the first to introduce this kind of contracts in the literature following a traditional approach. Later, Zhang et al. (2010) and Fu & Zhang (2010) characterized the contract under the vertical structure approach. Fu & Zhang (2010) study the competitive and welfare implications when an airport offers airlines the option of sharing its concession revenue. They stated that "concession revenue sharing allows the airport and airlines to exploit the demand complementarity between aviation services and concession services". On the other hand, Zhang et al. (2010) analyze the degree of revenue sharing depending on the downstream market structure; that is, if the airlines services are substitutes, complements or independent. Furthermore, they also study the effect of two competing airports, in which case, upstream competition results in a higher degree of revenue sharing. In contrast, the present analysis focuses on how airports use the concession revenue sharing contract rather than looking at the direct effects of such contracts. As Zhang et al. (2010) did, we consider two airports that share the same catchment area. Each airport has an airline operating there, and each airport-airline pair signs a concession revenue sharing contract. In this Chapter, different airport ownership are considered, which complements the literature on airport ownership and competition. And in the process of setting the concession revenue sharing contract, the airport and the airline involved bargain with regard of the terms of payment through a Nash bargaining process, which is not considered in previous papers.

We find that when two airports compete with each other, they can use the sharing proportion to influence competition and increase the number of passengers at the expense of the other competing airport. On the other hand, the level of the sharing proportion is directly related to the aeronautical charge. The aeronautical charge is linked to the type of regulation existing at each airport which, in general, is chosen by the regulatory institutions of the sector. The result is that if the aeronautical charge is high enough, the decision of the airport is to share all the concession revenues with the airline. That way, airlines obtain the whole positive externality they generate. Furthermore, the comparison of different airport ownership settings unveils that when airports distribute all their concession revenues with the airlines, that is, the sharing proportion is equal to one, the results, that is, the level of traffic, airfares and benefits will be the same. This fact shows that with a high enough aeronautical charge, the ownership effect is neutralized. On the other hand, in the case where airports do not share all their concession revenues, which is what happens in practice, it is confirmed that the privatization of airports causes a social welfare reduction. In addition, private airports tend to share less concession revenues than public ones.

The second objective of this Chapter is to consider parallel alliances in the downstream market. Several reasons push airlines to make alliances. In the most profitable years, the margins in the industry hardly ever reached 2,5-3 %; very smooth in comparison with other markets, see Doganis (2006a). However, in spite of low returns, other strategic incentives led airlines to get allied.[4] The three major global alliance groups, Star Alliance, One World and Sky Team, made up more than 61 % of the world market in 2015.[5] Park (1997) was the first to differentiate between complementary and parallel alliances. Subsequently, Park et al. (2001) and Zhang & Zhang (2006) found that complementary alliances benefit the industry whereas parallel alliances raise welfare concerns. Instead, Flores-Fillol (2009) analyzed when it is likely to form any of both alliances. He found that the formation and the type of an airline alliance depends on the size of the market and the intensity of economies of traffic density. In any case, the most of the attention within the literature has basically focused on complementary alliances where network effects have been considered.

[4]For instance, Zhang & Zhang (2006) reported: "strategic alliances allow firms to expand their networks, take advantage of product complementarities, realize economies of scale and scope, and improve product quality and customer service."

[5]World Air Transport Statistics 60th Edition, IATA.

Some representative examples in airline complementary alliances include Brueckner (2001) and Flores-Fillol & Moner-Colonques (2007). Brueckner (2001) analyzes a hub-and-spoke network simulating an international market with two international airports that connect with two other regional airports. Airlines form an alliance to provide the international direct flight services splitting the market between them. This fact concentrates the market causing an increase in the airfares in the interhub market, but in turn favors the connection with the spokes. The net result is that consumer surplus and social welfare increase despite the negative effect on the interhub connection. Flores-Fillol & Moner-Colonques (2007) analyze a network of four airports with four connections each operated by a monopolistic airline. Imagine that a passenger wants to fly from Valencia to New York and has two options, traveling through London or Frankfurt, this is a basic representation of the network. Then three scenarios are analyzed. The case where there is no alliance, the case with a single alliance, where a seamless service is offered for example in the Valencia-London-New York route, and, finally, the case with two competing alliances, where the airlines coordinate also on the Valencia-Frankfurt-New York route. This is a clear setting where the strategic effects of complementary alliances are analyzed. It is observed that, as expected, the alliances reduce the airfares, and therefore, improve the situation of the passengers. This Chapter contributes to the alliance literature studying the effects of a parallel alliance by taking into account the vertical structure of the industry in the presence of concession revenue sharing contracts. Following Zhang & Zhang (2006) an equity alliance[6] is examined because "it tends to yield greater firm values, measured in stock returns, than other types of strategic alliances," which implies airlines incorporate a fraction of its partners' profit in its decision. Contrary to preceding results, concession revenue sharing makes parallel alliances welfare improving in some cases. Furthermore, and specially with a setting compounded by private airports, parallel alliances also improve consumer surplus, then the total number of passengers in the

[6]Some examples are: Air France/KLM alliance, the Cathay Pacific/Air China Alliance, and Qantas/Air New Zealand Alliance.

industry increases. This result underlines new insights for policy-makers.

The formation of a parallel alliance also affects the vertical relationship between the airport and the airline. In particular, it is shown that the existence of alliances makes airports share more concession revenues with airlines. When the downstream market is concentrated, the number of passengers is reduced and, to neutralize this effect, airports have to increase the sharing proportion. On the other hand, the strategic relationship of airports is also changed. The strategic relationship of the airports is determined by the strategic relationship of the airlines in the downstream market. By establishing an alliance, competition among airlines is reduced. If the alliance is strong enough, it causes the strategic relationship of the airports to change, and go from being strategic substitutes to complementary ones. This is what also happens with airlines. As long as the parallel alliance is strong enough the airlines behave more like a single airline; then they behave as strategic complements instead of substitutes.

The next section sets out the basic model where two public airports compete and provides some comments about the contract. Section 3.3 introduces private airports and compares the different scenarios. A parallel alliance in the downstream market and its effects are presented in Section 3.4. Finally, we conclude with some remarks and policy recommendations.

3.2 Public airports and vertical structure competition

3.2.1 Basic model

Consider in this section two public airports, which compete for passengers, in a common catchment area that offer flights to the same destination areas. One and a different airline operates in each airport. There is airline competition because they provide substitute differentiated services in the eyes of passengers. The following utility function of a representative passenger describes the preferences:

$$U(q_1, q_2) = a(q_1 + q_2) - \frac{b}{2} q_1^2 - \frac{b}{2} q_2^2 - d\, q_1\, q_2 + y \tag{3.1}$$

For a, b and d being positive constants and y denoting an outside good used as the numeraire. The q_i's represent the number of passengers served by each airline in a given origin-destination route. Subscript i is used for one vertical structure formed by an airport-airline pair, whereas the other is identified by subscript j. Parameter a, denotes the maximum willingness to pay for traveling. Parameter d, which is assumed to be smaller than b, measures the degree of substitutability between airline services, so that a higher d implies less differentiated services, while $d = 0$ corresponds to the case of independent services. After utility maximization subject to the budget constraint (defined as $M = y + p_1 q_1 + p_2 q_2$ with M denoting the representative consumer's income), the following inverse demand system for services is obtained:[7]

$$p_i = a - b\, q_i - d\, q_j \quad \forall \quad i, j = 1,2 \quad i \neq j \tag{3.2}$$

in the region of quantity space where airfares become positive, where p_i is the airfare paid for traveling with airline i.

Airline i's profit function, π_i, is composed of two terms, the standard operating profits and profits derived from concessions. Operating profits are $(p_i - c - w)q_i$, where w denotes aeronautical charges per passenger paid by airlines to airports and c is the marginal cost per passenger. On the other hand, passengers spend money on non-aeronautical services at the

[7] The inverse demand system satisfies the usual properties: (i) downward-sloping demand $\frac{\partial p_i}{\partial q_i} = -b < 0$; (ii) own effects dominate cross effects $\frac{\partial p_1}{\partial q_1}\frac{\partial p_2}{\partial q_2} - \frac{\partial p_1}{\partial q_2}\frac{\partial p_2}{\partial q_1} = b^2 - d^2 > 0$.

airport, which generates additional revenue, denoted by hq_i, where h is the per passenger net surplus generated. Concession profits are, precisely given by $h\ r_i q_i - f_i$, where r_i is the proportion (share) of concession revenues that go to airline i and f_i is the fixed payment made by the airline to the airport in exchange.[8]

Airports also have two sources of revenue. They obtain wq_i from aeronautical activities. Note that w cannot be changed from the airport unilaterally since it is regulated. The other source comes from non-aeronautical activities, and it is composed of by the share of concession revenues they keep, $(1- r_i)hq_i$ plus the fixed fee, f_i.[9] Finally, τ is the marginal aeronautical costs, while fixed costs are normalized to zero. Therefore, airport profits denoted by Υ_i, are equal to $(w-\tau)q_i + (1- r_i)hq_i + f_i$, for $i = 1,2$.

Agents make decisions in two stages. In the first stage, each airport-airline pair decides simultaneously and independently over the concession revenue sharing contract (r_i, f_i), which is the outcome of a Nash bargaining process. In the second stage, airlines compete for the number of passengers served, given the sharing proportions. The next subsections characterize the subgame perfect Nash equilibrium of the game, which is solved in the standard backward way.

[8]The revenue sharing contract considered has been employed by Zhang et al. (2010) and Fu & Zhang (2010), and contains two variables, (r, f). The sharing proportion, r, displays the effort of airports to pursue more passengers. In exchange, airports ask airlines for a fixed payment which can be seen, for example, as a compromise to make any investment or to be attached to that airport for several years. We assume the two variable contract because it is consistent with situations in which airports and airlines can commit to medium/long-term cooperation. Furthermore, Zhang et al (2010) stated that this contract "gets more traffic volume and social welfare" than the contract with just one variable.

[9]The simple representation of the net concession revenue, h, where it is strictly complementary to passenger volume has been used by Zhang et al. (2010), Fu & Zhang (2010), and Yang et al. (2015), among others.

3.2.2 Downstream airline competition

Airline i chooses q_i, for $i, j = 1,2$, to maximize the following profits expression:[10]

$$\pi_i = (p_i - c - w + r_i h)\, q_i - f_i \tag{3.3}$$

Solving the two first-order conditions system and using the inverse demand functions in (3.2), the second-stage equilibrium values of q_i denoted by superscript star, as a function of r_i and r_j are obtained.[11] These are given by:

$$q_i^*(r_i, r_j) = \frac{(a-c-w)(2b-d) + (2b\, r_i - d\, r_j)h}{4\, b^2 - d^2} \quad \forall i, j = 1,2 \quad i \neq j; \tag{3.4}$$

where the total number of passengers in the industry is:

$$Q^* = q_i^* + q_j^* = \frac{2(a-c-w) + h(r_i + r_j)}{2b+d} \tag{3.5}$$

And the equilibrium prices are,

$$p_i^*(r_i, r_j) = \frac{(2b-d)(ab + (b+d)(c+w)) - hr_i\left(2b^2 - d^2\right) - bdhr_j}{4b^2 - d^2} \quad \forall i, j = 1,2 \quad i \neq j. \tag{3.6}$$

Proposition 4 *Airports bring in more passengers and induce lower airfares as the sharing proportion increases, i. e.* $\frac{\partial q_i^*}{\partial r_i} > 0, \frac{\partial Q^*}{\partial r_i} > 0, \frac{\partial p_i^*}{\partial r_i} < 0.$

[10]Empirical evidence from Brander & Zhang (1990, 1993) states that the model which best fits with airline market competition is Cournot, and, it has been widely used in the literature.

[11]Both the second-order conditions for a maximum ($\frac{\partial^2 \pi_i}{\partial q_i^2} = -2b < 0$) and the stability conditions are satisfied ($\frac{\partial^2 \pi_i}{\partial q_i^2}\frac{\partial^2 \pi_j}{\partial q_j^2} - \frac{\partial^2 \pi_i}{\partial q_i \partial q_j}\frac{\partial^2 \pi_j}{\partial q_j \partial q_i} = 4\, b^2 - d^2 > 0$). Also, there is strategic substitution among airlines ($\frac{\partial^2 \pi_i}{\partial q_i \partial q_j} = -d < 0$).

Equation (3.4) shows how airports compete to attract passengers through airlines using the sharing proportion. Absent concession revenues, the equilibrium number of passengers contains the usual terms, that is, the oligopoly profitability term corrected by the effect of substitutability between services. Now the consideration of concession revenues has a pro competitive effect as they shift outwards the respective reaction functions. An increment in the own sharing proportion allows the airport to obtain an increase in passengers of size $\frac{2bh}{4\,b^2 - d^2}$. This increase in demand comes partly from the loss of passengers from the rival airport, $\frac{dh}{4\,b^2 - d^2}$, plus a part that is generated by increasing demand for price reductions. It also improves welfare because the overall effect is to increase the total number of passengers by $\frac{h}{2b+d}$.

As can be seen, the inclusion of concession revenue sharing affects airport competition. Airports can play with this tool to attract more traffic to the detriment of their competitors. Since the rival airports will respond in a like manner, an increase in total traffic is observed boosting consumer surplus.

3.2.3 The revenue sharing equilibrium

The objective function of public airports is to maximize social welfare (SW),[12] where $SW = \sum_{i=1}^{2} (\Upsilon_i + \pi_i) + CS$. Also, $CS = U(q_1, q_2) - \sum_{i=1}^{2} p_i q_i$. Consumer Surplus only considers aeronautical activities, so any effects derived from shopping at the airport are not taken into account in consumer welfare.[13]

[12] This assumption is common in the literature, see Zhang & Czerny (2012), Czerny (2013), and Gillen & Mantin (2014).

[13] Although there are activities which may derive positive welfare effects, most of them substitute the place of consumption. For instance, the welfare effects of buying clothes or eating at the airport are the same, or very similar, to doing these activities in a mall. This approach of normalizing consumer surplus of concession revenues to zero is applied by Zhang et al. (2010) and Gillen & Mantin (2014). For a more complete analysis see Czerny (2013) and Flores-Fillol et al. (2018).

The contract equilibrium values are obtained through a two-step procedure. First, social welfare is maximized to obtain r_i with $i = 1,2$, and then each airport-airline pair bargains over the fixed payment, f_i with $i = 1,2$.

After maximizing SW with respect to r_i, the equilibrium sharing proportion[14] denoted by a star, is given by:

$$r_i^* = r_j^* = \begin{cases} \frac{(a-c)b+w(b+d)+(h-\tau)(2b+d)}{h(b+d)} & \text{if } 0 < w < w^* \equiv \frac{-(a-c+h)b+(2b+d)\tau}{(b+d)} \\ 1 & \text{if } w^* \leq w \leq \tau \end{cases} \tag{3.7}$$

As can be seen, the sharing proportion is affected by the differentiation of the airlines services, b, d, the operating costs of the vertical pair, c and τ, the willingness to pay of the passengers, a, and the aeronautical and commercial revenues of the airport, w and h. The aeronautical charge, w, is regulated and is key to establish if the sharing proportion is equal to or less than one, that is, if the airports share all the concession revenues with the airlines or just a proportion of them. On the aeronautical charge, there is also a condition to ensure a non-negative sharing proportion when $w > w^+ \equiv \frac{-(a-c)b-(h-\tau)(2b+d)}{b+d}$. Thus, $0 < r_i^* < 1$ as long as $w^+ < w < w^*$.

With respect to the case in which $r_i^* < 1$, the less differentiated the services are, d tends to b, the lower the share proportion is. This is because it is easier to attract passengers from the other airport the more similar the services are. Therefore, the airport can achieve the same impact with a lower sharing proportion.

[14]Second derivatives entail: (i)the concavity condition; (ii) strategic substitution between sharing proportions; (iii) and the stability condition.

The sharing proportion can be one, $r_i^* = 1$, due to two reasons. Either if the aeronautical charge is large enough, $w \geq w^*$, or under a specific system of airport regulation. There are two accounting approaches that apply to the various regulation systems, which are the single and the dual-till system. The single-till approach cross-subsidizes the aeronautical charge with concession revenues, whereas the dual-till approach splits the two sources of revenue, regulating just the aeronautical part. Thus, for the latter approach the regulated charge is computed matching the aeronautical cost, i.e. $w = \tau$. The dual-till approach has become relevant once airports exploit their commercial facilities. Instead, the debate continues on which approach is appropriate.

Proposition 5 *In the case of the dual-till approach, $w = \tau$, airports share the whole concession revenues, $r_i^* = r_j^* = 1$.*

Note that $r_i^* = r_j^* = \frac{(a-c)b+w(b+d)+(h-\tau)(2b+d)}{h(b+d)}$ is larger than one when $w = \tau$, if and only if $(a-c-\tau+h)b > 0$, which is the case. By definition, $h, b > 0$, and to guarantee positive equilibrium quantities, it is required that $a \geq c+\tau$, that is, the maximum willingness to pay for a flight must be at least equal to airlines' marginal cost. In order to find an equilibrium sharing proportion less than one, a single-till approach or some cross-subsidization is required, that is with $w < \tau$. In this case a reduction of the aeronautical charge decreases the sharing proportion; specifically, $\frac{\partial r}{\partial w} = \frac{1}{h} > 0$.

Once the sharing proportion has been chosen, a Nash bargaining process is set in order to obtain the equilibrium fixed payment, f_i. The bargaining power of each agent will determine the amount of it. However, f_i does not have any influence on the number of passengers. The parameter $\varphi \in (0,1)$ represents the bargaining power of airports. If $\varphi = 1$ the whole bargaining power goes to the airport while for $\varphi = 0$ the airline holds the power. The Nash bargaining problem is given by:

$$\underset{f_i}{Max} \quad [SW]^{\varphi} \; [\, \pi_i]^{1-\varphi} \tag{3.8}$$

By maximizing the Nash bargaining problem, the resulting equilibrium fixed payment is given by:

$$f_i^* = (\, p_i^* - c - w + \, r_i^* h) \; q_i^* \tag{3.9}$$

In any case, the fixed payment does not affect the consumer surplus, but serves as a mechanism that distributes the benefits of the vertical pair among the agents that comprise it. Equation (3.9) shows that in a vertical structure when the airport is public, the equilibrium fixed payment makes airlines profit equal to zero; i.e. the airlines' participation constraint is binding. Hence, airlines operating in public airports always get zero economic profits if a concession revenue sharing contract is signed. The airport shares with the airlines part of its commercial revenues to increase traffic and, therefore, its aeronautical and non-aeronautical revenues. On the other hand, the airport is able to extract the surplus of the airlines through the fixed payment.

After substitution for r_i^*, the fixed payment that matches the airline's participation constraint is given by:

$$f_i^* = f_j^* = \begin{cases} \frac{b(a-c+h-\tau)^2}{(b+d)^2} & \text{if } \; r_i^* = \; r_j^* < 1 \\ \frac{b(a-c+h-w)^2}{(2b+d)^2} & \text{if } \; r_i^* = \; r_j^* = 1 \end{cases} \tag{3.10}$$

The fixed payment in the case that $r_i^* = r_j^* < 1$ is greater than when $r_i^* = r_j^* = 1$. When evaluating the fixed payment at the minimum value of w in the case that the sharing proportion is one, w^*, both fixed payments are equal. Therefore, before any increase in the aeronautical charge so that $w > w^*$, the fixed payment decreases.

