Incentives, Service Quality, and Regulation: An Application to the Airline Industry

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Introducción

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1.1.1 Desarrollo histórico

El transporte aéreo dentro de la división clásica de los modos de transporte, es relativamente joven ya que cuenta con algo más de 100 años de antigüedad. Aunque el primer vuelo histórico data de 1783, efectuado en París por Pilâtre de Rozier y el Marqués de d´Arlandes en un globo de aire caliente de los hermanos Montgolfier, hasta el siglo XX no se comenzó a dominar el arte del vuelo, que posibilitó el nacimiento de la aviación comercial.

En 1884 Charles Renard y Arthur Krebs, del cuerpo de ingenieros del ejército francés demostraron, con un dirigible propulsado por un motor eléctrico, la factibilidad del vuelo controlado. Veinticinco años más tarde el conde Zeppelin creaba la primera compañía de transporte aéreo (Delag), empleando dirigibles que llevaron popularmente el nombre de su inventor.

El periodo pionero, hasta el final de la I Guerra Mundial, se caracteriza por la búsqueda de seguridad y alcance suficientes para la explotación comercial del avión. El periodo entreguerras aumenta la velocidad y tamaño, así como las plantas de potencia. Esto culmina en la postguerra con aviones presurizados, capaces de volar a mayores altitudes, añadiendo comodidad a los pasajeros y seguridad en vuelo.

La aparición del reactor en los años 40 y su aumento de productividad, seguida de los aviones de fuselaje ancho y gran capacidad a partir de 1970, mejoran notablemente la economía de la operación y permiten el acceso al transporte aéreo de una gran parte de la población mundial.

El periodo actual se caracteriza por la madurez económica, con el trasporte aéreo convertido en una mercancía de consumo masivo, y el esfuerzo tecnológico enfocado hacia la máxima economía de la operación y el aumento del alcance máximo de las aeronaves comerciales.

1.1.2 Beneficios económicos y sociales

La importancia socioeconómica del transporte aéreo ha sido considerada como estratégica para el desarrollo de la economía y la evolución de las sociedades avanzadas. Por ello ha sido uno de los sectores más regulados del campo de los servicios, tanto en su vertiente técnica (certificaciones de material, licencias al personal, certificados de operación), como económica (derechos de tráfico, fijación de tarifas, limitaciones de acceso al mercado).

Asimismo su carácter internacional lleva a que la gran mayoría de la regulación requiera de consenso internacional. Debido a esto la máxima autoridad en este sector, la OACI, Organización de Aviación Civil Internacional, es un organismo dependiente de las Naciones Unidas.

Este papel estratégico se puede corroborar con correlaciones a nivel mundial entre la coyuntura económica y las oscilaciones experimentadas por el transporte aéreo, medidas en PIB (producto interior bruto) y en PKT (pasajero por kilómetro transportado) respectivamente, o también en renta per cápita y viajes aéreos por persona y año (fuentes IATA).

De acuerdo con los estudios llevados a cabo en 2004 y actualizados en 2008 por el Oxford Economics dentro de ATAG (Air Transport Action Group, coalición independiente de organizaciones de transporte aéreo cuya misión es promover el crecimiento sostenible de la aviación en beneficio de la sociedad global, con más de 70 miembros), los efectos del transporte aéreo los podemos dividir en:

-Directos: derivados de aerolíneas, aeropuertos, mantenimiento de aviones, control de tráfico aéreo, actividades de servicios a pasajeros (handling, gestión de equipajes, tiendas y catering).

- Indirectos: en una segunda derivada incluyen a suministradores de combustible, constructores de aeronaves y aeropuertos, suministradores de piezas y subcomponentes de aeronaves, suministradores y fabricantes de bienes a tiendas de aeropuertos y actividades de servicios (centros de llamadas, tecnologías de la información, contabilidad).

- Inducidos: que incluyen a industrias de apoyo al transporte aéreo como tiendas, productores de bienes e industrias de servicios (bancos, restaurantes).

- Catalíticos: de la contribución económica como facilitador del crecimiento de otras industrias en el sentido de (1) promoción del comercio mundial, (2) del turismo y (3) mejora de la productividad, vía innovación e inversión, eficiencia de las operaciones y mercado laboral atrayendo personal altamente cualificado.

En cuanto a hechos y cifras de la industria del transporte aéreo y sus efectos, podemos resumirlo en lo siguiente (fuente ATAG abril 2008):

- Más de 2.000 aerolíneas alrededor del mundo operan una flota total de 23.000 aeronaves. Sirven a más de 3.750 aeropuertos a través de una red de varios millones de km gestionados por más de 160 proveedores de servicios de navegación aérea.

-Transporta 2,2 miles de millones de pasajeros y 44 millones de toneladas de carga aérea anualmente. El 40 % del comercio interregional es transportado por aire, que significa unos 3,5 billones de $, lo que representa un 35 % del comercio internacional.

Tiene un impacto económico global estimado de 3,650 miles de millones de $, equivalente al 7,5 % del PIB mundial: 408 miles de millones de $ en efecto directo, 465 miles de millones de $ en indirectos, 220 miles de millones de $ en inducidos, y el resto, 1800 miles de millones de $, en catalíticos.

-Genera un total de 32 millones de empleos (a nivel mundial, entre directos (5,5 millones / 408 miles de millones del PIB: 4.7 de la industria de aerolíneas y aeropuertos y 780.000 del sector aeroespacial civil), indirectos (6,3 millones / 465 miles de millones PIB, en la compra de bienes y servicios de la cadena de suministro), inducidos (2,9 millones) y de su impacto catalítico en el turismo y otros (17,1 millones).

- El 40 % del turismo internacional viaja por aire, representando dicha industria un empleo directo a nivel mundial de 79 millones de personas, representando el 3,4 % del PIB mundial.

En cuanto a la parte social, el transporte aéreo:

-A diferencia de otros modos, paga los costes de su propia infraestructura (pistas de aterrizaje, terminales de aeropuerto, control de tráfico aéreo), a través de las tasas.

- Contribuye al desarrollo sostenible, facilitando el comercio y el turismo, generando desarrollo económico, creando empleo, mejorando el nivel de vida, aliviando la pobreza, incrementando los ingresos públicos vía tasas, y reforzando la conservación de áreas protegidas.

- Facilita el transporte a áreas remotas y promueve la inclusión social conectando dichas comunidades con el resto de su país.

- Las redes de transporte aéreo facilitan la entrega de ayuda humanitaria y de emergencias en cualquier lugar de la tierra; también aseguran el suministro de aparatos médicos y órganos para trasplantes.

- Mejora la calidad de vida facilitando las experiencias de ocio y culturales a través de las fronteras. Permite destinos de vacaciones y visitas a amigos y familiares, lo cual no sería posible por la distancia mediante otros modos de transporte.

- Las aeronaves son hoy un 70 % más eficientes en consumo de combustible y 20 decibelios (75 %) menos ruidosos, que hace 40 años, consumiendo 3,5 litros de queroseno por pasajero cada 100 km (mucho menos que los coches familiares).

1.1.3 Regulación en el transporte aéreo

En cuanto al marco institucional del transporte aéreo internacional en el que se ampara su regulación podemos hablar de tres acuerdos y Convenios.

- *Convenio de Varsovia.*

Firmado por 31 países en 1929, tenía como objetivo regular de manera uniforme las condiciones del transporte aéreo internacional en lo referente a los documentos empleados para tal transporte y a la responsabilidad del transportista.

Lo más importante era la responsabilidad del transportista, según 4 principios: siempre un contrato internacional (título de transporte), el transportista siempre responsable (responsabilidad objetiva), indemnizaciones máximas por pasajero y por kg de carga o equipaje, los cuales podían superarse si se probaba la existencia de una emisión incorrecta del billete.

- *Convenio de Chicago.*

Tras la 2^a Guerra Mundial para establecer un régimen para la aviación civil internacional, se reunieron 52 Estados en 1944 en la Conferencia de Chicago, en la que se adoptaron una serie de 4 Apéndices, cuyos temas principales a efectos regulatorios son los siguientes:

- Reconocimiento de la soberanía exclusiva y absoluta de cada Estado sobre la zona aérea que abarca su territorio, incluidas las aguas territoriales adyacentes.

- Establecimiento de qué servicio aéreo internacional regular requiere el permiso especial u otra autorización del Estado y se realizará bajo las condiciones de dicho permiso o autorización. En cambio, no exige esas condiciones para el tráfico no regular, que podrá realizarse sin permiso previo, aunque cada Estado tiene libertad de imponer las reglamentaciones, condiciones o restricciones que estime convenientes.

- La reserva el tráfico de cabotaje (transporte entre dos aeropuertos del mismo Estados) a los nacionales de cada Estado.

-Establecimiento de la nacionalidad de las aeronaves, que será única, estará vinculada a su matrícula y deberá exteriorizarse mediante las correspondientes marcas.

- Cada Estado será responsable de las normas de aeronavegabilidad correspondientes a sus propias compañías (sin perjuicio del asesoramiento técnico de OACI).

- Creación de OACI (Organización de la Aviación Civil Internacional).

- Acuerdo relativo al Tránsito de los Servicios Aéreos Internacionales con facultades para los Estados contratantes.

- Definición de las "libertades del aire", que han servido siempre de referencia en toda clase de negociaciones entre países.

- *Convenios internacionales bilaterales* (ASA's, Acuerdos sobre Servicios Aéreos).

El Sistema de Convenios es el tradicional de Derecho Internacional. Representantes de los países afectados firman un texto que deberá, posteriormente, ser confirmado mediante depósito del consiguiente instrumento de ratificación, no entrando en vigor hasta que este último haya sido ratificado por un número predeterminado de Estados.

Los convenios multilaterales y bilaterales son formas complementarias de regular en el transporte aéreo. El Convenio de Chicago o el de Varsovia son los ejemplos clásicos de este tipo de acuerdo.

El mecanismo normal de un convenio bilateral es el siguiente:

- Los contratantes son dos Estados (a través de sus Ministerios de Asuntos Exteriores)

- Hacen referencia al Convenio de Chicago.

- Designan una o varias compañías aéreas para explotar los derechos de tráfico del acuerdo.

- Determina qué rutas, escalas y derechos de tráfico se conceden mutuamente.

- Delegan en las compañías aéreas designadas las discusiones de tarifas, muchas veces fijadas por IATA (International Air Transport Association) o los Estados, de frecuencias y capacidad en las rutas determinadas previamente.

Según la Organización Mundial del Comercio (WTO, 2006), los siete indicadores relevantes para la apertura al servicio aéreo programado son los siguientes: (1) Garantía de los derechos / libertades del aire (2) Claúsula de capacidad: regulación de volumen de tráfico, frecuencia y/o tipo de avión (3) Aprobación de tarifas (4) Retención: condiciones de operación para un transportista extranjero como propietario (5) Designación del n^o de aerolíneas que pueden servir el mercado de rutas entre los 2 países (6) Intercambio de estadísticas de operación (7) Acuerdos cooperativos de Marketing entre las dos aerolíneas.

La mayoría de los ASA's se regulan normalmente en precio, capacidad y acuerdos cooperativos, siendo el 60 % de designación múltiple (Fu, Oum y Zhang, 2010).

1.2 Procesos de Liberalización del Transporte Aéreo

1.2.1 Proceso de la Desregulación en EE.UU.

En lo referente al transporte aéreo el 24 octubre de 1978, el Congreso de EEUU aprobaba la Ley Pública 95-504, titulada "Airline Deregulation Act 1978", con el fin de eliminar una gran parte del control de la Administración sobre los aspectos comerciales del transporte aéreo, e incentivar la competencia entre las compañías aéreas, en beneficio del usuario.

Anteriormente a esta ley, existían dos organismos con competencias en esta área:

- FAA (Federal Aviation Agency), que se ocupaba de las normas de aeronavegabilidad, seguridad, certificación, control de espacio aéreo y demás problemas técnicos de la Aviación Civil.

- El CAB (Civil Aeronautics Board) que controlaba rutas, frecuencias, tarifas y el resto de los aspectos comerciales. La "Deregulation Act" preveía su eliminación, a través de un proceso gradual en el que en 1982 desaparecería su control sobre rutas y frecuencias, en 1983 el control de tarifas, en 1984 se iniciaría el cierre paulatino de sus instalaciones, para dejar de existir en 1985.

Las competencias del FAA han quedado como estaban y los servicios estadísticos y burocráticos del CAB pasaron a otros centros del Departamento de Transportes (DOT).

El sistema de control implantado por el CAB, en vigor con pequeñas modificaciones desde

1938, exigía permiso administrativo para que una compañía iniciará las operaciones en una ruta, para que aumentara la oferta en n^o de frecuencias o en cantidad de asientos, y para introducir una nueva tarifa. Tradicionalmente el CAB sólo autorizaba aumentos de oferta si el factor de ocupación en la ruta subía por efecto de la demanda y no daba permiso a nuevas compañías a menos que las existentes no fuesen capaces de aumentar su oferta. A estos efectos el CAB gozaba de inmunidad frente a la ley antimonopolio norteamericana.

Para la fijación de los niveles tarifarios, todas las compañías aéreas norteamericanas tenían obligación de comunicar trimestralmente al CAB una relación pormenorizada de gastos, de modo que esta Agencia pudiese calcular las tarifas a aplicar en base a los costes medios en cada ruta, un 55 % de factor de ocupación y una rentabilidad objetivo del 12 % que, con las comisiones ocultas y otras prácticas no declaradas, se reducía a menos de la mitad. Con todo esto los beneficios de las compañías dependían sobre todo de su eficiencia relativa. De esta forma, se creaba un entorno muy regulado y poco competitivo, en el que era muy difícil entrar para las nuevas empresas, y al mismo tiempo era difícil perder dinero.

Los resultados difieren en muchos aspectos del imaginado por Alfred Kahn, economista de Harvard y padre de la Deregulation Act. Según su proyecto, las nuevas compañías acabarían haciendo desaparecer a las poderosas Aerolíneas de bandera, porque estas tenían estructuras empresariales burocratizadas, incapaces de hacer frente a la competencia de los recién llegados que disfrutarían de costes mucho menores al tener todo el personal de nuevo ingreso. Sin embargo, las compañías establecidas reaccionaron ideando formas imaginativas de hacer valer su mayor tamaño y su mayor implantación en el mercado. Así, durante los primeros años 80 desarrollaron diversos sistemas de marketing que les dieron una considerable ventaja sobre sus nuevos competidores, y que hoy están prácticamente incorporados por casi todas las grandes compañías mundiales. Entre esos elementos destacan los siguientes:

-Red de rutas "hub & spoke": al instaurarse la libertad de acceso al mercado nacional en Estados Unidos, las compañías se encontraron de pronto con la posibilidad de penetrar en más mercados de los que sus recursos físicos les permitían. Algunas compañías se lanzaron a una expansión acelerada que les condujo a la quiebra en la recesión de los primeros años 80. Otras modificaron su red de rutas para cubrir con su flota el mayor n^o de puntos posibles, mediante el "hub & spoke". Con este dispositivo como ejemplo, podían reunirse 7 puntos entre sí, reemplazando 21 vuelos directos por 6 indirectos, aunque requieran estos últimos un cambio de avión. Las ventajas de esto eran notables: se sirven más rutas punto a punto con el mismo n^o de vuelos, los vuelos que sirven un "hub" agrupan tráficos de diversos destinos y pueden utilizarse aviones mayores, de menor coste unitario, el factor de ocupación aumenta y es menos sensible a la estacionalidad, al acumularse tráficos diferentes. Como inconvenientes pueden citarse la disminución del n^o de enlaces directos, requerir la disposición de capacidad suficiente en los aeropuertos "hub", reducción de la utilización de los aviones, al aumentar los tiempos de escala en el hub y el tiempo de los aviones fuera de base.

-Sistemas de reserva por ordenador (CRS, computer reservation systems): la creación de una gran red informática, que permita a las Agencias de viaje manejar en tiempo real un sistema tarifario crecientemente complejo desde la libertad de fijación de precios, requiere una gran inversión que las pequeñas compañías no podían permitirse. La tendencia general ha sido la concentración.

- Programa de Fidelización: conocidos como "viajero frecuente" en los que se premia con viajes gratis a los clientes fieles de una misma compañía aérea, fueron iniciados por American Airlines, bajo el nombre de "AmericaAdvantage". El propio sistema de "hub & spoke", facilita múltiples posibilidades de volar entre dos puntos a través de distintas escalas intermedias, por lo que la oferta de recompensas solo alcanzables por acumulación de viajes en la misma empresa se convierte en un poderoso instrumento de marketing. Su diseño original se basaba en una contabilidad de millas voladas, con las que se obtenían billetes gratis o promociones a clases superiores dentro del avión. Con el tiempo, estos programas están evolucionando hacia un sistema de puntos, que pueden ganarse también en hoteles, alquileres de coches u otros servicios conexos.

1.2.2 Proceso de la Desregulación en la UE

Una vez definidos los objetivos de integración del trasporte aéreo en el Mercado Único Europeo y los instrumentos legales para alcanzarlos (Directivas y Reglamentos), se decidió que el paso al nuevo régimen legal se haría por fases, agrupando las medidas en lo que se ha dado en llamar "paquetes" legislativos:

-Primer paquete (dic. 1987), y en él se abrían posibilidades de incrementar unilateralmente la oferta entre dos países de la CEE, dentro de ciertos límites, y aplicar descuentos también limitados por unas bandas tarifarias predeterminadas.

-Segundo Paquete (jun. 1990): permitiendo el tráfico de 5^a libertad dentro de la CEE (vuelos entre dos países de la CEE efectuados por aeronaves de un 3^o), introduciendo el concepto de doble desaprobación de tarifas (una compañía podrá proponer tarifas para vuelos entre dos países de la CEE, que sólo serían suspendidas si los dos países afectados las desaprobaban).

-Tercer Paquete (jul.1992), con las condiciones definitivas del Mercado único, en vigor el 12 de enero de 1993.

El contenido de este Tercer paquete legislativo produce una completa liberalización del mercado intracomunitario, manteniendo algunas excepciones temporales que desaparecieron, prácticamente en abril de 1997. En su contenido destaca lo siguiente:

- Concesión de licencias: los requisitos permiten obtener licencias de explotación a empresas controladas por ciudadanos comunitarios, en el país de la CE donde tengan su base principal, cumpliendo normas comunes mínimas, tanto técnicas (Air Operator Certificate) como financieras. Desaparece, por tanto, la condición de que las compañías aéreas de un país de la UE tengan que ser mayoritariamente propiedad de ciudadanos de ese país.

- Acceso al mercado: libertad total para la compañías comunitarias, salvo restricciones hasta abril de 1997 para las rutas domésticas, y permanentes en Servicio Público, Congestión, Rutas Regionales y Medioambiente:

- La limitación que desaparece en abril de 1997 prohibía a las compañías comunitarias hacer vuelos interiores en otros países de la Unión, a menos que esta etapa fuera continuación de un vuelo internacional y que en ese trayecto no se ofreciese a la venta más del 50 % de la capacidad del avión.

- En rutas regionales, la UE limitó durante 2 años la competencia en una nueva ruta servida por aviones de menos de 80 plazas, a este tamaño de aviones, como protección a las compañías de pequeño tamaño. Igualmente, un Estado miembro puede limitar a un operador una ruta si la declara de Interés Público, pero tienen la obligación de sacar a concurso su concesión entre todas las compañías de la UE.

- Las limitaciones por Congestión (bien sean por falta de Servicios de Control adecuados o existencia de menos slots aeroportuarios de las que solicita la demanda) deben ser fijados públicamente por cada Estado en condiciones equitativas.

- Tarifas: libertad total para compañías comunitarias, controlada por la Comisión, que actuará a petición de parte en los casos de precios abusivos o venta por debajo de costes,.

A estas condiciones específicas del transporte aéreo habría que añadir los efectos de la aplicación de las reglas generales de competencia en la CE, como acuerdos restrictivos, posición dominante, concentraciones y ayudas públicas.

1.2.3 Efectos económicos de la Desregulación

Pese a tener una serie de objetivos comunes, entre los que se cuentan incentivar la competencia y reducir los precios del transporte aéreo, los procesos liberalizadores norteamericano y europeo difieren en un aspecto esencial: el nivel de intervención de las Administraciones Públicas. Mientras que en EEUU el propósito declarado es reducir al máximo, la participación administrativa en el funcionamiento del sector, con independencia de su evolución, la UE no pretende reducir las normas existentes sino cambiarlas para aumentar el nivel de competencia entre las empresas transportistas, en beneficio del consumidor. En ambos casos, los poderes públicos disponen de elementos legales de intervención para prevenir la competencia desleal o el abuso de posición dominante, pero su aplicación es mucho más frecuente en UE que en EEUU.

Un segundo factor diferencial es la política exterior, con EEUU intentando exportar su filosofía de cielos abiertos para los vuelos internacionales excluyendo, eso sí, el acceso a su mercado interior (cerca del 30 % de todos los PKT's -pasajeros por kilómetro transportados- mundiales), que queda reservado a sus propias compañías. La política de la UE no está, por el momento tan claramente definida puesto que, a la disparidad de opiniones entre sus Estados miembros, se une el problema de la falta de reconocimiento mundial a considerar vuelos interiores los vuelos internacionales entre países de la UE.

Fu, Oum y Zhang (2010) han investigado el crecimiento de tráfico y económico sustancial que ha conllevado la liberalización del transporte aéreo, concluyendo los siguientes efectos de dicha desregulación:

- El aumento de competencia, que reduce precios y estimula el crecimiento de tráfico por: (1) ganancias de eficiencia productiva por la optimización de las redes de vuelos de las aerolíneas y sus estrategias de precios, debido a la presión competitiva para la supervivencia; (2) externalidades positivas generadas para la economía global (empleo, turismo, comercio y transporte logístico).

- La liberalización permite a las aerolíneas optimizar su red de vuelos para cubrir los mercados intra e intercontinentales, mediante: (1) la red de vuelos "hub & spoke" consigue ganancias en ingresos y/o costes de producción; (2) la consolidación del mercado vía fusiones y adquisiciones se podrá llevar a cabo si la propiedad extranjera y el control de restricciones se relaja en cuanto a normativa, lo cual reforazará la posición competitiva de las redes de vuelos de las aerolíneas; (3) las alianzas estratégicas, que permiten a las aerolíneas obtener su segunda mejor conexión a vuelos intercontinentales donde los Acuerdos Bilaterales Internacionales (ASA) son más restrictivos.

- El rápido crecimiento de las aerolíneas de bajo coste (LCC, low cost carriers) ha traído un impacto significativo en la industria aérea. Existe una correlación LCC- liberalización / desregulación porque el incremento de competencia conlleva una reducción de tarifas, y por tanto se estimula el tráfico. Además las LCC's se han beneficiado más por la creación de bases en países extranjeros en la UE, si bien todavía hay restricciones a las LCC como por ejemplo en Asia.

1.2.4 Obligaciones de Servicio Público EAS /PSO

Las obligaciones de servicio público en el transporte aéreo sirven de excepción confirmatoria de la regla en los procesos liberalizadores de EE.UU y de la UE. En ambos, dichos servicios (Programas de Servicios Aéreos Esenciales –EAS-, y Obligaciones de Servicio Público –PSO-) eran previos y se les ha dado continuidad por su alcance (las pequeñas comunidades) y por sus objetivos (asegurar que las pequeñas comunidades no salieran perjudicadas con los procesos desreguladores, continuando con la contribución de las rutas aéreas para el desarrollo económico de este tipo de regiones).