Once the concession revenue sharing contract is obtained, the corresponding equilibrium variables are reported below.

Result 2 *In a public airports setting with concession revenue sharing it happens that:*
a) when $r_i^* = r_j^* < 1$

1. $q_i^* = \frac{a-c+h-\tau}{b+d}$;

2. $p_i^* = c + \tau - h$; *the first best is achieved making airfares equal to net marginal cost.*

3. $\Upsilon_i^* + \pi_i^* = 0$

4. $SW^* = CS^* = \frac{(a-c+h-\tau)^2}{b+d}$.

b) when $r_i^* = r_j^* = 1$

1. $q_i^* = \frac{a-c+h-w}{2b+d}$;

2. $p_i^* = \frac{ab+(b+d)(c+w-h)}{2b+d}$;

3. $\Upsilon_i^* + \pi_i^* = \frac{((a-c+h)b+w(b+d)-\tau(2b+d))(a-c+h-w)}{(2b+d)^2}$

4. $CS^* = \frac{(b+d)(a-c+h-w)^2}{(2b+d)^2}$;

5. $SW^* = \frac{(a-c+h-w)((3b+d)(a+h-c)+(b+d)w-2(2b+d)\tau)}{(2b+d)^2}$.

The two outcomes that can be observed depend on whether the sharing proportion is below one or is equal to one, which in turn depends on the value of the aeronautical charge.

As can be seen in part *a)*, the aeronautical charge w is eliminated from the results, which means complete vertical integration and achieving the first-best outcome. Alternatively, in the case when the sharing proportion is one, the airport cannot completely internalize the effect that a concession revenue sharing contract has on traffic. This lower traffic level leaves the airport-airline pair with positive surplus at the expense of consumers, finally resulting in lower total welfare.

These results show the importance of aeronautical regulation and how it affects the level of traffic. Faced with this situation with public airports, regulators should seek a sufficiently low aeronautical charge to guarantee that the sharing is not complete. In this way, the elimination of the distortion created by w implies that total welfare is maximized and the agents transfer their benefits to passengers. What is achieved is that the consumer surplus is maximized, a condition that is lost if the aeronautical charge causes the sharing proportion to be one. This also highlights the debate on what type of regulation is effective in which situations. Here it is observed that a dual-till would lead to a loss of social welfare.

Proposition 6 *At the revenue sharing equilibrium with two public airports facing competition, when airlines are symmetric and provide substitutable services, (i) traffic and welfare are greater and (ii) prices are lower than in the absence of revenue sharing, no matter* $r_i \leq 1$.

Proposition 4 already advanced these results. Instead, it was necessary to do the checks due to the interactions that take place between airports and airlines. It is noted that the concession revenue sharing improves the situation of passengers, no matter what their level is. This fact urges the authorities to consider this type of vertical agreements between airports and airlines. Despite the fact that anti-competitive issues could arise, there are improvements that benefit the passengers.

3.3 Private airports in the vertical structures

In 1987, the UK decided to privatize some airports, this measure was followed afterwards by many countries. Although various reasons existed for it, the main reason to privatize some airports was the need of self-financing because of the budget constraints governments suffered. As a consequence, several kinds of ownership coexist. The basic model presented in section 2 has focused on public airports, while now we are going to consider also private airports, the usual case examined in the literature, to see the main differences between them. The second stage where airlines compete in quantities remains the same, and the changes happen in the first stage where airlines interact with airports.

3.3.1 Private structures in the upstream market

Consider now two private airports competing that implying their respective objective functions change as they pursue profit maximization. In this case, each airport-airline pair maximizes its aggregate profit when choosing the sharing proportion r_i, $\underset{r_i}{Max} \quad \Upsilon_i + \pi_i$. Then, the equilibrium sharing proportion, denoted by superscript P for private, is given by:

$$r_i^P = r_j^P = \begin{cases} \frac{(a-c)d^2+w\left(4b^2+2bd-d^2\right)+2b(2b+d)(h-\tau)}{h\left(4b^2+2bd-d^2\right)} & \text{if } 0 < w < \frac{-d^2(a-c+h)+2b(2b+d)\tau}{4b^2+2bd-d^2} \equiv w^P \\ 1 & w^P \leq w \leq \tau \end{cases} \tag{3.11}$$

As in the basic model, there is a condition ensuring that $r_i^P > 0$. In this case it is when $w > w^{P+} \equiv \frac{-(a-c)\; d^2-2b(2b+d)(h-\tau)}{4\; b^2+2bd-\; d^2}$. Then, $0 < r_i^P < 1$ as long as $w^{P+} < w < w^P$, and w is positive.

Notice that the bounds on w that determine when the sharing proportion falls below one do not coincide with the previous case. In fact, the one for private airports is greater than the one for public airports, $w^P > w^*$. This means that the regulation on w may have a different effect on the sharing proportion depending on the ownership structure of airports. In any case, full sharing will arise in more cases when airports are public.[15] This fact also happens with the values of w that states where the sharing proportion is positive and less than one, $w^{P+} > w^+$. Regarding the regulation system, Proposition 5 continues to hold, so that the sharing is complete under the case in which a dual-till regulation system takes place.

To make the sharing proportion positive, the authorities have to impose a higher aeronautical charge. This means that in a situation with private airports, the aeronautical charge should be larger compared to the case with public airports to ensure concession revenue sharing.

After obtaining the sharing proportions, the Nash bargaining problem is solved to obtain the fixed payment in this case. The objective function changes to $\underset{f_i}{Max} \quad [\Upsilon_i]^{\varphi} \, [\pi_i]^{1-\varphi}$. The change with respect to the basic model is that private airports maximize their profits. Furthermore, consumer surplus is not part of this negotiation. Then, the resulting fixed payment is given by:

$$f_i^P = (\varphi(p_i^* - c + h - \tau) - (w - \tau + (1 - r_i^P)h))\, q_i^* \tag{3.12}$$

substituting for the corresponding (r_i^P, r_j^P), yields,

$$f_i^P = f_j^P = \begin{cases} \frac{2b\left(2b^2\varphi + d^2(1-\varphi)\right)(a-c+h-\tau)^2}{\left(4b^2+2bd-d^2\right)^2} & \text{if } r_i^P = r_j^P < 1 \\ \frac{(a-c+h-w)(b\varphi(a-c+h+w-2\tau)-(2b+d(1-\varphi))(w-\tau))}{(2b+d)^2} & \text{if } r_i^P = r_j^P = 1 \end{cases} \tag{3.13}$$

[15] All thresholds on w for the different cases are provided and ranked in the Appendix.

It can be seen that in a private airports setting, the bargaining power of the agents involved is important to determine the fixed payment, an element that does not play any role when airports are public. In the case of public airports, the fee was such that they could extract the airlines profits. But in this case it would not happen, unless the airport had the full bargaining power, $\varphi = 1$. It is observed how, as the bargaining power of the airport increases, the value of the fixed rate increases, $\frac{\delta f_i^P}{\delta \varphi} > 0$, as expected. Once the sharing proportions and the fixed payments are computed, the results are reported below.

Result 3 *In a private airports setting with concession revenue sharing, it happens that:*
a) for $r_i^P = r_j^P < 1$

1. $q_i^P = \frac{2b(a-c+h-\tau)}{(4b^2+2bd-d^2)}$;
2. $p_i^P = \frac{a(2\,b^2-\,d^2)+(c-h+\tau)2b(b+d)}{(4b^2+2bd-d^2)}$
3. $\Upsilon_i^P + \pi_i^P = \frac{2b(2\,b^2-\,d^2)\,(a-c+h-\tau)^2}{(4b^2+2bd-d^2)^2}$
4. $CS^P = \frac{4\,b^2(b+d)\,(a-c+h-\tau)^2}{(4b^2+2bd-d^2)^2}$.
5. $SW^P = \frac{4\,b(3\,b^2+bd-\,d^2)\,(a-c+h-\tau)^2}{(4b^2+2bd-d^2)^2}$

b) when $r_i^P = r_j^P = 1$ *Result 2 part b) holds.*

Result *3 b)* states that no matter the ownership, if the aeronautical charge is large enough, $w > w^P$, the same outcome is obtained. This situation happens as long as the airports share completely their concession revenue with airlines, $r = 1$. Then, airlines fully internalize the positive externality they generate. We also note that Proposition 6 holds in this scenario. Thus, concession revenue sharing contracts, even with private airports, improves traffic levels and social welfare, lowering the airfares.

A notable difference with regard to the basic case is that the existence of private airports means that consumer surplus is not maximized when $r_i, r_j < 1$. In this case, the social welfare is shared among the different agents. The joint profits between airports and airlines are shared depending on the bargaining power of airports. This shows that although consumer surplus is lower in a private setting, the results improve when concession revenue sharing is allowed.

Next section analyzes the concession revenues sharing contract in the last possible scenario, when a private and a public airport compete. It also shows a comparison of the three scenarios analyzed.

3.3.2 Asymmetric competition

As already mentioned, only the first stage is different where now two airports with a different ownership structure, and hence different objective functions, compete. Each airport-airline pair will have a different equilibrium contract because of the asymmetry. Superscript A denotes the asymmetric case, and subscript 1 is the private airport whereas subscript 2 identifies the public airport.

By proceeding as above, the equilibrium contracts for the case of sharing proportions smaller than one are obtained. In particular, the pair (r_1, f_1) for the private airport reads as follows:

$$(r_1^A, f_1^A) = (\frac{2bd^2(a-c)(b-d)+w\left(8b^4-8b^2d^2+d^4\right)+\left(8b^4-6b^2d^2-2bd^3+d^4\right)(h-\tau)}{h\left(8b^4-8b^2d^2+d^4\right)}, \frac{8b^3(b-d)^2\left(2b^2\varphi+d^2(1-\varphi)\right)(a-c+h-\tau)^2}{\left(8b^4-8b^2d^2+d^4\right)^2})$$

while the pair for the public airport is given by,

$$(r_2^A, f_2^A) = \left(\frac{(a-c)\left(8b^4-8b^3d+2bd^3-d^4\right)+w\left(8b^4-8b^2d^2+d^4\right)+(h-\tau)(16b^4-8b^3d-8b^2d^2+2bd^3)}{h\left(8b^4-8b^2d^2+d^4\right)}, \frac{b\left(8b^3-6b^2d-2bd^2+d^3\right)^2(a-c+h-\tau)^2}{\left(8b^4-8b^2d^2+d^4\right)^2}\right)$$

The conditions on the aeronautical charge that make the sharing contract smaller than one for the private and the public airport are, respectively:

$$w < \frac{\tau\left(8b^4-6b^2d^2-2bd^3+d^4\right)-2bd^2(b-d)(a-c+h)}{8b^4-8b^2d^2+d^4} \equiv w_1^A,$$

$$w < \frac{\tau\left(16b^4-8b^3d-8b^2d^2+2bd^3\right)-\left(8b^4-8b^3d+2bd^3-d^4\right)(a-c+h)}{8b^4-8b^2d^2+d^4} \equiv w_2^A$$

where $w_1^A > w_2^A$.

This situation leaves three possible scenarios depending on the value of the aeronautical charge, w. If $w < w_2^A$ the pairs of contracts correspond to those reported above. If $w_2^A < w < w_1^A$, the public airport shares all its concession revenues, $r_2^A = 1$, while the private airport does not, $r_1^A < 1$. Finally, if $w > w_1^A$ both airports sharing proportion are the same and equal to one, $r_1^A = r_2^A = 1$. Also, note that the equilibrium fixed payments that correspond to the case where $r_1^A = r_2^A = 1$ are the same as in equations (3.9) and (3.12).

In case $w > w_1^A$, the sharing proportion in both airports is one, and the contract reads as follows:

$$\begin{cases} (r_1^A, f_1^A) = \left(1, \frac{(a-c+h-w)(b\varphi(a-c+h+w-2\tau)-(2b+d(1-\varphi))(w-\tau))}{(2b+d)^2}\right) \\ (r_2^A, f_2^A) = \left(1, \frac{b(a-c+h-w)^2}{(2b+d)^2}\right) \end{cases}$$

These results show under what conditions the sharing proportion is equal to unity. On the other hand, we must also ensure that the sharing proportion is positive. Thus,

$$\begin{cases} r_1^A > 0 \quad if \quad w > \frac{-2b\ d^2(a-c)(b-d)-(h-\tau)(8\ b^4-6\ b^2\ d^2-2b\ d^3+\ d^4)}{8\ b^4-8\ b^2\ d^2+\ d^4} \equiv\ w_1^{A+} \\ r_2^A > 0 \quad if \quad w > \frac{-(a-c)(8\ b^4-8\ b^3\ d+2b\ d^3-\ d^4)-(h-\tau)(16\ b^4-8\ b^3\ d-8\ b^2\ d^2+2b\ d^3)}{8\ b^4-8\ b^2\ d^2+\ d^4} \equiv\ w_2^{A+} \end{cases}$$

In this case, $w_1^{A+} > w_2^{A+}$, therefore, to ensure that the sharing proportion is always positive we must have that $w > w_1^{A+}$. Otherwise, there may be a case in which the private airport would have a negative sharing proportion. But this raises another question, whether the value of w_1^{A+} is greater than the values of w that make the sharing proportion equal to one, (w_1^A, w_2^A). It can be checked that $w_1^A > w_1^{A+}$, that is, the sharing proportion of the private airport is less than one. However, this is not necessarily true for the pulic airport, since w_2^A can be bigger or smaller than w_1^A, so there is a range of w values for which $0 < r_2^A < 1$, and that happens when the net concession revenue per passenger is high enough, that is, $h > \frac{(a-c-\tau)\ (2b-d)^2(2\ b^2-\ d^2)}{2b(b-d)(4\ b^2+bd-\ d^2)} \equiv\ h^A$. Otherwise, the sharing proportion of the public airport would always be one.

Once all the conditions under which the sharing proportions are positive and less than the unity are identified, the case can be analyzed in which the private airport distributes all its concession revenue and the public does not, that is, $r_1^A = 1$ and $r_2^A < 1$. There are two conditions under which this case is met depending on the value of the net concession revenue per passenger, h, and the aeronautical charge, w. These conditions are:

$$if \begin{cases} h > \ h^A \quad and \quad w_2^A < w < \ w_1^A \\ h < \ h^A \quad and \quad w_1^+ < w < \ w_1^A \end{cases}$$

Under these conditions, the resulting contracts are as follows:

$$\begin{cases} r_1^A = \frac{(a-c)(2b-d)d^2+w(8b^3-4bd^2+d^3)+h(8b^3-2bd^2-d^3)-\tau(8b^3-2bd^2)}{4bh(2b^2-d^2)} \\ r_2^A = 1 \end{cases}$$

And the fixed payments are given by:

$$\begin{cases} f_1^A = \frac{((a-c+h)(2b-d)+wd-2b\tau)^2(2b^2\varphi+d^2(1-\varphi))}{8b(2b^2-d^2)^2} \\ f_2^A = \frac{((a-c+h)(4b^2-2bd-d^2)-w(4b^2-d^2)+2bd\tau)^2}{16b(2b^2-d^2)^2} \end{cases}$$

Once the contracts have been calculated in all possible situations, the values of traffic, airfares and the benefit of the agents in each case are obtained.

Result 4 *In an asymmetric airports setting with concession revenue sharing it happens that: a) for* $r_1^A < 1$ *and* $r_2^A < 1$*, which happens as long as* $h > h^A$ *and* $w_1^+ < w < w_2^A$*,*

1. $q_1^A = \frac{4\, b^2(b-d)(a-c+h-\tau)}{(8\, b^4-8\, b^2\, d^2+ d^4)}$

2. $q_2^A = \frac{(8\, b^3-6\, b^2 d-2b\, d^2+ d^3)(a-c+h-\tau)}{(8\, b^4-8\, b^2\, d^2+ d^4)}$

3. $Q^A = \frac{(12b^3-10b^2 d-2bd^2+d^3)(a-c+h-\tau)}{(8\, b^4-8\, b^2\, d^2+ d^4)}$

4. $p_1^A = \frac{2ab(b-d)(2b^2-d^2)+(4b^4+4b^3 d-6b^2 d^2-2bd^3+d^4)(c-h+\tau)}{(8\, b^4-8\, b^2\, d^2+ d^4)}$

5. $p_2^A = \frac{a(2\, b^3 d-2\, b^2\, d^2-b\, d^3+ d^4)+(8b^4-2b^3 d-6b^2 d^2-bd^3)(c-h+\tau)}{(8\, b^4-8\, b^2\, d^2+ d^4)}$

6. $\Upsilon_1^A + \pi_1^A = \frac{2\, b^3\, (b-d)^2(2\, b^2-\, d^2)\, (a-c+h-\tau)^2}{(8\, b^4-8\, b^2\, d^2+ d^4)^2}$

7. $\Upsilon_2^A + \pi_2^A = \frac{d\, (b-d)(2\, b^2-\, d^2)\, (8\, b^3-6\, b^2\, d-2b\, d^2+ d^3)(a-c+h-\tau)^2}{(8\, b^4-8\, b^2\, d^2+ d^4)^2}$

8. $CS^A = \frac{b\, (80\, b^6-64\, b^5\, d-92\, b^4\, d^2+72\, b^3\, d^3+16\, b^2\, d^4-12b\, d^5+ d^6)(a-c+h-\tau)^2}{2(8\, b^4-8\, b^2\, d^2+ d^4)^2}.$

9. $SW^A = \frac{(112\, b^7-96\, b^6\, d-132\, b^5\, d^2+104\, b^4\, d^3+40\, b^3\, d^4-24\, b^2\, d^5-5b\, d^6+2\, d^7)(a-c+h-\tau)^2}{2(8\, b^4-8\, b^2\, d^2+ d^4)^2}$

b) when $r_1^A = r_2^A = 1$ *Result 2 part b) holds.*

c) for $r_1^A < 1$ *and* $r_2^A = 1$*:*

1. $q_1^A = \frac{(a-c)(2b-d)+wd+h(2b-d)-2b\tau}{4b^2-2d^2}$

2. $q_2^A = \frac{(a-c+h)(4b^2-2bd-d^2)-w(4b^2-d^2)+2bd\tau}{4b(2b^2-d^2)}$

3. $Q^A = \frac{(a-c+h)(8b^2-4bd-d^2)-w(4b^2-2bd-d^2)-\tau(4b^2-2bd)}{4b(2b^2-d^2)}$

4. $p_1^A = \frac{a(2b-d)+(c-h)(2b+d)+wd+2b\tau}{4b}$

5. $p_2^A = \frac{a(4b^2-2bd-d^2)+(c-h)(4b^2+2bd-3d^2)+w(4b^2-3d^2)+2bd\tau}{8b^2-4d^2}$

6. $\Upsilon_1^A + \pi_1^A = \frac{((a-c+h)(2b-d)+wd-2b\tau)^2}{8b(2b^2-d^2)}$

7. $\Upsilon_2^A + \pi_2^A = \frac{((a-c+h)(4b^2-2bd-d^2)-w(4b^2-d^2)+2bd\tau)((a-c+h)(4b^2-2bd-d^2)+w(4b^2-3d^2)-2\tau(4b^2-bd-2d^2))}{16b(2b^2-d^2)^2}$

8. $CS^A = \frac{1}{32b(2b^2-d^2)^2}((a^2+c^2+h^2-2ac+2h(a-c))(32b^4-32b^2d^2+4bd^3+5d^4)+ w^2(16b^4-20b^2d^2+5d^4)+\tau^2(16b^4-12b^2d^2)-(a-c+h)(w(32b^4-40b^2d^2+4bd^3+ 10d^4)+\tau(32b^4-24b^2d^2+4bd^3))+\tau w4bd^3)$

9. $SW^A = \frac{1}{32b(2b^2-d^2)^2}((a^2+c^2+h^2-2ac+2h(a-c))(96b^4-64b^3d-48b^2d^2+28bd^3+ 3d^4)-w^2(16b^4-20b^2d^2+5d^4)+\tau^2(48b^4-32b^3d-20b^2d^2+16bd^3)-(a-c+ h)(w(32b^4-32b^3d-8b^2d^2+12bd^3-2d^4)+\tau(160b^4-96b^3d-88b^2d^2+44bd^3+ 8d^4))+\tau w((64b^4-32b^3d-48b^2d^2+12bd^3+8d^4)))$

In all cases, it happens that the public airport has a greater sharing proportion than the private airport. This entails that the fixed payment is also superior. Except in the intermediate case where the fixed payment of the private airport is greater if the services are very similar. The public airport, which looks after common interests, has the function of counteract to favor the common good. Thus, the sharing proportion is superior to offset the loss of existing passengers due to the presence of the private airport.