Aunque los procesos son similares en cuanto a su licitación, sus características en determinadas variables hacen que difieran en eficiencia (Williams and Pagliari, 2004):

-En el proceso de Obligación de Servicio Público en la UE se publica oficialmente la licitación para una determinada ruta o grupo de rutas consideradas previamente como elegibles por la UE a propuesta de Estado miembro. En dichas rutas se estipula un mínimo de nivel de servicio (frecuencias y asientos) y las tarifas máximas. En primer lugar el licitador invita a las aerolíneas a prestar el servicio sin subvención, y si ninguna se presta a ello, se lleva a cabo una segunda vuelta en la que se invita a las aerolíneas a pujar con lo que pedirían de subvención. El licitador toma la decisión de la adjudicación en base a (1) cantidad de subvención solicitada por la aerolínea, (2) nivel de servicio ofrecido, y (3) otras consideraciones relevantes. La administración de la Obligación del Servicio Público puede ser por el Gobierno Central (ejemplo de Irlanda, Portugal, Noruega y Suecia) o por una Autoridad Regional (caso de Francia, Alemania, Italia y España). Una vez asignada la obligación, la aerolínea ganadora mantiene el monopolio por tres años.

-En cuanto al proceso de licitación del Programa de Servicios Aéreos Esenciales (EAS) de EEUU, el Departamento de Transportes (DOT) determina la elegibilidad de la ruta o rutas, así como el nivel de servicio. Si una aerolínea no puede prestar el servicio sin incurrir en pérdidas, el programa provee la compensación de las rutas (aproximadamente un retorno de la inversión del 5 % sobre los costes operativos más el coste de oportunidad de no operar en otra ruta más rentable). Los criterios de elección se basan en (1) factor coste presentado, (2) fiabilidad de la aerolínea y (3) acuerdos de marketing con grandes “hubs”, código compartido o de interlinea con aerolíneas. Una vez concedido el programa, se permite la competencia, de tal manera que si otra aerolínea ofrece gratis el servicio, el DOT se lo notifica al incumbente para dejar de pagarle. La subvención del servicio se hace a nivel federal.

Aunque existe cierto paralelismo entre ambos procesos, el programa EAS presenta claras diferencias favorables en su gestión que deberían ser cuanto menos analizadas por la UE para introducir mejoras legislativas en las PSO (Reynolds- Feighan, 1995b):

-En cuanto a la administración de este tipo de servicios, la gestión a nivel Federal del programa EAS vs el nivel Estado miembro de las PSO asegura que la elegibilidad del servicio va más allá de los Estados, con el objetivo de no desfavorer a los Estados menos desarrollados. Una administración única desde la UE en las PSO reduciría las inconsistencias y desequilibrios entre los Estados, y también la presión de los lobbies. Asimismo la subvención a nivel Federal presenta ventajas de transparencia frente a la Estatal de la UE. Se podría plantear pagos parciales de la Comunidad Local y/o Estado, pero siempre prevaleciendo una administración del dinero a mayor nivel administrativo. Esto ayudaría a evitar subsidios cruzados a aerolíneas bandera. También debería plantearse cierta regulación en la mejora respecto de los servicios mínimos establecidos en el servicio de PSO.

- En lo que respecta a la competencia, el monopolio de tres años a la aerolínea adjudicataria del servicio PSO frente a la libre entrada del programa EAS, perjudica al bienestar social. Además los costes hundidos ("sunk cost") y las economías de escala en el monopolio que se generan a lo largo de los tres años del PSO, suponen una barrera de entrada para nuevas aerolíneas para pujar por el servicio.

1.3 Panorama actual y futuro

1.3.1 Aerolíneas de Bandera

Para el desarrollo de la red de vuelos (Fu, Oum y Zhang, 2010) en el caso de que los mercados domésticos e internacional estuvieran ambos desregulados, las aerolíneas de red se expandirían vía red de vuelos multihub hacia los mercados globales. Esto supondría fusiones y adquisiciones intercontinentales, ya que estas son más baratas que expandir la red (Oum, Taylor y Zhang, 1993). Las negociaciones EEUU-UE en materia de desregulación van en el sentido de la propiedad extranjera de aerolíneas, lo cual desmantelaría completamente los Acuerdos Bilaterales Internacionales (ASA).

Bajo la liberalización gradual el escenario será que las aerolíneas se verán forzadas a reestructurar sus redes de vuelo en estos sentidos:

- Las aerolíneas tradicionales se consolidarán bajo fusiones y adquisiciones en mercados domésticos e intra continentales para reforzar posiciones en su continente.

- Los mercados intercontinentales se reforzarán vía alianzas estratégicas (Oum, Park y Zang, 2000). Las redes intercontinentales se verán fuertemente influenciadas por las estructuras de redes domésticas y continentales. Estudios previos sugieren que las alianzas intercontinentales bajan tarifas, crecen el mercado y mejoran las operaciones entre socios así como su calidad de servicio.

1.3.2 Aerolíneas Regionales

El efecto desregulatorio ha sido menor sobre las compañías regionales, cuya estructura estaba ya concebida en términos adecuados a un entorno comercial poco regulado en cuanto a flexibilidad de tarifas y mercados, y enlaces punto a punto. Como nuevos problemas se presentan los altos costes financieros y la dificultad para conseguir "slots" (derechos de aterrizaje y despegue en determinados horarios) en algunos aeropuertos, así como la necesidad de integrarse en los CRS para asegurarse más puntos de venta. Por otra parte el abandono de las rutas menos densas por parte de las compañías nacionales ha favorecido el crecimiento en tamaño de las regionales y su progresiva concentración. Otras características que han desarrollado han sido la asociación con las grandes compañías para hacer funciones de aporte y dispersión en aeropuertos importantes a la vez que figuran en sus Sistemas de Reservas. También en aviación regional se ha aumentado progresivamente del tamaño medio del avión, que desde las 20 plazas de antes de la desregulación, ha pasado por las 33 y 50 hasta el rango de las 70 plazas actuales.

1.3.3 Aerolíneas de Bajo Coste

La desregulación EEUU de 1978 supusó la desaparición de las aerolíneas más débiles por bancarrota y fusiones, a la vez que aparecieron y progresaron aerolíneas de bajo coste en el mercado doméstico, siendo Southwest el caso de éxito más significativo por su expansión y la continuidad de sus bajas tarifas.

La liberalización en UE y los grados de libertad del aire del 5^o al 9^o han sido más aprovechados por las compañías de bajo coste al poder abrir bases fuera de sus estados de origen (Dobruszkes, 2009).

A la vez aparece una competencia entre aerolíneas de bajo coste y aerolíneas de bandera a nivel doméstico. Hay tres vías de la competencia doméstica que afectan al rendimiento internacional (Clougherty y Zang, 2009):

- Suponiendo que hay los mismos competidores doméstico-internacionales, si se introdujera más competencia doméstica, se incrementaría la competencia internacional.

-La unión de economías de producción deriva en el tamaño del incumbente que opera en el doméstico, lo cual afecta al rendimiento internacional en la industria aérea.

-La rivalidad doméstica también presiona a la calidad y productividad, aumentando a su vez la competencia en el internacional.

La regulación todavía pone barreras a las aerolíneas de bajo coste, sobre todo en Asia, p.ej. Air Asia tiene que entrar en otros mercados regionales vía joint ventures.

1.4 Posicionamiento Estratégico en Aerolíneas y Motivación de la Tesis

La descripción detallada de los principales acontecimientos y características del sector de transporte aéreo de pasajeros es fundamental. La valoración adecuada del entorno competitivo ayuda indudablemente a la gerencia en la toma de decisiones correctas para los tres tipos de aerolíneas. Merece la pena resaltar que las aerolíneas compiten tanto en la dimensión precio como en variables de dimensión distinta al precio. Conjuntamente definen su posicionamiento estratégico. Dichas variables se contemplan a lo largo de los distintos capítulos, tal y como sigue:

-El cambio de estructura accionarial de la privatización de aerolíneas bandera (antes propiedad de los Estados), así como el nuevo modelo de aerolíneas de bajo coste, y las aerolíneas regionales ya nacidas en estructura de propiedad privada, saca a la luz un nuevo sistema de incentivos para los administradores gestión de la aerolínea: compartir la propiedad (estos aspectos motivan el análisis del capítulo uno).

-La operación de la red de vuelos de "hub & spoke" de las aerolíneas bandera y las regionales, frente al "punto a punto"-operación directa- de las de bajo coste, también permite una estrategia diferenciadora de fijación de precios. Este tipo de operación, debe ser tenido en cuenta por el regulador para las Obligaciones de Servicio Público con el fin de maximizar el bienestar social (este punto motiva el análisis del capítulo dos).

-La calidad de servicio ha tomado mayor peso como estrategia de diferenciación entre las aerolíneas de bandera y las de bajo coste, en todos sus atributos incluida la fidelización a través de su sistema de gestión en programas, lo que influye en la recompra de billetes y, por tanto, en los resultados empresariales (esta observación motiva el análisis del capítulo tres) .

1.5 Objetivos de la Tesis

La presente tesis doctoral tiene objetivo el estudio de estrategias y variables de aplicación en el transporte aéreo para propietarios, gerentes y reguladores. El hilo conductor de los distintos capítulos se fundamenta en lo siguiente.

La relativa juventud de la industria del transporte aéreo (poco más de 100 años), unido a los elevados estándares de calidad y seguridad de sus operaciones, hace que sea un sector altamente regulado tanto en la parte técnica como en la legislativa. Es por ello que el proceso de liberalización se está acometiendo desigualmente en el tiempo y en el espacio (EEUU a partir de 1978, UE a partir de 1993), si bien sirve como proceso de aprendizaje de aciertos y errores, y como base de acometidas desreguladoras futuras del sector.

El impacto más inmediato y objetivo de las medidas de liberalización es la generación de competencia, con lo que las aerolíneas de bandera, regionales y chárter previas a la desregulación se han adaptado o han desaparecido ante este nuevo escenario. Sus estrategias para mantener la ventaja competitiva sostenible en el largo plazo, sobre todo ante la aparición de las aerolíneas de bajo coste con estrategias basadas en bajos precios, es objetivo dinámico prioritario en la agenda de propietarios y gerentes de las aerolíneas de cualquier modelo de negocio. Asimismo los reguladores tienen que hacer especial hincapié en los aspectos donde la regulación debe mantenerse.

En base a lo anterior, la presente tesis tiene tres líneas de estudio que afectan a propietarios, gerentes y reguladores de aerolíneas de bajo coste, regionales y de bandera. En concreto en un primer término se estudiará cómo los sistemas de incentivos de reparto de la propiedad que propone el propietario al gerente afectan a la competencia. Posteriormente, se lleva a cabo un análisis de las variables que influyen en la Regulación de Obligación de Servicio Público con el fin de que el Regulador actúe adecuadamente en escenarios que se le pueden plantear. Para cada una de las partes de la tesis se plantea un caso práctico con el fin de contrastar las hipótesis planteadas (aerolíneas de EE.UU y la UE), ejemplos para modelos de gestión (estudio de mercado de pasajeros europeos) y análisis real de mercados (OSP de Canarias). Por último, se investigará cómo los gerentes pueden optimizar la estrategia de diferenciación vía calidad de servicio y sus correspondientes atributos en cuanto a la asignación de recursos.

1.5.1 Resumen de los Capítulos

En el **primer capítulo** se analiza, tanto desde un punto de vista teórico como aplicado, la efectividad en términos estratégicos de un sistema de incentivos basado en compartir la propiedad. Aunque hay varios sistemas de incentivos que ya se han analizado, es novedoso analizar uno basado en compartir la propiedad. El modelo básico supone una estructura de gerente-propietario en el que se plantea un juego en tres etapas: en la primera el propietario regala de manera altruista parte de la propiedad en forma de acciones al gerente; en la segunda etapa el gerente elige el esfuerzo a realizar, y en la tercera se compite en el mercado con estructuras de monopolio y duopolio, en la que se estudian los incentivos estratégicos. Las predicciones del modelo teórico se contrastan para una base de datos construida para aerolíneas europeas y norteamericanas, divididas por tipo de aerolíneas en función del modelo de negocio (de bandera, de bajo coste y regional). Dicha base de datos contiene variables de beneficios, ingresos y pasajeros de las compañías aéreas a lo largo del periodo 2000-2008, distinguiendo por aerolínea el grado de profundidad del sistema de incentivos de compartir la propiedad vía acciones (desde el consejo de administración, pasando por ejecutivos hasta legar a los empleados).

En el **segundo capítulo** se desarrolla un análisis formal de la Regulación del transporte aéreo. En el transporte aéreo de pasajeros, existe un número de rutas reguladas bajo normativa de Obligación de Servicio Público (Programas de Servicios Aéreos Esenciales –EAS- en EE.UU, y Obligaciones de Servicio Público –PSO- en Europa). Estas sirven de excepción confirmatoria de la regla en los procesos liberalizadores de EE.UU y de la UE. Se trata de rutas cuyas frecuencias y tarifas (entre otras variables) son fijadas por las autoridades en un esfuerzo por garantizar una cierta calidad en el servicio de transporte aéreo. Este capítulo indaga en los efectos de tal regulación para evaluar (i) si hay provisión de frecuencias por encima o por debajo del óptimo social, (ii) si la presencia de competidores afecta a los resultados, y (iii) si hay una estructura de red de vuelos preferida entre la conexión completa o directa y la conexión en estrella o indirecta. Se observará que el tipo de red y la estructura de mercado juegan un papel determinante en el análisis.

En el **tercer capítulo** podemos ver cómo el incremento de la competencia en el sector del transporte aéreo, sobre todo con la aparición de las aerolíneas de bajo coste, convierte la diferenciación por Calidad de Servicio en una de las posibles estrategias de las compañías de bandera. Se estudia para ello el caso de un modelo para la toma de decisiones estratégicas de los gerentes de aerolíneas sobre la calidad de servicio. Dicho modelo consiste en un sistema de información sobre la satisfacción e importancia que los atributos de calidad de servicio tienen para los pasajeros, y cómo esto impacta en sus intenciones de comportamiento en cuanto a recomendación y recompra.

La metodología utiliza el instrumental propio de la teoría de juegos y que es la base de la investigación en el campo de la organización industrial. Además de una revisión bibliográfica para cada capítulo, se realiza la modelización teórica. Con ella se obtienen resultados formales que se puedan exponer en proposiciones y teoremas. En dos de los capítulos también se utilizan técnicas cuantitativas de estimación, y en el otro capítulo se exponen los datos de un caso real que permiten contrastar los resultados e hipótesis planteadas.

1.6 Conclusiones

Los resultados de los artículos son relevantes en diversos aspectos. De ellos se desprenden implicaciones para la gerencia de indudable utilidad. La utilización de incentivos basados en compartir la propiedad tiene efectos estratégicos y sobre la intensidad de la competencia. Por otro lado, el establecimiento de los elementos prioritarios en la calidad de servicio permite una gestión más adecuada de una aerolínea al poder medir sus efectos sobre la probabilidad de recompra de billetes. Finalmente, un análisis de mercados regulados con varias variables resulta particularmente útil para la toma de decisiones del regulador.

Conclusiones del Capítulo 1.

En cuanto a la primera hipótesis, la que indica que el sistema de incentivos de reparto de la propiedad es fuente de ventaja competitiva, incrementando los beneficios de la empresa, queda contrastada de manera significativa en la base de datos para aerolíneas "majorz regionales. Con más detalle podemos decir que las aerolíneas "major.ºbtienen un 24 % más de ingresos por pasajero si reparten acciones hasta el nivel de los ejecutivos o hasta el de los empleados que si sólo reparten acciones al Consejo. De la misma manera las aerolíneas regionales obtienen un 39 % más de ingresos por pasajero si reparten acciones a los ejecutivos y un 15,7 % más si lo hacen hasta el nivel de empleado que si sólo reparten a los miembros del Consejo. Los incrementos obtenidos en las aerolíneas de bajo coste son positivos pero no significativos., es significativo repartírselas a los empleados frente al consejo en cuanto a que se obtienen más beneficios. Respecto a la segunda hipótesis, la que indica que es sistema de incentivos es más efectivo cuando menos diferenciado es el producto, no se llega a ninguna conclusión pues no se han obtenido datos que permitan determinar que tipo de aerolínea ofrece servicios más homogéneos, si que se ha obtenido el resultado que indica que para un mismo *nivel* de reparto de las acciones tipo de incentivo,las aerolíneas "major"siempre ontienen mas ingresos por pasajero que los otros tipos de aerolíneas.

Conclusiones del Capítulo 2.

En cuanto a la provisión de frecuencias, para una línea aérea monopolística, se demuestra que el equilibrio de mercado produce en general un defecto de provisión de frecuencias en relación con el óptimo social, independientemente del tipo de red - ya sea una red de conexión completa o una red en estrella. Así surge la necesidad de regular las frecuencias cuando la disposición a pagar por el transporte no es lo suficientemente grande ya que el equilibrio del mercado ofrece frecuencias demasiado bajas.

Mirando a la preferencia por una estructura de red, la de estrella alcanza mayores beneficios y bienestar social en comparación con la estructura de red directa cuando la disposición a pagar por el transporte no es lo suficientemente grande, y cuando la desutilidad de los pasajeros de vuelos indirectos es lo suficientemente baja. Los límites de estos parámetros no son los mismos en la comparación de los beneficios y del bienestar social, dando lugar a un conflicto entre los incentivos privados y sociales. El análisis identifica los potenciales fallos de mercado asociados a la arquitectura de la red.

Para el análisis de competencia, en un duopolio y suponiendo una red completamente conectada, se demuestra que el equilibrio de mercado produce un exceso de frecuencias no óptimo en los servicios de transporte: las dos compañías establecen mayores frecuencias en relación con el óptimo social. En un duopolio mixto, si el operador público es relativamente más eficiente que el operador maximizador de beneficios, entonces se reduce la distorsión en las frecuencias; el operador que maximiza los beneficios fija muchas frecuencias, pero el operador público establece muy pocas en comparación con el óptimo social. El mismo tipo de divergencia se mantiene cuando el operador público es relativamente más ineficiente, y sin embargo la distorsión es mayor.

Esto sugiere que tener una aerolínea pública que compite en el mercado es una forma alternativa de controlar las frecuencias totales previstas, a la regulación directa de dichas frecuencias.

Conclusiones del Capítulo 3.

Los resultados sobre las hipótesis planteadas muestran que la importancia relativa y el nivel de satisfacción de los atributos prioriza aquellos atributos sobre los que tomar decisiones. En el caso de la muestra, los cinco de los doce atributos más importantes (puntualidad, tarifas, horarios/frecuencias, atención personal a bordo y comodidad en cabina) tienen diferentes niveles de satisfacción, siendo la puntualidad, tarifas y comodidad en cabina el enfoque que se debería dar a las acciones de inversión / asignación de recursos por tener menor nivel de satisfacción y, por tanto, mayor potencial de mejora. En una segunda derivada, el análisis de regresión probit muestra que cuatro de los doce atributos son significativos a la hora de aumentar la probabilidad de recompra y / o recomendación con aumentos en sus niveles de satisfacción. Otros dos atributos son significativos en aumentos exclusivos de la probabilidad de recomendación. Los atributos significativos en recompra y recomendación son puntualidad, tarifas, comodidad en cabina y comidas/bebidas, siendo la comodidad en cabina la de mayor impacto, seguido de comidas / bebidas, tarifas y puntualidad en cuanto a recompra y al revés respecto a la recomendación. La tipología del pasajero en cuanto a motivo del viaje (negocio, ocio, visita a familiares-otros) no es significativa en lo referente a que el pasajero business no determina mayor o menor probabilidad de recompra y /o recomendación que el resto. Pero sí que el pasajero de negocios añade dos atributos significativos en aumento de la probabilidad de recomendación: embarque e idiomas.

Por tanto el modelo planteado y apoyado por un caso de estudio se revela como un sistema de información simple y de ayuda en la toma de decisiones estratégicas en cuanto a Calidad de Servicio para los ejecutivos de aerolíneas, lo cual es el objetivo principal de la presente investigación.

Part II

Thesis chapters

Chapter 2

The Impact of Managerial Profit-Sharing Systems on Performance and Market Competition

2.1 Introduction

The neoclassical view of the firm considers it as a black-box with the objective of profit maximization. There are certainly other goals, both economic (market share, revenue growth, customer satisfaction, etc) and non-economic (product quality and services, social responsibility, etc) and firms decide optimally to get closest to their goals. The objectives themselves and how they are achieved become particularly relevant in modern economies where the separation of ownership and control is a central feature. Normally, the managers' objectives differ from those of the shareholders. Thus, in the context of a principal-agent model, many would argue that the assumption of profit maximization is wrong. Still, endogenously treating the incentive structure within the firm has shown that managers may be motivated to pursue objectives that improve the owners' profit in an oligopoly game. Firms now try and design incentive schemes that allow them to retain talent in their efforts to maintain competitive advantage and better compete in the global market. This chapter is a contribution to the literature on delegation games and looks into the strategic effects of a profit-sharing incentive scheme, both theoretically and empirically.

The use of incentive schemes[1], whether based on absolute or relative performance, is widespread. The number and type of compensation practices is varied and although they may respond to different problems within the firm, they are certainly designed to achive overall firm competitiveness. Amongst them, compensation contracts based on profit-sharing systems are our focus of analysis here. Such systems are employed in many industries like automobiles, mutual funds, newspapers, construction, distribution, and so on. In particular, they are used in the airline industry. This chapter studies profit-sharing schemes in imperfectly competitive markets; the model proposed delivers some testable hypotheses that are empirically examined for a sample of airline companies.

The hierarchical view of the firm and the role of strategic delegation have been extensively examined in the literature[2]. In an oligopoly framework it has been shown that players can gain strategic advantage by using agents who play the game on their behalf and this can be a part of an equilibrium behaviour. Representative papers include Vickers (1985), Sklivas (1987) and Fershtman and Judd (1987), where the final stage is in quantities. The vertically separated firm, if the rival is integrated, achieves the outcome of a Stackelberg leader when the choice variables are strategic substitutes. So the literature suggests that firms should always delegate for strategic reasons. In particular, their simpler formulation exhibits the property that the equilibrium under delegation appears more competitive than the standard Cournot model.[3]

What these contributions offer is a game-theoretic explanation for managers' *nonprofit-*

[1] Prendergast (1999) provides an overview on the provision of incentives in firms.

[2] The effects of the hierarchical structure of firms have been studied in the context of international oligopolies (Brander and Spencer (1988), Das, 1997, Moner-Colonques, 1997), as well as in dividing production into competing divisions and franchises (Baye et al. 1998, Moner-Colonques et al. 1998, González-Maestre, 2000, Rysman, 2001), regarding the exit of rivals in models of financial contracting (Bolton and Scharfstein, 1990) or firm performance in models of investment decisions (DeMarzo and Fishman, 2007), and regarding the choice of distribution channels for different products (Moner-Colonques et al. 2004), to mention a few.