In the following Proposition we present several interesting comparisons among the three ownership scenarios considered above. For simplicity, and in order to extract some conclusions, we just compare the symmetric situations where airports sharing proportions are less than one, $r_i, r_j < 1$, or equal to one, $r_i = r_j = 1$. However, there are intermediate cases which are new results.

Proposition 7 *1. The comparison of the three ownership airport structures yields the following orderings when every $r < 1$ and $w < w_2^A$:*

(a) $r_2^A > r_i^* > r_i^P > r_1^A$ *and* $f_2^A > f_i^* > f_i^P > f_1^A$

(b) $q_2^A > q_i^* > q_i^P > q_1^A$ *and* $p_i^P > p_1^A > p_2^A > p_i^*$

(c) $SW^* > SW^A > SW^P$ *and* $CS^* > CS^A > CS^P$ *and* $Q^* > Q^A > Q^P$

(d) $\Upsilon_i^P + \pi_i^P > \Upsilon_i^A + \pi_i^A > \Upsilon_i^* + \pi_i^* = 0$

2. When $r = 1$ for each scenario for $w > w_1^A$:

(a) Result 2 part b) holds by any scenario. Then, it does not matter the ownership scenario because the result is going to be the same. The only difference is about the fixed part in the revenue sharing contract. $f_i^* = f_2^A < f_i^P = f_1^A$.

The sharing proportion and the fixed payment are ranked in the same way because if an airport shares more concession revenues, it also asks for a higher effort or compensation from airlines. The reason why the public airport in the asymmetric setting shares the higher amount is because it wants to balance the negative effect that makes the private airport to maintain the same level of passengers in the industry. Since r_i choices behave as strategic substitutes for airports, the private airport sharing proportion is ranked the smallest.

The number of passengers is directly related to the sharing proportion; however, airfares are ranked following the level of privatization in the industry. That shows that private settings lead to higher airfares than public settings. Social welfare, consumer surplus, and total passengers rank in the same way. The effects of privatization damage passengers at the expense of the other agents; however, their gains are not enough to cover the passenger losses.

Therefore, it can be concluded that the privatization of airports entails a loss of welfare, above all for passengers. In the case where public and private airports coexist, the behavior of the public airport compensates for the negative effect on welfare caused by the presence of the private airport. That is why its sharing proportion is the greatest.

In the case that all the scenarios are compared when the sharing proportion is one, the above presented results are equal. This fact has policy implications because with a sufficiently large aeronautical charge the factor of ownership of the airports is eliminated. On the other hand, there is a loss of welfare when $r = 1$, so it would be advisable to establish a sufficiently low aeronautical charge to favor a better vertical integration and so this would be transferred to the passengers.

3.4 Parallel airline alliances in the downstream market

The second part of this Chapter considers the formation of parallel alliances in the downstream market. For many reasons, airlines get allied in order to survive and to gain access to other markets; consequently, many alliances with several motivating forces are spread worldwide. Park (1997) formally distinguished between complementary and parallel alliances. Increased airport rivalry implies that the chance to find parallel airline alliances increases. The purpose of this section is to analyze how parallel alliances affect the sharing proportions, airport competition and social welfare. We follow Zhang & Zhang (2006), who stated that "an equity alliance tends to yield greater firm values, measured in stock returns, than other types of strategic alliances." In the second stage, every airline maximizes the following expression:

$$\underset{q_i}{Max} \quad \Pi_i = \pi_i + \alpha \, \pi_j \tag{3.14}$$

When airlines cooperate its objective function changes, and they maximize its own profit plus a weight on their partner's profit. Parameter $\alpha \in [0,1]$ denotes the degree of cooperation; $\alpha = 0$ represents the Cournot case presented earlier whereas $\alpha = 1$ symbolizes a single airline. The degree of cooperation, α, is assumed equal for both airlines involved. Here

Despite forming an alliance, each airline chooses the number of passengers independently. In this case, the number of passengers per airline and the total number of passengers in the industry would be the following:

$$q_i^{\alpha} = \frac{(a-c-w)(2b-(1+\alpha)d)+(2b\, r_i-(1+\alpha)d\, r_j)h}{4\, b^2 - \, (1+\alpha)^2 \, d^2} \tag{3.15}$$

$$Q^{\alpha} = \, q_i^{\alpha} + \, q_j^{\alpha} = \frac{2(a-c-w)+h(\, r_i + \, r_j)}{2b+(1+\alpha)d}, \tag{3.16}$$

where superscript α identifies the alliance case. Then, the following result can be established.

Proposition 8 *Parallel alliances reduce total traffic, i. e.* $\frac{\partial \, Q^{\alpha}}{\partial \alpha} = -\frac{d}{2b+(1+\alpha)d} \cdot \, Q^{\alpha} < 0.$

This was expected because the concentration in the downstream market reduces total traffic. Nevertheless, and despite the fact that the loss of global passengers occurs, the effects at the different airports depend on the sharing proportion of each one. Therefore, we must pay attention to these variables. In the case that both airports behave symmetrically, that is, the sharing proportion is equal, $r_i = r_j$, there is a loss of passengers on both airlines to form an alliance, $\frac{\partial\, q_i^{\alpha}}{\partial \alpha} < 0 \quad \forall \quad i, j$. When there is asymmetry, that is, an airport distributes more sharing than the other, the airport with less sharing always reduces its traffic, as expected due to the effect of market concentration. On the other hand, the airport with the higher sharing can see its traffic increased if the sharing proportion is large enough and smaller than one. This is due to the substitution effect that exists between airports when establishing alliances. The airline that operates at the airport with the lowest sharing proportion, transfers passengers to the other airport, since in this way they obtain greater profit.

With these results, it is clear that parallel alliances produce a negative effect in terms of traffic level. Park et al. (2001) found empirical evidence where a parallel alliance decreases total traffic by an average of 11-15 %. The degree of cooperation, that is, the value of α, will determine if the scenario seems more like a Cournot, or a monopoly case, although we do not consider the latter scenario. As the degree of cooperation increases, other things equal, airlines can increase airfares, which is why they have incentives to cooperate, since they obtain greater profits. For this effect the parallel alliances are expected to be harmful, however, upstream market behavior can mitigate this effect. In this case, as argued through the Chapter, airports can influence the outcome in the downstream market through vertical agreements such as concession revenue sharing contracts.

Earlier results do not consider the possibility of a formal vertical relationship between airports and airlines, so that the effect of any market concentration downstream inevitably leads to a reduction in production, in this case, in the number of passengers. However, when considering concession revenue sharing contracts there are situations in which traffic increases due to the ability of airports to influence the equilibrium in the downstream market. In the case where the airports distribute all the concession revenue, i.e. $r = 1$, there is always a reduction in traffic due to parallel alliances. This happens because airports cannot increase the sharing proportion to modify the behavior of airlines. But if the sharing proportion is not complete, we find cases where alliances increase traffic. Specifically when both airports are private. It also occurs partially in the asymmetric case when the services of the airlines are not too differentiated and the degree of airline cooperation is very strong. From a regulatory perspective, this shows how, in situations where there are private airports, authorities can set a sufficiently small aeronautical charge to guarantee that the sharing proportion is less than one and, therefore, there is scope for airports to further increase the sharing proportion finally leading parallel airline alliances to generate a traffic increase.

Once the results and the implications of the parallel alliances on the second stage equilibrium have been established, we move up to characterize the first stage equilibrium. Depending on airports ownership we have three cases from which different results of the contract, (r_i, f_i), are obtained. Proposition 9 shows how cooperative behavior in the downstream market shapes the behavior of airports.

Proposition 9 *As a response to airline cooperation, airports increase the concession revenue sharing proportion, i.e.* $\frac{\partial r_i}{\partial \alpha} > 0$*. This happens except for the case of the public airport in the asymmetric ownership structure when sharing proportions are less than one,* $r_1^A, r_2^A < 1$*, and the airports' sharing proportions behave as strategic substitutes.*

As Proposition 4 indicates, airports can increase the number of passengers through the sharing proportion. By establishing an airline parallel alliance in the downstream market, the airport responds by increasing the sharing proportion to offset the decrease in passenger traffic. Even so, as indicated by Proposition 7, there is a generalized loss of traffic, which would be higher if there was no sharing proportion, $Q^{\alpha}(r) > Q^{\alpha}(0)$. There is an exception that occurs in the case of asymmetric competition between airports as stated above. Public airports have a higher sharing proportion in equilibrium than private airports. It happens that the public airport decreases the sharing proportion with increase in the degree of cooperation, that is, $\frac{\partial r_2^A}{\partial \alpha} < 0$. The reason behind this is that there is a transfer of passengers between airports due to the airlines alliance. Airlines transfer passengers from the least profitable airport to the most profitable one, that is, from the private to the public, which partly leads to a fall in the number of passengers. Then, the public airport, to avoid that behavior, reduces the sharing proportion, so that the private airport increases its traffic, which is better for social welfare.

It is also worth mentioning the strategic relationship of airports. This relationship is preceded by the strategic relationship that exists between the airlines in the downstream market. When an alliance is established, if it is strong enough, the strategies of the airlines are aligned, so they stop behaving as strategic substitutes. This causes airports, which use the sharing proportion as a tool to compete among them, to change their behavior.

Proposition 10 *Airports' strategic relation changes from substitutability to complementarity for a large enough degree of cooperation among airlines, that is for* $\alpha \in (\hat{\alpha}, 1]$*, where* $\hat{\alpha} = (\frac{2b^2-d^2-2b\sqrt{b^2-d^2}}{d^2})$.

For a better understanding, suppose airlines merge and form a monopoly. The single airline will prefer the airport with the highest sharing proportion to increase its profit; i.e. the airline can transfer passengers between airports for the sake of its benefit. Aware of that, airports, to avoid passenger transference, behave as strategic complements in sharing proportions; i.e., if one airport increases its sharing, the rival increases it too.

Proposition 7 part a) still holds in the presence of parallel alliances. However, when taking into account a parallel alliance in the downstream market, it is worth looking at how it affects social welfare. It is known that the consumer surplus is reduced by the concentration in the market and that is found in the analysis of Proposition 7. The next Proposition specifies the conditions for social welfare to increase with the degree of cooperation.

Proposition 11 *If there is at least one private airport and the sharing proportions are smaller than one, parallel alliances are welfare improving for any degree of cooperation, i.e.* $\frac{\partial SW}{\partial \alpha} > 0$. *Instead, when the sharing proportions are equal to one, social welfare decreases with the degree of cooperation.*

In the basic model with two public airports, as they maximize social welfare, airports can play with the sharing proportion to internalize the loss of passengers and make it null. Therefore, neither the number of passengers nor social welfare, which is maximum, are altered. In the case that $r_i, r_j = 1$, the airports cannot influence the downstream market more than they actually do. Therefore, any increase in the degree of cooperation reduces the SW, because the airport does not have the ability to respond to it. Thus, if the degree of cooperation increases, the only effect that arises over the traffic level is the negative effect because of the downstream market concentration.

In the private and asymmetric cases when $r_i, r_j < 1$ parallel airline alliances are welfare improving. The case with two private airports is the most significant. Social welfare is made up of consumer surplus and the profits of airlines and airports. In this case, the airlines have incentives to establish an alliance, unless the degree of substitutability of their services is very high, $\frac{d}{b} > 0,78$. On the other hand, parallel alliances also increase consumer surplus. So the increase in social welfare is preceded by the increase in consumer surplus and the profits of airlines to the detriment of the airport profits, which is the part affected. That is, in a setting with private airports and concession revenue sharing, if a sufficiently small aeronautical charge is guaranteed that makes $r_i, r_j < 1$ and the airline services are sufficiently differentiated, it happens that airlines are willing to form a parallel alliance and this type of alliances are welfare improving, and what is more, they also increase consumer surplus.

3.5 Conclusions

This Chapter has investigated the competition between two vertical structures formed by an airport-airline pair through concession revenue sharing contracts, where the two airports share a catchment area. Previous studies have analyzed the implications of this type of contracts under the vertical structure approach. The concession revenue sharing contracts allow to exploit the complementarities between aeronautical and commercial revenues. This Chapter focuses on analyzing how airports are able to influence the downstream market to compete with other airports located within the same catchment area. In reality, competition comes from airlines that share the same destination, but airports can influence their decisions through vertical contracts such as concession revenue sharing. It is found that, effectively, airports have a real influence and that they can attract passengers from competing airports using the sharing proportion as a mechanism. In the context of both airports being public, and the sharing proportion is less than one, the first-best is achieved, because the complementarities within the vertical structure are internalized. On the other hand, a privatization process would harm the levels of social welfare and consumer surplus, in addition to increasing airfares.

The second objective is to analyze the parallel alliances between airlines. Parallel alliances, because they imply and increase in concentration in the downstream market, have not been widely analyzed, unlike complementary alliances. We have found novel results when parallel alliances are analyzed in a context of vertical structure approach and under concession revenue sharing contracts. It is found that, in effect, parallel alliances reduce total traffic by concentrating the downstream market. However, they cause airports to increase the sharing proportion to alleviate that loss of passengers and make it smoother. Besides, it is also found that, under certain conditions, social welfare increases as well as consumer surplus and total traffic, which emphasizes the need for further study of this type of alliances in different contexts.

As a general conclusion, airports can influence the downstream market through contracts such as concession revenue sharing. Airports compete through the airlines that operate there and that are the ones who attract passengers. A positive externality is created in which airports exploit their commercial part to extract a greater income for passengers. Through concession revenue sharing contracts, the airlines can internalize this externality and so increase their traffic levels. Both airports and airlines have incentives to sign some type of vertical contract, the contract analyzed allows both to benefit from the current development and operation of the non-aeronautical area of the airports. It is also evident that the privatization of airports produces worse results than those of a public nature; however, in this matter there are other parameters to be taken into account such as financing needs.

Nowadays and due to the market power that is related to airports, there are several ways to regulate aeronautical charges. This Chapter does not enter to value regulation, but it does show how institutions can set aeronautical charges to increase welfare. In general terms, it can be said that if concession revenue sharing contracts are set, it is better to choose a sufficiently low aeronautical charge to guarantee that airports can effectively influence the downstream market increasing traffic. In a setting made up of private airports, when considering parallel airline alliances, if a sufficiently low aeronautical charge is set, this type of alliance becomes welfare-improving and increases the level of traffic. As can be seen, the choice of the aeronautical charge by the authorities has consequences, not only in the level of traffic or welfare, but also in the structure of markets. A new horizon opens up where vertical structures can be allowed through certain types of agreements, such as concession revenue sharing contracts, and the formation of parallel alliances between airlines.

This Chapter also has other implications for future research. There are cases in which there are multi-airport areas where more than two airports compete. Thus, it would be interesting to study multi-airport competition analyzing cooperation upstream, and/or network effects of airlines. Because there are only two airlines, the effects of the network have not been analyzed. Different treatments to the net concession revenue, h, instead of a direct relationship with demand, adding an incentive scheme to airlines, is also a possibility to be considered.

3.6 Appendix

Throughout the Chapter there are some restrictions on the value of the relevant parameters, which are used in the proofs that follow:

1. $b > d > 0$
2. $a, c, \tau, h, w > 0$
3. $a > c + \tau$
4. $\alpha \in [0, 1]$
5. $\varphi \in [0, 1]$

Second order conditions in the first stage of the game

1. Concavity

   (a) Public airports

   $\frac{\partial^2 \mathrm{SW}}{\partial \mathrm{r}_i^2} = -\frac{b\left(4b^2-3d^2\right)h^2}{\left(4b^2-d^2\right)^2} < 0$

   (b) Private airports

   $\frac{\partial^2 \Upsilon_i + \pi_i}{\partial \mathrm{r}_i^2} = -\frac{4b\left(2b^2-d^2\right)h^2}{\left(4b^2-d^2\right)^2} < 0$

2. Strategic substitution

$$\frac{\partial^2 \; SW}{\partial r_i \; \partial r_j} = \frac{\partial^2 \;\; \Upsilon_i + \pi_i}{\partial r_i \; \partial r_j} = -\frac{d^3 h^2}{\left(4b^2-d^2\right)^2} < 0$$

3. Stability condition

   (a) Public airports

$$\frac{\partial^2 \mathrm{SW}}{\partial \mathrm{r}_1^2}\frac{\partial^2 \mathrm{SW}}{\partial \mathrm{r}_2^2} - \frac{\partial^2 \mathrm{SW}}{\partial \mathrm{r}_1 \partial \mathrm{r}_2}\frac{\partial^2 \mathrm{SW}}{\partial \mathrm{r}_2 \partial \mathrm{r}_1} = \frac{(b-d)(b+d)h^4}{\left(4b^2-d^2\right)^2} > 0$$

   (b) Private airports

$$\frac{\partial^2 \;\; \Upsilon_1 + \pi_1}{\partial r_1^2}\frac{\partial^2 \;\; \Upsilon_2 + \pi_2}{\partial r_2^2} - \frac{\partial^2 \;\; \Upsilon_1 + \pi_1}{\partial r_1 \; \partial r_2}\frac{\partial^2 \;\; \Upsilon_2 + \pi_2}{\partial r_2 \; \partial r_1} = \frac{\left(16b^4-12b^2d^2+d^4\right)h^4}{\left(4b^2-d^2\right)^3} > 0$$

Thresholds on the sharing proportion

We set conditions on the aeronautical charge to know when the different sharing proportions are smaller than one. These conditions depend on the ownership structure of airports we have considered, giving rise to four thresholds. The different thresholds are:

1. $w^* \equiv \frac{-(a-c+h)b+(2b+d)\tau}{(b+d)}$, for the public airports case.
2. $w^P \equiv \frac{-d^2(a-c+h)+2b(2b+d)\tau}{4b^2+2bd-d^2}$, for the private airports case.
3. $w_1^A \equiv \frac{-2bd^2(b-d)(a-c+h)+\tau\left(8b^4-6b^2d^2-2bd^3+d^4\right)}{8b^4-8b^2d^2+d^4}$, for the private airport in the asymmetric case.
4. $w_2^A \equiv \frac{-\left(8b^4-8b^3d+2bd^3-d^4\right)(a-c+h)+\tau\left(16b^4-8b^3d-8b^2d^2+2bd^3\right)}{8b^4-8b^2d^2+d^4}$, for the public airport in the asymmetric case.