[3] In fact, the strategic advantage of delegation remains when the final stage variables are strategic complements, as in McGuire and Staelin (1983) and Bonnano and Vickers (1988). However, in contrast with Cournot, delegation is both in the individual and collective interest of upstream firms.

maximizing behaviour. This conclusion can be stated alternatively as follows: a certain degree of managerial nonprofit-maximizing behaviour serves the owners' profit-maximizing objectives, which is somehow a paradoxical result. In the aforementioned papers, VFJS for short, managers receive a compensation/bonus that is proportional to a linear combination of profits and sales revenue. Other papers have focused on relative performance incentives. Thus, Salas (1992) extends this literature so that a manager's objective function is a function of own and rivals' profits. He noted that the use of relative performance incentives produces a conflict between risk sharing and the strategic effects of delegation. Compensation contracts based on relative performance evaluation are examined by Aggarwal and Samwick (1999). Their model predicts that firms will place greater weight on rivals' performance relative to own firm performance the higher the degree of competition in the industry.

More recently, Jansen et al. (2007) propose a delegation model based on profits and market shares. These authors assume that each manager's remuneration in a duopoly is a weighted sum of profits and market share; they show that the equilibrium in a market share delegation game leads to higher duopoly profits than in a sales delegation game. Interestingly, they examine duopoly games where each manager is offered a different contract. In fact, they show that, if owners decide whether to delegate or not and, if so, how to design the contract for the manager, the dominant strategy for the owners is to hire a manager with a bonus contract that includes profits and market share components. The strategic consequences of other managerial incentives in oligopoly are studied in a richer setting by Jansen et al. (2009). They distinguish four bonus systems: pure profits evaluation, sales evaluation, market share evaluation, and relative profits evaluation. Jansen et al. (2009) show that the dominant strategy for an owner is to design a contract with a bonus based on relative profits evaluation.

These theoretical findings have relevant implications regarding the evaluation of managers' performance in strategic settings, indeed providing testable implications when accounting for the nature of competition. - whether differentiated Bertrand or Cournot. Thus Aggarwal and Samwick (1999) predict that, under differentiated Bertrand competition, the optimal contract compensates the manager positively on both own and rival-firm performance; it compensates negatively on rival-firm performance under differentiated Cournot competition. Their empirical findings, for a sample of executive compensations in US firms 1995, are consistent with the Bertrand specification and so confirm that the use of relative performance schemes has the effect of softening competition.[4] The recent paper by Anderson et al. (2010) draws attention to the fact that, despite the improvement in firm performance following the implementation of bonus plans, a complete analysis must consider their impacts on goals. With detailed data on a US specialty retailer, these authors find that the introduction of bonus plans with participative goal setting is accompanied by lower goals that are more accurate predictors of subsequent sales performance. In fact, differences among managers (like career horizon and local store knowledge) explain diminished sales and sales goal growth relative to the industry following the introduction of the bonus plan.

Finally, experimental investigations on the issue of strategic delegation have also been provided. Thus, Huck et al. (2004) design an experiment to test the predictions of the VFJS model: subjects do not choose the contract with a sales bonus. Nevertheless, such behaviour is rational given that managers do not play according to the subgame perfect equilibrium prediction when asymmetric contracts are given. More recently, Georgantzís et al. (2008) test the predictions of relative performance compensation schemes. In particular, they report experimental evidence that confirms the received prediction of owners' preference for relative performance incentives over profit-revenue contracts.

Our contribution is twofold. First, we add to this literature by considering a further incentive scheme. The profits sharing compensation system consists of owners remunerating their managers with shares; the manager thus becomes a proprietor whose work is rewarded according to an absolute performance measure. In addition, the model assumes that the manager's effort, which is costly, translates into greater demand. It is shown that the use of the profit

[4] Although basically focused on the study of internal labour markets, it is worth alluding to the extensive empirical literature devoted to analyze how human capital theories can explain compensation and careers in organizations. Ortín-Angel and Salas (1998) explore the determinants of bonus payments among a large sample of top and middle managers from Spanish firms. Their analysis considers whether firms employ a bonus and, if so, decide on the size of the bonus. Interestingly, they find a trade-off between the use of bonus-based and promotion-based incentives; bonuses play more of a role in slow-growing industries where promotion opportunities and rewards are lower.

sharing incentive system results in greater output, effort, owner profit and manager's utility relative to the case of no use. In fact, these statements hold true in a duopolistic environment, where the rival owner-manager pair does not employ such incentive scheme thus confirming their strategic role. Besides, the percentage of shares assigned to managers is higher in more competitive environments.

These theoretical findings call for empirical analysis, which is our second contribution. We build a data set that distinguishes the depth in the use of this compensation system for a number of airline companies during 2000-2008. The estimation considers major, low-cost and regional airlines, and three levels of use in the profit-sharing scheme - shares given just to the board of directors, also to executives, and also to any members in the firm. It is found that low-cost and regional airlines that employ the incentive system further down in the hireracy do perform better. Furthermore, it is shown that mean profits for low-cost and regional airlines are higher than for major airlines, where competition is weaker.

The next section briefly presents the case of an airline company, Vueling, that has made use of the profit sharing incentive scheme. Section 2.3 develops the model and assumptions; the analysis distinguishes the monopoly and the duopoly case. The results obtained deliver some testable hypotheses. The empirical analysis is given in Section 2.4. Some concluding remarks close the chapter.

2.2 The case of Vueling

The attraction and preservation of talent in the firm is nowadays a source of sustainable competitive advantage. That is why the choice of incentive schemes becomes a crucial issue. Besides such schemes must take into account the endogenous (like the life cycle) as well as the exogenous (like macroeconomic variables) characteristics surrounding the firm.

The case study we briefly present, the low-cost airline Spanish Vueling, comprises the period since its birth until the year after it went public following a time of exponential growth. The passenger air traffic sector was witnessing, at that time, months of strong competition and growth with the emergence of low-cost carriers. In addition, this type of airlines has meant an element of product differentiation in the industry for this segment has been the one with a greater growth rate.

The technical complexity in this sector requires specialized workforce and both the regulation and the intensity of capital invested increases entry and exit market barriers. In the given period of analysis, Vueling was compelled to efforts above those signed in otherwise incomplete contracts. Such efforts can only be implemented if there is a strong underlying personal commitment. An effective incentive scheme is necessary to push human capital to perform well above the average. The type of incentives employed by Vueling was the *"profit-sharing system"*, by which the firm owners give shares altruistically to the board of managers thus linking them contractually to the future of the firm, and also in an emotional way because of the feeling of property derived from such compensation scheme. It implies a long term commitment which makes it different from other commonly studied short term schemes, such as those based on annual profits and/or sales revenues. It is the emotional component that supports the extra effort specified in contracts and limited by Labour Law in both remuneration and working hours.

In the light of the aforementioned complex environment intrinsic to the passenger air traffic sector, and the important intensity of competition in the development of low-cost carriers, the data contained in Table 2.1 below reveal Vueling's high growth rates and suggest the strong human capital effort made to attain such figures.

	May 2004	May 2006	May 2007
Staff	90	630	1100
Fleet (Airbus A320)	2	14	21
Routes	4	35	57
Daily Flights	16	98	150
Passengers	0	$>$ 4 million	$>$ 9 million

Table 2.1: Vueling Growth 2004-07

Vueling constitutes a real life example that calls for a formal model to study incentive schemes based on sharing the property of the firm and to further test some hypotheses with data from US and European airlines.

2.3 The model

The model considers the firm as a vertical structure à la VFJS, so that it consists of an owner-manager structure. The profit level enjoyed by the firm depends on the effort level exerted by the manager, taking into account that effort is costly.[5] As shall be made clear below, the managerial compensation system is one based on a profit-sharing scheme, which is in contrast with the various bonus compensation systems assumed in previous research based on VFJS. The profit-sharing system is captured by α, the percentage of shares given to the manager, for $0 \leq \alpha < 1$. The allocation of the percentage of shares is made by the owner and is prior to the managers' choices of effort and output levels (the market competition variables). Thus, the owner might decide not to give any shares to his manager, $\alpha = 0$, which would reduce the analysis to a pure profit scheme. But the owner can certainly not give away all shares, $\alpha = 1$, since he would no longer be the owner.[6]

We follow the standard treatment in the literature in that service is an element of vertical differentiation. The (indirect) utility obtained by a consumer is greater when the service is incorporated into the product (higher quality) than when it is not (lower quality). Such service is related to the manager's effort, e. This can be represented by an inverse demand $p(q, e)$, with $\partial p/\partial e > 0$. This implies that the market-clearing price will depend on how much is produced and also on the level of effort exerted by the manager. The provision of effort is costly and it is assumed to be equal to $\gamma e^2/2$, with γ a positive constant. That is, it indicates that raising the effort level raises costs and does so at an ever-increasing rate - it exhibits diminishing returns.

The inverse demand for the product is given by $p = a + e - q$, which collects that a positive choice of effort level, e, induces a parallel outward shift in demand since the maximum price that consumers are willing to pay will be higher. The price of the product is denoted by p,

[5] This analysis is fairly standard in the IO literature (see e.g. Church and Ware 2000, and Pepall, Richards and Norman, 2011).

[6] It is not our purpose to discuss on how decisions are taken inside the firm when an important percentage of shares is not in the hands of the owner. Rather, we are interested in assessing whether a choice of some α improves firm's profit when such compensation system is employed.

whereas q stands for output level; a is the maximum willingness to pay absent any effort.

To keep things simple we assume that the manager's labour, L, is the only input necessary for production, and that one unit of labour transforms into one unit of output. Hence, if w is the wage (per unit of labour), we have that the manager's salary is wL, which is equal to wq, the cost of labour to the firm. It is assumed that $a > w$. When choosing output, the manager is told to maximize profits, that is,

$$\pi = (p - w)q \tag{2.1}$$

The manager, when choosing effort, maximizes his utility function as given by,

$$V = \alpha\pi + wq - \frac{\gamma e^2}{2} \tag{2.2}$$

so that he receives, in addition to his salary (wq), some remuneration under a profit sharing system ($\alpha\pi$) noting that effort is costly ($\gamma e^2/2$). Altogether we have that a positive effort level e has both a positive effect (on demand) and a negative effect (on cost).

The owner will consequently earn π^O, a proportion of total profit according to the percentage of shares that he keeps, that is,

$$\pi^O = (1 - \alpha)(p - w)q \tag{2.3}$$

To see the effect of a profit sharing system we proceed to solve two multi-stage games (of complete information). In the first of the games, the owner does not employ the incentive system. Specifically, the manager chooses his effort level in the first stage of the game, whereas in the second, and knowing the effort level, chooses an output level. In the second game, we consider a stage prior to the two already described, where the owner decides on the participation in profit that incentives the manager's behaviour. Comparing the results of these two games will allow us to establish the possible effectiveness and goodness of the remuneration system proposed. The analysis will distinguish the monopoly and the duopoly cases to see the effect of market structure in the design of incentives, and both effort and output choices.

2.3.1 Monopoly

We begin our analysis with one firm consisting of an owner-manager pair, and start presenting *the game with profit sharing compensation.*

As usual, the game is solved in the usual backward way. In the third stage of the game, for given α and e, the manager chooses the profit maximizing output level, that is,

$$\max_{q} \pi = (p - w)q \tag{2.4}$$

Taking the derivative of π with respect to q and setting it equal to zero yields the (subgame perfect) equilibrium output, $q = (a + e - w)/2$. It is straightforward to check that the second order condition (s.o.c.) for a maximum holds.

We now move to the second stage of the game. Plugging q above in (2.2), the manager's utility function, allows us to write it in terms of effort e and profit participation α. Therefore, the manager solves:

$$\begin{aligned} \max_{e} V &= \alpha\pi + wq - \frac{\gamma e^2}{2} = \\ &= \frac{1}{4}\left(\alpha(a+e-w)^2 + 2w(a+e-w)\right) - \frac{\gamma e^2}{2} \end{aligned} \tag{2.5}$$

Solving $\partial V/\partial e = 0$ for e gives

$$e = \frac{a\alpha + (1-\alpha)w}{2\gamma - \alpha} \tag{2.6}$$

where the s.o.c. for a maximum holds. It can be seen that effort is positively related with market size, a,the wage, w, and also to profit participation, α. In the first stage the owner chooses the percentage of shares that maximizes profit and is given to the manager to enhance his effort. Therefore, the owner solves,

$$\begin{aligned} \max_{\alpha} \pi^O &= (1-\alpha)(p-w)q = \\ &= \frac{(1-\alpha)(2\gamma(a-w)+w)^2}{4(\alpha-2\gamma)^2} \end{aligned} \tag{2.7}$$

Solving $\partial\pi^O/\partial\alpha = 0$ gives the next equilibrium expression for profit participation

$$\alpha^s = 2(1-\gamma) \tag{2.8}$$

Superscript s is used to denote the equilibrium when the profit-sharing scheme is employed. The fulfillment of the s.o.c. for a maximum imposes that $\gamma > 1/2$. This condition, and together with the fact that the profit participation cannot exceed unity, implies that the parameter γ must belong to the interval $(1/2, 1)$. We may then write down the equilibrium output, effort and owner's profit as follows:

$$q^s = \tfrac{2a\gamma + w(1-2\gamma)}{8\gamma-4} \quad e^s = \tfrac{2a(1-\gamma)+w(2\gamma-1)}{4\gamma-2} \tag{2.9}$$

$$\pi^s = \frac{[2a\gamma + w(1-2\gamma)]^2}{32\gamma - 16} \tag{2.10}$$

and the equilibrium utility for the manager is given by

$$V^S = \frac{4(a-w)\gamma(a(1-\gamma)+w\gamma)+w^2}{16\gamma-8} \tag{2.11}$$

Let us now solve the model in a setting where *the owner does not employ any incentive system* prior to effort choice and product market competition. Making α zero in the above analysis leads us to

$$e^* = \tfrac{w}{2\gamma} \quad q^* = \tfrac{2a+w(1-2\gamma)}{4\gamma} \quad \pi^* = \tfrac{(2a+w(1-2\gamma))^2}{16\gamma} \quad V^* = \tfrac{w(4a\gamma+w(1-4\gamma))}{8\gamma} \tag{2.12}$$

where superscript $*$ is used to denote the equilibrium variables when the profit-sharing scheme is not employed. To study the effects of the profit sharing incentive system we can compare the equilibrium effort levels, with and without it, that is:

$$e^s - e^* = \frac{(1-\gamma)[2a\gamma + w(1-2\gamma)]}{(2\gamma-1)2\gamma}, \tag{2.13}$$

which leads us to conclude that the profit sharing mechanism induces a greater effort level as long as $\gamma \in (1/2, 1)$.

Regarding profits we can take the difference and obtain:

$$\pi^s - \pi^* = \frac{[2a\gamma + w(1-2\gamma)]^2}{32\gamma - 16} - \frac{(2a + w(1-2\gamma))^2}{16\gamma} = \frac{(1-\gamma)^2(2a\gamma + w(1-2\gamma))^2}{16\gamma^2(2\gamma-1)}, \quad (2.14)$$

so that profit is higher when $(2\gamma - 1) > 0$ i.e. for $\gamma > 1/2$.

As for the manager's utility we have that:

$$V^s - V^* = \frac{(1-\gamma)[2\gamma a + w(1-2\gamma)]^2}{8\gamma(2\gamma-1)} \quad (2.15)$$

which is positive since $\gamma \in (1/2, 1)$.We can then state the following result.

Proposition 1 *Under monopoly, there is a parameter range for the cost of effort, γ, such that:*
i) a profit sharing system induces more effort by the manager than without the system;
ii) a profit sharing system generates a higher profit level for the owner than without it and,
iii) a profit sharing system generates a higher utility level for the manager than without the system.

To see the consistency of our results, i.e. that $0 \leq \alpha < 1$, recall that it must be the case that $\gamma \in (1/2, 1)$. Regarding positive effort in equilibrium, we must have that $a/w > (1-2\gamma)/(1-\gamma)$; since $a > w$ we get the same condition on γ. Finally, equilibrium output will be positive as long as $2\gamma(a - w) + w$, which holds since $a > w$. The intuition for the result goes as follows. Note that the provision of effort is worthy to the manager - profit and quantity increase with e - but costly (see equation (2.5)). Without the incentives, the equilibrium price p^* is equal to $[2a(2\gamma - 1) + w(1 + 2\gamma)]/4\gamma$, whereas the equilibrium price p^s under the profit-sharing incentive becomes $[2\gamma a + 3w(2\gamma - 1)]/[4(2\gamma - 1)]$. The provision of effort shifts out demand: the shift is greater with the incentive since $e^s > e^*$. So although output increases ($q^s > q^*$), it is also the case that price is higher, that is, $p^s > p^*$. The use of the incentive scheme induces more effort in such a way that the total profit to be shared is now higher and so both the owner and the manager are better off.

The effect of competition is studied in the next subsection.

2.3.2 Cournot duopoly

We now assume that there are two owner-manager pairs; only one of the pairs is allowed to employ the profit sharing system.

The basic assumptions of the monopoly model are maintained. The extension to duopoly will allow us to identify whether there exists a *unilateral incentive* to employ a profit sharing system that makes that owner-manager pair gain a strategic advantage in the product market. We assume that there is Cournot competition and that products are imperfect substitutes. In particular, the system of inverse demand functions is given by[7]:

$$p_1 = a + e_1 - q_1 - dq_2 \qquad p_2 = a + e_2 - dq_1 - q_2 \tag{2.16}$$

where parameter d belonging to $(0, 1)$ represents the degree of product differentiation; as d approaches 1 products become homogeneous and they are independent when d equals zero.

The game with profit sharing compensation. Let us then characterize the subgame perfect equilibrium when, say firm 1, employs the profit sharing system whereas firm 2 does not. Superscripts sn denote this situation. As usual, we solve the game backwards. In the third stage, the managers compete in quantities to solve:

$$\max_{q_1} \pi_1^{sn} = (p_1 - w)q_1 \qquad \max_{q_2} \pi_2^{sn} = (p_2 - w)q_2 \tag{2.17}$$

Setting $\partial\pi_1^{sn}/\partial q_1$ and $\partial\pi_2^{sn}/\partial q_2$ equal to zero and solving for q_1 and q_2 yields:

$$q_1 = \frac{(a - w)(2 - d) + 2e_1 - de_2}{4 - d^2} \tag{2.18}$$

$$q_2 = \frac{(a - w)(2 - d) + 2e_2 - de_1}{4 - d^2} \tag{2.19}$$

We now move up to the second stage of the game where the managers simultaneously choose their effort levels. Noting that the manager of firm 1 is incentivized with a percentage of shares, we may write

[7] The utility function U is assumed to be separable, linear in the numeraire commodity and quadratic and strictly concave in the differentiated good: $U = y + (a + e_1)q_1 + (a + e_2)q_2 - (1/2)(q_1^2 + q_2^2 + 2dq_1q_2)$, where $d \in (0, 1)$.

$$\max_{e_1} V_1 = \alpha\pi_1^{sn} + wq_1 - \gamma e_1^2/2 \qquad \text{and} \qquad \max_{e_2} V_2 = wq_2 - \gamma e_2^2/2 \tag{2.20}$$

We have that:

$$\frac{\partial V_1}{\partial e_1} = \frac{2(2-d)w(2+d-2\alpha) + 4\alpha(a(2-d) + 2e_1 - de_2) - (4-d^2)\gamma e_1}{(4-d^2)^2} \tag{2.21}$$

and the s.o.c. for a maximum implies that $\frac{\partial^2 V_1}{\partial e_1^2} < 0$, that is, $\gamma(4-d^2)^2 - 8\alpha > 0$. Similarly, for manager of firm 2 we have that:

$$\frac{\partial V_2}{\partial e_2} = \frac{2w}{4-d^2} - \gamma e_2 \tag{2.22}$$

Note that the derivative of V_2 with respect to e_2 is not a function of e_1 and so we cannot talk about strategic substitutability or complementarity regarding the variable effort in this asymmetric setting. Solving the system of first order conditions, $\partial V_i/\partial e_i = 0$, $i = 1, 2$, yields the following (subgame perfect) equilibrium effort levels:

$$e_1^{sn} = \frac{2\gamma(2-d)^2(2+d)[2a\alpha - w(2(\alpha-1)-d)w] - 8dw\alpha}{\gamma(4-d^2)(\gamma(4-d^2) - 8\alpha)} \tag{2.23}$$

$$e_2^{sn} = \frac{2w}{\gamma(4-d^2)} \tag{2.24}$$

Plugging (2.23) and (2.24) into the equilibrium quantities (2.18)-(2.19) allows us to write the objective function of the owner as a function of the parameters and α. We can therefore write down the problem for owner of firm 1 as:

$$\begin{aligned} \max_{\alpha} \pi_1^O &= (1-\alpha)(p_1 - w)q_1 = \\ &= \frac{(1-\alpha)(2-d)^2[(a-w)\gamma(4-d^2) + 2w]}{(\gamma(4-d^2) - 8\alpha)^2} \end{aligned} \tag{2.25}$$

so that setting the derivative of π_1^O with respect to α equal to zero and solving for α results in

$$\alpha^{sn} = \frac{16 - \gamma(4-d^2)^2}{8} \tag{2.26}$$

The fulfillment of the s.o.c. for a maximum imposes that γ must be greater than $8/(4-d^2)^2$, which is indeed the same condition for equilibrium α^{sn} to be lower than 1. Besides, γ must be smaller than $16/(4-d^2)^2$ for $\alpha^{sn} > 0$.Hence, under duopoly, the parameter γ must belong to the interval $(\frac{8}{(4-d^2)^2}, \frac{16}{(4-d^2)^2})$. Interestingly, $\partial\alpha^{sn}/\partial d > 0$, so that when competition is stronger (d tending to one) the owner transfers a higher percentage of shares to the manager.

We can express the equilibrium quantities as

$$q_1^{sn} = \frac{(2-d)[(a-w)\gamma(4-d^2)+2w]}{2(\gamma(4-d^2)-8)} \tag{2.27}$$

$$q_2^{sn} = \frac{[(a-w)\gamma(4-d^2)+2w][(2+d)(4+d)(2-d)^2\gamma-16]}{4(\gamma(4-d^2)-8)(4-d^2)\gamma}, \tag{2.28}$$

effort levels as,

$$e_1^{sn} = \frac{-16dw+(2-d)^2(2+d)\gamma(8a+w(d(4+d)-4))-(1/2)(2-d)^4(2+d)^3\gamma^2(a-w)}{2(\gamma(4-d^2)-8)(4-d^2)\gamma} \tag{2.29}$$

$$e_2^{sn} = \frac{2w}{\gamma(4-d^2)}, \tag{2.30}$$

and manager 1's utility and profits as

$$\begin{aligned} V_1^{sn} = {} & \frac{64d^2w^2-4(2-d)^2(2+d)w\gamma(16da-(2-d)(4+d(8+d))w)}{16\gamma(4-d^2)^2(\gamma(4-d^2)^2-8)} + \\ & + \frac{4(2-d)^4(2+d)^2(4a+d(4+d)w)\gamma^2(a-w)}{16\gamma(4-d^2)^2(\gamma(4-d^2)^2-8)} - \\ & - \frac{(2-d)^6(2+d)^4\gamma^3(a-w)^2}{16\gamma(4-d^2)^2(\gamma(4-d^2)^2-8)} \end{aligned} \tag{2.31}$$

$$\pi_1^O = (1-\alpha)\pi_1^{sn} = \frac{(2-d)^2[(a-w)\gamma(4-d^2)+2w]^2}{32(\gamma(4-d^2)-8)} \tag{2.32}$$

$$\pi_2^{sn} = \frac{[(a-w)\gamma(4-d^2)+2w]^2[(2-d)^2(2+d)(4+d)\gamma-16]^2}{16\gamma^2(4-d^2)^2(\gamma(4-d^2)^2-8)^2}. \tag{2.33}$$

We next apply the same logic as above to solve the game where *none of the owners implements the profit sharing system*. The symmetric equilibrium results are the following, where superscript $*$ is again used:

$$
\begin{aligned}
q_1^* &= q_2^* = \frac{(a-w)\gamma(4-d^2)+2w}{(2-d)(2+d)^2\gamma} && (2.34)\\
e_1^* &= e_2^* = \frac{2w}{\gamma(4-d^2)} && (2.35)\\
V_1^* &= V_2^* = w\left(\frac{a-w}{2+d}+\frac{2(1-d)w}{\gamma(4-d^2)^2}\right) && (2.36)\\
\pi_1^* &= \pi_2^* = \frac{[(a-w)\gamma(4-d^2)+2w]^2}{(2-d)^2(2+d)^4\gamma^2} && (2.37)
\end{aligned}
$$

where we see that $e_2^{sn} = e_1^* = e_2^*$.

As we did in the monopoly case, we now conduct a number of comparisons to assess the effects of the profit sharing incentive system. Before proceeding, recall that $\gamma \in (\frac{8}{(4-d^2)^2}, \frac{16}{(4-d^2)^2})$. Since the degree of product differentiation d ranges between 0 and 1, we have it that $8/9 < \gamma < 16/9$ when competition is maximal ($d = 1$). Positive equilibrium quantities require that the numerator in q_2^{sn} be positive; hence $(2+d)(4+d)(2-d)^2\gamma - 16 > 0$ leads to $\gamma > \frac{16}{(2+d)(4+d)(2-d)^2}$. This means that $q_2^{sn} = 0$ as long as $\gamma \in (\frac{8}{(4-d^2)^2}, \frac{16}{(2+d)(4+d)(2-d)^2})$ whereas the duopoly is viable when $\gamma \in (\frac{16}{(2+d)(4+d)(2-d)^2}, \frac{16}{(4-d^2)^2})$.

Regarding *effort levels*, it is easily checked that $e_1^{sn} - e_2^{sn} > 0$. Since $e_2^{sn} = e_1^*$ it follows that manager 1 makes a greater effort under the profit sharing system and that effort level is greater than the rival's.

Regarding the *profits of the owner*, $\pi_1^O - \pi_2^{sn} > 0$ and $\pi_1^O - \pi_1^* > 0$. This confirms the unilateral incentive to employ a profit sharing system to achieve a strategic advantage. Finally, the manager of firm 1 achieves a greater utility level when receiving a percentage of shares, $V_1^{sn} > V_1^* = V_2^*$. Consequently, the following result can be established.

Proposition 2 *Under duopoly, there is a parameter range for the cost of effort γ, i.e. $\gamma \in (\frac{16}{(2+d)(4+d)(2-d)^2}, \frac{16}{(4-d^2)^2})$, such that:*

i) A profit sharing system induces more effort by the manager than without the system. Such effort level is greater than the rival's, who is not given the incentive.

ii) A profit sharing system generates a higher profit level for the owner than without the system. Such profit level is greater than the rival's, who does not employ the system.

iii) A profit sharing system generates a higher utility level for the manager than without the *system, and greater than the rival manager.*

Let us give some intuition about how the profit sharing incentive works. Consider the reaction function space in the last stage of the game where quantities are chosen. Quantity q_i is a function of effort e_i. Equations (2.30) and (2.35) tell us that the manager who is not given the incentives chooses the same effort level regardless of whether the rival manager is given the incentives or not. So the reaction function of the manager of firm two remains the same. However, the manager of firm one, when given the profit sharing incentives, makes a greater effort. The "direct" effect of effort is to increase own demand; there are no externalities in efforts. This translates into an outward shift in its output reaction function: the equilibrium quantity of firm one is bigger and, since the variables are strategic substitutes, the equilibrium quantity of firm two decreases. A greater output results in higher profit and, although effort is costly, the net effect is that the manager's utility and profits exceed those when the incentive scheme is not employed - the division of profit, α, is chosen such that both the owner and the manager are better off.

To further see the effects following the introduction of competition, we next establish some comparisons between the monopoly and the duopoly cases.

Proposition 3 *For a given parameter range for the cost of effort, the percentage of shares given to the manager in a duopoly is higher than in a monopoly.*

The latter result follows from taking the difference $\alpha^{sn} - \alpha^{s} = \frac{16-\gamma(4-d^2)^2}{8} - 2(1-\gamma) = \frac{d^2(8-d^2)\gamma}{8}$, which is positive. Notice that the range of values for γ in the monopoly case is $\gamma \in (1/2, 1)$, whereas that range is $\gamma \in (\frac{16}{(2+d)(4+d)(2-d)^2}, \frac{16}{(4-d^2)^2})$ in the duopoly case - the interval shifts to the right when there is competition. The comparison would only be meaningful when both intervals overlap.

From the analysis the following testable hypotheses are derived.

- H1: Firms that employ a profit-sharing incentive system perform better than those who do not.

Hypothesis 1 is a consequence of Propositions 1 and 2 above, whereby an owner that incentives his manager is capable of achieving higher profits than without them and profits that exceed those of the rival. Therefore, if H1 were confirmed, we would say that the profit-sharing incentive system is a source of competitive advantage.

- H2: The profit sharing incentive scheme is more effective in giving a competitive advantage the stronger the competition.

The statement of hypothesis 2 follows from Proposition 3 and also from the fact that a greater value of d results in higher α and more effort, (see equations (2.26) and (2.23)).

2.4 Empirical analysis

2.4.1 The data

We wish to provide evidence that supports the testable hypotheses derived from the theoretical model developed. To this end we have constructed a database for the passenger airline sector, the sector we have presented as the motivating example. First, we selected the sources that contained performance indicators of US and European airlines. The sources are the US Department of Transport and the company reports available at the airlines webpages - be them in the stock list or not. The airline types in the database are classified according to the following:

- "Major", these are flag carriers that operate in networks with medium and long haul flights (these are no-low-cost airlines),

- "Low Cost", airlines that fly point-to-point (non-stop flights), these are low-cost carriers operating medium and short haul flights, and

- "Regional", airlines that fly point-to-point providing short haul flights, these are no-low-cost carriers serving connections with the "Major" airlines.

The database comprises 23 airlines, 17 are North American and the remaining 6 are European. According to the above classification there are 8 major companies, 10 low cost companies (6 of which are in the EU) and 5 regional companies (see Table 2.2).

	Major	Low Cost	Regional
USA	ALASKA, AMERICAN AIRLINES, CONTINENTAL AIRLINES, DELTA AIRLINES HAWAIAN, .NORTHWEST, USAIRWAYS, UNITED AIRLINES	AIRTRAN, ALLEGIANTAIR JETBLUE, SOUTHWEST,	ATLANTIC SOUTHEAST, EXPRESSJET, FRONTIER, MESA, .SKYWEST
EU		AIRBERLIN, CLICKAIR, EASYJET, FLYBE, RYNAIR,VUELING,	

Table 2.2 Airlines by Region of Origin and Category Type

We have taken data of some quantitative variables reflecting firm performance, and collected information about the incentive schemes based on profit sharing at different levels within the firm. As for firm performance, the variables are total *number of passengers and annual revenue (to obtain revenue per passenger).* The total number of observations for the period 2000-2008 is 168. Regarding the incentive schemes, the reports provide information about whether, during the period of analysis, a particular airline company employed profit sharing in any form, such as stock options, giving shares, and so on. Furthermore the reports also provide information on how far down in the hierarchy do the schemes apply. This allows us to distinguish the following levels of use:

- "Board", comprising the members that belong to the board of directors,
- "Executives", that embodies all the executive posts in the firm, and
- "Employees", including all members in the firm (from pilots to clerks).

Therefore, the depth in the use of profit-sharing incentive system is stronger in the category "employees", followed by "executives" and then by "board". We can rephrase hypothesis H1 saying that firms that employ a deeper incentive system (from board to employees) perform better. All revenues have been converted to euros and deflated using the consumer price index. Details on the database are given in the Appendix.

2.4.2 Analysis

One of the results in the theoretical model is that a firm that employs a profit-sharing incentive scheme performs better than a firm that does not do so. To compare revenues per passenger across airline type and profit-sharing incentives, we use panel data techniques to estimate a random effects model using the following reduced form equation:

$$\begin{aligned} \log(\text{revenue/pax})_{it} = \; & b_0 + b_1 \text{ Regional} + b_2 \text{ Low-cost} + b_3 \text{ Executive} + b_4 \text{ Regional } \times \text{Executive} \\ & + b_5 \text{ Low-cost } \times \text{Executive} + b_6 \text{ Employee} + b_7 \text{ Regional } \times \text{Employee} \\ & + b_8 \text{ Low-cost } \times \text{Employee } + u_{it} \end{aligned} \tag{2.38}$$

The dependent variable is the logarithm of revenue per passenger. *Regional* is a dummy variable that takes value one if the observation corresponds to a regional airline and zero otherwise; *Low-cost* is a dummy variable that takes value one if the observation corresponds to a Low-cost airline and zero otherwise; *Executive* is a dummy variable that takes value one if the observation corresponds to a company operating an executive profits sharing scheme; and finally, *Employee* is a dummy variable that takes value one if the observation corresponds to a company operating an employee profits sharing scheme. The interactive terms capture the intersection between airline type and the incentive scheme, for instance, the variable *Regional x Executive* takes value one for a regional airline operating a profit sharing scheme at the executive level. Eventually, $u_{it} = \alpha_i + \varepsilon_{it}$ is a compound error term where α_i is the individual effect considered as random effects and ε_{it} is an error term with the classical properties.

By construction, $\hat{b}_0$ is the estimated mean revenue per passenger that corresponds to the omitted category, i.e. a major airline operating an incentive scheme at the board level. Adding up to this baseline the estimates of the dummies that correspond to a firm of a given airline type using a given incentive scheme, we can obtain the mean revenue per passenger corresponding to that firm. For example, the estimated mean revenue per passenger of a low-cost firm using an employee incentive scheme would be given by $\hat{b}_0 + \hat{b}_2 + \hat{b}_6 + \hat{b}_8$. Further, the estimation of the reduced form above allows us to test statistically whether there exist differences between any pair of firms that differ either only in one of the characteristics analyzed (airline type and incentive) or in both of them.

As the dependent variable is in logs, the revenue per passenger difference, computed from the estimated coefficients $\hat{b}_i$ as $100\ (\exp(\hat{b}_i) - 1)$, shows the average percentage difference in revenue per passenger between a major airline operating a board incentive scheme and any different combination of airline type and incentive type. Table 2.3 below shows the results with the transformed estimates, where the transformed values are denoted by $\hat{b}_i^*$.

Variable	% variation	p-value
Regional	-53.04	(0.000)
Low cost	-52.64	(0.005)
Executive	23.89	(0.162)
Regional x Executive	15.74	(0.510)
Low cost x Executive	-18.06	(0.543)
Employee	24.50	(0.013)
Regional x Employee	-9.23	(0.271)
Low cost x Employee	-8.40	(0.785)
Robust p values in parentheses		

Table 2.3: Transformed Estimates for $\hat{b}_i^* = 100\ (\exp(\hat{b}_i) - 1)$

The pairwise comparisons carried out in Table 2.4 allow testing possible differences in revenue per passenger for different profit sharing incentive schemes taking into consideration the type of carrier to which the airline belongs to. To start, our estimation results for major companies suggest that revenues per passenger are related to the deepness of the profit-sharing incentive scheme: revenues per passenger are significantly higher when major airlines run executive and employee schemes that when they run the board one (revenues per passenger are about 24% higher in both cases). In the same line for regional airlines, extensions of the profit-sharing incentive scheme from board to executive or employee also result in higher revenues per passenger (39.6% and 15.7% higher for executive and employee, respectively)[8]. However, the lack of significance of the pairwise comparisons shown in the third column of Table 2.4 suggest that for low-cost carriers the type of profit-sharing incentive scheme does not have any influence on mean revenues per passenger.

% DIFFERENCES	MAJOR	REGIONAL	LOW-COST
Executive-Board	$\widehat{b_3^*}$ = 23.89 *(0.162)*	$\widehat{b_3^*} + \widehat{b_4^*}$ = 39.63 *(0.034)*	$\widehat{b_3^*} + \widehat{b_5^*}$ = 5.83 *(0.812)*
Employee-Board	$\widehat{b_6^*}$= 24.50 *(0.013)*	$\widehat{b_6^*} + \widehat{b_7^*}$ = 15.27 *(0.000)*	$\widehat{b_6^*} + \widehat{b_8^*}$ = 16.09 *(0.571)*
Employee-Executive	$\widehat{b_6^*} - \widehat{b_3^*}$ = 0.61 *(0.973)*	$\widehat{b_6^*} + \widehat{b_7^*} - \widehat{b_3^*} - \widehat{b_4^*}$ = 24.36 *(0.197)*	$\widehat{b_6^*} + \widehat{b_7^*} - \widehat{b_3^*} - \widehat{b_4^*}$ = -10.26 *(0.629)*
Robust p values in parentheses			

Table 2.4: Pairwise Comparison of the Effects on Revenue per Passenger of Incentive Schemes by Airline Type

We may therefore conclude that H1 is confirmed in a significant way in the case of major and regional airlines: the profit-sharing incentive scheme is thus a source of competitive advantage in the air passenger sector.

The pairwise comparisons shown in Table 2.5 suggest the relevance of type of profit sharing incentive as a determinant of differences in revenues per passenger across the three types of carriers considered. Thus, when incentives are at the board level revenues per passenger are about 53% lower for regional and low cost carriers than for major carriers. Analogously, when incentives are at the employee level (the deepest level of incentives) revenues per passenger are also lower for regional and low-cost carriers than for major airlines, and this time this difference

[8]Furthermore for the regional airlines, pairwise comparison suggest not statistically significant difference between the mean revenues per passenger for companies running employee and executive incentive schemes.

is even larger (revenues per passenger are 62% and 61% lower for regional and low-cost carriers, respectively). However, when incentives are at executive (intermediate) level the only significant difference is between low-cost and major carriers as revenues per passenger of major companies are 70.7% higher than those of low cost carriers.[9]

% DIFFERENCES	BOARD	EXECUTIVE	EMPLOYEE
Regional-Major	$\widehat{b_1^*}$ = -53.04 *(0.000)*	$\widehat{b_1^*} + \widehat{b_4^*}$ = -37.30 *(0.116)*	$\widehat{b_1^*} + \widehat{b_7^*}$ = -62.26 *(0.000)*
Low-cost-Major	$\widehat{b_2^*}$= -52.64 *(0.005)*	$\widehat{b_2^*} + \widehat{b_5^*}$ = -70.70 *(0.000)*	$\widehat{b_2^*} + \widehat{b_8^*}$ = -61.05 *(0.003)*
Regional-Low-cost	$\widehat{b_1^*} - \widehat{b_2^*}$ = -0.39 *(0.975)*	$\widehat{b_1^*} + \widehat{b_4^*} - \widehat{b_2^*} - \widehat{b_5^*}$ = 33.40 *(0.150)*	$\widehat{b_1^*} + \widehat{b_7^*} - \widehat{b_2^*} - \widehat{b_8^*}$ = -1.21 *(0.952)*
Robust p values in parentheses			

Table 2.5: Pairwise Comparison of the Effects on Revenue per Passenger of Airline Type by Incentive Type.

2.5 Conclusions

With the modern view of the firm and the separation of ownership and management, the literature has identified the role and effects of strategic delegation. However, strong competitive environments open the door to new incentive schemes. This chapter has studied the effectiveness and the strategic role of a profit-sharing incentive scheme. On a theoretical ground, the owner that employs the incentive scheme achieves higher profits than without them, and such profits exceed those of the rival firm. Besides, the percentage of shares given to the manager is higher

[9] Although we are able to show that, once considering a particular incentive level, mean revenues per passenger are typically higher for major airlines. We have not enough information to determine the level of competition in each of the different carrier types. Therefore no empirical test has been undertaken related to $H2$.

when competition is stronger. At the empirical level, the chapter provides evidence confirming the results derived from the model. The profit-sharing scheme can encompass further down in the hierarchy. Increasing their depth can be advantageous as the empirical analysis reveals. Using a database of North American and European airlines, estimates confirm that major and regional airlines that employ the incentive system further down in the hierarchy do perform better. Furthermore, it is shown that, once considering a particular incentive level, mean revenues per passenger are typically higher for major airlines.

The chapter delivers some useful managerial implications. Firstly, the design of a compensation scheme is important for firm success. Earlier work has shown that incentive payments based on absolute and relative performance objectives give the firm a strategic advantage vis a vis rivals. We have shown that an absolute performance evaluation scheme like giving shares to managers is indeed a source of competitive advantage. Secondly, managers put great effort to distinguish their products from rivals. Though costly, the profit-sharing scheme encourages such effort as long as it enhances demand for the differentiated product; this turns out to be a profitable instrument for the owner-manager pair. Thirdly, the participation of managers in a firm's ownership structure particularly serves a double purpose in strong competition environments; on the one hand, managers become tougher competitors in the market and, on the other, the firm has a useful tool to retain talent. Our model has been applied to the air passenger transport sector. There are certainly other features that can help explain the rapid growth and success of some low-cost and regional carriers, yet we believe the profit-sharing incentive scheme to be an important one. Future research may include the consideration of externalities in effort choices as well as establishing whether profit-sharing is strategically chosen (and is a better one) relative to other incentive schemes.

2.6 Appendix

As indicated in the text, the data sources are the US Department of Transport as well as the company reports available at the airlines webpages. From there information per airline about how deep the incentive system is implemented has been obtained. The dependent variable in the regressions is total revenue per passenger. Note however that homogeneity in the data is required. Thus, to control for any country of origin differences we have employed the exchange rates in the table below to have revenue data in euros.

YEAR	USD	GBP	CHF	JPY	SEK	DKK	NOK
2000	0.924	0.609	1.558	152.33	8.446	7.454	8.114
2001	0.896	0.622	1.510	99.53	9.256	7.452	8.049
2002	0.945	0.629	1.467	108.73	9.159	7.431	7.510
2003	1.131	0.692	1.521	118.06	9.124	7.431	7.999
2004	1.243	0.679	1.544	130.96	9.125	7.440	8.372
2005	1.245	0.684	1.548	134.40	9.280	7.452	8.013
2006	1.256	0.682	1.573	136.87	9.253	7.459	8.046
2007	1.371	0.685	1.643	146.06	9.252	7.451	8.018
2008	1.471	0.797	1.587	161.24	9.617	7.456	8.225

Table 2.6: Exchange rates 2000-2008

Finally, the data have been deflated with the Consumer Price Indices displayed below.

YEAR	USA	IRELAND	UK	GERMANY	SPAIN
2000	3.4	5.4	0.8	2.1	4.0
2001	1.6	4.9	1.1	1.6	2.7
2002	2.4	4.6	1.2	1.2	4.0
2003	1.9	3.5	1.3	1.0	2.6
2004	3.3	2.2	1.3	2.3	3.2
2005	3.4	2.5	2.0	1.4	3.7
2006	2.5	4.0	2.3	1.4	2.7
2007	4.1	4.9	2.4	3.1	4.2
2008	0.1	4.1	3.8	1.1	1.4
2009	2.7	-4.5	2.3	0.9	0.8

Table 2.7: Consumer Price Indices 2000-2009

The following tables provide the summary statistics of revenues per passenger sorted by airline type. For each type of incentive the statistics provided are in the following order:

maximum value, minimum value, mean and standard deviation.

MAJOR AIRLINES	
INCENTIVE TYPE	rev/pax
BOARD	301.0699
	190.7439
	241.6968
	31.5989
EMPLOYEE	360.4727
	242.2312
	300.7757
	37.7796
EXECUTIVE	434.2086
	175.1001
	307.5233
	76.6745
ALL INCENTIVES	434.2086
	175.1001
	289.3798
	65.2317

Table 2.8: Summary Statistics Major Airlines

REGIONAL AIRLINES	
INCENTIVE TYPE	rev/pax
BOARD	133.2801
	133.2801
	133.2801
	-
EMPLOYEE	190.2768
	101.2799
	132.2523
	23.8533
EXECUTIVE	290.5233
	100.4350
	174.5510
	54.0181
ALL INCENTIVES	290.5233
	100.4350
	150.4097
	44.1896

Table 2.9: Summary Statistics Regional Airlines

LOW-COST AIRLINES	
Incentive	**rev/pax**
BOARD	202.2474
	56.9974
	142.9666
	38.0302
EMPLOYEE	220.1189
	54.3145
	123.0355
	44.43807
EXECUTIVE	171.0768
	71.1193
	116.6911
	31.4335
ALL INCENTIVES	220.1189
	54.3145
	128.6342
	41.4319

Table 2.10: Summary Statistics Low-cost Airlines

Next Table reports the $\hat{b}_i$ estimates of equation and p-values.

Variable	**General model**
Regional	-0.756
	(0.000)
Low-cost	-0.747
	(0.004)
Executive	0.214
	(0.160)
Regional x Executive	0.146
	(0.509)
Low cost x Executive	-0.199
	(0.543)
Employee	0.219
	(0.012)
Regional x Employee	-0.097
	(0.269)
Low cost x Employee	-0.088
	(0.784)
Constant	5.480
	(0.000)
Observations	168
Number of index	23
R square	0.656
Robust p values in parentheses	

Table 2.11: Results of the regression

Chapter 3

The Impact of Network Structure in Public Service Obligations in Passenger Air Transport

3.1 Introduction

Following the deregulation in the USA (1978) and in Europe (1997), many changes have been observed in the airline sector. Among these, it is worth mentioning the reorganization of networks into hub-and-spoke structures, the formation of alliances, and the emergence of low-cost carriers. These subjects have been studied in the literature. However, there exist regulated routes under the norms of public service obligation services (PSO). These are routes whose frequencies and fares are fixed by authorities in an effort to guarantee a certain quality in air transport services. This chapter enquires into the effects of such regulation to assess i) whether there is an underprovision or an overprovision of frequencies relative to the social optimum, ii) whether the results are affected by the presence of competitors, and ii) whether there is a preferred network architecture, either a fully-connected network or a star network[1].