The thresholds are ranked in this way: $w_1^A > w^P > w^* > w_2^A$. Thus, the public airport in the asymmetric case is going to reach the whole concession revenue $r = 1$ before any other.

1. To prove that $w_1^A > w^P$, notice that $w_1^A - w^P = \frac{d^3(2b-d)\left(2b^2-d^2\right)(a-c+h-\tau)}{\left(4b^2+2bd-d^2\right)\left(8b^4-8b^2d^2+d^4\right)}$ which is positive.

2. By the same reasoning, $w^P > w^*$ if $w^P - w^* = \frac{(2b+d)\left(2b^2-d^2\right)(a-c+h-\tau)}{(b+d)\left(4b^2+2bd-d^2\right)}$ is positive, which is true.

3. Similarly, $w^* > w_2^A$, when $w^* - w_2^A = \frac{d^3\left(2b^2-d^2\right)(a-c+h-\tau)}{(b+d)\left(8b^4-8b^2d^2+d^4\right)}$ is positive, which is true.

Proofs

Proof of Proposition 4

By inspection:

1. $\frac{\partial\, q_i^*}{\partial\, r_i} = \frac{2bh}{4\, b^2 -\, d^2} > 0$

2. $\frac{\partial\, p_i^*}{\partial\, r_i} = -\frac{(2\, b^2 -\, d^2)h}{4\, b^2 -\, d^2} < 0$

Proof of Proposition 5

If $w = \tau$ then $r_i^* = r_j^* = \frac{(a-c-\tau)b+h(2b+d)}{(b+d)h}$. Thus, the sharing proportions are greater than one if $(a-c-\tau+h)b > 0$, which is true.

Proof of Proposition 6

1. First, check the output level, although it can be checked the result in proposition 4.

The output level when there is no sharing is $q_i^{r_i=0} = \frac{a-c-w}{2b+d}$.

First, we check the case when the sharing is less than one, so that it is verified that $q_i^{r_i<1} > q_i^{r_i=0}$, so that $\frac{a-c+h-\tau}{b+d} > \frac{a-c-w}{2b+d}$. Reorganizing terms and leaving the equality in terms of w the condition is obtained for the sharing to be positive, that is,

$w > w^+ \equiv \frac{-(a-c)b-(h-\tau)(2b+d)}{b+d}$. Therefore, under this condition it is observed that the level of traffic when there is concession revenue sharing is greater than when it is not.

is straightforward to see that $q_i^{r_i=1} > q_i^{r_i=0}$ and hence, $\frac{a-c-w+h}{2b+d} > \frac{a-c-w}{2b+d}$.

Following the same methodology, prices are analyzed: $p_i^{r_i=0} = \frac{ab+(b+d)(c+w)}{2b+d}$. First we see that $p_i^{r_i<1} < p_i^{r_i=0}$, so that $c+\tau-h < \frac{ab+(b+d)(c+w)}{2b+d}$. By rearranging the terms and clearing for w, $w > w^+ \equiv \frac{-(a-c)b-(h-\tau)(2b+d)}{b+d}$, which shows that, effectively, prices are reduced with concession revenue sharing.

The case when $r_i = 1$ is more trivial. We have that $p_i^{r_i=1} < p_i^{r_i=0}$ since $\frac{ab+(b+d)(c+w-h)}{2b+d} < \frac{ab+(b+d)(c+w)}{2b+d}$.

With respect to social welfare, $SW^{r_i=0} = \frac{(a-c-w)((a-c)(3b+d)+w(b+d)+2(h-\tau)(2b+d))}{(2b+d)^2}$. To check if $SW^{r_i<1} > SW^{r_i=0}$, what we do is to compute and check that $SW^{r_i<1} - SW^{r_i=0} > 0$, so that $SW^{r_i<1} - SW^{r_i=0} = \frac{((a-c)b+w(b+d)+(h-\tau)(2b+d)\ )^2}{(b+d)(2b+d)^2} > 0$, which is true because all terms are positive.

When checking when $SW^{r_i=1} > SW^{r_i=0}$ is not as simple as before. Now, $SW^{r_i=1} - SW^{r_i=0} = \frac{h((a-c)2b+2w(b+d)+h(3b+d)-2\tau(2b+d))}{(2b+d)^2} > 0$, and for the term to be positive, the second term of the numerator must be. Therefore, it is noted that $SW^{r_i=1} > SW^{r_i=0}$ provided that $w > \frac{-(a-c)2b-h(3b+d)+2\tau(2b+d)}{2(b+d)}$. This is true as long as the condition that makes $r_i > 1$ is greater than this value, $w^* > \frac{-(a-c)2b-h(3b+d)+2\tau(2b+d)}{2(b+d)}$.

Proof of Proposition 7

1. We first prove the rankings when $r < 1$.

1.a. Regarding the terms of the contract rankings, we have that $r_2^A > r_i^* > r_i^P > r_1^A$ and $f_2^A > f_i^* > f_i^P > f_1^A$

1.a.i) Notice that $r_2^A - r_i^* = \frac{d^3\left(2b^2-d^2\right)(a-c+h-\tau)}{h(b+d)\left(8b^4-8b^2d^2+d^4\right)}$, which is positive, so that $r_2^A > r_i^*$.

1.a.ii) Similarly, $r_i^* > r_i^P$ if $r_i^* - r_i^P = \frac{(2b+d)\left(2b^2-d^2\right)(a-c+h-\tau)}{h(b+d)\left(4b^2+2bd-d^2\right)}$ is positive, which is true.

1.a.iii) In the same way, $r_i^P > r_1^A$ when $r_i^P - r_1^A = \frac{d^3(2b-d)\left(2b^2-d^2\right)(a-c+h-\tau)}{h\left(4b^2+2bd-d^2\right)\left(8b^4-8b^2d^2+d^4\right)}$ is positive, which is also the case.

Therefore, the full ranking $r_2^A > r_i^* > r_i^P > r_1^A$ is obtained.

1.a.iv) To prove that $f_2^A > f_i^*$, notice that
$f_2^A - f_i^* = b\left(\frac{\left(8b^3-6b^2d-2bd^2+d^3\right)^2}{\left(8b^4-8b^2d^2+d^4\right)^2} - \frac{1}{(b+d)^2}\right)(a-c+h-\tau)^2$ must be positive.

This requires $\frac{\left(8b^3-6b^2d-2bd^2+d^3\right)^2}{\left(8b^4-8b^2d^2+d^4\right)^2} - \frac{1}{(b+d)^2} > 0$. Or equivalently $\frac{\left(8b^3-6b^2d-2bd^2+d^3\right)^2(b+d)^2-\left(8b^4-8b^2d^2+d^4\right)^2}{\left(8b^4-8b^2d^2+d^4\right)^2(b+d)^2} > 0$. The denominator is positive, whereas the numerator is positive as long as $2b^2-d^2 > 0$, which is true.

1.a.v) $f_i^* > f_i^P$ when $f_i^* - f_i^P = b\left(\frac{1}{(b+d)^2} - \frac{2\left(2b^2\varphi+d^2(1-\varphi)\right)}{\left(4b^2+2bd-d^2\right)^2}\right)(a-c+h-\tau)^2$ is positive.

That requires the following term to be positive $\left(\frac{1}{(b+d)^2} - \frac{2\left(2b^2\varphi+d^2(1-\varphi)\right)}{\left(4b^2+2bd-d^2\right)^2}\right)$, or equivalently $\frac{(2b^2-d^2)(8b^2+8bd+d^2-2(b+d)^2\varphi)}{(b+d)^2\left(4b^2+2bd-d^2\right)^2} > 0$, which always holds.

1.a.vi) Finally, $f_i^P > f_1^A$, if
$f_i^P - f_1^A = 2b\left(\frac{1}{\left(4b^2+2bd-d^2\right)^2} - \frac{4b^2(b-d)^2}{\left(8b^4-8b^2d^2+d^4\right)^2}\right)\left(2b^2\varphi+d^2(1-\varphi)\right)(a-c+h-\tau)^2$ is pos-

itive.

It requires that $\left(\frac{1}{\left(4b^2+2bd-d^2\right)^2}-\frac{4b^2(b-d)^2}{\left(8b^4-8b^2d^2+d^4\right)^2}\right)=\frac{d(2b-d)\left(2b^2-d^2\right)\left(16b^4-4b^3d-14b^2d^2+2bd^3+d^4\right)}{\left(4b^2+2bd-d^2\right)^2\left(8b^4-8b^2d^2+d^4\right)^2}$, be positive which is always true since $\left(16b^4-4b^3d-14b^2d^2+2bd^3+d^4\right)$ is decreasing in d and it is positive for $d=b$.

Therefore, the full ranking $f_2^A > f_i^* > f_i^P > f_1^A$ is obtained.

1.b. Regarding price and quantity orderings, we have that $p_i^P > p_1^A > p_2^A > p_i^*$ and $q_2^A > q_i^* > q_i^P > q_1^A$.

1.b.i) In order to prove that $p_i^P > p_1^A$, $p_i^P - p_1^A = \frac{d(2b-d)\left(2b^2-d^2\right)^2(a-c+h-\tau)}{\left(4b^2+2bd-d^2\right)\left(8b^4-8b^2d^2+d^4\right)}$ must be positive which is true.

1.b.ii) In the same way, $p_1^A > p_2^A$ as long as $p_1^A - p_2^A = \frac{\left(4b^4-6b^3d+3bd^3-d^4\right)(a-c+h-\tau)}{8b^4-8b^2d^2+d^4}$ is positive, which is also true.

1.b.iii) Similarly, $p_2^A > p_i^*$ if $p_2^A - p_i^* = \frac{d(b-d)\left(2b^2-d^2\right)(a-c+h-\tau)}{8b^4-8b^2d^2+d^4}$ is positive, which holds true.

Therefore, the full ranking $p_i^P > p_1^A > p_2^A > p_i^*$ is obtained.

1.b.iv) $q_2^A > q_i^*$ if $q_2^A - q_i^* = \frac{\left(2b^3d-bd^3\right)(a-c+h-\tau)}{(b+d)\left(8b^4-8b^2d^2+d^4\right)}$ is positive and it is.

1.b.v) For $q_i^* > q_i^P$, $q_i^* - q_i^P = \frac{\left(2b^2-d^2\right)(a-c+h-\tau)}{(b+d)\left(4b^2+2bd-d^2\right)}$ has to be positive, which is true.

1.b.vi) Finally, $q_i^P > q_1^A$, if
$q_i^P - q_1^A = 2b\left(\frac{1}{4b^2+2bd-d^2} - \frac{2b(b-d)}{8b^4-8b^2d^2+d^4}\right)(a-c+h-\tau)$ is positive. Or equivalently if $\left(\frac{1}{4b^2+2bd-d^2} - \frac{2b(b-d)}{8b^4-8b^2d^2+d^4}\right) = \frac{d(2b-d)\left(2b^2-d^2\right)}{\left(4b^2+2bd-d^2\right)\left(8b^4-8b^2d^2+d^4\right)} > 0$, which is true.

, the full ranking $q_2^A > q_i^* > q_i^P > q_1^A$ is obtained.

c. Regarding SW, CS and the total number of passengers rankings $SW^* > SW^A > SW^P$, $CS^* > CS^A > CS^P$, and $Q^* > Q^A > Q^P$.

1.c.i) To prove that $SW^* > SW^A$, it is straightforward to see that
$SW^* - SW^A = \frac{b(b-d)\left(4b^2-3d^2\right)\left(2b^2-d^2\right)^2(a-c+h-\tau)^2}{2(b+d)\left(8b^4-8b^2d^2+d^4\right)^2}$ is positive.

1.c.ii) To prove $SW^A > SW^P$,
$SW^A - SW^P = \frac{(2b-d)\left(2b^2-d^2\right)^2\left(32b^6-16b^5d-40b^4d^2+12b^3d^3+14b^2d^4+bd^5-2d^6\right)(a-c+h-\tau)^2}{2\left(4b^2+2bd-d^2\right)^2\left(8b^4-8b^2d^2+d^4\right)^2}$ must be positive, which is true. Note that $\left(32b^6-16b^5d-40b^4d^2+12b^3d^3+14b^2d^4+bd^5-2d^6\right) > 0$ can be written as a polynomial of degree six of the ratio $\frac{d}{b} \equiv z \in [0,1]$. It has two real roots which are $z_1 = -1.108$ and $z_2 = 2.812$ and it happens that for $z \in [z_1, z_2]$ the polynomial is positive.

Therefore, the full ranking $SW^* > SW^A > SW^P$ is obtained.

1.c.iii) To prove $CS^* > CS^A$, notice that
$CS^* - CS^A = \frac{1}{2}\left(\frac{2}{b+d} - \frac{b\left(80b^6-64b^5d-92b^4d^2+72b^3d^3+16b^2d^4-12bd^5+d^6\right)}{\left(8b^4-8b^2d^2+d^4\right)^2}\right)(a-c+h-\tau)^2$ is positive as long as the first term is. This term can be written as
$\frac{(b-d)\left(2b^2-d^2\right)\left(24b^5+16b^4d-22b^3d^2-16b^2d^3+bd^4+2d^5\right)}{(b+d)\left(8b^4-8b^2d^2+d^4\right)^2}$, which is positive.

1.c.iv) $CS^A > CS^P$ if
$CS^A - CS^P = \frac{1}{2}b\left(\frac{80b^6-64b^5d-92b^4d^2+72b^3d^3+16b^2d^4-12bd^5+d^6}{\left(8b^4-8b^2d^2+d^4\right)^2} - \frac{8b(b+d)}{\left(4b^2+2bd-d^2\right)^2}\right)(a-c+h-\tau)^2$ is positive. The first term can be written as
$\frac{(2b-d)(2b+d)\left(2b^2-d^2\right)\left(96b^6-32b^5d-152b^4d^2+56b^3d^3+58b^2d^4-24bd^5+d^6\right)}{\left(4b^2+2bd-d^2\right)^2\left(8b^4-8b^2d^2+d^4\right)^2}$, which is positive since the term $\left(96b^6-32b^5d-152b^4d^2+56b^3d^3+58b^2d^4-24bd^5+d^6\right)$ is decreasing in d and positive for $d=b$.

Therefore, the full ranking $CS^* > CS^A > CS^P$ is obtained.

1.c.v) To prove that $Q^* > Q^A$, notice that $Q^* - Q^A = \frac{(b-d)(2b+d)\left(2b^2-d^2\right)(a-c+h-\tau)}{(b+d)\left(8b^4-8b^2d^2+d^4\right)}$ must be positive, which is true.

1.c.vi) $Q^A > Q^P$, if $Q^A - Q^P = \frac{(2b-d)\left(2b^2-d^2\right)\left(4b^2-2bd-d^2\right)(a-c+h-\tau)}{\left(4b^2+2bd-d^2\right)\left(8b^4-8b^2d^2+d^4\right)} > 0$, which is true.
Therefore, the full ranking $Q^* > Q^A > Q^P$ is obtained.

2. Finally, for the case where in all scenarios concession revenues are fully taken by airlines.

To obtain $r=1$ in every scenario, it is required that $w > w_1^A$, and the different fixed payments rank as follows, $f_i^* = f_2^A > f_i^P = f_1^A$.

To prove that $f_i^* = f_2^A > f_i^P = f_1^A$, notice that
$f_i^* - f_i^P = \frac{(1-\varphi)(a-c+h-w)(b(a-c+h)-\tau(2b+d)+w(b+d))}{(2b+d)^2}$. This is positive as long as
$w > w^f = -\frac{(a-c+h)b+\tau(2b+d)}{b+d}$, which is true because $w_1^A > w^f$.

Proof of Proposition 9

Consider we are in the case of two public airports:

$\frac{\partial\ r_i^*}{\partial \alpha} = \frac{\partial \frac{(a-c)(b+\alpha d)+(h-\tau)(2b+(\alpha+1)d)+w(b+d)}{h(b+d)}}{\partial \alpha} = \frac{d(a-c+h-\tau)}{h(b+d)} > 0$

The partial derivative is always positive, which happens in every other case, even though the computation might be slightly different.

However there is a case where the proposition does not adapt completely, and it is when both airports sharing proportions are less than one, $r_1^A, r_2^A < 1$. Then,

$\frac{\partial\ r_2^A}{\partial \alpha} = \frac{8b^2(b-d)d^3(a-c+h-t)(4b^2\alpha-d^2(1+\alpha)^2)}{h(8b^4+d^4(1+\alpha)^2-4b^2d^2(2+\alpha))^2}$

Every term is positive by definition except the last term of the numerator, $(4b^2\alpha - d^2(1+\alpha)^2)$, whose sign is unclear. Accordingly, this term is positive as long as $\alpha > \hat{\alpha} = \frac{2\ b^2 -\ d^2 - 2b\sqrt{\ b^2 -\ d^2}}{d^2}$. This value of α corresponds with the value where the airports change their strategic behavior related with the Proposition 10.

Proof of Proposition 10

To analyze the strategic relationship between airports, we have to know the sign of
$\frac{\partial^2 SW}{\partial\ r_i^* \partial\ r_j^*} = \frac{dh^2\left(4\alpha b^2-(\alpha+1)^2d^2\right)}{\left((\alpha+1)^2d^2-4b^2\right)^2}$

This sign is determined by the sign of $4\alpha b^2 - (\alpha+1)^2 d^2$. Solving this term to obtain the roots we get, $\alpha^- = (2b^2 - d^2 - 2b\sqrt{b^2-d^2})/d^2$, and $\alpha^+ = (2b^2 - d^2 + 2b\sqrt{b^2-d^2})/d^2$, where the term is positive for $\alpha^- < \alpha < \alpha^+$ with $\alpha^+ > 1$ and $0 < \alpha^- < 1$.

Then, airports are strategic substitutes if $\alpha^- < \alpha < 1$, and they are strategic complements as long as $0 < \alpha < \alpha^-$.