The literature has examined the effects on frequencies and fares both in a fully-connected

[1] The reader may see Borenstein (1992) for an overview after the liberalization of the US airline industry, and Doganis (1994) for Europe.

network and a star network. As already mentioned, the deregulation process led to an increased use of the hub-and-spoke (HS) networks. The comparison of networks can be cast in terms of a cost approach and/or a demand approach. Regarding the former approach, a key feature is the presence of the airline technology exhibiting economies of scope: if the fixed cost of operating a route is rather high and there are fewer passengers, then the HS network is less costly than a fully-connected (FC) one. Regarding the latter approach, their comparison entails the consideration of how much passengers value a direct flight along with flight frequency. Thus a monopoly airline will make more profit in an HS network when passengers' valuation of direct flights is sufficiently low; frequencies and fares will be higher than under a fully connected network. A compact self-contained comparison can be found in Shy (1995, pages 440-448), where passengers are homogeneous in their preferences. A formal and more recent analysis can be found in Brueckner (2004) where passengers are heterogeneous in travel benefits and incur costs of scheduling delay, and there are economies of operating larger aircraft. Brueckner (2004) establishes conditions under which either the HS or the FC network is preferred by the monopoly airline. However, the welfare analysis shows that flight frequency, traffic volumes and aircraft size all fall below the socially optimal solution.

The analysis of airline competition has mainly been conducted in a deregulated framework, which is a natural direction of research given the competition environment over the last decades. In this context, network choice becomes a strategic variable for airline firms. Oum, Zhang and Zhang (1995) first developed a model where duopolistic carriers choose their route structures before they compete in output levels. In a setting with cost and demand interactions, these authors show that, typically, HS networks have strategic advantages over FC networks. Encaoua et al. (1996) consider asymmetric carriers to analyze the strategic choice of departure times-then-price for two airlines when one relies on connecting traffic from the other in an HS network. The results are driven by demand side arguments since passengers on a one-stop flight between a city pair see the two legs of a journey as two complementary components of the full trip. None of these papers investigates the welfare implications in different types of networks. Barla and Constantatos (2005), in a setting where each airline decides on its capacity under demand uncertainty, note the flexibility-precommitment tradeoff between both types of network: both structures can be a Nash equilibrium. However, the HS network is shown to be welfare superior in terms of both technological and allocative efficiency. The recent contribution by Flores-Fillol (2009) includes demand and supply network effects in a two-stage game where first airlines choose their network configuration and then compete in frequencies and fares. Carriers adopt an HS (resp. FC) structure when transport costs are sufficiently low (resp. high); asymmetric equilibria also arise. It is found that frequencies characterizing FC network structures are below the social optimum. Interestingly, flight frequency can become excessive under HS network configurations and so his analysis provides an explanation to the observed overprovision of frequencies in unregulated markets where HS networks prevailed.

Another aspect of strategic behaviour is related with an airline's response about network structure in the face of entry. The earlier paper by DeVany (1975) studied entry in the by then regulated air transportation industry. He drew attention to the relevance of schedule rivalry, i.e. flight frequency, in assessing the effects that changes in the various sorts of deregulation might produce. In a setting where passengers value service quality (due to increases in flight frequency), Oum, Zhang and Zhang (1995) have shown that hubbing is useful in deterring entry by reducing rival's profit. Hendricks, Piccione and Tang (1997) develop a hub-and-spoke model to show that the hub incumbent operator finds it optimal not to exit from the spoke market and entrants (regional carriers) are forced to leave: the argument rests on the network externalities that arise in the connecting flights between a pair of non-hub cities. Finally, Berechman et al. (1998) assume heterogeneous passengers regarding their value of time. If alone a monopoly airline makes more profit under an FC network, whereas it is better off with an HS network when there is entry in one of the routes; it cannot deter entry but finds it strategically profitable to switch its network configuration. This chapter contributes to the literature in that a welfare analysis is provided. Regarding the monopoly case, and because the airline can choose whether to serve all passengers or leave the market partially covered, the market equilibrium may provide the socially optimal frequencies - a result that contrasts with earlier findings. Besides, when the disutility incurred by passengers taking an indirect flight is sufficiently large the complete network attains greater welfare; private and social interests need not be aligned depending on the size of the disutility incurred relative to the willingness to pay for travelling.

The empirical literature that examines the influence of market structure on airline competition is extensive (see Brander and Zhang, 1990, Brueckner and Spiller, 1994, Marin, 1995, and Fisher and Kamerschen, 2003, only to mention a few). Some have studied the effect of competition on frequencies, such as those of Pai (2010) and Wei and Hansen (2007). However, the number of papers that look into regulatory aspects in the airline industry is scarce. Williams (2005) notes how the different interpretation of PSO across EU countries calls for an amendment of the European PSO legislation; he praises the benefits of the tendering process employed in Norway. Bitzan and Junkwood (2006) study airfares in thin US routes (fares are 11% higher for flights serving smaller communities) whereas Santana (2009) concludes that airlines under PSO programmes do have higher costs thereby affecting their economic performance. For the Spanish case, the recent paper by Calzada and Fageda (2011) shows that prices are higher in routes with price discounts to residents flying elsewhere; whether discounts affect frequencies is unclear. However, regarding intra-island routes in the Canary and Balearic Islands, price caps and frequency floors have led to lower prices and higher frequencies as compared with other unregulated routes having similar features.

There now exist a number of papers on mixed oligopolies. These study the social desirability of having a public firm maximizing total surplus competing against private profit-maximizing firms. The idea is to check whether the presence of a public operator can discipline competition and lead to an outcome that is closer to the social optimum. See De Fraja and Delbono (1990) for a survey with homogeneous products. Papers in the context of product differentiation include Cremer et al (1991), Grilo (1994) and Anderson et al. (1997). Note that in a transportation setting, passengers value both frequency and fares; an adequate modelling of consumer behaviour requires the use of an address model of product differentiation. The analysis of private and mixed oligopolies where means of transport are in competition can be particularly helpful to assess the expected effects of deregulation. Cantos-Sánchez and Moner-Colonques (2005) consider intermodal competition between means that are vertically differentiated and compete in frequencies and prices. They find that the presence of a (public) non-profit maximizing operator is a useful measure to get closer to the social optimum. When both operators are (private) profit maximizers, some control measures such as price caps and minimum service availability would reduce the distortions from the social optimum. This chapter goes further in that it characterizes the equilibrium in a network type of model where indirect flights cause disutility to passengers. Comparisons are conducted both in a monopolistic and duopolistic settings and network type is found to matter.

For a monopoly airline, we prove that the market equilibrium typically produces an under-provision of frequencies relative to the social optimum regardless of the network type - whether an FC or an HS network. So there arises the need for regulating frequencies when the willingness to pay for transport is not large enough since the market equilibrium delivers too low frequencies. Besides, the star network attains greater profits and welfare when compared to the complete one when the willingness to pay for transport is not large enough and when passenger disutility of indirect flights is sufficiently low. The bounds on these parameters are not the same in the profits and the welfare comparison thus giving rise to a conflict between private and social incentives; the analysis identifies potential market failures associated with the network architecture. In a duopoly, and assuming a fully-connected network, it is shown that the market equilibrium produces a suboptimal excess of frequencies in the transport services: both airlines set higher frequencies relative to the social optimum. In a mixed duopoly, if the public operator is relatively more efficient than the profit-maximizing operator, then distortions in the frequencies provided are reduced; the profit-maximizing operator sets too many flights but the public operator sets too few compared to the social optimum. The same type of divergence remains when the public operator is relatively more inefficient, yet the distortion is higher. This suggests that having a public airline competing in the market is an alternative way of controlling the total frequency provided, other than regulating them directly.

The next section provides a discussion of PSO around Europe to then give a more detailed picture of the Spanish case. This motivates the analysis that is presented in section 3.3. A model is developed where a monopolist airline sets frequencies and fares under profit maximization and compare them with the socially optimal choices. Two network architectures are considered: a fully-connected network and a star network. Section 3.4 presents the duopoly case in the context of a fully-connected network. In addition to the private duopoly equilibrium, the mixed duopoly will also be characterized and compared with the social optimum. Some concluding remarks close the chapter.

3.2 Some background on PSO in the airline sector

Before the liberalization reform initiated in the nineties, universal services in network industries were provided by public or regulated monopolies and financed through subsidies from the public budget and through cross-subsidies from profitable to unprofitable consumers. The analysis that follows in Section 3.3 is motivated by many regulation cases in Europe and, in particular, we will look in detail into the case of the Spanish Canary Islands in subsection 3.2.1. In the early 90s, the EU adopted a series of legislative measures to protect smaller communities since it was feared that competition and reorganization of airline networks (as a result of the Third Package of Air Transport Liberalisation Measures 1993-96) might leave these communities without air services they already had. It is in this context that the imposition of PSO in some routes becomes particularly relevant, given that its goal is to ensure an adequate supply of transport services. Although the measures adopted were not equivalent, the US also developed laws in view of protecting small communities from the adverse effects derived from the Airline Deregulation Act of 1978.

Regarding how different states have made use of the PSO mechanism, Reynolds-Feighan (1995a, 1995b), study the impact of the deregulation process, both in Europe and the US, in smaller communities, by comparing their management and legislative structures. Also, Williams and Pagliari (2004) and Williams (2005), evaluate and test how different member states in the EEA have adopted and used the PSO in air transport. These authors, as well as Reynolds-Feighan (1995b), would favour the centralization of PSO management at the European Commission level to achieve a more efficient and egalitarian distribution of subsidies - there have been cases of reported abuses of PSO due to different interpretations of the law by member states.

The implementation of PSO in some routes tried to ensure an adequate provision of air transport services in terms of regularity, frequency and fares, in those cases where airline companies would fail to if strictly following their commercial interests (Council Regulation 2408/92). Besides, the authority to impose a PSO lies in every member state. So there are no fixed criteria and this fact has given rise to a number of different interpretations regarding its applicability.

Currently there are ten member states applying a PSO in some of their routes: Germany, Spain, Finland, France, Greece, Ireland, Italy, Portugal, Sweeden and United Kingdom, as well as other countries that belong to the European Common Space: Iceland and Norway.

In Spain and the UK most of the PSO are found in inter-island air services. There are 15 regulated routes operating in the Highlands and the islands (see Table 3.1) under the Highlands and Islands Air Services Act of 1980. The routes are financed by the Scottish government, that allows the public sector to have a say on the level and quality of the services supplied, including the fares. Whereas the competence in air traffic policy lies with the central British government, the Scottish government takes responsibility in the management of PSO in Scotland.

COUNTRY	ROUTE	AIRLINE (S)
UK	Kirkwall - Eday	Loganair
UK	Kirkwall - Sanday	Loganair
UK	Kirkwall - Stronsay	Loganair
UK	Kirkwall - Westray	Loganair
UK	Kirkwall - Papa Westray	Loganair
UK	Kirkwall - North Ronaldsay	Loganair
UK	Kirkwall - Sumburg/Tingwall	Loganair
UK	Shetland Mainland - Papa Stour	Loganair
UK	Shetland Mainland - Out Skerries	Loganair
UK	Shetland Mainland - Fair Isle	Loganair
UK	Benbecula - Barra	Loganair
UK	Stornoway - Benbecula	Highland Airways
UK	Glasgow - Campbeltown	Loganair
UK	Glasgow - Tiree	Loganair
UK	Glasgow - Barra	Loganair

Table 3.1: Routes under Public Service Obligation Regulation in UK

In Portugal, a PSO was imposed in some routes of the autonomous region of Madeira and the Azores islands back in 1999, in accordance with royal decree 23rd April of 1999 and routes are subsidized, just as with the case of Scotland. In addition, the government subsidizes air transport of residents in Azores and Portuguese students (regardless of where they live) in a similar way to residents in the Canary Islands. The routes subject to regulation in Azores are displayed in Table 3.2, yet there's no airline reported that covers Madeira.

COUNTRY	ROUTE	AIRLINE (S)
PORTUGAL	Ponta Delgada - Santa Maria	SATA Air Azores
PORTUGAL	Ponta Delgada - Terceira	SATA Air Azores
PORTUGAL	Ponta Delgada - Horta SATA	SATA Air Azores
PORTUGAL	Ponta Delgada - Pico SATA	SATA Air Azores
PORTUGAL	Ponta Delgada - São Jorge	N.A.
PORTUGAL	Ponta Delgada - Flores	N.A.
PORTUGAL	Terceira - Graciosa	SATA Air Azores
PORTUGAL	Terceira - São Jorge	SATA Air Azores
PORTUGAL	Terceira - Pico	SATA Air Azores
PORTUGAL	Terceira - Horta	SATA Air Azores
PORTUGAL	Terceira - Flores	SATA Air Azores
PORTUGAL	Terceira - Corvo	N.A.
PORTUGAL	Horta - Flores	SATA Air Azores
PORTUGAL	Horta - Corvo	SATA Air Azores
PORTUGAL	Corvo - Flores	SATA Air Azores

Table 3.2: Routes under Public Service Obligation Regulation in Portugal

In France routes under PSO have been gradually designated since 1994, and along with Norway, is the country that has made a greater use of such regulatory mechanism. The routes chosen are the ones connecting smaller regional airports with Paris, as well as the connections between the main French cities and the island of Corsica. Likewise in Portugal, there are subsidies for residents and students from peripheric regions. Table 3.3 shows the characteristics of PSO routes for France.

COUNTRY	ROUTE	AIRLINE (S)
FRANCE	Marseille - Ajaccio	CCM Airlines / Air France
FRANCE	Marseille - Bastia	CCM Airlines / Air France
FRANCE	Marseille - Calvi	CCM Airlines / Air France
FRANCE	Marseille - Figari	CCM Airlines / Air France
FRANCE	Nice - Ajaccio	CCM Airlines / Air France
FRANCE	Nice - Bastia	CCM Airlines / Air France
FRANCE	Nice - Calvi	CCM Airlines / Air France
FRANCE	Nice - Figari	CCM Airlines / Air France
FRANCE	Paris (Orly) - Ajaccio	CCM Airlines / Air France
FRANCE	Paris (Orly) - Bastia	CCM Airlines / Air France
FRANCE	Paris (Orly) - Calvi	CCM Airlines / Air France
FRANCE	Paris (Orly) - Figari	CCM Airlines / Air France

Table 3.3: Routes under Public Service Obligation Regulation in France

The way this regulation is implemented in Norway is different from the rest of European countries. When the Norwish government first applied the regulation in 1997, it established an auction so that companies could bid for an all-route operation service. However, in the next rounds, the network was divided in 15 independent areas so that the companies could bid for those routes they were actually interested in, the government being able to increase the number of competitive bids. In 2005 the Ministry of Transports and Communications redefined the configuration of areas and changed to 16 areas (see Table 3.4). At the end of this process, Wideroe, the company that had thus far operated all routes got the license for eleven of them; the rest are operated by CoastAir (with a license for three areas), Kato Airline and Danish Air Transport , with one each. It is very likely that Norway has the most transparent process thus favouring the highest number of bids (Williams, 2005).

COUNTRY	ROUTE	AIRLINE (S)
NORWAY	Lakselv–Tromsø	Wideroe
NORWAY	Andenes–Bodø, Andenes–Tromsø	Coast Air
NORWAY	Svolvær–Bodø	Wideroe
NORWAY	Leknes–Bodø	Wideroe
NORWAY	Røst–Bodø	Kato Airline
NORWAY	Narvik (Framnes)–Bodø	Wideroe
NORWAY	Brønnøysund–Bodø,	Wideroe
NORWAY	Brønnøysund–Trondheim	Wideroe
NORWAY	Sandnessjøen–Bodø,	Wideroe
NORWAY	Sandnessjøen–Trondheim	Wideroe
NORWAY	Mo i Rana–Bodø, Mo i Rana–Trondheim,	Wideroe
NORWAY	Mosjøen–Bodø, Mosjøen–Trondheim	Wideroe
NORWAY	Namsos–Trondheim, Rørvik–Trondheim	Wideroe
NORWAY	Florø–Oslo, Florø–Bergen	Danish Air Transport
NORWAY	Førde–Oslo, Førde–Bergen	Wideroe
NORWAY	Sogndal–Oslo, Sogndal–Bergen	Wideroe
NORWAY	Sandane–Oslo, Sandane–Bergen,	Wideroe
NORWAY	Ørsta/Volda–Oslo, Ørsta/Volda–Bergen	Wideroe
NORWAY	Fagernes–Oslo	Coast Air
NORWAY	Røros-Oslo	Coast Air

Table 3.4: Routes under Public Service Obligation Regulation in Norway

3.2.1 The case of the Spanish Canary Islands

In Spain, the Public Service Obligation first came into force in 1998 on the routes that cover the flights between the seven islands that form the Canary Islands. Table 3.5 below shows the routes involved according to *Orden Ministerial* July 30th 1998. Although the regulation did not impede competition, the airline company Binter Canarias was the sole operator between July 1998 and 2003 when a second operator entered the market, Islas Airways. There is another PSO implemented in routes of the Balearic Islands since 2003 and currently one under development between the Southern cities of Almeria and Seville.

The PSO regulation is done by the DGAC (Dirección General de Aviación Civil). In general terms, the legislation establishes the following:

1) Declaration of routes under PSO, stating the minimum annual supply (in terms of seats and aircraft capacity), frequencies, time schedules, and maximum fare. All of these are without any restrictions on entry by different operators. The central and/or the corresponding regional government will subsidize 50% of the fare for resident passengers.

2) In case all the airlines together fail to provide the minimum number of seats established, a contest takes place and the service will be allocated to one only company. Additional subsidies

are granted on an annual basis to cover operational costs.

As for the Canary Islands, the PSO includes 13 routes and must meet the aforementioned requirements and, in particular,

- the maximum capacity, measured in number of seats, per IATA season both in winter and summer.

- the minimum frequency and timetable with a limit of 75% continued load factor.

- the maximum fares, where promotional discounts are permitted.

To describe the market note that there are seven main islands with an airport, and the island of Tenerife holds two, North and South. Currently, 21 routes are operated, 13 of them under the regulatory framework specified (as shown in the map below) and listed in Table 3.5.

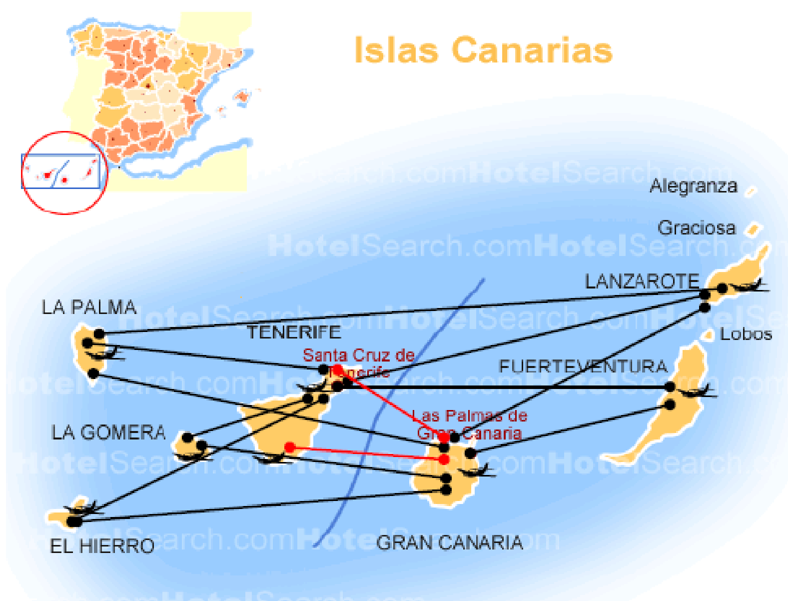

Figure 3.1: Routes under Public Service Obligation Regulation in Canary Islands

COUNTRY	ROUTE	AIRLINE (S)
SPAIN	Gran Canaria - Tenerife Norte	Binter Canarias / Islas Airways
SPAIN	Gran Canaria - Lanzarote	Binter Canarias / Islas Airways
SPAIN	Gran Canaria - Fuerteventura	Binter Canarias / Islas Airways
SPAIN	Gran Canaria - La Gomera	Binter Canarias
SPAIN	Gran Canaria - El Hierro	Binter Canarias
SPAIN	Gran Canaria - Santa Cruz de la Palma	Binter Canarias
SPAIN	Gran Canaria - Tenerife Sur	Binter Canarias
SPAIN	Tenerife Norte - Lanzarote	Binter Canarias / Islas Airways
SPAIN	Tenerife Norte - Fuerteventura	Binter Canarias / Islas Airways
SPAIN	Tenerife Norte - Santa Cruz de la Palma	Binter Canarias / Islas Airways
SPAIN	Tenerife Norte - La Gomera	Binter Canarias
SPAIN	Tenerife Norte - El Hierro	Binter Canarias
SPAIN	Santa Cruz de la Palma - Lanzarote	Binter Canarias

Table 3.5: Routes under Public Service Obligation Regulation in the Canary Islands

At present there are two main airline operators: Binter and Islas Airways. Additionally other companies provide flights but these are basically connecting flights with the peninsula and Europe, via tour operators, major airlines and low cost airlines like Air Europa, Spanair, Vueling and EasyJet.

• Binter Canarias: in May 1989 it began operating in the Canary Islands with Iberia as its main stakeholder. At that time, Binter Canarias was the only airline providing passenger services with its four CN-235 fleet. These were substituted for by the more convenient ATR aircraft in 1997. In June 1999 the fleet consisted of 11 ATR planes, complemented at times by DC-9 hired to Iberia. In the year 2002, and after its acquisition by a group of investors from the islands, an important fleet renewal took place; eight new ATR-72/500 were purchased, with seating capacity for 72 passengers, that substituted the oldest aircraft. At present, Binter Canarias operates with a fleet of 18 ATR-72 aircraft. Over the years, the conditions regulating passenger air transport in the islands have changed substantially. Back in 1989 the market was regulated and basically in the hands of one operator, Iberia, to which Binter Canarias was attached. Nowadays, the market has been deregulated but the specificity of the islands market is that it remains regulated regarding frequencies, total number of seats supplied and maximum fares by the PSO legislation. Binter Canarias was born as a regional airline company and as such it is the only company that operates in the eight Canarian airports. On top of that, since 2005, an internationalization process was initiated that currently translates to connections with Marrakech, Aaiún and Madeira.

• Islas Airways: the company was created on the 7th September 2001. It is in 2003 that Islas Airways operates its first flight. Only three years later, the company has captured an important market share; the escalation is constantly progressing and reaching one million passengers after two years of operation. The initial fleet consisted of two aircraft then expanded to five ATR with seating capacity for 72 passengers. Islas Airways continues its growth trend and its commitment of service with the incorporation, in the first quarter of 2006, of a corporate group chaired by Miguel Concepción Cáceres, representing Sociedades Agrupadas de Canarias (SOAC).

The next section develops a model where a monopolist airline sets frequencies and fares under profit maximization and compare them with the socially optimal choices. These comparisons would somehow reflect a pre-entry situation and two network architectures are considered: a fully-connected network and a star network. Then a duopolistic setting is analyzed in the context of a fully-connected network - which is the network chosen under some conditions and was effectively implemented in the Canary islands. In addition to the private duopoly equilibrium, the mixed duopoly will also be characterized and compared with the social optimum.

3.3 The model

Consider an economy (country or region) that consists of a set of three different cities H, I and J. Each city pair is connected by one airline route and so it is served by one means of transport. Thus there are three city-pair markets IH, HJ, IJ, in which passengers originate in one city and terminate in the other; these markets or routes are labelled $1, 2,$ and 3 respectively. To simplify the analysis we disregard round trips. Each route can be considered as a different market. A passenger can travel either directly or indirectly through a third city; such a city is called a hub, city H. Two basic types of networks are distinguished . One is a fully-connected-network (FC) where passengers can fly directly between any city pair. Another is a hub-and-spoke network (HS) in which only direct flights are possible for those passengers whose final destination is the hub city. Figures 3.2.a and 3.2.b illustrate an FC and an HS network with a hub located at city H.

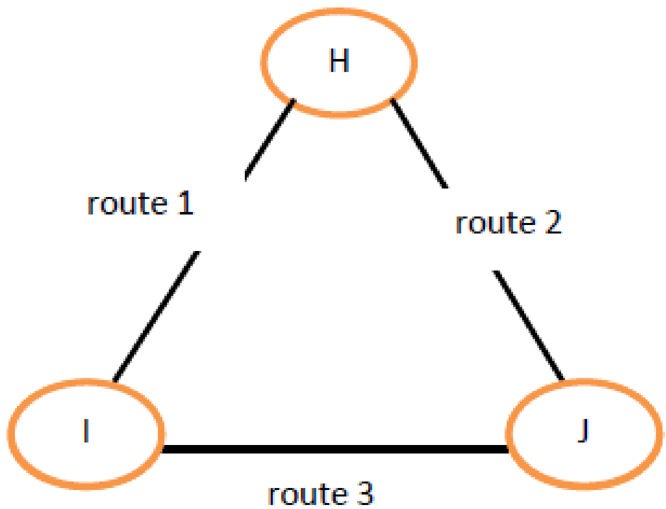

Figure 3.2.a: Fully Connected Network

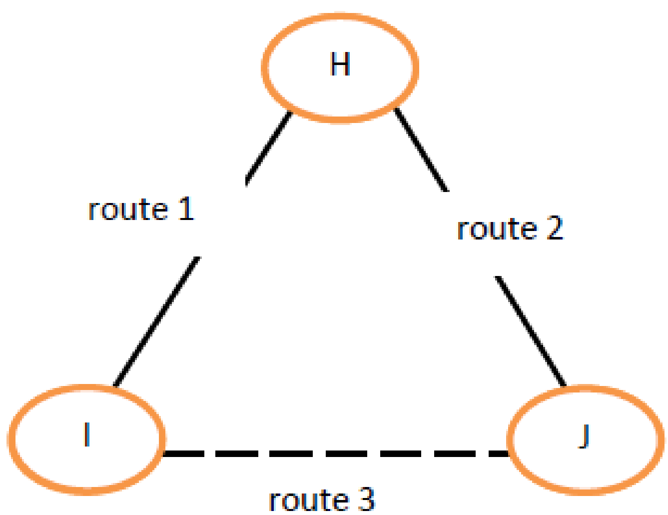

Figure 3.2.b: Hub and Spoke Network

We assume that, on each route i, $i = \{1, 2, 3\}$, there is a continuum of passengers which are uniformly distributed over the interval $[0, 1]$, with density one. Consider the airline to be located at zero so that proximity to zero means preference for travelling (with that airline)[2]. Note that each route has a maximum demand of 1. The (indirect) utility of a passenger in route i is influenced negatively by the fare, p_i, and positively by the number of departures, n_i, since a higher frequency of service implies shorter waiting time. Each user, indexed by $\tau \in [0,1]$ has the following utility function, denoted by $u_{i\tau}$,

$$u_{i\tau} = \begin{cases} v + n_i - p_i - td_\tau & \text{if flying} \\ 0 & \text{if does not fly at all} \end{cases}, \tag{3.1}$$

where v is the baseline willingness to pay for travelling, and d_τ is the distance in the characteristic space between zero and the location of user τ. Parameter t is a measure of the sensitivity of the disutility incurred by a passenger not taking his/her ideal airline.

In this situation the airline company is the monopolist in the market and has to decide whether to serve the full market. Then for any given price and frequency, demand for air transport in route i is as follows:

$$q_i(p_i) = \begin{cases} 0 & \text{if } p_i \geq v + n_l \\ \frac{v+n_i-p_i}{t} & \text{if } v + n_i - t < p_i < v + n_i \\ 1 & \text{if } p_i \leq v + n_i - t \end{cases} \tag{3.2}$$

Where it is now clear that a sufficiently low price will induce all potential users to fly.

3.3.1 The complete network

Let us consider that all flights are direct, i.e. the FC network - in fact, this would quite faithfully correspond to the network design in the Canary Islands. The total cost of operation for the airline is assumed separable as follows: $TC = c(n_1^2 + n_2^2 + n_3^2)$. The cost function is convex to reflect diseconomies of scale in the provision of higher frequencies. The increase in flight frequency is imposing higher complexity on the organization of inputs. Basically, how crews , planes and land services are organized involving the same route. That complexity increase will

[2] In the next section we will assume the presence of a competitor means of transport. It might be thought of either as a rival airline or as an alternative means of transport. Then, in the characteristics space the air transport monopolist will be located at zero while the other tranport mode will be located at one.

suggest a typical diseconomies of scale cost structure in frequencies.

The airline profits in route i reads as follows:

$$\pi_i(p_i) = \begin{cases} -cn_i^2 & \text{if } p_i \geq v + n_i \\ (p_i - g)(\frac{v+n_i-p_i}{t}) - cn_i^2 & \text{if } v + n_i - t < p_i < v + n_i \\ (p_i - g) - cn_i^2 & \text{if } p_i \leq v + n_i - t \end{cases} \tag{3.3}$$

where g stands for the marginal cost per passenger. Total profits are just the sum $\Pi = \sum_i \pi_i$, $i = 1, 2, 3$. We are going to consider the *market equilibrium* case, that is when the monopolist sets prices and frequency to maximize profits, and the *social optimal outcome.*

The market equilibrium

The airline first chooses the frequency and then sets its price. The sequentiality of the choice is meant to capture that prices adapt more rapidly than frequencies and so are a short-run variable choice. Thus the monopolist sets the price to maximize profits for any given frequency that implies either that the market is partially served at the interior solution $p_i = \frac{v+n_i+g}{2}$ with $q_i = \frac{p_i-g}{t}$ or that it is fully served at the corner solution $p_i = v + n_i - t$, with $q_i = 1$. This leads to the following profits expression as a function of frequency:

$$\pi_i(n_i) = \begin{cases} \frac{(v-g+n_i)^2}{4t} - cn_i^2 & \text{if } n_i < 2t - v + g \\ (v + n_i - t) - cn_i^2 & \text{if } n_i \geq 2t - v + g \end{cases} \tag{3.4}$$

Solving $\partial\pi_i(n_i)/\partial n_i = 0$ for n_i we obtain that:

a) $n_i^* = \frac{v-g}{4ct-1}$ if $(v - g) < 2t - \frac{1}{2c}$ (the interior solution) with $q_i^* = \frac{2c(v-g)}{4ct-1} < 1$, profits equal to $\frac{c(v-g)^2}{4ct-1}$, price $\frac{4ct(v+g)-2g}{2(4ct-1)}$.

b) $n_i^* = \frac{1}{2c}$ if $(v - g) > 2t - \frac{1}{2c}$ and the full market is served. Profits are equal to $v - t + \frac{1}{4c}$ and price $\frac{(v+g)}{2} + \frac{1}{4c}$.

Star superscripts indicate equilibrium variables. We next compute consumer surplus and social welfare corresponding to this case. First of all note that consumer surplus for route i is defined as follows: $CS_i = \int_0^{q_i} (v + n_i - p_i - tx)\ dx$ with $0 \leq q_i \leq 1$. Social welfare for route i

is just the sum of profits and consumer surplus. Substituting back the equilibrium prices and quantities we obtain:

$$CS_i^* = \begin{cases} \frac{2tc^2(v-g)^2}{(4ct-1)^2} & \text{if } (v-g) < 2t - \frac{1}{2c} \\ \frac{t}{2} + \frac{1}{c} & \text{if } (v-g) > 2t - \frac{1}{2c} \end{cases} \tag{3.5}$$

$$SW_i^* = \begin{cases} \frac{(6ct-1)c^2(v-g)^2}{(4ct-1)^2} & \text{if } (v-g) < 2t - \frac{1}{2c} \\ v - g - \frac{t}{2} + \frac{5}{4c} & \text{if } (v-g) > 2t - \frac{1}{2c} \end{cases} \tag{3.6}$$

The social optimum outcome

This is the situation that would arise when a social welfare maximizer chose prices and frequencies. First note that the optimal price is just to set price equal to the marginal cost, $p_i = g$ and this entails an optimal number of users which is equal to either $q_i = \frac{v-g+n_i}{t} < 1$ if $n_i < t-(v-g)$ or $q_i = 1$ if $n_i > t-(v-g)$. Taking this into account, the social planner chooses the frequency that maximizes welfare, as defined above, finding that:

$$(n_i)^{so} = \begin{cases} \frac{v-g}{2ct-1} & \text{if } (v-g) < t - \frac{1}{2c} \\ \frac{1}{2c} & \text{if } (v-g) > t - \frac{1}{2c} \end{cases} \tag{3.7}$$

Superscripts SO denote equilibrium variables in the social optimum. The interior solution entails an optimal level of demand $(q_i)^{so} = \frac{2c(v-g)}{2ct-1} < 1$. Consumer surplus and social welfare are in this case equal to:

$$CS_i^{so} = \begin{cases} \frac{2tc^2(v-g)^2}{(2ct-1)^2} & \text{if } (v-g) < t - \frac{1}{2c} \\ v - g - \frac{t}{2} + \frac{1}{2c} & \text{if } (v-g) > t - \frac{1}{2c} \end{cases} \tag{3.8}$$

$$SW_i^{so} = \begin{cases} \frac{c(v-g)^2}{2ct-1} & \text{if } (v-g) < t - \frac{1}{2c} \\ v - g - \frac{t}{2} + \frac{1}{4c} & \text{if } (v-g) > t - \frac{1}{2c} \end{cases} \tag{3.9}$$

Results

We now compare the performance of the market equilibrium with respect to the social optimum outcome. First note that, since $2t - \frac{1}{2c}$ is greater that $t - \frac{1}{2c}$, it happens that the social optimum outcome serves the full market for lower levels of $(v - g)$, i.e. the baseline willingness to pay net of marginal cost. Therefore we should distinguish three cases. First, the case of $(v-g) < t - \frac{1}{2c}$ in which both the market and the social optimum imply that some users do not travel. Second, the case of $t - \frac{1}{2c} < (v - g) < 2t - \frac{1}{2c}$, which implies that the market equilibrium leads to partial market coverage whereas the optimal situation leads to full market coverage. Third, the case of $2t - \frac{1}{2c} < (v - g)$,which implies full market coverage under both scenarios.

Proposition 4 *The market equilibrium produces a suboptimal underprovision of frequencies in the transport service i.e.* $n_i^* < (n_i)^{so}$, *if* $v - g < 2t - \frac{1}{2c}$. *Otherwise the market equilibrium reaches the social optimum* $n_{ij}^* = (n_i)^{so}$.

Proof: Straightforward since $\frac{v-g}{2ct-1} > \frac{v-g}{4ct-1}$ always, and $\frac{1}{2c} > \frac{v-g}{4ct-1}$ when $(v - g) < 2t - \frac{1}{2c}$.

The natural and expected result that frequencies are below the socially optimal solution is confirmed. As noted in the Introduction, this finding was suggested by Brueckner (2004) for the case of a monopoly, yet under different assumptions from those in our model. In his paper, passengers incur a cost of scheduling delay - so that demand is non-linear in frequency -, and there are economies of operating a larger aircraft. However, with full market coverage, we find that the private equilibrium reproduces the optimal frequency, though not the prices which exceed the optimal ones. The policy implication is that the market works efficiently as to the provision of frequencies when $v - g$ is sufficiently large.

3.3.2 The star network

Consider now that the monopoly airline does not provide a direct flight between cities I and J. Passengers flying on route 3 must fly via the hub city H. We thus need to make some further assumptions. The next (indirect) utility function shows the level of utility derived by passenger τ :

$$u_{i\tau} = \begin{cases} v + n_i - p_i - td_\tau & \text{if flies directly to destination} \quad i = 1,2 \\ v - \mu + \frac{n_1+n_2}{2} - f - td_\tau & \text{if flies to destination via the hub} \\ 0 & \text{if does not fly at all} \end{cases}, \tag{3.10}$$

Parameter μ represents the basic disutility that a passenger attaches to hubbing, with $\mu < v$. Note that, when flying via the hub, a passenger is better off by the average of the frequencies in each of the two legs of the trip, n_1 and n_2. Finally, f is the price of an indirect flight from I to J. Note that passengers buying a ticket from city I to city J can costlessly get off or on a plane at the hub H, thereby terminating or starting their journey at H. This implies taking into account the following non-arbitrage conditions: i) the prices on routes 1 and 2 cannot exceed the airfare on route 3, that is, $p_1, p_2 < f$, and ii) the fare on route 3 must be smaller than the sum of the fares on routes 1 and 2, that is, $f < p_1 + p_2$. This ensures that the airline separates those passengers on a short trip from those travelling between I and J.

For routes 1 and 2 with a direct flight demands are as in (2) above whereas for route 3, with an indirect flight, demand is given by,

$$q_3(f) = \begin{cases} 0 & \text{if } f \geq v - \mu + \frac{n_1+n_2}{2} \\ \frac{2(v-\mu)+n_1+n_2-2f}{2t} & \text{if } v - \mu + \frac{n_1+n_2}{2} - t < f < v - \mu + \frac{n_1+n_2}{2} \\ 1 & \text{if } f \leq v - \mu + \frac{n_1+n_2}{2} - t \end{cases}. \tag{3.11}$$

The market equilibrium

The profit function for this connection follows inmediatly from (3.11) assuming hereafter that $g = 0$**.** Note that the three markets are separable in the third-stage of the game as the monopolist is able to price the indirect flight separately. Solving for the prices that maximize the monopolist's profits we find the same equilibrium prices for the direct connections as in the previous section for the FC network and the following equilibrium prices for the indirect connection:

a) $f^* = \frac{v-\mu+\bar{n}}{2}$, where $\bar{n} = \frac{n_1+n_2}{2}$, and $q_3(f^*) = \frac{f^*}{t}$ if the market is not fully served (that is, when $\bar{n} < 2t - v + \mu$) and

b) $f^* = v - \mu - t + \bar{n}$, and $q_3(f^*) = 1$ if $\bar{n} \geq 2t - v + \mu$.

Combining these results with those for direct flights there arise several possible combinations of markets fully served and not fully served depending on the levels n_1, n_2 and $\bar{n}$. Full market coverage is attained at direct connections when $n_i \geq 2t - v$, $i = 1, 2$; while for indirect connections at $\bar{n} \geq 2t - v + \mu$. Therefore, and taking for instance $n_1 = n_2 = \bar{n}$, both the direct markets are fully covered while the two-leg route is not when $2t - v < \bar{n} < 2t - v + \mu$. That is, more frequency is required to fully cover the indirect connection. Also note that depending on the value of the baseline willingness to pay we can find cases where only full market coverage is an option. That is the case for $v > 2t + \mu$. Users value the trip so much that they travel at the equilibrium prices for any frequency chosen. Similarly for $2t < v < 2t + \mu$ the monopolist has to decide just whether to fully cover the indirect connection because the direct ones are always fully covered[3]. Finally, the most complex case arises when $v < 2t$ since initially all possible combinations of full versus partial coverage are attained by properly setting n_1 and n_2.

There are four possible first-stage profits:

a) Direct connections, $i = 1, 2$.

a.1) Partial market coverage: $\pi_i(n_i) = \frac{(v+n_i)^2}{4t} - cn_i^2$.

a.2) Full market coverage: $\pi_i(n_i) = (v + n_i - t) - cn_i^2$.

b) Indirect connection.

b.1) Partial market coverage: $\pi_3(\bar{n}) = \frac{(v-\mu+\bar{n})^2}{4t}$.

b.2) Full market coverage: $\pi_3(\bar{n}) = (v + \bar{n} - \mu - t)$.

[3] In the star network, there is no service - and hence no frequency - in route 3. So that departing from I we have a unit mass of passengers willing to fly to H and a unit mass of passengers willing to fly to J. It is implicitly assumed that aircraft size is enough to take all these passengers; rather the focus is on whether covering the market or not.

Proposition 5 *The market equilibrium for the star network is symmetric in terms of frequency (i.e. $\hat{n}_1^* = \hat{n}_2^* = \hat{n}^*$), and reads,*

$$\hat{n}^* = \begin{cases} \frac{3v-\mu}{8ct-3} & \mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct} \\ \frac{v-\mu+4t}{8ct-1} & 2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{3}{4c} + \mu \\ \frac{3}{4c} & v > 2t - \frac{3}{4c} + \mu \end{cases},$$

and profits are given by

$$\hat{\Pi}^* = \begin{cases} \frac{4ct((v-\mu)^2+2v^2)-\mu^2}{2t(8ct-3)} & \mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct} \\ 2(v-t) + \frac{(v-\mu)^2}{4t} + \frac{(v-\mu+4t)^2}{4t(8ct-1)} & 2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{3}{4c} + \mu \\ 3(v-t) - \mu + \frac{9}{8c} & v > 2t - \frac{3}{4c} + \mu \end{cases}.$$

Proof: See the Appendix.

We employ the superscript hat to denote the equilibrium variables in the star network case. Note that when the baseline willingness to pay is small enough, $\mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$, then no connection is fully covered in equilibrium. For this case to happen it must be that $2t - \frac{3}{4c} + \frac{\mu}{8ct} > \mu$, that is $\mu < \frac{2t(8ct-3)}{8ct-1}$; otherwise, the monopolist never partially covers the direct flights in equilibrium. As v increases, that is for $2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{3}{4c} + \mu$, only direct connections are fully covered. Finally when $v > 2t - \frac{3}{4c} + \mu$, the three markets are fully covered. In fact and in the latter case, the equilibrium frequency is just determined by the parameter cost of frequency; otherwise, and since more frequencies increase the willingness to pay, the equilibrium frequency also depends on demand parameters. Another comment worth making is that symmetric solutions dominate the asymmetric ones for two reasons. When revenues are a function of $\bar{n}$ any asymmetric combination of frequencies for connections IH and HJ that yield the same average frequency is always dominated by the symmetric outcome since costs are convex. If alternatively, revenues are not a function of $\bar{n}$, which is the case when only one direct connection is either fully or partially covered, then it is proven in the Appendix that the monopolist is always better off partially covering the direct flights.

The social optimum

In this subsection we compute the social optimum both in terms of prices and frequencies for the star network. Consumer surplus for the case of direct connections is calculated as in the case of the complete network, that is $CS_i = \int_0^{q_i}(v + n_i - p_i - tx)\ dx = (v + n_i - p_i)q_i - \frac{tq_i^2}{2}$ with $0 \leq q_i \leq 1$ and $i = 1, 2$. For the indirect connection a similar expression can be found: $CS_3 = \int_0^{q_3}(v - \mu + \bar{n} - f - tx)\ dx = (v - \mu + \bar{n} - f)q_3 - \frac{tq_3^2}{2}$ with $0 \leq q_3 \leq 1$. The latter expressions give rise to the generic social welfare function as follows: $SW = \sum_{i=1,2}[(v + n_i)q_i - \frac{tq_i^2}{2}] + (v - \mu + \bar{n})q_3 - \frac{tq_3^2}{2} - cn_1^2 - cn_2^2$, where depending on the level of demands, either smaller than one or equal to one, we can get back to any possible combination of fully or partially covered connections. Also, the above expression captures the typical definition as welfare is just the users' utility minus the link costs, since the monopolist revenues are direct transfer from users and consequently they cancel out in the social welfare expression. Taking the first order conditions for a maximum in prices (i.e. $\frac{\partial SW}{\partial p_1} = 0$, $\frac{\partial SW}{\partial p_2} = 0$ and $\frac{\partial SW}{\partial f} = 0$), we find that SW is increasing in the number of users (demand). Then, either prices do not play any role in increasing demand $-$ since the market is fully covered given frequencies and then prices only have distributional effects $-$, or they are used to increase the demand when frequencies are such that markets are partially covered. In the latter case, and once a reduction in price implies that demand reaches unity, any further reduction in prices only has, as in the former case, distributional effects. To be more precise, the prices that maximize demands are $0 \leq p_i \leq \max\{v + n_i - t, 0\}$ for $i = 1, 2$ and $0 \leq f \leq \max\{v - \mu + \bar{n} - t, 0\}$. In fact, it is any non-negative price that implies that the full market is covered at the given frequency, or zero if the frecuencies are so low that the market cannot be fully covered even at zero price. Intutitively, a social planner will use prices to increase as much as possible the number of users for any given frequency.

The next step is to compute the optimal frecuency of flights, noting that only symmetric solutions make sense, i.e. $(\hat{n}_1)^{so} = (\hat{n}_2)^{so} = \hat{n}^{so}$, and that we focus on the case where optimal prices are zero. First consider the case where all the markets are fully covered, i.e. $\frac{(v-\mu)+\frac{n_1+n_2}{2}}{t} \geq 1$ then $SW = 3v - \mu + n_1 + n_2 + \bar{n} - \frac{3t}{2} - cn_1^2 - cn_2^2$, which reaches a maximum at $\hat{n}^{so} = \frac{3}{4c}$ and this value is consistent with full market coverage as long as $\frac{3}{4c} > t + \mu - v$. Next, consider the case where only direct flights are fully covered, that is, for $\frac{(v-\mu)+\frac{n_1+n_2}{2}}{t} < 1$ and $\frac{v+n_i}{t} \geq 1$, $i = 1, 2$, with $SW = 2v - t + n_1 + n_2 + (v - \mu + \bar{n})q_3 - \frac{tq_3^2}{2} - cn_1^2 - cn_2^2$, which yields the optimal symmetric frequency of $\hat{n}^{so} = \frac{v-\mu+2t}{4ct-1}$, and is consistent as long as $\frac{(v-\mu)+n^{so}}{t} < 1$ and $\frac{v+n^{so}}{t} \geq 1$, or $t - \frac{3}{4c} + \frac{\mu}{4ct} < v \leq t - \frac{3}{4c} + \mu$. Finally, take the case of all markets partially covered which will imply an optimal frequency given byl $\hat{n}^{so} = \frac{3v-\mu}{4ct-3}$, for $\mu < v \leq t - \frac{3}{4c} + \frac{\mu}{4ct}$. A condition on μ is required to make this case possible, $\mu < \frac{t(4ct-3)}{4ct-1}$; otherwise it is never optimal to leave the direct connections partially covered. To sum up, the optimal frequency and welfare attained are the following:

$$\hat{n}^{so} = \begin{cases} \frac{3v-\mu}{4ct-3} & \mu < v \leq t - \frac{3}{4c} + \frac{\mu}{4ct} \\ \frac{v-\mu+2t}{4ct-1} & t - \frac{3}{4c} + \frac{\mu}{4ct} < v \leq t - \frac{3}{4c} + \mu \\ \frac{3}{4c} & v > t - \frac{3}{4c} + \mu \end{cases}$$

$$\widehat{SW}^{so} = \begin{cases} \frac{2ct(v-\mu)^2+4ctv^2-\mu^2}{t(4ct-3)} & \mu < v \leq t - \frac{3}{4c} + \frac{\mu}{4ct} \\ \frac{2c(v-\mu)^2+t(8cv+3)-4ct^2-2\mu}{4ct-1} & t - \frac{3}{4c} + \frac{\mu}{4ct} < v \leq t - \frac{3}{4c} + \mu \\ 3v - \mu - \frac{3t}{2} + \frac{9}{8c} & v > t - \frac{3}{4c} + \mu \end{cases}.$$

Results

We are ready to compare the performance of the market equilibrium with respect to the social optimum outcome. There are two different sources of discrepancy, one is the number of frequencies for each interval and the other is the intervals themselves. Direct inspection of the expressions is enough to conclude that $\hat{n}^* < \hat{n}^{so}$ when there is partial coverage of at least one market, while $\hat{n}^* = \hat{n}^{so}$ when the three markets are fully covered in both cases, that is for $v > 2t - \frac{3}{4c} + \mu$. It is also important to highlight that since optimal prices are smaller than monopoly ones, a lower frequency is required to fully cover a given market in the former case. Regarding the interval ordering, it is important to note that we assume that $\mu < \frac{t(4ct-3)}{4ct-1} < \frac{2t(8ct-3)}{8ct-1}$, that is partial coverage for all markets is both an optimal and a market equilibrium for some values of the parameters. If this is the case then the ranking in thresholds is $t - \frac{3}{4c} + \frac{\mu}{4ct} < t - \frac{3}{4c} + \mu < 2t - \frac{3}{4c} + \frac{\mu}{8ct} < 2t - \frac{3}{4c} + \mu$. This ranking means that it is optimal to fully cover the three markets when the monopolist at equilibrium only partially covers those markets. Comparing equilibrium frequencies with optimal ones for each possible situation we get the following result.