Proof of Proposition 11

1. In the case of two private airports with $r_i, r_j < 1$:

$$\frac{\partial SW^P}{\partial \alpha} = \frac{4bd^2\left(2b^2-(\alpha+1)d^2\right)(a-c+h-\tau)^2}{\left(4b^2+2bd-(\alpha+1)d^2\right)^3} > 0$$

2. In the asymmetric case with $r_i, r_j < 1$:

$$\frac{\partial SW^A}{\partial \alpha} = \frac{2bd^2(b-d)^2\left(2b^2-(\alpha+1)d^2\right)\left(8(1-\alpha)b^4+4\left(2\alpha^2+\alpha-1\right)b^2d^2-(\alpha+1)^3d^4\right)(a-c+h-\tau)^2}{\left(8b^4-4(\alpha+2)b^2d^2+(\alpha+1)^2d^4\right)^3} > 0$$

The denominator is positive since it is decreasing in α and positive when evaluated at $\alpha = 0$. Therefore it remains to prove that the next term in the numerator $\left(8(1-\alpha)b^4 + 4\left(2\alpha^2+\alpha-1\right)b^2d^2 - (\alpha+1)^3d^4\right) > 0$. Divide the expression by b^4, in this way a convex quadratic polynomial in ($x = (\frac{d}{b})^2$, with $x \in [0,1]$) is defined. The polynomial $\left(8(1-\alpha)+4\left(2\alpha^2+\alpha-1\right)x-(\alpha+1)^3x^2\right)$ is positive for x in the interval defined by the roots. Note that the mentioned roots are $x^- = \frac{2\left(2\alpha^2+\alpha-1-\sqrt{\alpha\left(2\alpha^3-3\alpha+2\right)+3+}\right)}{(\alpha+1)^3}$ and $x^+ = \frac{2\left(2\alpha^2+\alpha-1+\sqrt{\alpha\left(2\alpha^3-3\alpha+2\right)+3+}\right)}{(\alpha+1)^3}$, with $x^- < 0 < 1 < x^+$, then proving that the term is positive for all $x \in [0,1]$ then the result is proven.

3. In the private and asymmetric case when $r_i, r_j = 1$:

$$\frac{\partial SW}{\partial \alpha} = -\frac{2d(a-c+h-w)((a-c+h)(b+\alpha d)-\tau(2b+(\alpha+1)d)+w(b+d))}{(2b+\alpha d+d)^3}.$$

In order to have $\frac{\partial SW}{\partial \alpha} > 0$, it is required $w < \frac{-(a-c+h)(b+\alpha d)+\tau(2b+(1+\alpha)d)}{b+d}$. This value of w is equal to $w*$. The values that make $r_i, r_j = 1$ are w^P and w_1^A, which are higher than wj, then $\frac{\partial SW}{\partial \alpha} < 0$ for every possible value of w.

4. In the asymmetric case when $r_2^A < 1$ and $r_2^A = 1$: $\frac{\partial SW}{\partial \alpha} > 0$ if:

   (a) $w < \frac{-(a-c+h)(2b-d)+2b\tau}{d} \equiv w_{min}^A$

   (b) $w < \frac{-(a-c+h)(4b^3-2b^2d(1-\alpha)-(b-d)d^2(1+\alpha))-\tau(8b^3-2b^2d(1-\alpha)-2bd^2(1+\alpha))}{(4b^3+4b^2d-(b+d)d^2(1+\alpha))} \equiv w_{max}^A$

The parameter w_{min}^A is out of range, while $w_2^A < w_{max}^A < w_1^A$. Then, $\frac{\partial SW}{\partial \alpha} > 0$ when $w_2^A < w < w_{max}^A$, and $\frac{\partial SW}{\partial \alpha} < 0$ when $w_{max}^A < w < w_1^A$.

5. With dual-till regulation and when $r_i, r_j = 1$:

   $\frac{\partial SW}{\partial \alpha} = -\frac{2d(b+\alpha d)(a-c+h-\tau)^2}{(2b+\alpha d+d)^3} < 0.$

Chapter 4

An efficiency analysis of Spanish airports: a parametric and a non-parametric approach

4.1 Introduction

The airport industry has moved to a situation where every airport operates on its own. This fact has favored the entry of private capital through privatization processes. However, Spain is the only big country that maintains the joint management of a network of airports through a public company, Aeropuertos Españoles y Navigación Aérea (AENA). Even though in 2015 AENA was privatized up to 49 %, the management keeps public. The decision of a joint management was justified on the grounds that complementarities would improve the competitiveness against other European airports.

However, it happens that most airports within the AENA network share a catchment area with other airports. This suggests that there may be concerns about the strategic relationship of the airports and how this may affec their efficiency. There is a debate about the closing of some airports due to their low performance, since keeping them open also affects other neighboring airports that lose passengers, which impedes the explotation of economies of scale.

This Chapter analyzes the technical efficiency of AENA's airports, as well as what factors determine that efficiency. In this way, a ranking between airports can be established, in addition to observing the trend in the period analyzed. On the other hand, the endogenous and exogenous factors that explain the technical efficiency of airports are examined, since inefficiencies are not only the result of managerial decisions, but also depend on external factors.

Regarding the analysis of the technical efficiency of airports, two approaches have been employed in the literature. Those approaches are a non-parametric approach with Data Envelopment Analysis (DEA) and a parametric or Stochastic Frontier Analysis (SFA) approach. Both approaches are used in airport benchmarking. Liebert & Niemeier (2013) present a survey where they review more than fifty papers on benchmarking of airports in different markets using the parametric and/or the non-parametric approach. Other relevant surveys in the transport economics are, for example, De Borger et al. (2002) on public transport, Oum et al. (1999) and Cantos et al. (2012) on the rail sector, and Gonzalez & Trujillo (2009) on seaports.

Both methodologies differ in their model specification and data requirements, which can lead to different results, and that is one of the reasons why both models are used in this Chapter. Farrel (1957) was the first to measure the technical efficiency in a non-parametric form, which led to the development of DEA by Charnes, Cooper & Rhodes (1978). In turn, Aigner & Chu (1968) and Aigner et al. (1977) developed parametric techniques for the same purpose. Over time, both techniques have been improved giving rise to a rich variety of possible models to be used.

The particularity of DEA is that it does not need the specification of a functional form on production, but uses linear programming to build the frontier that is determined by the most efficient airports in the sample. The main limitation of DEA is that it does not allow hypotheses to be tested, since it is not part of a statistical analysis. In contrast, SFA, in addition to explaining inefficiencies, incorporates stochastic random error that accounts for noise. The problem is that it is necessary to specify a functional form between inputs and outputs. There are differences between these models, although the purpose of their use is the same. In this Chapter, both are used to analyze possible differences in the sample and to test the robustness of the results.

Regarding the air transport market, the most relevant articles that analyze airport efficiency through the SFA are Pels et al. (2001), Pels et al. (2003) and Scotti et al. (2012). The latter use a multi-output translogarithmic function, and apply a two-stage process to analyze the competitive determinants of technical efficiency. Regarding DEA, Barros & Dieke (2008) and Barros (2008) are the closest to this Chapter, since they run an analysis in two stages to an output oriented function applying the techniques of Simar & Wilson (2007) for the second stage.

The literature has also focused on specifically studying the technical efficiency of Spanish airports. Martín & Roman (2001) and Tapiador et al. (2008) did an analysis applying DEA. On the other hand, Martín et al. (2009) analyzes efficiency with a cost function, while the focus of this Chapter is on a production function. Finally, Tovar & Martín-Cejas (2009, 2010) take an SFA with an input-oriented production function. The purpose of this Chapter is to analyze the technical efficiency of AENA's Spanish airports network through a two-step process using an SFA with a multi-output and output oriented production function and a DEA output oriented and variable returns to scale.

The reasons for this analysis is to analyze AENA's decisions regarding management and the privatization of the network. AENA has decided to carry out the partial privatization of the network, so that all airports operate under the same entity that makes the decisions. The literature has shown that the efficiency of airports does not depend on their ownership. On the other hand, there are other aspects that are affected by this aspect. In particular, the development of the commercial area of airports. AENA has a performance in this area below the global average and much lower than the key airports in the industry. Oum & Yu (2004) concluded that the higher the share of non-aeronautical revenues, the higher the productivity of airports. Therefore, placing the focus in this area would favor the increase of efficiency due to the complementarities in these two areas. On the other hand, it is observed how AENA increases its non-aeronautical revenues year after year. As indicated by Oum et al. (2006), the private airports have to put the focus on the development of the commercial area which in turn, indirectly, improves the technical efficiency of the airports. This is a key aspect to take into account in the future development of the industry and the AENA network.

The next aspect to analyze is the joint management decision. AENA has preferred to maintain the integrity of the network through the principle of solidarity between airports. However, under this decision the free competition of the airports is limited, in addition to a decision-making more adapted to the situation of each one. Tapiador et al. (2008) states that each airport has aspects that determine its functionality, so an individualized management would allow a better decision-making. AENA has simply divided the airports into three categories, which does not allow adequate adaptation within each of them. An individualized management would ensure competition in the market, nonexistent by how the network is formed, and the development of new market strategies.

The following section describes the current situation of the Spanish airport market. Sections 4.3 shows the methodology applied in the analyzes of the first and second stages. Section 4.4 presents the data. In Sections 4.5 and 4.6, the estimations and the interpretation of the results of the analysis of both, airport efficiencies and their conditioning factors, are carried out. Section 4.7 presents an analysis over the non-aeronautical revenues of airports and their significance. Finally, Section 4.8 presents the conclusions and suggestions for future research.

4.2 The Spanish airport system

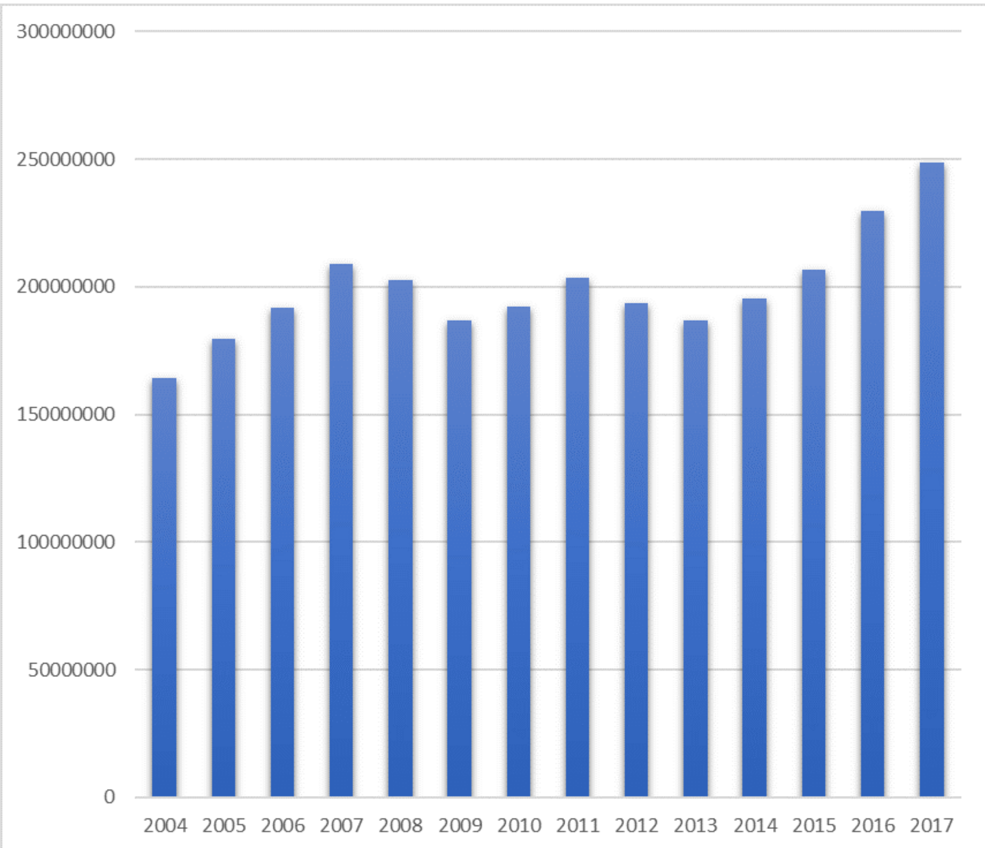
Nowadays, AENA is a public company that manages the network of Spanish airports. This network consists of 46 airports and 2 heliports. In addition, AENA manages, through its international subsidiary, another 15 airports in Europe and America. AENA is organizationally attacthed to Ministerio de Fomento and jointly take all management decisions such as the allocation of slots, airport charges, accounting policies, investments and fees, negotiations with airlines, etc.

In 2011 the process of privatization of the airport sector in Spain began with the creation of a mercantile society, Sociedad Mercantil AENA Aeropuertos, S.A. This company keeps exercising the functions of management of airport services, while the public entity of AENA supervises the competence in air navigation. The provision of control tower services is also liberalized in some airports, with the intention of reducing costs and increasing the competitiveness of air transport.

The creation of this mercantile society occurred as a step to privatize the company. In 2014, a partial minority privatization of 49 % was made, and a 21 % of which was distributed among reference partners: Corporación Financiera Alba (8 %), TCI (6.5 %) and Ferrovial (6.5 %). The rest, 28 %, went public in February 2015.

As for the data of AENA, Figure 4.1 shows the evolution of passenger air traffic in Spain since 2004. For the last five years of data, 2013-2017, the number of passengers has increased by 33 %, to reach almost 250 million. The air transport movements, ATM, increased by 21 % to more than 2.1 million movements. This increase boosted job growth, which rose by 12.5 % to reach 8,234 in 2017. Other interesting data is the large increase in EBITDA, with a growth of 57 % and more than 2,500 million of euros. The good development of the commercial area must be highlighted, which almost doubled in this period increasing by 90 %, up to more than 1,000 million euros.

Fig. 4.1 AENA passengers between 2004-2017.



The decision of the Spanish government was to maintain an integrated and centralized airport system. This decision is different from that adopted by many other countries such as France, Italy, Germany and the UK in Europe, and Canada and the United States in America. These countries decided to establish a decentralized management of airports. Spain opted for centralization to avoid the possible negative effects of competition between the airports of the network, and by the position of AENA in Latin America.

Another main reason for maintaining joint and centralized management is due to the single or common fund. This allows AENA to take advantage of economies of scale when accessing the credit for investments. However, the most important thing is that there is a policy of solidarity and redistribution, where financial resources are transferred from profitable to non-profitable airports. This fact can raise incentive problems. Airports with losses have no incentives to reduce them, while those with profits also have no incentive to generate more profitability if they cannot appropriate it. It should be pointed out that the surplus far exceeds the amount of deficit airports.

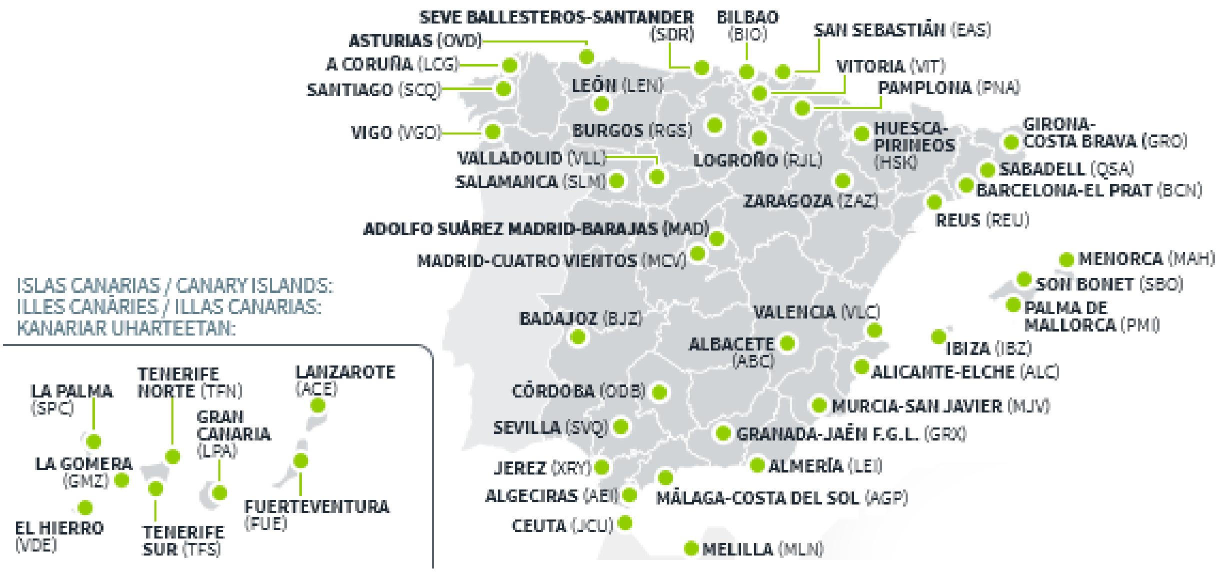
This measure on cross-subsidies is usually used to ensure the connectivity of remote areas where there is no alternative, also known as public services obligation routes (PSOs). But that is not the case of Spain, especially in the peninsula. This has led to an excess of small underutilized airports, affecting public financial resources (European Commission, European Court of Auditors, 2014). This decision, therefore, affects the efficiency of airports and the network, and has raised a question about airport competition in Spain.

To analyze the competition in the Spanish airport network, the literature distinguishes three types of competition[1]

[1]Extracted from Santaló & Socorro (2015).

Competition for catchment area or spatial competition. 26 airports in the network have at least one airport less than 130 km away, as can be seen in Figure 4.2. This indicates that there is a strong competitive factor to attract the potential passengers within the catchment area. However, the fact that airports are centralized does not actually allow the existence of such competition. We should find airports offering the same or similar routes, but empirical evidence shows that nearby airports tend to specialize or assume excess demand in certain routes. Then, the intensity of competition, in case the management was individual, remains uncertain.

Fig. 4.2 Network of airports managed by AENA



Competition for tourist destinations. Spain has 14 tourist airports. These airports face two types of competition. Competition within the Spanish market, and competition with other international destinations. This is one of the reasons why AENA claimed to remain a centralized management.

Competition for connection traffic. This is the competence of hub airports. In Spain there are two hub airports, Adolfo Suárez Madrid-Barajas and Barcelona-El Prat. The international competitive pressure for connection traffic is high, therefore, in a hypothetical case in which both airports compete, the effect would not be too significant.

Within the efficiency analysis, privatization does not guarantee that better results are achieved. However, competition may encourage higher levels of efficiency. An appropriate way to achieve competition would be through an individualized management of airports. In this way, each airport would look after its interests taking the most appropriate measures to capture traffic and to generate a positive impact in the territory where it is located.

Airport competition brings benefits for all agents in the economy. The most directly affected are the airlines, since they receive a better service and reduce the costs of the derived services. This fact has a direct impact on airfares, as long as the airlines pass on to their customers the reduction in costs. In this case, the demand would increase, producing a positive externality in the commercial part of the airport.

It is our purpose to analyze the efficiency of the airports in the AENA network. As indicated by Martín et al. (2009), “there are always different stakeholders, viz., regional planners, regulators or investors who need information on the cost structure and efficiency of airports”. That is to say, the analysis of the efficiency has policy and managerial implications and will become more relevant with potential changes in the air industry.

4.3 Methodology

It has been noted that SFA and DEA are two widely used methods in the literature and both allow the inclusion of multiple inputs and output to calculate production frontiers and measure efficiency with respect to the constructed frontier. The efficiency analysis carried out in this Chapter is derived from two sources: the estimation of the efficiency values and the analysis of determinants of efficiency. Each of them is presented below following the two approaches previously named, parametric (SFA) and non-parametric (DEA).

4.3.1 Estimation of parametric efficiency scores

A stochastic distance function econometric model is used to obtain the technical efficiencies of airports. There are some issues when applying DEA that SFA overcomes, such as the sensitivity to the number of inputs and outputs used relative to the number of observations, the presence of outliers affecting the efficiency levels of the rest of the airport, and the lack of dynamism and justification behind the efficiency scores, (Zarraga, 2017). The function used is the Translog Multioutput Distance Function that reflects how many inputs are used to generate the outputs. Then, the more resources the airport has, the more production can be obtained.

The data set does not include monetary variables, but physical inputs and outputs with the aim of measuring technical efficiency. Then, the input combination yielding the minimum cost is not identified. In this case, an output oriented stochastic distance function seems to be more appropriate than an input oriented. This is because, at least in the short run, many inputs in airport operation are indivisible.

In this framework, the airports' production possibility set is defined as $P(x)$ - i.e., the output vector $y\varepsilon R^M_+$ that can be obtained using the input vector $x\varepsilon R^M_+$. that is: $P(x) = y\varepsilon R^M_+ : \{x \quad can \quad produce \quad y\}$. By assuming that the technology, $P(x)$, satisfies the axioms listed in Fare et al. (1994), the Shephard (1970) output-oriented distance function is introduced:

$$D_O(x,y) = min\{\theta : (y/\theta)\varepsilon P(x)\},$$

where $\theta \leq 1$. The distance function is non-decreasing, positively linearly homogeneous, and convex in y, and decreasing in x, Lovell et al. (1994). $D_O(x,y) = 1$ means that y is located on the outer boundary of the production possibility set - i.e., $D_O(x,y) = 1$ if $y \varepsilon IsoqP(x) = \{y : y\varepsilon P(x), \quad \omega y \notin P(x), \quad \omega > 1\}$. If instead $D_O(x,y) < 1$, y is located below the frontier; in this case, the distance represents the gap between the observed output and the maximum feasible output.

Following Coelli and Perelman (2000), the translog distance function is given by:

$$\begin{aligned} ln(D_{Oit}/y_{Mit}) = \alpha_0 + \sum_{m=1}^{M-1} \alpha_m lny^*_{mit} + \frac{1}{2}\sum_{m=1}^{M-1}\sum_{n=1}^{M-1} \alpha_{mn} lny^*_{mit} lny^*_{nit} \\ + \sum_{k=1}^{K} \beta_k lnx_{kit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{kl} lnx_{kit} lnx_{lit} \\ + \sum_{k=1}^{K}\sum_{m=1}^{m-1} \gamma_{km} lnx_{kit} lny^*_{mit}, \end{aligned} \tag{4.1}$$

where i denotes the ith airport in the sample. M is the number of outputs denoted by y, and K is the number of inputs denoted by x. D_{Oit} is the output distance from the frontier of firm i in period t and $y^*_{mit} = y_{mit}/y_{Mit}$. Symmetry is imposed as:

$$\alpha_{mn} = \alpha_{nm}; \quad m,n = 1,2,...,M, \quad and \quad \beta_{kl} = \beta_{lk}; \quad k,l = 1,2,...,K.$$

The required the restriction for homogeneity of degree +1 in outputs are:

$$\begin{aligned} \sum_{m=1}^{M} \alpha_m = 1, \\ \sum_{n=1}^{M} \alpha_{mn} = 0, \quad m = 1, \quad 2, \quad ..., \quad M, \\ \sum_{m=1}^{M} \gamma_{km} = 0, \quad k = 1, \quad 2, \quad ..., \quad K. \end{aligned} \tag{4.2}$$

Then, Equation (4.1) can be written as $ln(D_{Oit}/y_{Mit}) = TL(x_{it}, y_{it}/y_{Mit}, \alpha, \beta, \gamma)$, where TL stands for the translog function. Hence:

$$-ln(y_{Mit}) = TL(x_{it}, y_{it}/y_{Mit}, \alpha, \beta, \gamma) - ln(D_{Oit}) \tag{4.3}$$

where, $ln(D_{Oit})$ is non-observable and can be interpreted as an error term in a regression. If it is replaced with $(v_{it} - u_{it})$, the typical SFA composed error term is achieved: v_{it} are random variables that are assumed to be *iid* as $N(0, \sigma_v^2)$ and independent of the u_{it}; the latter are non-negative random variables distributed as $N(m_{it}, \sigma_u^2)$. The inefficiency scores are given by u_{it}, whereas v_{it} represent the random shocks. Hence, the translog output oriented stochastic function for estimation can be written as:

$$\begin{aligned} -ln(y_{Mit}) = \alpha_0 + \sum_{m=1}^{M-1} \alpha_m lny^*_{mit} + \frac{1}{2} \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} lny^*_{mit} lny^*_{nit} \\ + \sum_{k=1}^{K} \beta_k lnx_{kit} + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} lnx_{kit} lnx_{lit} \\ + \sum_{k=1}^{K} \sum_{m=1}^{m-1} \gamma_{km} lnx_{kit} lny^*_{mit} + v_{it} - u_{it}. \end{aligned} \tag{4.4}$$

To investigate the determinants of inefficiency, a single-stage estimation procedure following Battese and Coelli (1992) is applied, where the technical inefficiency effect, u_{it} in Eq. (3) can be specified as:

$$u_{it} = \{exp[-\eta(t-T)]\} u_{it} \tag{4.5}$$

This model is such that the non-negative inefficiencies, u_{it}, decrease, remain constant or increase as t increases, if $\eta > 0$, $\eta = 0$ or $\eta < 0$, respectively. The parameter η is an unknown scalar, whereas T represents the time periods. The case in which η is positive is likely to be appropriate when firms tend to improve their level of technical efficiency over time. This equation characterizes the improving learning curve over time.

The technical efficiency of airport i at period t is defined as follows:

$$TE_{it} = e^{-u_{it}} \tag{4.6}$$

where $0 \leq TE_{it} \leq 1$.

Tobit analysis of determinants of efficiency

Regression analysis is often applied in a second stage in which the efficiency estimate is regressed against a set of potential variables. Then, a Tobit regression model is used since the dependent variable has a left limit of 0 and an upper limit of 1. Thus, the Tobit model is represented in the following equation:

$$TE_{it} = a + \beta_k W_{itk} + \varepsilon_{it} \tag{4.7}$$

where TE_{it} represents the efficiency estimated for airport i at time t, W_i is used to interpret the dependent variables, α is a constant term, β_k indicates the parameter entries for each explanatory variable, and ε_{it} is a random error vector.

4.3.2 Estimation of non-parametric efficiency scores

Charnes et al. (1981) describe the DEA methodology as "a mathematical programming model applied to observational data that provides a new way of obtaining empirical estimates of external relations; such as the production functions and/or efficient production possibility surfaces that are a cornerstone of modem economics."

Originally, DEA was designed as a non-parametric method of frontier estimation to evaluate the relative efficiency of decision-making units (DMUs), which use multiple inputs to produce multiple outputs, without a clear identification of the relation between them. That is, DEA assumes neither a specific functional form for the production function nor the inefficiency distribution. Basically, there are two basic DEA models; variable returns to scale (VRS), and constant return to scale (CRS). DMUs that do not lie on the frontier are inefficient and the measurement of the degree of inefficiency is determined by the selection of the model.

There must be a good understanding over the data set used. It is especially important to have some idea about the hypothetical returns to scale that exist in the industry, because this is going to determine the envelopment surface-constant return to scale CRS (Charnes et al., 1978) or variable return to scale VRS (Banker et al., 1984) of the model. For the purpose of this analysis, VRS is chosen because there are airports of different sizes and types, that is, with different scales.

Furthermore, there are two main orientations: input and output. In each case, efficiency is measured in terms of a proportional change in inputs or outputs. An input orientation minimizes inputs while satisfying at least the given output levels, whereas the output orientation maximizes outputs without requiring more of any observed input values. The units involved in the study determine the selection of the orientation. As explained for the SFA model, an output-oriented model is used because of the indivisibility of airport inputs in the short run.

The standard procedure in the non-parametric approach is followed. For each period t, there is a set of N airports $(i = 1,...,N)$. Each airport produces a vector of y_{im} outputs $(m = 1,...,M)$ using x_{ik} inputs $(k = 1,...,K)$. The measurement of each airport's efficiency is obtained through the comparison with a linear combination of the total number of airports included in the analysis. Formally, the output-oriented DEA efficiency for airport i is calculated through the following linear programming problem:

$$\begin{aligned} & Max \quad \theta_j^{VRS} \\ s.t. \quad & \sum_i \lambda_i y_{im} \geq \theta_j y_{jm} \quad \forall m, \\ & \sum_i \lambda_i x_{ik} \geq y_{jk} \quad \forall k, \\ & \sum_i \lambda_i = 1 \\ & \lambda_i \geq 0 \end{aligned} \tag{4.8}$$

The solution of this problem gives N optimal values for θ^{VRS}, that is, the airports efficiencies when using VRS and an output oriented analysis. The efficiencies are expressed in such a way that $0 \leq \theta^{VRS} \leq 1$.[2] Those airports with $\theta^{VRS} < 1$ are considered inefficient, while they are efficient when meet $\theta^{VRS} = 1$. The parameter λ shows the weights assigned to each airport to perform the analysis.

Simar-Wilson analysis of determinants of efficiency

For this case, the approach of Simar & Wilson (2007) has been used. A common practice in the DEA literature has been the use of the Tobit-estimator until demonstrated the inadequacy of such approach. Therefore, those papers that have used a two-step analysis are invalid according to Simar & Wilson (2007), who showed a data generation process (DGP) that is consistent when using a second stage. This approach is based on a truncated-regression with a bootstrap process. Then, the econometric model is given by:

$$\theta_{it}^{VRS} = \alpha + Z_{it}\delta_i + \varepsilon_{it}, \quad i = 1, ..., n, \tag{4.9}$$

[2]The efficiency measure considered as the technical efficiency is calculated as the inverse of the maximum proportional output that can be obtained for the indicated inputs, $\frac{1}{\theta_j^{VRS}}$.

where,

$$\varepsilon_{it} \sim N(0, \sigma_{\varepsilon}^2), \quad such \quad that \quad \varepsilon_{it} \geq 1 - \alpha - Z_{it}\delta, \quad i = 1, ..., n \tag{4.10}$$

In equation (4.9), $\theta_{it}^{VRS} \varepsilon\,(0,1]$ is the efficiency calculated with the DEA technique, α is the constant term, ε_{it} is the statistical noise and Z_{it} is a vector that contains the variables that try to explain the efficiency. Since θ_{it}^{VRS} is bounded by unity, $\varepsilon_{it} \geq 1 - \alpha - Z_{it}\delta$, and is assumed that the distribution is truncated normal with zero mean.

4.4 Data

Spain has a total of 51 airports, 46 of which are managed by AENA and the other 5 are privately owned or inoperative. Figure 4.2 shows the map of the AENA airport network in Spain, while Table 4.1 shows a classification of these airports according to their typology.

From Table 4.1 it can be seen that AENA has two heliports and several air military bases that it manages together with the Spanish Armed Forces. Some of these airports do not have civil traffic. Therefore, for the analysis of this Chapter, there is a total of 38 airports in the AENA network, where heliports and general aviation airports are excluded from the analysis. That is, the list is reduced to hub, touristic and regional airports.[3] The data included in the analysis are collected from the public information of AENA.

[3] Albacete and Melilla are excluded because of their very low activity. Vitoria is also excluded because it is specialized in cargo instead of passengers.

Table 4.1 Types of airports managed by AENA

Type of Airports	Number of airports
Hub: Adolfo Suárez Madrid-Barajas and Barcelona-El Prat.	2
Touristic: Alicante-Elche, Almería, Fuerteventura, Girona-Costa Brava, Gran Canaria, Ibiza, La Palma, Lanzarote, Málaga-Costa del Sol, Menorca, Palma Mallorca, Reus, Tenerife Sur and Valencia.	14
Regional: A Coruña, Albacete, Asturias, Badajoz, Bilbao, Burgos-Villafría, El Hierro, FGL Granada-Jaén, Jerez, La Gomera, León, Logroño-Agoncillo, Melilla, Murcia-San Javier, Pamplona, Salamanca, San Sebastián, Santander, Santiago, Sevilla, Tenerife Norte, Valladolid, Vigo, Vitoria and Zaragoza.	25
Heliport: Algeciras and Ceuta	2
General aviation: Córdoba, Huesca-Pirineos, Madrid-Cuatro Vientos, Sabadell and Son-Bone	5

For the first stage where airport efficiency is analyzed, a balanced panel with a total of 152 observations is used, since the data collected is from 38 airports in the 2011-2014 period. This period has been chosen because of data availability. A multi-input/multi-output distance function output oriented with three outputs and three inputs is used. Table 4.2 shows a summary of the descriptive statistics of these six variables. These variables are broadly used in the literature, as Liebert & Niemeier (2013) present in their survey. The financial variables, NAR and EMP, are deflated and expressed in 2011 euros.

Table 4.2 Descriptive Statistics of Output (O) and Input (I) Variables

	Mean	**Std. Dev.**	**Min**	**Max**
ATM (O)	47669.78	76213.18	1201	429390
SIZE (O)	73.66409	40.7989	2.290864	153.504
NAR (O) *mill.*	17.92023	37.44989	.01	207.0323
EMP (I) *mill.*	9.548649	12.30422	.460333	79.58212
RUNW (I) *meters*	3534.414	2511.259	1250	15450
TERM (I) m^2	90938.5	190723.8	2326	955305

Three outputs are considered. The annual number of aircraft movements (ATM), the average size of aircraft (SIZE), and the non-aeronautical revenue (NAR). Regarding the ATM, Figure 4.3 shows its evolution since 2004, and reflects the negative impact caused by the financial crisis in Spain in 2007. Nowadays, ATM has exceeded 2004 values, but has not yet achieved full recovery, though a similar trend will allow to close the gap shortly.

Fig. 4.3 Air Transport Movements between 2004-2017

The average size of aircraft is defined as the ratio between yearly passenger volume and ATM, such as $SIZE = PAX/ATM$[4]. This output is taken into account to measure the relative efficiency of each airport due to the fact that in the sample there are airports of different categories. In the hubs, or connecting airports, larger aircraft usually allow greater movement of people and, therefore, a more efficient behavior. This contrasts with the type of existing aircraft in regional airports that are smaller and with a much lower capacity.

The non-aeronautical revenue, NAR, is also analyzed. Increasingly, airports are relying on this type of income to make improvements and investments. It is therefore important to control for this element as it is an indicator of how efficiently an airport uses its facilities and the behavior of passengers. AENA, compared to other airports, is not well positioned with respect to the commercial development of airports, which indicates that there is a great potential to be exploited.

With regard to inputs, the deflated costs of each airport in employees (EMP), the length of runways in meters (RUNW) and the area in square meters of the airport terminal (TERM) are taken into account. Regarding employment, we do not have data on the number of employees per airport, however, since it is a single company that manages all workers and is under a public management, an approximation is made using the employee costs of each airport. It is understood that all workers, no matter which airport they are, belonging to the same company, have equal salaries.

As a measure to analyze the operational capacity of the airport, the runway length is used. 31 of the 38 airports analyzed have only one runway. The Adolfo Suárez Madrid-Barajas airport has four runways, the most numerous, followed by Barcelona-El Prat, which has three.

[4]This specification of the variable SIZE is used by Oum et al. (2006) and Tovar & Martín-Cejas (2009, 2010), among others.

Finally, the area of the terminal is used. This variable directly influences the commercial development of airports. The growth of terminals and runways is not linear, but occurs in a discrete way. Therefore, decisions about investing in these variables is important because it affects the efficiency of airports in the short and long term.

Table 4.3 Pearson Correlation of Output (O) and Input (I) Variables

	ATM (O)	SIZE (O)	NAR (O)	EMP (I)	RUNW (I)	TERM (I)
ATM (O)	1.0000					
SIZE (O)	0.5192	1.0000				
NAR (O)	0.9706	0.5078	1.0000			
EMP (I)	0.9594	0.6015	0.9461	1.0000		
RUNW (I)	0.8937	0.4221	0.8910	0.8719	1.0000	
TERM (I)	0.9470	0.4770	0.9724	0.9312	0.8821	1.0000

Table 4.3 shows the Pearson correlation coefficients. It is observed how the inputs are correlated showing a congruence between the operative and functional part of the airports. It is also observed how the outputs, ATM and NAR are related to each other. This correlation is to be expected since a greater number of passengers leads to the commercial revenues of the airport growing. On the other hand, there is a correlation between outputs and inputs showing that airports try to make an optimum use of their facilities.

4.5 Efficiency of airports

This section analyzes the results regarding the efficiency scores of airports. In this first stage, the technical efficiencies are obtained by applying the techniques described above, SFA and DEA.

4.5.1 SFA results

The following multi-output stochastic distance function is estimated in order to obtain the efficiency values:

$$-ln(ATM_{it}) = TL(SIZE_{it}/ATM_{it}, NAR_{it}/ATM_{it}\alpha, EMP_{it}, RUNW_{it}, TERM_{it}, \alpha, \beta, \gamma) + v_{it} - u_{it} \tag{4.11}$$

where ATM_{it} is the normalizing output (i.e., $SIZE_{it}$ and NAR_{it} are expressed in ATM_{it} terms), α is a vector of coefficients for $SIZE_{it}/ATM_{it}$ and $NAR_{it}/ATM_{it}\alpha$, β is a vector of coefficients regarding inputs, and γ is a vector of coefficients related to output-input interactions.

Table 4.4 presents the results. Of the first order coefficients, the only one that is significant is non-aeronautical revenue (NAR'), which demonstrates the strong relationship between the number of flights and commercial revenues obtained by an airport. It is logical to think that the more people attending an airport, the non-aeronautical revenues increase by the complementarity between both demands. Concerning second-order coefficients, the size of the aircraft ($SIZE'$), non-aeronautical revenues (NAR') and the runway length ($RUNW$) are statistically significant. Furthermore, some interaction effects are statistically significant.