Proposition 6 *The market equilibrium produces a suboptimal underprovision of frequencies in the airline service (i.e. $\hat{n}^* < \hat{n}^{so}$) if $\mu < v < 2t - \frac{3}{4c} + \mu$. Otherwise the market equilibrium reaches the social optimum number of frequencies, $\hat{n}^* = \hat{n}^{so}$.*

Proof: See the Appendix.

Propositions 4 and 6 together tell us that, regardless of the network type, there arises the need for regulating frequencies when v is not large enough since the market equilibrium delivers too few frequencies relative to the social optimum. Otherwise the policy implication for a regulator is do nothing as far as frequencies are concerned for the market is working efficiently in that respect.

3.3.3 The complete vs the star network

We wish to find conditions under which the complete network attains greater welfare than the star network and next we also compare the two networks in terms of the monopolist's profits. Regarding the social incentive to implement a given network we firstly have a neat result for the case of $\mu = 0$, since then *the star network is always preferred*. The reason is that the excess of frequency cost in the star network (greater than or equal to the number of frequencies than under the complete network but more costly due to the decreasing returns) is more than compensated by the advantage the star network has in terms of marginal welfare derived by one more flight. The star network is serving more users per frequency than the complete one, and since the users do not care about indirect flights, the star network does better.

Proposition 7 *The star network attains greater welfare when compared to the complete one if μ is sufficiently low and when v is sufficiently large. A sufficient condition for the complete network to yield higher welfare is $\mu > \frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c}$.*

Proof: See the Appendix.

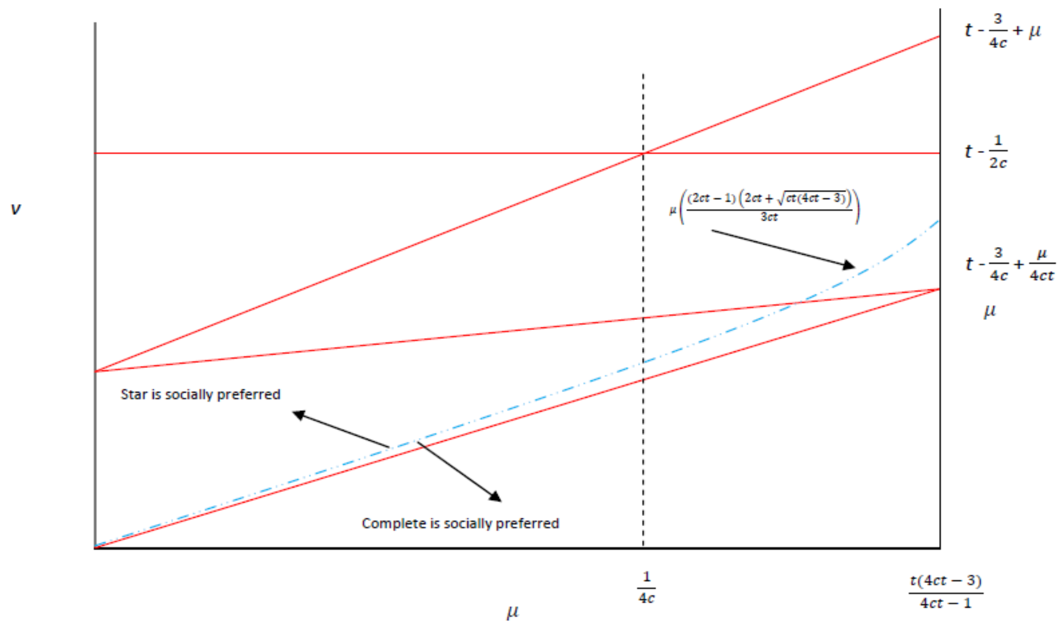

Figure 3.3: Star vs Complete: Social Welfare

When we analyze which network would be chosen by the monopolist we find that when consumers do not care for indirect flights ($\mu = 0$) then the star network always yields higher profits than the complete one. The reason is similar to the case of welfare, the excess of frequency cost in the star network is more than compensated by the advantage the star network has in terms of marginal profits per flight. When consumers do not care about indirect flights, we have that, with less flights, all consumers travel. This part of the result certainly conforms with the received literature, as specified in the Introduction. The next proposition displays the monopolist's choice for positive μ.

Proposition 8 *The star network attains greater profits when compared to the complete one if μ is sufficiently low and when v is sufficiently large. A sufficient condition for the complete network to yield higher profit is* $\mu > \frac{8ct+1-\sqrt{(16ct-1)(4ct-1)}}{6c}$.

Proof: See the Appendix.

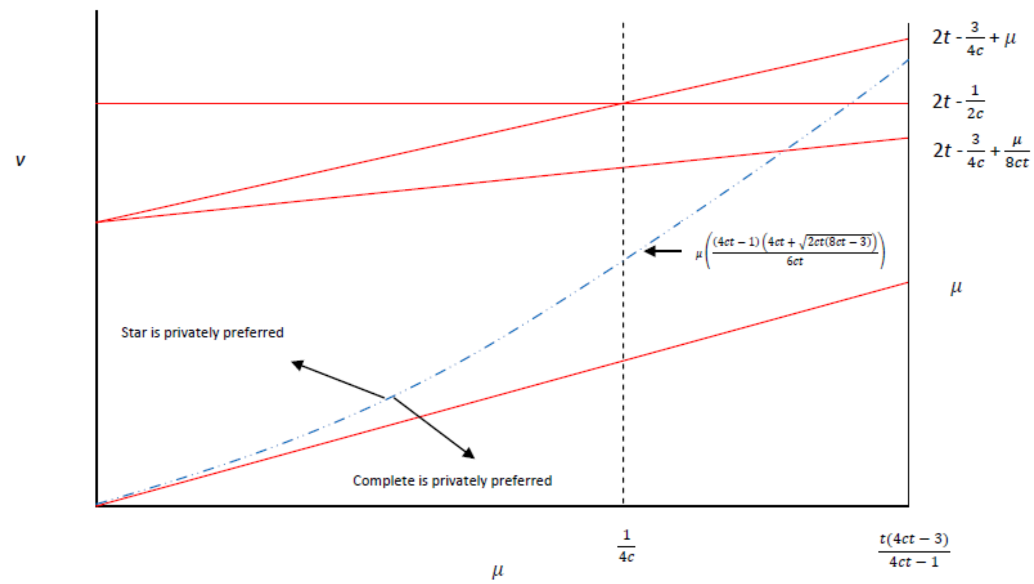

Figure 3.4: Star vs Complete: Profits

Finally, we identify market failures in terms of network choice as follows. There are regions on the $\{v, \mu\}$ parameter set where the star network is the optimal choice while the monopolist will choose the complete network. This happens for instance for all $v \in [\frac{(2ct-1)(2ct+\sqrt{ct(4ct-3)})}{3ct}\mu, \frac{(4ct-1)(4ct+\sqrt{ct(8ct-3)})}{6ct}\mu]$ and $\mu \leq \frac{1}{4c}$. In sum, and provided that the market equilibrium typically fails to reproduce the social optimum, the previous two Propositions identify the potential market failure in terms of network architecture.

3.4 A duopolistic market

We now consider that all three routes are served by two airlines – or, in general, by two means of transport. The analysis might reflect what happened in the Canary Islands market after 2003, when Binter faced competition from Islas Airways.[4]

For each route there is continuum of passengers with density one which are uniformly distributed across the interval $[0, 1]$, where now proximity to zero means preference for air transport

[4] Given that the analysis is motivated by the Canary Islands market, we focus on a fully connected network. An alternative interpretation is that, given the sequentiality of events, the parameter μ is assumed large enough thus leading, in the first place, to opt for a fully connected network.

(incumbent airline) while users close to unity show preference for the alternative transport mode (entrant airline). Therefore, in the characteristics space the air transport monopolist is located at zero while the rival transport mode is located at one. Thus in route i each user $\tau \in [0,1]$ has the following (indirect) utility function,

$$u_{i\tau} = \begin{cases} v + n_i^I - p_i^I - td_{\tau I} & \text{if } i \text{ flies with the incumbent,} \\ v + n_i^E - p_i^E - td_{\tau E} & \text{if } i \text{ flies with the entrant,} \\ 0 & \text{if } i \text{ does not fly at all.} \end{cases}, \tag{3.12}$$

where the variables are as above, and now I and E are used to denote the incumbent and the entrant airline, respectively. Also, $d_{\tau I}$ is the distance in the characteristic space between zero and the location of user τ while $d_{\tau E}$ is her distance to 1, therefore, $d_{\tau I} + d_{\tau E} = 1$.

We shall consider several competition environments in the market. In one of them, the two means of transport are managed by profit maximizing firms; this is the *market equilibrium* case. Then, we will consider the case of a profit maximizing firm in air transport competing with a social welfare maximizing operator; this is the *mixed equilibrium* case. Finally, we will characterize the *social optimum outcome.*

The market equilibrium

The demand for air services in route i is determined by the following equation:

$$v + n_i^I - p_i^I - td_{\tau I} = v + n_i^E - p_i^E - t(1 - d_{\tau E}) \tag{3.13}$$

thus giving the following demand function for the incumbent airline:

$$q_i^I(p_i^I, p_i^E) = \begin{cases} 0 & \text{if } p_i^I \geq n_i^I - n_i^E + p_i^E + t, \\ \frac{1}{2} + \frac{n_i^I - n_i^E - p_i^I + p_i^E}{2t} & \text{if } n_{ij}^I - n_i^E + p_i^E - t < p_i^I < n_i^I - n_i^E + p_i^E + t, \\ 1 & \text{if } p_i^I \leq n_i^I - n_i^E + p_i^E - t. \end{cases} \tag{3.14}$$

Firm I profits in route i read:

$$\pi_i^I(p_{ij}^I, p_{ij}^s) = \begin{cases} -c^I(n_i^I)^2 & \text{if } p_i^I \geq n_i^I - n_i^E + p_i^E + t \\ (p_i^I - g)(\frac{1}{2} + \frac{n_i^I - n_i^E - p_i^I + p_i^E}{2t}) - c^I(n_i^I)^2 & \text{if } n_{ij}^I - n_i^E + p_i^E - t < p_i^I < n_i^I - n_i^E + p_i^E + t \\ (p_i^I - g) - c^I(n_i^I)^2 & \text{if } p_i^I \leq n_i^I - n_i^E + p_i^E - t \end{cases} \quad (3.15)$$

where c^I is the cost parameter in the incumbent's cost function for frequencies. Total profits are just the sum $\Pi^I = \sum_i \pi_i^I$, $i = 1, 2, 3$. The expressions for the entrant airline follow straighforwardly by making the necessary changes.

The airlines first compete in frequencies and then compete in prices. We now compute the (subgame perfect) equilibrium in the final stage. Solving $\partial\Pi^I/\partial p_i^I = 0$ and $\partial\Pi^E/\partial p_i^E = 0$ delivers the following interior equilibrium: $(p_i^m)^* = t + g + \frac{n_i^m - n_i^h}{3}$, for $m, h = I, E$ and $I \neq E$. Therefore, the equilibrium price set by an airline increases with the disutitlity parameter, t, with marginal cost, g, and with the number of flights of that airline whereas it decreases with the frequency of the rival airline. Note that the difference in equilibrium prices just reflects the difference in frequencies. It is also true that $(q_i^m)^* = \frac{(p_i^m)^* - g}{2t}$. The first-stage reduced profit functions for route i become:

$$\pi_i^m(n_i^I, n_i^E) = \begin{cases} -c^m(n_i^m)^2 & \text{if } n_i^m \leq n_i^h - 3t \\ (t + \frac{n_i^m - n_j^h}{3})(\frac{1}{2} + \frac{n_i^m - n_i^h}{6t}) - c^m(n_i^m)^2 & \text{if } n_i^h - 3t < n_i^m < n_i^h + 3t \\ (t + \frac{n_i^m - n_i^h}{3}) - c^m(n_i^m)^2 & \text{if } n_i^h + 3t \leq n_i^m \end{cases} \quad (3.16)$$

$$\text{for } m, h = I, E \text{ and } m \neq h.$$

Note that large differences in frequencies may induce the exit of one of the airlines.

Firms now maximize profits by selecting the frequency. The following interior equilibrium is obtained $(n_i^m)^* = \frac{9c^m t - 1}{18c^I c^E t - c^I - c^E}$, for $m = I, E$. Therefore the firm with higher frequency cost sets the higher equilibrium frequency. The interior equilibrium is the global equilibrium if and only if $t > \frac{c^I + c^E}{18c^I c^E} \geq \max\{\frac{1}{9c^I}, \frac{1}{9c^E}\}$. When one of the airlines is too inefficient with respect to the other then only the efficient airline will operate in the market. For instance, the entrant would be out of the market when $c^E > c^I$ and $t < \frac{1}{9c^E}$. Focusing on the interior equilibrium we obtain the following equilibrium prices, quantities, profits.

$$\begin{aligned} q_i^{m*} &= c^m (n_i^m)^*; \\ p_i^{m*} &= 2tc^m (n_i^m)^* + g; \\ \pi_i^{m*} &= \frac{c^m(18c^m t - 1)(n_i^m)^{*2}}{9}. \end{aligned}$$

We next compute consumer surplus and social welfare corresponding to this case. First of all note that the consumer surplus for route i is defined as follows:

$$CS_i = \int_0^{q_i} (v + n_i^I - p_i^I - tx)\ dx + \int_0^{1-q_i} (v + n_i^E - p_i^E - tx)\ dx;\ \text{with } 0 \leq q_i \leq 1. \tag{3.17}$$

And after substituting back the equilibrium prices and quantities we obtain:

$$\begin{aligned} CS_i^* &= v - g - \frac{5t}{4} + \frac{n_i^{I*} + n_i^{E*}}{2} + \frac{(n_i^{I*} - n_i^{E*})^2}{36t} \\ SW_i^* &= v - g - \frac{t}{4} + \frac{n_i^{I*} + n_i^{E*}}{2} + \frac{5(n_i^{I*} - n_i^{E*})^2}{36t} - c^I (n_i^{I*})^2 - c^E (n_i^{E*})^2 \end{aligned}$$

The mixed equilibrium case

In this case we consider that one of the airlines behaves as a social maximizer operator. Consider, without loss of generality, that the entrant sets frequency and price to maximize social welfare. To find the equilibrium pair of prices for each route, we solve the following system of equations, $\frac{\partial \pi_i^I}{\partial p_i^I} = 0$, and $\frac{\partial SW_i}{\partial p_i^E} = 0$. Noting that social welfare simplifies to $SW_i = v - g - \frac{t}{2} + n_i^E + (n_i^I - n_i^E)q_i^I + tq_i^I(1 - q_i^I) - c^I(n_i^I)^2 - c^E(n_i^E)^2$, the equilibrium prices are $p_i^{I**} = p_i^{E**} = t + g + n_i^I - n_i^E$, where the difference in frequencies does not affect the difference in prices.[5]

As in the private case large differences in frequencies might end up in one airline exiting the market. In particular, if $n_i^I > n_i^E + t$, then the entrant will not operate. Substituting

[5] Double star superscripts are used to denote the equilibrium variables in the mixed duopoly case.

the equilibrium prices back in π_i^I and SW_i we obtain the first-stage reduced profits and welfare denoted by $\pi_i^I(n_i^I, n_i^E)$ and $SW_i(n_i^I, n_i^E)$. The interior equilibrium in frequencies is the solution to $\frac{\partial \pi_i^I(n_i^I, n_i^E)}{\partial n_i^I} = 0$, and $\frac{\partial SW_i(n_i^I, n_i^E)}{\partial n_i^E} = 0$ and reads $n_i^{I**} = \frac{2c^E t - 1}{4c^I c^E t - c^I - 2c^E}$, and $n_i^{E**} = \frac{c^I t - 1}{4c^I c^E t - c^I - 2c^E}$. Note the difference with the private duopoly: the less efficient airline does not necessarily set a higher equilibrium frequency than the rival. The interior equilibrium is the global equilibrium if and only if $t > \max\{\frac{1}{c^I}, \frac{1}{2c^E}\}$. Substituting back the equilibirum frequencies we obtain the following prices, quantities and profits for route i :

$$
\begin{aligned}
q_i^{I**} &= c^I n_i^{I**}; 1 - q_i^{I**} = 2c^E n_i^{E**} \\
p_i^{I**} &= 2tc^I n_i^{I**} + g; p_i^{E**} = 2tc^E n_i^{E**} + g \\
\pi_i^{I**} &= c^I(2c^I t - 1)(n_i^{I**})^2
\end{aligned}
$$

Similarly, consumer surplus and welfare reads,

$$
\begin{aligned}
CS_i^{**} &= v - g - \frac{5t}{4} + \frac{3n_i^{I**} - n_i^{E**}}{2} + \frac{(n_i^{I**} - n_i^{E**})^2}{4t} \\
SW_i^{**} &= v - g - \frac{t}{4} + \frac{n_i^{I**} + n_i^{E**}}{2} + \frac{(n_i^{I**} - n_i^{E**})^2}{4t} - c^I(n_i^{I**})^2 - c^E(n_i^{E**})^2
\end{aligned}
$$

The social optimum outcome

This is the situation that would arise if a social welfare maximizer chose prices and frequencies of the two airlines. Therefore, solving $\frac{\partial SW_i}{\partial p_i^I} = 0; \frac{\partial SW_i}{\partial p_i^E} = 0$ for (p_i^I, p_i^E) we obtain the second stage optimal prices, $(p_i^I)^{so} = (p_i^E)^{so} = p_i^{so}$ which imply that any price level is optimal with the proviso that both airlines be priced equally. Substituting back into the social welfare function and solving $\frac{\partial SW_i}{\partial n_i^I} = 0; \frac{\partial SW_i}{\partial n_i^E} = 0$ for (n_i^I, n_i^E) we get $(n_i^I)^{so} = \frac{2c^E t - 1}{2(4c^I c^E t - c^I - c^E)}$ and $(n_i^E)^{so} = \frac{2c^I t - 1}{2(4c^I c^E t - c^I - c^E)}$. The interior equilibrium is the global equilibrium if and only if $t > \max\{\frac{1}{2c^I}, \frac{1}{2c^E}\}$. Substituting back the equilibrium frequencies we obtain the following quantities and profits, the latter being a parametric function of p_i^{so}:

$$
\begin{aligned}
(q_i^I)^{so} &= c^I (n_i^I)^{so}; 1-(q_i^I)^{so} = c^E (n_i^E)^{so} \\
(\pi_i^I)^{so} &= \frac{(p_i^{so}-g)(t+(n_i^I)^{so}-(n_i^E)^{so})}{2t} - c^I((n_i^I)^{so})^2 \\
(\pi_i^E)^{so} &= \frac{(p_i^{so}-g)(t+(n_i^E)^{so}-(n_i^I)^{so})}{2t} - c^E((n_i^E)^{so})^2
\end{aligned}
$$

Similarly for consumer surplus and welfare:

$$
\begin{aligned}
CS_i^{so} &= v - p_i^{so} - \frac{t}{4} + \frac{(n_i^I)^{so}+(n_i^E)^{so}}{2} + \frac{((n_i^I)^{so}-(n_i^E)^{so})^2}{4t} \\
SW_i^{so} &= v - g - \frac{t}{4} + \frac{(n_i^I)^{so}+(n_i^E)^{so}}{2} + \frac{((n_i^I)^{so}-(n_i^E)^{so})^2}{4t} - c^I((n_i^I)^{so})^2 - c^E((n_i^E)^{so})^2
\end{aligned}
$$

Results

We firstly state the next result that deals with the full comparison of frequencies for the symmetric case.

Proposition 9 *If $c^I = c^E = c$, the market equilibrium produces a suboptimal excess of frequencies in the transport services. Both $(n_i^I)^{so} < n_i^{I*}$ and $(n_i^E)^{so} < n_i^{E*}$. The full ranking is $(n_i^I)^{so} < n_i^{I*} < n_i^{I**}$ and $n_i^{E**} < (n_i^E)^{so} < n_i^{E*}$.*

Then, when competition is the driving force in setting frequencies, firms are spending too much in frequencies as compared with the optimal choice. Also the existence of a public firm, that is a firm that makes decisions to maximize welfare, is imposing an increase in the private firm frequency choice as a reaction to the decrease in frequencies by the public firm. Interestingly enough, the frequency level of the public firm falls short of the optimal one.

In the case of cost asymmetry between the incumbent firm and the entrant, we find that $(n_i^I)^{so} < n_i^{I**}$ and $n_i^{E**} < (n_i^E)^{so}$. This means that the ranking between the market and the mixed equilibrium case is robust to cost asymmetry. Finally, and regarding the ranking between the market equilibrium and the social optimum outcome, the following result holds: $(n_i^I)^{so} < n_i^{I*}$ and $(n_i^E)^{so} < n_i^{E*}$ if and only if cost asymmetry is not very marked, that is for $0.546153 < \frac{c^I}{c^E} < 1.4766$.

Together Propositions 4, 6 and 9 unveil the importance of market structure in assessing any divergences relative to the social optimum. Under monopoly, the market equilibrium provides too few frequencies and may even reach the socially optimal number of flights. In contrast, a duopoly structure results in too many frequencies relative to the socially optimal solution. Note that the predictions of our model reproduce what actually happened in the Canary Islands after 2003. As explained above, the market with all the islands fully connected had just one operator, Binter Canarias. Quite logically one might think that the regulation was indeed having an effect and that had it not been in place Binter would have supplied less frequencies. The minimum frequency requirement imposed by the regulator was just met. Following the entry by Islas Airways, it can be observed in Figure 3.5 that such requirement is widely fulfilled. Given that aircraft size remained the same, the increase in the number of seats offered can only be explained by an increase in frequency. Figure 3.6 is referred to the route Gran Canaria-Tenerife as an illustrative example. The same has happened in the other routes.