Table 4.4 SFA estimates

Parameter	**Estimate**	**Est. Error**
Constant	17.573	13.090
SIZE’	1.000	1.065
NAR’	2.800***	1.043
EMP	1.161	0.849
RUNW	1.887	2.157
TERM	-0.544	0.960
SIZE’2	-0.165***	0.056
NAR’2	0.092*	0.050
SIZE’ x NAR’	0.027	0.039
EMP2	-0.158	0.099
RUNW2	-0.601***	0.207
TERM2	-0.076	0.052
EMP x RUNW	0.130	0.116
EMP x TERM	-0.100**	0.052
RUNW x TERM	0.051	0.129
EMP x SIZE’	-0.067	0.042
EMP x NAR’	0.129*	0.069
RUNW x SIZE’	-0.111	0.145
RUNW x NAR’	-0.171	0.158
TERM x SIZE’	-0.150***	0.045
TERM x NAR’	-0.043	0.064
Log-likelihood	135.461	
Nobs	152	

Note *, **, *** denote significance at 10 %, 5 % and 1 % respectively; and ’ denotes normalized output (SIZE/ATM and NAR/ATM)

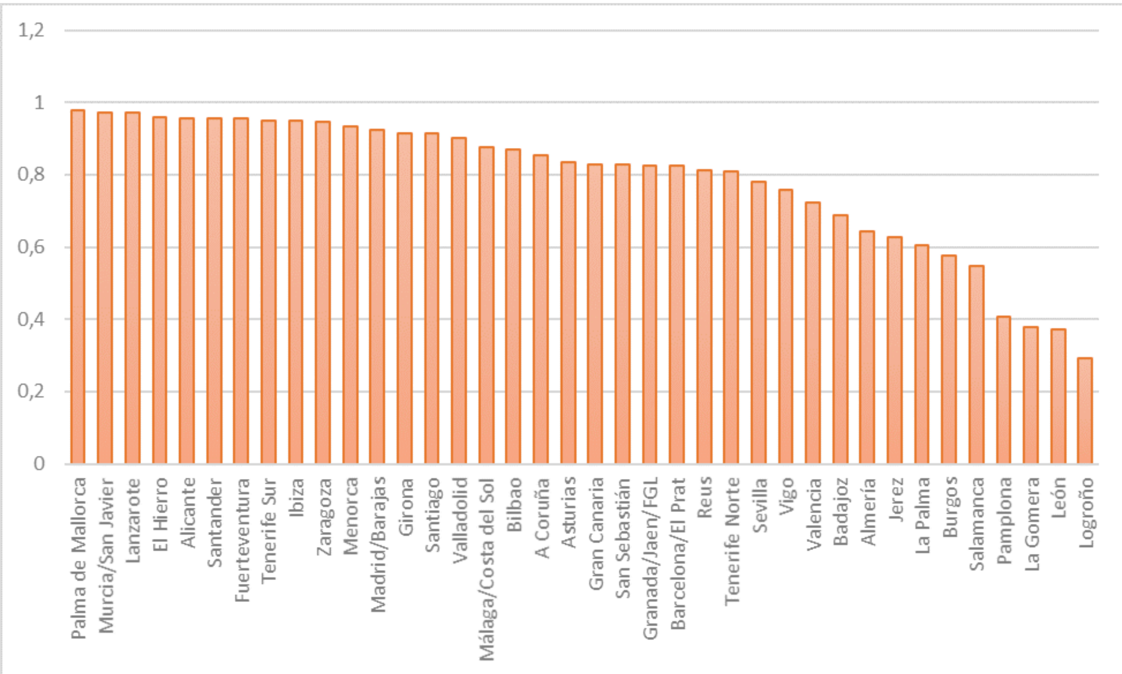
The technical efficiency scores of airports per year are gathered in Table 4.5. The average is around 0.8, which matches with Tovar & Martín-Cejas (2009, 2010). Even so, there are significant differences between airports, since there are airports that almost reach the unit with very little inefficiency, while there are cases that are only 30 %. The trend has been decreasing in the years of the sample. On average, a 3.24 % efficiency was lost. The airport that has seen its efficiency reduced the most has been Logroño. As can be seen in Figure 4.2, Logroño shares a catchment area with five airports, the airport, together with Bilbao, with most surrounding airports. On the other hand, those that have suffered the least losses have been the most efficient airports named previously.

Table 4.5 Airport's Technical SFA Efficiency Scores

Airport	2011	2012	2013	2014	Mean	% Var
A Coruña	.870	.865	.859	.853	.862	-1.90
Alicante	.962	.960	.959	.957	.959	-.529
Almería	.677	.665	.653	.641	.659	-5.24
Asturias	.853	.848	.841	.835	.844	-2.16
Badajoz	.718	.708	.697	.686	.702	-4.46
Barcelona/El Prat	.845	.839	.832	.825	.835	-2.29
Bilbao	.885	.880	.875	.870	.877	-1.67
Burgos	.615	.602	.589	.575	.596	-6.48
El Hierro	.964	.963	.961	.960	.962	-.49
Fuerteventura	.961	.960	.958	.956	.959	-.53
Girona	.925	.922	.918	.915	.920	-1.06
Gran Canaria	.846	.840	.834	.827	.837	-2.27
Granada/Jaen/FGL	.845	.839	.832	.826	.836	-2.29
Ibiza	.955	.953	.951	.949	.952	-.629
Jerez	.664	.652	.640	.628	.646	-5.49
La Gomera	.427	.411	.395	.379	.403	-11.10
La Palma	.644	.631	.619	.606	.625	-5.90
Lanzarote	.975	.974	.973	.972	.973	-.341
León	.418	.402	.386	.370	.394	-11.36
Logroño	.340	.324	.308	.293	.316	-13.85
Madrid /Barajas	.933	.930	.927	.924	.929	-.944
Málaga/Costa del Sol	.889	.885	.880	.875	.882	-1.60
Menorca	.941	.939	.936	.934	.938	-.82
Murcia/San Javier	.976	.975	.973	.972	.97	-.33
Palma de Mallorca	.980	.979	.978	.977	.978	-.27
Pamplona	.454	.438	.422	.407	.430	-10.34
Reus	.832	.826	.819	.812	.822	-2.49
Salamanca	.587	.574	.560	.546	.567	-7.08
San Sebastián	.846	.840	.833	.827	.836	-2.28
Santander	.961	.960	.958	.956	.959	-.53
Santiago	.924	.920	.917	.914	.919	-1.08
Sevilla	.804	.796	.788	.780	.792	-2.96
Tenerife Norte	.831	.824	.817	.810	.820	-2.52
Tenerife Sur	.956	.954	.952	.950	.953	-.61
Valencia	.751	.742	.732	.722	.737	-3.87
Valladolid	.912	.908	.904	.900	.906	-1.25
Vigo	.785	.776	.768	.759	.772	-3.29
Zaragoza	.953	.951	.949	.947	.950	-.65
Average	**.808**	**.801**	**.795**	**.788**	**.798**	**-3.24**

Figure 4.4 shows a ranking of airports with respect to their TE in 2014. The five most efficient airports in 2014 with more than 0.95 of average TE are Palma de Mallorca, Murcia/San Javier, Lanzarote, El Hierro and Alicante. On the other hand, the three most inefficient are La Gomera, León and Logroño. Airports are inefficient by definition, but you can find cases with very significant inefficiencies. Eliminating some exception, these airports are located in the interior of the peninsula. They are regional airports in areas of low tourist interest, with low population densities and that often share an area of influence with other nearby airports. On the other hand, it can be seen how the first nine airports are located on the coast. These airports are located in areas of high tourist interest. It seems that an important element is the location and here in Spain the tourist attraction of sun and beach prevails.

Fig. 4.4 Ranking of airports by Technical Efficiency in 2014



4.5.2 DEA results

When obtaining the values of efficiency using the non-parametric DEA technique, the three inputs and the three outputs previously exposed are used without altering. In this case, the imposition of any functional form is not required. The DEA efficiencies can be calculated in different ways. In this study, efficiencies are estimated through an output-oriented approach, assuming that airports aim to maximize the profits they obtain from their activities. In addition, variable returns to scale between inputs and outputs are assumed following the model presented by Banker et al. (1984). Table 4.6 shows the efficiency of the airports in the AENA network analyzed.

Table 4.6 Airport's Technical DEA Efficiency Scores

Airport	2011	2012	2013	2014	Mean	%Var
A Coruña	.827	.755	.809	.866	.814	4.72
Alicante	.977	.988	1	1	.991	2.30
Almería	.564	.486	.695	.676	.605	19.86
Asturias	.803	.877	.884	.805	.843	.229
Badajoz	.795	1	.823	1	.904	25.64
Barcelona/El Prat	1	.987	.989	1	.994	0
Bilbao	1	.837	1	.998	.958	-.17
Burgos	1	.640	.622	.626	.722	-37.33
El Hierro	1	.600	.952	1	.888	0
Fuerteventura	.922	.851	.975	.994	.936	7.78
Girona	.880	.832	.964	.861	.884	-2.17
Gran Canaria	1	.920	.934	.913	.942	-8.61
Granada/Jaen/FGL	.660	.538	.607	.600	.601	-9.12
Ibiza	1	.918	.984	1	.975	0
Jerez	.993	.922	1	.911	.956	-8.26
La Gomera	.570	.316	.484	.551	.480	-3.37
La Palma	.619	.569	.635	.646	.617	4.30
Lanzarote	1	.961	1	1	.990	0
León	.420	.326	.404	.419	.393	-.20
Logroño	.343	.286	.321	.367	.329	6.85
Madrid /Barajas	1	1	.961	1	.990	0
Málaga/Costa del Sol	1	.856	.860	.876	.898	-12.37
Menorca	.693	.684	.799	.813	.747	17.29
Murcia/San Javier	1	.977	1	1	.994	0
Palma de Mallorca	1	.992	1	1	.998	0
Pamplona	.403	.299	.430	.401	.383	-.36
Reus	.765	.621	.721	.698	.701	-8.78
Salamanca	1	.722	1	.825	.886	-17.46
San Sebastián	1	1	.969	1	.992	0
Santander	.760	.678	.812	.736	.747	-3.13
Santiago	.810	.764	.848	.831	.813	2.57
Sevilla	.790	.681	.730	.739	.735	-6.55
Tenerife Norte	.979	.798	1	.912	.922	-6.86
Tenerife Sur	.974	.979	1	1	.988	2.65
Valencia	1	.837	.890	.897	.906	-10.24
Valladolid	.732	.592	.721	.699	.686	-4.47
Vigo	.673	.612	.620	.613	.629	-8.94
Zaragoza	.587	.474	.532	.504	.524	-14.05
Average	**.830**	**.741**	**.815**	**.810**	**.799**	**-1.79**

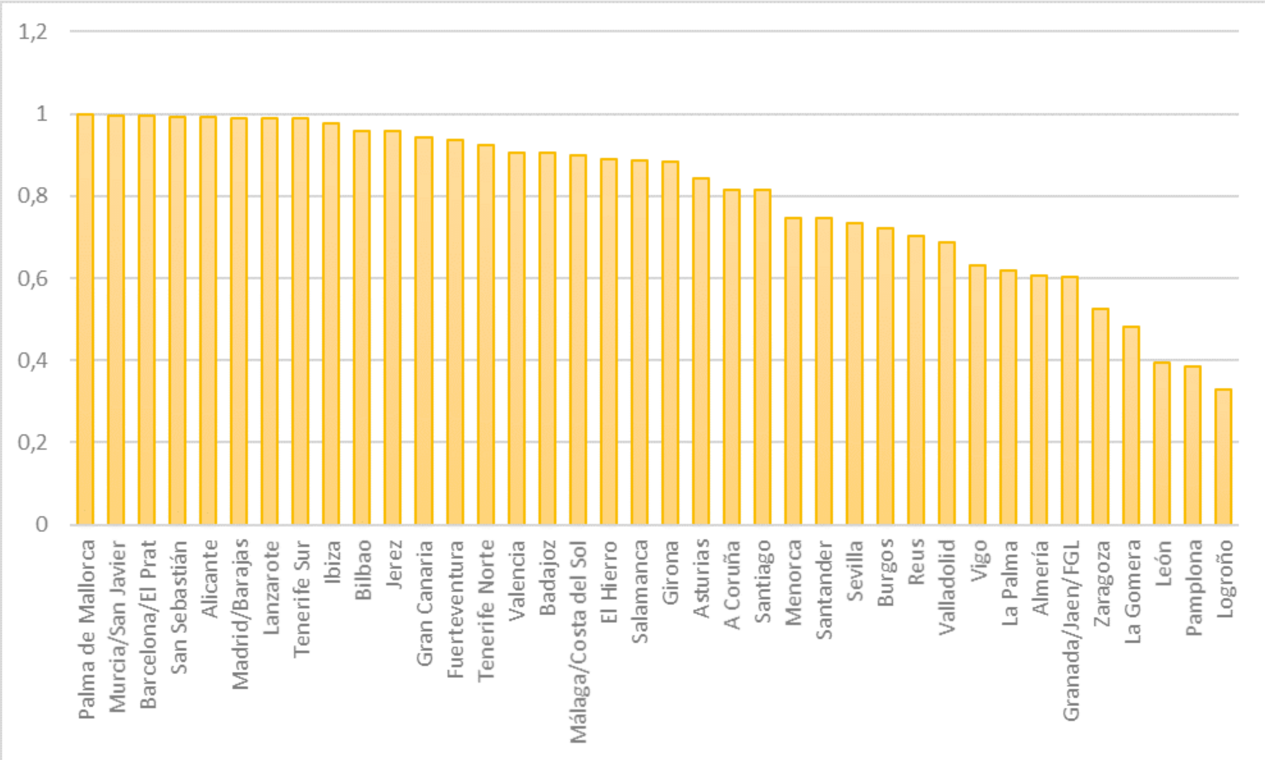
The DEA efficiency score is between zero and 1. The airports with DEA scores equal to 1 are efficient. Any airport with a score less than one is relatively inefficient, that is, an airport with a score of 0.9 is only 90 % efficient as the best performing airport. Efficiencies scores are not absolute, but are relative because they depend on the rest of airports. Having said that, significant differences can be observed between Spanish airports as in previous research (Martín & Roman, 2001, and Tapiador et al., 2008).

Despite these differences, the average is almost 80 %. However, many airports have a high level of inefficiency, as shown in Figure 4.5. In addition, the variation in efficiency, although negative, has been low. Although it should be noted that some airports decrease their efficiency, while others increase it. It would be expected that smaller airports would be the ones that increase the efficiency, since their margin of improvement and growth is greater, but this does not happen.

By comparing the results with those obtained with SFA, it is observed that they are similar with a correlation of 0.66. In addition, on average it can be seen that the value of efficiency is very similar (0.798 in SFA against 0.799 in DEA) and the variation has been also negative.

As can be seen in Figure 4.5, the five most efficient airports on average and with more than 0.99 are Palma de Mallorca, Murcia/San Javier, Barcelona/El Prat, San Sebastian and Alicante; the most inefficient are León, Pamplona and Logroño. As noted, there is some difference, although many airports coincide comparing these results with the ones of the parametric distance function.

Fig. 4.5 Ranking of airports by DEA efficiency averages



4.6 Determinants of efficiency

In the second stage, the determinants that explain the technical efficiency of airports are analyzed. As in the first stage, financial variables, SUB and EBITDA, are deflated in prices of 2011. Therefore, the dependent variables in this analysis are the efficiency estimates calculated in the first stage. Table 4.7 summarizes the descriptive statistics of the variables used in the second-stage analysis.

Table 4.7 Descriptive Statistics of the second stage

Variable	Obs	Mean	Std. Dev.	Min	Max
TE_{SFA}	152	.7984425	.1815546	.2932976	.9800863
θ_{DEA}	152	.7995202	.2028277	.286638	1
ISLE	152	.2894737	.4550173	0	1
HUB	152	.0526316	.2240351	0	1
TOUR	152	.3684211	.483971	0	1
COMP *units*	152	1.526316	1.395107	0	5
NARPAX *euros/pax*	152	3.092941	1.145663	.2821113	7.968853
LCC	152	.5855263	.4942595	0	1
SUB *mill.*	152	1.031532	1.406445	-.2623907	8.619001
EBITDA *mill.*	152	35.07294	94.51639	-7.74	555.0049
HSR	152	.1973684	.3993285	0	1
HH	152	3290.86	2478.323	483.772	9701.45

The explanatory variables used are ISLE, which is a dummy variable that indicates whether the airport is located on an island. In total, there are eleven airports located on islands and it is intended to analyze if there is a difference with the airports in the hinterland, since the catchment area in islands is limited by their extension.

Following the type of airports in Table 4.1, dummies of each category are introduced, where the regional airports are used as a variable of control. Therefore, the dummies that are introduced are HUB and TOUR, for hub and tourist airports. In Figure 4.2, the relation of airports and their geographic disposition is shown. Then, a variable is introduced that measures the potential competition of each airport, COMP. Competition is measured as the number of airports that share a catchment area within a 150 km radius. As can be seen, every airport has at least one close airport, whereas Bilbao and Logroño have five airports less than 150 km away.

The variable NARPAX measures the non-aeronautical revenues per passenger. Depending on the type of airport, the behavior of purchase and consumption of passengers varies. Therefore, it is important to consider this variable to determine its influence on efficiency levels.

Because the low-cost carriers have influenced the aeronautical industry, a dummie, LCC, is introduced. This variable indicates when the airline that moves the most passengers at the airport is a low cost carrier. Many airports have survived thanks to LCC. As observed in Table 4.7, in more than half of airports it is an LCC that attracts the most traffic.

To measure the bargaining power of the airport against airlines, the Herfindahl-Hirschman index, HH, is used. This index measures the concentration of the airlines within each airport by passenger volume, and ranges from 0 to 10,000, being 10,000 the value that marks the monopoly of the market, that is, a single airline operating in one airport. It is expected that a higher level of concentration will give airlines greater bargaining power. For example, La Gomera is the most concentrated airport with almost absolute monopoly, 9701 from 10000. However, AENA manages all airports in the network, so the bargaining power is centralized and not individualized. Airports cannot negotiate terms or conditions unilaterally with airlines. This fact reduces the chance of airlines to increase bargaining power in an isolated airport. It should be noted that La Gomera flights is under the PSO regulation.

In order to control for some financial variables, the subsidies that the airports receive, SUB, are introduced. Since airports are public, they usually have grants from different agencies. It is observed that, on average, airports receive one million euros a year of subsidies. The EBITDA is also introduced, which shows an indicator of the operating profitability of the business without taking into account any financial aspects. Of the 152 data, 67 are negative. In addition, 12 airports have a negative EBITDA in the entire period analyzed, compared to 17 that have a positive EBITDA. However, there is an average of more than 35 million euros of exploitation. This is due to the fact that those with a positive EBITDA generate, on average, more than 66 million euros, while those that generate losses are only slightly less than 3 million euros. This fact reinforces the theory that cross-subsidization does not affect the network because the airports that make losses, lose very little, and those that win, earn a lot. If net effects are taken into account, it is still profitable to maintain the current system.

Due to the emergence of multimodal competition, and that Spain is, after China, the country with the largest High Speed Rail (HSR) network, we introduce a variable that is activated when the city airport has a HSR station. In Spain there is no airport that has an integrated HSR station, but there are eight cities that have a HSR station. To be sure, the competition between the HSR and the regional flights has had a real impact, and it is reasonable to analyze if this fact affects the technical efficiency of airports.

Finally, three temporal dummies (T11, T12, T13) are introduced to analyze the evolution of technical efficiency and if there is some event that requires a more exhaustive analysis. The control dummy corresponds to the year 2014; the last period of the panel.

4.6.1 Discussion of results

In the second stage, the determinants of technical efficiency are analyzed. Once obtained the technical efficiencies under each model used in stage one, the data is analyzed, although with a different treatment in each case. In addition, the function that is analyzed is the following:

$$Eff = f(ISLE, HUB, TOUR, COMP, NARPAX, LCC, HH, SUB, EBITDA, HSR, T11, T12, T13) \tag{4.12}$$

To perform the analysis of the TE obtained under the parametric distance function, a Tobit regression with panel data is carried out, where the dependent variable is the technical efficiency obtained in the first stage through SFA.

On the other hand, to perform the analysis of the DEA estimates, the technique of Simar & Wilson (2007) is applied. The technical efficiencies under DEA are not parametric. In addition, they are censored since there are usually several DMUs with value one, and there is a problem of correlation between the estimated values. They propose a double bootstrap procedure that improves statistical efficiency in the second-stage regression.

Table 4.8 shows the results of the estimates for each model specified above. Both models show similar results and do not contradict each other, that is, they do not find significant values with a different sign. That the sign is positive indicates that the variable has a positive relationship with efficiency, as long as this relationship is significant. In the case of non-significant values, it is understood that the relation is null.

Table 4.8 Second Stage Regression

	Tobit (SFA)	**Simar Wilson (DEA)**
Constant	0.866***	0.163***
ISLE	-0.006	-0.166***
HUB	0.062	-1.622*
TOUR	0.061***	-0.071
COMP	-0.032*	-0.078***
NARPAX	-0.003***	-0.014
LCC	-0.000	0.093**
SUB	0.001	0.020
EBITDA	0.000**	0.008***
HSR	0.008	-0.183***
HH	-0.005*	-0.089***
T11	0.018***	0.019
T12	0.013***	-0.038
T13	0.007***	0.026

Note *, **, *** denote significance at 10 %, 5 % and 1 % respectively.

The variables that have the same relationship in both models for significance and sign are the competition between airports ($COMP$), the pre-tax benefits ($EBITDA$) and the concentration of the airlines at the airport (HH). The rest of variables, except the subsidies (SUB), are significant in one of the two models applied. Public subsidies do not affect the efficiency of airports because it is an extended practice among all airports, so everyone is in the same situation. Looking at Table 4.7, the standard deviation is 1.40, while the average is over 1 million euros per year. Except for some airports that have received significant amounts in some periods, the rest receive a systematic subsidy around the average.

Attending to the AENA network intracompetition, Figure 4.2 shows the airports in the network and how many of them share a catchment area with neighboring airports. That is what the variable *COMP* measures, the number of adjoining airports within a 150 km radius. Competition is expected to improve efficiency because airfares are lowered and more passengers are attracted; instead, the opposite is observed. Note that, in this case, there is no competition because it is the same company who manages the whole network of airports, therefore that competitive component is not transferred to the prices or to the relationship with airlines. The result is that there is a loss of efficiency. Airports instead of accessing new passengers, they have to share the existing demand in the same catchment area.

AENA decided not to individualize the management of the airports so as not to disadvantage the airports with less activity, the regional ones, and that could continue operating within the network. This decision monopolizes the principle of solidarity between airports, but keeps alive the debate about the closure of some airports. In the peninsula, the geographical location of airports is relevant. Those located on the coast enjoy the competitive advantage of tourism. On the other hand, the regional airports that are in the interior do not have this advantage, so the competition factor to have airports in their same catchment area affects them negatively. Tapiador et al. (2008) supports the hypothesis that an individualized management would help airports compete under their particular characteristics. So competition between neighboring airports may also encourage the development of new market strategies, reaching the situation in which the relationship of this variable with the efficiency of airports is positive.

The geographical characteristics explain why tourist airports are more efficient than regional airports. This is to be expected since the tourist airports are quite specialized and attract a specific type of passengers. In addition, regional airports have the problem that they attract less demand and this explains their lower technical efficiency. Both of them are usually point-to-point airports that can optimize their resources much better than hub airports. Hub airports are more inefficient than regional ones according to the non-parametric analysis. This is due to the fact that hub airports have to satisfy a more heterogeneous demand. Besides, investments are scattered, which makes the optimization of resources more complicated.

Airports located on islands also have a geografical limitation. They are less efficient due to the fact that they lack of the potential to reach more customers. Investments at airports are discrete, so there is always a tendency to overinvest so that demand is adjusted step by step to supply. In addition, it is the case that in almost all the islands there is at least one airport, which limits even more the power of attraction between neighboring islands.

Another important aspect that affects the performance of airports is the structure of the air market. From a theoretical point of view, Basso & Zhang (2007) began to consider the influence of the downstream airline market structure on the performance and decision-making of airports. The different changes in the industry have caused the relationship between airports and airlines to be influenced (see D'Alfonso & Nastasi, 2014). Therefore, it is interesting to analyze how the air structure within the airport affects its efficiency. The Herfindahl-Hirschman Index shows the concentration of airlines within each airport. With this variable it is observed how airlines power affects the technical efficiency of each airport. The result is that less concentrated airports are more efficient, that is, the concentration of the airlines causes inefficiency. AENA manages airports with equal policies depending on their type, therefore, there are few chances for airlines to bargain and influence decisions. The interaction of the airlines within the airport can favor this result, since in a concentrated market entry barriers to other airlines can be imposed, fostering greater inefficiency or a worse use of airport resources.

Another aspect that influences the structure of the air market is the type of airports. In Spain there are only two hub airports, the rest are regional and tourist airports where most of the flights are point-to-point. Under this model, low-cost companies have expanded. Then, the low-cost model is quite widespread in the AENA network, also worldwide. Therefore, it was an element to control to analyze its relevance. It is observed that the airports in which the leading airline is a low-cost, are more efficient according to the non-parametric approach. This may be due to the fast turn-around and the sharing of different aeronautical services with other airlines.

The next element to analyze, which is very timely nowadays, is intermodal competition, HSR. The parametric analysis indicates that it does not affect the efficiency, this is due to the fact that HSR stations are not integrated in airports; contrary to what happens in other countries. On the other hand, the non-parametric analysis produces a negative and significant result. This indicates that those airports whose cities have an HSR station are more inefficient this meaning that the substitution effect is higher than the complementary effect.

The value of $EBITDA$, although significant, is practically zero. Even so, the result was to be expected, that is, more efficient airports are expected to be the most profitable. Hub and tourist airports generate positive EBITDA, in contrast to regional, whose EBITDA is close to zero or even slightly negative.

Finally, the evolution of technical efficiency is analyzed where it is observed that it is decreasing over time. Table 4.5 also shows this trend, where during the period analyzed efficiency is systematically lost in all airports. It is also observed how this does not happen with the non-parametric analysis, since in that case this pattern was not found and therefore there is no significance in this second stage as the results show. Perhaps this tendency is the product of the chosen type of analysis.

The variable NARPAX measures the non-aeronautical revenue airports make per passenger. This measure is relevant because it indicates the behavior of passengers inside the airport. In the Tobit analysis it is very significant and has a negative effect, indicating that airports with higher non-aeronautical revenues are less efficient. The airports most focused on their commercial part have larger facilities that do not directly affect technical efficiency. That is, they could work with smaller facilities, although they would eliminate the commercial part of the business.

4.7 Non-aeronautical revenue

It is convenient to set aside a section to non-aeronautical revenue due to its importance and relevance in the evolution of the air sector. Globally, non-aeronautical revenues account for approximately 40 % of total revenue, and there are cases where it exceeds 70 %. However, this figure varies depending on the region where it is located and the type of airport. Other factors that affect that proportion are the volume and type of passengers, the size of the airport, as well as the room dedicated to commercial activities, the type of existing regulation, congestion, dwell time and stress of passengers, etc. In the case of Spain, non-aeronautical revenues account for 30 % of total revenue as it can be seen in the third colum of Table 4.9, *%NAR*. Due to the importance of this type of income, their omission in the calculation of efficiency would be biased, especially in those airports that focus on their exploitation. In addition, its inclusion allows us to examine the implications in the business diversification strategies of airports.

To place the data of Spanish airports in comparison with the rest of the world, Graham (2009) shows a table with global results by region according to *%NAR*. These data indicates that AENA only exceeds the Latin America/Caribbean airports in this variable. ATRS (2017) shows more recent data where it can be glimpsed that Spanish hubs are among the airports whose share of non-aeronautical revenues are the lowest in the world. Although each data has its particularities, there is great potential to work in this field and to fill the gap with the best airports worldwide. In addition, except for regional airports, there is no clear growth trend in the data presented. This points out that efforts must be made in this area.

Several factors have made this type of income indispensable today. To begin with, the evolution of airports from public entities, that favored the transfer of people, to commercial multiplatform with different sources of income. This fact has been favored by the development and the need for funding from airports, making them to look for alternatives to undertake new investments. On the other hand, before the surge of airport privatizations, the institutions decided to regulate a sector whose structure is, a priori, a natural monopoly. Faced with the regulation of the main revenue source of an airport, alternatives were quickly sought. Non-aeronautical revenues, also known as commercial revenues, are not regulated, so there is more room for action on them, as well as a greater potential growth.

The most relevant sources of non-aeronautical revenues have been retail, which includes shops and also food and beverage, car parking and car rental. But other ways of monetizing this area have shown up such as convention centers, museums and exhibitions, golf facilities, karaoke, swimming pool and bathing room, etc. As it can be seen, the possibilities are endless. The first column in Table 4.9 indicates the non-aeronautical revenues per airport. The diferences among type of airports are huge, which directly depends on the volume and type of passengers.

In addition to the evolution of the airport market, the airline sector has also changed. Given the liberalization of the sector, there is greater competition among airlines, greater mobility that makes airports begin to lose market power. All these factors have favored the growth and importance of non-aeronautical revenues. Also, because of the fast growth in the number of passengers worldwide. So the second column of Table 4.9 shows the increase of non-aeronautical revenue, ΔNAR, that has been superior to 30 % in the period analyzed. The trend has been growing in a generalized manner except for some cases. It should be noted that within the regional airports there are some airports that show very dispersed data. This happens because they tend to be small airports with very large economies of scale, underused and whose growth has been exponential. (See Burgos, León and Salamanca.)

To estimate the technical efficiency of airports, we have taken into account the non-aeronautical revenue. Its inclusion, as has been mentioned before, is to avoid a bias in the analysis due to its importance. Oum, Yu & Fu (2003) and Oum & Yu (2004) use it to calculate TFP, while Oum, Adler & Yu (2006) and Oum, Yan $ Yu (2008) use NAR as output in the calculation of VFP. In other analyzes of Spanish airports, Tovar & Martín-Cejas (2009, 2010) introduce it as the share of non-aeronautical revenue in total airport revenue NAR/AR.

However, although it is important to take into account these revenues to calculate efficiency, the most important is to test how they affect this efficiency. In our case we have done it through the variable *NARPAX* that measures the non-aeronautical revenue per passenger. This measure is relevant because it indicates the behavior of passengers inside the airport. The Tobit analysis from Table 4.8 determines that it is very significant and has a negative effect, indicating that airports with higher non-aeronautical revenues are less efficient. A possible explanation for this result is that the airports most focused on their commercial part have larger facilities that do not directly affect technical efficiency. That is, they could work with smaller facilities, although they would eliminate the commercial part of the business.

Table 4.9 Non-aeronautical revenue per type of airport in 2014

Airport	Nar	ΔNAR	%NAR	Δ%NAR	NAR/pax	ΔNAR/pax
Barcelona/El Prat	170.31	36.34 %	23.90 %	-16.79 %	4.54	24.74 %
Madrid/Barajas	211.38	26.60 %	22.82 %	0.60 %	5.06	50.22 %
Average	**190.85**	**31.47 %**	**23.36 %**	**-8.10 %**	**4.80**	**37.48 %**
Alicante	46.26	33.24 %	32.95 %	3.75 %	4.60	31.20 %
Almería	2.7	-7.53 %	34.57 %	-12.15 %	3.64	-3.37 %
Fuerteventura	14.39	12.95 %	29.11 %	-4.96 %	3.06	17.64 %
Girona	7.06	-16.84 %	31.32 %	-8.32 %	3.27	15.68 %
Gran Canaria	35.86	27.16 %	29.08 %	-2.79 %	3.54	29.88 %
Ibiza	17.77	40.47 %	27.28 %	1.57 %	2.87	27.48 %
La Palma	2.16	5.88 %	43.37 %	15.66 %	2.55	30.73 %
Lanzarote	17.57	29.29 %	28.91 %	-4.47 %	3.03	21.27 %
Málaga	61.24	33.57 %	31.92 %	2.60 %	4.46	24.40 %
Menorca	7.4	16.35 %	27.29 %	-0.59 %	2.82	13.74 %
Palma de Mallorca	69.28	44.21 %	25.25 %	8.58 %	3.00	41.77 %
Reus	2.76	-1.43 %	32.62 %	18.96 %	3.25	57.49 %
Tenerife Sur	34.29	20.23 %	28.61 %	-10.57 %	3.77	13.18 %
Valencia	18.59	16.92 %	31.51 %	6.12 %	4.05	26.43 %
Average	**24.09**	**18.18 %**	**30.99 %**	**0.96 %**	**3.42**	**24.82 %**
A Coruña	2.79	14.81 %	27.01 %	-1.97 %	2.82	17.54 %
Asturias	3.32	-5.14 %	29.30 %	0.30 %	3.12	19.23 %
Badajoz	0.06	50.00 %	16.22 %	54.05 %	1.52	117.04 %
Bilbao	14.13	6.16 %	28.15 %	0.92 %	3.55	7.79 %
Burgos	0.1	900.00 %	38.46 %	669.23 %	4.63	1540.00 %
El Hierro	0.2	-13.04 %	40.00 %	-0.87 %	1.34	-0.64 %
Granada/Jaen/FGL	1.75	-3.85 %	27.96 %	7.06 %	2.69	29.00 %
Jerez	4.18	-4.78 %	44.19 %	2.87 %	5.58	30.08 %
La Gomera	0.14	27.27 %	50.00 %	9.09 %	4.84	43.95 %
León	0.12	0.00 %	40.00 %	103.33 %	5.19	270.61 %
Logroño	0.03	-40.00 %	15.00 %	-31.00 %	2.45	-12.35 %
Murcia/San Javier	4.05	15.06 %	36.52 %	4.79 %	3.70	32.61 %
Pamplona	0.64	-5.88 %	40.51 %	27.48 %	4.63	62.33 %
Salamanca	0.13	160.00 %	34.21 %	228.42 %	7.09	427.21 %
San Sebastián	0.93	13.41 %	38.75 %	3.96 %	3.80	14.80 %
Santander	1.93	-2.53 %	26.37 %	7.33 %	2.37	33.45 %
Santiago	7.42	32.03 %	29.68 %	18.67 %	3.57	55.75 %
Sevilla	13.85	6.29 %	29.31 %	7.58 %	3.58	35.93 %
Tenerife Norte	9.62	25.59 %	31.28 %	15.46 %	2.65	41.67 %
Valladolid	0.52	-39.53 %	28.73 %	0.22 %	2.33	24.79 %
Vigo	2.33	12.02 %	30.10 %	23.02 %	3.43	60.75 %
Zaragoza	1.63	8.67 %	21.36 %	8.52 %	3.90	95.09 %
Average	**3.11**	**49.43 %**	**31.95 %**	**52.65 %**	**3.51**	**129.12 %**
Global Average	**20.33**	**35.93 %**	**31.15 %**	**30.41 %**	**3.51**	**84.78 %**

A further possible explanation is that non-aeronautical revenues are relatively low in Spain and that there are no large differences in the sample or by type of airport. This causes that the result is not significant in the non-parametric analysis. As Table 4.9 presents, passengers have been increasing their spending over time. This also shows the change in consumer behavior inside the airport. However, the levels of other airports are not yet reached, as shown by Graham (2009). Although the data is from 2007, it is observed how the European average was in 12.15$ of 2007, against 4.80€ of Spanish hubs in 2014. In Fuerst et al. (2011) we can see how the Spanish hubs are behind in this aspect, a fact that agrees with the previous data.

In the literature it has been found that *%NAR* increases the productivity of airports. In particular, Oum & Yu (2004) and Oum et al. (2006) point out this result. This indicates that the airports that further develop their commercial side of the business are more productive than those that only develop their aeronautical part. On the other hand, this diversification of the business allows them to exploit the complementarities between aeronautical and commercial services that in turn improve efficiency.

From this analysis, it can be said that AENA has enormous potential to exploit the commercial area of Spanish airports. It also stands out that there has not been an improvement over time, but it is noted that this improvement comes from the change in the behavior of passengers, who spend more overtime. Traveling by plane is becoming more common, which makes passengers more accustomed to the environment which supposes a lower level of stress that favors consumption.

It is also worth noting that this analysis has been carried out between the years 2011-2014. In contrast, AENA has been partially privatized in 2015. Since then, non-aeronautical revenues have grown as well as % of non-aeronautical revenues. This positive trend is unknown if it is due to inertia or if it is due to the privatization effect, an effect that will have to be analyzed in the future, since Oum et al. (2006) found that "private majority ownership derives a much higher proportion of their total revenue from non-aviation services than any other category of airports." Although AENA if of public majority ownership, has undergone a transformation from a situation where it was completely public.

4.8 Conclusions

Air transport is the gateway to the world of millions of passengers whose number is increasing every year. The aeronautical industry has undergone an evolution fulfilling the demand of society to have a more connected world. It is an essential key piece in the development of communications and the global economy.

It should also be noted that it is a relatively young market that is expanding and constantly evolving. It is therefore important to analyze its structure and performance, due to the impact that is generated in many sectors such as tourism, business development, technology, freight transport, etc. In addition to that, there are various interested groups affected by the performance of the industry such as passengers, public institutions and investors, among others.

For Spain, it is an essential sector. A country with approximately 46 million inhabitants that moves around 200 million air passengers per year. In recent years, important decisions have been taken in the Spanish air sector. Given the need for expansion and access to private capital to undertake investments, decisions have been made regarding privatization and the management model. Finally, it was decided to bet on a joint management model and access the partial privatization of the company that manages the Spanish airport network, AENA.

Given these decisions, it is important to analyze the behavior of airports and check if the reasons for these decisions correspond to actual data. To this end, an analysis of the technical efficiency of airports and their determinants is carried out. Two techniques are used to offer a more conclusive result, an SFA and an DEA. It also includes an analysis of the commercial area of airports, due to the significant relevance that this part of the business is acquiring.

The main limitation of this analysis has been the availability of data, that only allows to analyze a period from 2011 to 2014. To solve this problem, two different techniques have been used that provide robustness to the analysis.

Several conclusions can be drawn, although perhaps the most relevant is that the existence of joint management of airports affects negatively the technical efficiency. The majority of airports share catchment area with other airports. However, this competitive pressure that, in theory, positively affects passengers, does not exist. Therefore, the growth of demand due to the competitive effect does not occur, affecting technical efficiency negatively. This invigorates the debate about whether some regional airports should remain open or not.

The separation of airports into three types does not fit the reality. Each airport has its particularities and an individualized management would allow the adoption of more precise measures that favor a better performance of airports. Maintaining a global network ensures the continuity of some airports, but in turn limits their growth and high levels of inefficiency are obtained. Perhaps, a formula that allows greater power in individual decision-making while maintaining the joint network would be a possible solution to assess. This would favor competition within the network and the specialization of some airports, which would benefit passengers and entities.

With respect to the commercial development of airports, AENA's performance is very much improvable. The AENA network is well below the global and European averages, which indicates that there is great potential in this area. In addition, the data shows that AENA has not focused on these issues in recent years, so it would be a great opportunity to focus on this area in the present and future. An improvement in commercial revenues can lead to lower charges with the consequent improvement in technical efficiency or to undertake investments that increase the quality of the service provided to passengers.

As future research, it would be interesting to analyze in a more exhaustive way the implications of the development of the commercial area of airports and investigate their economic implications. In addition, due to the particularity of the AENA network, the analysis can be extended by type of airport, the existing competition inside and outside the network, the geographical situation, the state of the economy by regions, etc.

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