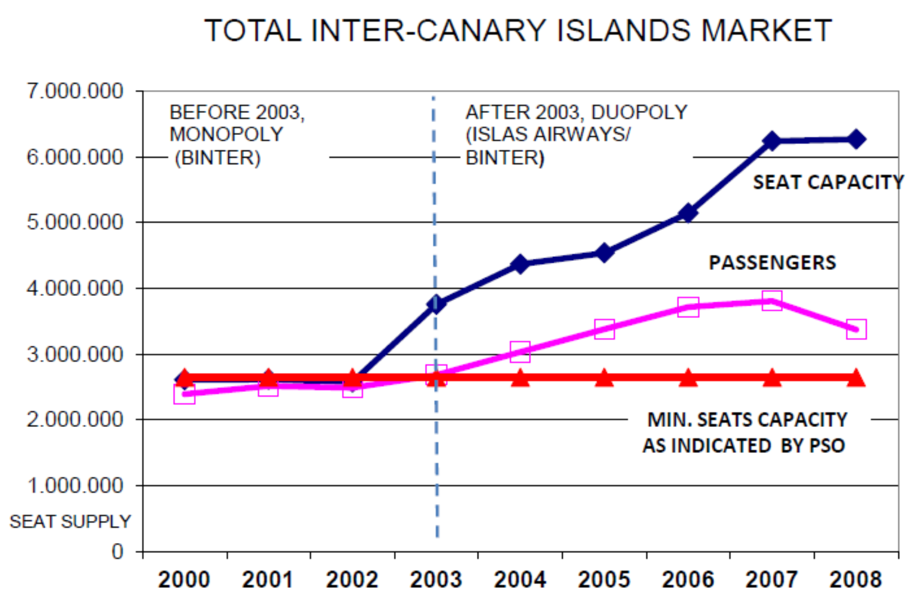

Figure 3.5: Total Inter-Canary Islands Market

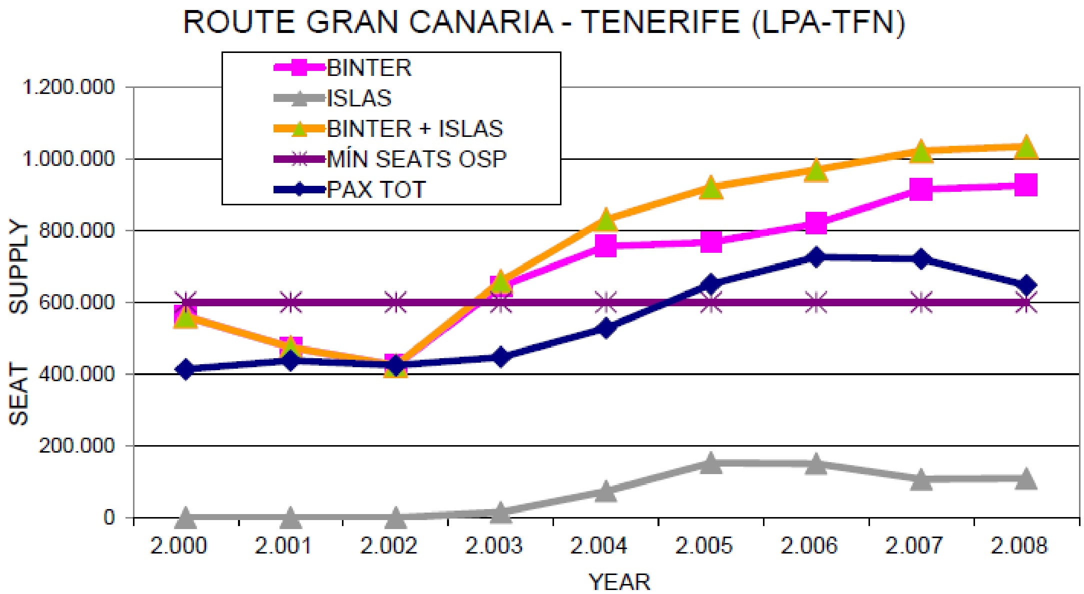

Figure 3.6: Route Gran Canaria-Tenerife Norte

What our analysis suggests is an alternative way to straight regulation of frequencies. Note that entry by a firm with social welfare maximizing objectives disciplines the market in two ways. On the one hand, the mixed duopoly allows for setting the optimal prices. On the other, the public firm chooses frequencies below the socially optimal so that distortions from the socially optimal solution are reduced.

3.5 Concluding remarks

The objective of imposing an adequate provision of air services is a commendable one. As noted in Section 3.2 above, the PSO mechanism has become increasingly used and the experience from it is varied. This is certainly a research area that deserves more attention. This chapter is a contribution that emphasizes the importance of the type of network as an element in the implementation of PSO services. It also brings attention to market structure. Major consideration has been devoted to the comparison of the socially optimal number of frequencies with those provided by market competition. The analysis thus identifies a potential market failure in that a monopolist typically supplies too few frequencies whereas a duopoly supplies too many, relative to the social optimum. Any policy recommendations should be taken with the necessary qualifications but the results offer justification to regulate passenger air transport. When carriers are both profit maximizers, some control measures over *(prices or)* frequencies should be established in order to minimize distortions. Alternatively, our model suggests that a mixed duopoly is a useful way of public intervention. Some of the policies adopted comprise caps on fares and/or subsidies. The interesting conclusions obtained are an invitation for further research on the role played by regulated fares in air transport competition.

3.6 Appendix

3.6.1 Second stage market equilibrium for the Star Network.

Before proceeding note that depending on v three different situations arise. First if $v > 2t + \mu$ only full market coverage is an option. Also, for $2t < v < 2t + \mu$ the monopolist only has to decide whether to fully cover the indirect connection because the direct ones are always fully covered. Finally, when $v < 2t$ all possibilities might arise. We will use this restriction on v as necessary in the below analysis.

I) The case of the three markets fully covered ($n_i > 2t - v$ for $i = 1, 2$ and $\bar{n} > 2t - v + \mu$).

Monopolist profits are: $\Pi = \sum \pi_i(n_i) + \pi_3(\bar{n}) = (v + n_1 - t) - cn_1^2 + (v + n_2 - t) - cn_2^2 + (v + \bar{n} - \mu - t)$.

Note that the monopolist revenues in the above expression can be expressed as a function of $\bar{n}$, implying that any combination of n_1, n_2 that results in the same $\bar{n}$ will yield the same revenue. If that is the case, the following result applies:

Result: If revenues are function of $\bar{n}$ *then the symmetric solution (i.e.* $n_1 = n_2$*) dominates all other possible combinations* (n_1, n_2) *that imply the same* $\bar{n}$*.*

The reason is that symmetry will minimize connection costs as they are convex in n_1 and n_2.

Then taking $n_1 = n_2 = \bar{n}$ and maximizing Π with respect to $\bar{n}$, we find $n_1 = n_2 = \hat{n}^* = \frac{3}{4c}$ and $\Pi = 3(v - t) - \mu + \frac{9}{8c}$. This solution applies as long as $n^* > 2t - v + \mu$, or equivalently for $v > 2t - \frac{3}{4c} + \mu$. Otherwise, the solution is the corner solution: $\hat{n}^* = 2t - v + \mu$. Summarizing:

$$\hat{n}_I^* = \begin{cases} \hat{n}_{I,cor}^* = 2t - v + \mu & v < 2t - \frac{3}{4c} + \mu \\ \hat{n}_{I,int}^* = \frac{3}{4c} & v > 2t - \frac{3}{4c} + \mu \end{cases};$$

$$\hat{\Pi}_I^* = \begin{cases} \hat{\Pi}_{I,cor}^* = 3t + 2\mu - 2c(2t - v + \mu)^2 & v < 2t - \frac{3}{4c} + \mu \\ \hat{\Pi}_{I,int}^* = 3(v - t) - \mu + \frac{9}{8c} & v > 2t - \frac{3}{4c} + \mu \end{cases}$$

where the subindex I refers to case I and the subindices cor and int refer to corner and interior solution, respectively. Regarding consumer surplus and since all users travel $CS_i = \int_0^1 (v + n_i - p_i - tx)\ dx = v + n_i - p_i - \frac{t}{2} = \frac{t}{2}$ (since $p_i = v + n_i - t$) for $i = 1, 2$, and similarly $CS_3 = \int_0^1 (v - \mu + \bar{n} - f - tx)\ dx = \frac{t}{2}$. Thus aggregate consumer surplus is $CS = CS_1 + CS_2 + CS_3 = \frac{3t}{2}$.

II) The case where only direct connections are fully covered ($n_i > 2t - v$ for $i = 1, 2$ and $\bar{n} < 2t - v + \mu$).

Monopolist profits are: $\Pi = \sum \pi_i(n_i) + \pi_3(\bar{n}) = (v + n_1 - t) - cn_1^2 + (v + n_2 - t) - cn_2^2 + \frac{(v - \mu + \bar{n})^2}{4t}$ where it is easy to note that total revenue is a function of $\bar{n}$, and then only symmetric solutions matter. Solving we get $n_1 = n_2 = \hat{n}^* = \frac{v - \mu + 4t}{8ct - 1}$, with $\hat{\Pi}^* = 2(v - t) + \frac{(v - \mu)^2}{4t} + \frac{(v - \mu + 4t)^2}{4t(8ct - 1)}$. However, this interior solution only applies if $2t - v < \hat{n}^* < 2t - v + \mu$. Or equivalently, for $2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{3}{4c} + \mu$. When v lies outside these bounds corner solutions apply as follows:

$$\hat{n}_{II}^* = \begin{cases} \hat{n}_{II,cor}^* = 2t - v & v < 2t - \frac{3}{4c} + \frac{\mu}{8ct} \\ \hat{n}_{II,int}^* = \frac{v - \mu + 4t}{8ct - 1} & 2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{3}{4c} + \mu \\ \hat{n}_{II,cor}^* = 2t - v + \mu & v > 2t - \frac{3}{4c} + \mu \end{cases};$$

$$\hat{\Pi}_{II}^* = \begin{cases} \hat{\Pi}_{II,cor}^* = 3t - \mu + \frac{\mu^2}{4t} - 2c(2t - v)^2 & v < 2t - \frac{3}{4c} + \frac{\mu}{8ct} \\ \hat{\Pi}_{II,int}^* = 2(v - t) + \frac{(v - \mu)^2}{4t} + \frac{(v - \mu + 4t)^2}{4t(8ct - 1)} & 2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{3}{4c} + \mu \\ \hat{\Pi}_{II,cor}^* = 3t + 2\mu - 2c(2t - v + \mu)^2 & v > 2t - \frac{3}{4c} + \mu \end{cases}$$

where subindex II is used for this case. Regarding consumer surplus, note that for the case of direct connections the outcome is the same as above since it does not depend on the flight frequency when the market is fully covered. However for the indirectly connected market

$CS_3 = \int_0^{q_3} (v - \mu + \bar{n} - f - tx)\ dx$, with $q_3 = \frac{2(v-\mu)+n_1+n_2-2f}{2t} < 1$ and after substituting the equilibrium price $f^* = \frac{v-\mu+\bar{n}}{2}$, we obtain $CS_3 = \frac{(2(v-\mu)+n_1+n_2)^2}{32t} = \frac{2t(2c(v-\mu)+1)^2}{(8ct-1)^2}$.

III) The case of all markets partially covered ($n_i < 2t - v$ for $i = 1, 2$).

For this case to happen v must be smaller that $2t$. Monopolist profits are: $\Pi = \sum \pi_i(n_i) + \pi_3(\bar{n}) = \frac{(v+n_1)^2}{4t} - cn_1^2 + \frac{(v+n_2)^2}{4t} - cn_2^2 + \frac{(v-\mu+\bar{n})^2}{4t}$. The symmetric solution is the correct one since profits are just symmetric in n_1 and n_2. Maximizing Π with respect ton_1 and n_2 we get $n_1 = n_2 = \hat{n}^* = \frac{3v-\mu}{8ct-3}$ with $\hat{\Pi}^* = \frac{4ct((v-\mu)^2+v)-\mu^2}{2t(8ct-3)} = \frac{2v^2+(v-\mu)^2+(3v-\mu-(8ct-3))\hat{n}^*}{4t}$. This interior solution applies for $v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$, otherwise the corner solution applies, where subindex III is used in this case.

$$\hat{n}^*_{III} = \begin{cases} \hat{n}^*_{III,int} = \frac{3v-\mu}{8ct-3} & v < 2t - \frac{3}{4c} + \frac{\mu}{8ct} \\ \hat{n}^*_{III,cor} = 2t - v & v > 2t - \frac{3}{4c} + \frac{\mu}{8ct} \end{cases} ;$$

$$\hat{\Pi}^*_{III} = \begin{cases} \hat{\Pi}^*_{III,int} = \frac{4ct((v-\mu)^2+2v^2)-\mu^2}{2t(8ct-3)} & v < 2t - \frac{3}{4c} + \frac{\mu}{8ct} \\ \hat{\Pi}^*_{III,cor} = 3t - \mu + \frac{\mu^2}{4t} - 2c(2t-v)^2 & v > 2t - \frac{3}{4c} + \frac{\mu}{8ct} \end{cases}$$

Finally $CS_i = \frac{(v+n_i)^2}{8t} = \frac{(v+\hat{n}^*)^2}{8t} = \frac{(8ctv-\mu)^2}{8t(8ct-3)^2}$ for $i = 1,\ 2$ and $CS_3 = \frac{(2(v-\mu)+n_1+n_2)^2}{32t} = \frac{(4ct(v-\mu)+\mu)^2}{2t(8ct-3)^2}$.

IV) One direct connection market partially covered, say market 2, the others fully covered ($n_2 < 2t - v$, and $\bar{n} > 2t - v + \mu$).

As in case III) v must be smaller that $2t$.

Monopolist profits are: $\Pi = \sum \pi_i(n_i) + \pi_3(\bar{n}) = (v+n_1-t) - cn_1^2 + \frac{(v+n_2)^2}{4t} - cn_2^2 + (v+\bar{n}-\mu-t)$. Maximizing with respect to n_1 and n_1 we obtain the interior solutions $\hat{n}_1^* = \frac{3}{4c}$ and $\hat{n}_2^* = \frac{v+t}{4ct-1}$.

However, note that $\frac{v+t}{4ct-1} < 2t - v$ only if $v < 2t - \frac{3}{4c}$. Therefore in case $2t - \frac{3}{4c} < v < 2t$, the solution is the corner one $n_2^* = 2t - v$ which implies all markets fully covered. In such a case $n_2^* = 2t - v$ and $n_1^* = \frac{3}{4c}$ cannot be an equilibrium since the monopolist is better setting a symmetric solution with the proviso that all markets are fully covered.

Finally in case $v < 2t - \frac{3}{4c}$ (i.e $\hat{n}_2^* = \frac{v+t}{4ct-1}$ applies) it must be verified that for $\hat{n}_1^* = \frac{3}{4c}$ the indirect market is fully covered. This is equivalent to checking if $\hat{n}_1^* > 4t - 2v + 2\mu - \hat{n}_2^*$ and substituting for $\hat{n}_2^*$ and $\hat{n}_1^*$, $\frac{3}{4c} > 4t - 2v + 2\mu - \frac{v+t}{4ct-1}$,or, $v > \frac{8ct-2}{8ct-1}\mu + 2t - \frac{3}{4c}$. However the two conditions on v cannot be simultaneously satisfied as long as $ct > \frac{1}{4}$, which is the case. Therefore, the monopolist will end up in a corner solution $\hat{n}_1^* = 4t - 2v + 2\mu - \frac{v+t}{4ct-1}$ for connection 1. Profits become

$\hat{\Pi}^{*}=\frac{(v+\frac{v+t}{4ct-1})^{2}}{4t}+(v+4t-2v+2\mu-\frac{v+t}{4ct-1})-c(4t-2v+2\mu-\frac{v+t}{4ct-1})^{2}-c(\frac{v+t}{4ct-1})^{2}.$

V) One direct connection fully covered, say market 1, the others partially covered ($n_2<2t-v$, $n_1>2t-v$ and $\bar{n}<2t-v+\mu$).

This case can only arise if $v<2t$. Monopolist profits are $\Pi=\sum\pi_i(n_i)+\pi_3(\bar{n})=(v+n_1-t)-cn_1^2+\frac{(v+n_2)^2}{4t}-cn_2^2+\frac{(v-\mu+\bar{n})^2}{4t}$. Maximizing with respect to n_1 and n_2 we obtain the interior solutions $\hat{n}_1^*=\frac{(8ct-1)v+2(16ct-5)t-2(4ct-1)\mu}{8ct(8ct-3)+1}$ and $\hat{n}_2^*=\frac{(24ct-1)v+2t-8ct\mu}{8ct(8ct-3)+1}$, implying $\bar{n}=\frac{(16ct-1)v+4(4ct-1)t-(8ct-1)\mu}{8ct(8ct-3)+1}$. Again we check the conditions that the interior solution must satisfy: a) $\hat{n}_1^*>2t-v$ iff $v>2t-\frac{3}{4c}+\frac{\mu}{8ct}$, b) $\hat{n}_2^*<2t-v$ iff $v<2t-\frac{3}{4c}+\frac{\mu}{8ct}$. Thus we conclude that the interior solution is never attained. We have then two possibilities according to v.

i) for $v>2t-\frac{3}{4c}+\frac{\mu}{8ct}$, $\hat{n}_1^*\geq 2t-v$ and $\hat{n}_2^*$ is the corner solution $\hat{n}_2^*=2t-v$ which imply that the two direct connections are fully covered and therefore, a symmetric equilibrium always yields higher profits.

ii) for $v<2t-\frac{3}{4c}+\frac{\mu}{8ct}$, $\hat{n}_2^*\leq 2t-v$ and $\hat{n}_1^*$ is the corner solution $\hat{n}_1^*=2t-v$. Given that, the monopolist maximize profits at $\hat{n}_2^*=\frac{v+t}{4ct-1}$, which as in case IV) corresponds to an interior solution for $\hat{n}_2^*$ only if $v<2t-\frac{3}{4c}$. Summarizing we have:

$\hat{n}_1^*=\hat{n}_2^*=2t-v$ with $\hat{\Pi}^*=3t-\mu+\frac{\mu^2}{4t}-2c(2t-v)^2$ for $2t-\frac{3}{4c}<v<2t-\frac{3}{4c}+\frac{\mu}{8ct}$,

and ($\hat{n}_2^*=\frac{v+t}{4ct-1}$, $\hat{n}_1^*=2t-v$) with $\hat{\Pi}^*=\frac{(v+\frac{v+t}{4ct-1})^2}{4t}+\frac{(v+2t-2\mu\frac{v+t}{4ct-1})^2}{4t}-c(2t-v)^2-c(\frac{v+t}{4ct-1})^2$ for $v<2t-\frac{3}{4c}$.

3.6.2 Proof of Proposition 5

First note that any interior solution yields no lower profits than the correponding corner solution by definition. Take first the case of $v>2t-\frac{3}{4c}+\mu$. Then we have to compare $\hat{\Pi}^*_{I,int}$ with $\hat{\Pi}^*_{II,cor}$ and $\hat{\Pi}^*_{III,cor}$. Noting that $\hat{\Pi}^*_{II,cor}=\hat{\Pi}^*_{I,cor}$, then $\hat{\Pi}^*_{I,int}>\hat{\Pi}^*_{II,cor}$ if $v>2t-\frac{3}{4c}+\mu$. Also, $\hat{\Pi}^*_{I,int}>\hat{\Pi}^*_{III,cor}$ when $v>2t-\frac{3}{4c}+\mu$ and $ct>1/8$, which is the case. Therefore, for $v>2t-\frac{3}{4c}+\mu$, $\Pi^*_{I,int}$ dominates the other cases II) and III).

Similarly, take $2t-\frac{3}{4c}+\frac{\mu}{8ct}<v<2t-\frac{3}{4c}+\mu$, then we check the ranking for $\hat{\Pi}^*_{I,cor}$ with $\hat{\Pi}^*_{II,int}$ and $\hat{\Pi}^*_{III,cor}$, but $\hat{\Pi}^*_{II,cors}=\hat{\Pi}^*_{I,cor}$ and $\hat{\Pi}^*_{II,cori}=\hat{\Pi}^*_{III,cor}$, then $\hat{\Pi}^*_{II,int}$ dominates the other cases I) and III) for $2t-\frac{3}{4c}+\frac{\mu}{8ct}<v<2t-\frac{3}{4c}+\mu$.

Finally, when $v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$, we compare $\hat{\Pi}^*_{III,int}$ with $\hat{\Pi}^*_{II,cor}$ and $\hat{\Pi}^*_{I,cor}$. Note that as before $\hat{\Pi}^*_{II,cor} = \hat{\Pi}^*_{III,cor}$ and therefore, $\hat{\Pi}^*_{III,int} > \hat{\Pi}^*_{II,cor}$. Also, $\hat{\Pi}^*_{III,int} > \hat{\Pi}^*_{I,cor}$ since $\hat{\Pi}^*_{III,int} - \hat{\Pi}^*_{I,cor}$ is a convex quadratic function on v with no real roots.

There only remains to show that for $v < 2t - \frac{3}{4c}$, $\hat{\Pi}^*_{III,int}$ dominates the profits obtained in the two possible asymmetric cases, case IV) and V).

a) $\hat{\Pi}^*_{III,int} > \frac{(v+\frac{v+t}{4ct-1})^2}{4t} + (v + 4t - 2v + 2\mu - \frac{v+t}{4ct-1}) - c(4t - 2v + 2\mu - \frac{v+t}{4ct-1})^2 - c(\frac{v+t}{4ct-1})^2$ for case IV).

b) $\hat{\Pi}^*_{III,int} > \frac{(v+\frac{v+t}{4ct-1})^2}{4t} + \frac{(v+2t-2\mu\frac{v+t}{4ct-1})^2}{4t} - c(2t-v)^2 - c(\frac{v+t}{4ct-1})^2$ for case V).

In both cases it is easy to check that the corresponding differences are a convex quadratic function of v with no real roots, thus always positive.

3.6.3 Proof of Proposition 6

In this Appendix we compare the flight frequecies that a monopolist will provide in a star network with the optimal ones. Remind that n^* and n^{so} are respectively,

$$n^* = \begin{cases} \frac{3v-\mu}{8ct-3} & v \leq 2t - \frac{3}{4c} + \frac{\mu}{8ct} \\ \frac{v-\mu+4t}{8ct-1} & 2t - \frac{3}{4c} + \frac{\mu}{8ct} < v \leq 2t - \frac{3}{4c} + \mu \\ \frac{3}{4c} & v > 2t - \frac{3}{4c} + \mu \end{cases} ; n^{so} = \begin{cases} \frac{3v-\mu}{4ct-3} & v \leq t - \frac{3}{4c} + \frac{\mu}{4ct} \\ \frac{v-\mu+2t}{4ct-1} & t - \frac{3}{4c} + \frac{\mu}{4ct} < v \leq t - \frac{3}{4c} + \mu \\ \frac{3}{4c} & v > t - \frac{3}{4c} + \mu \end{cases}$$

Note that there are two different sources of discrepancy, first the number of frequencies for each interval and the second the intervals themselves. Direct inspection of the expressions is enough to conclude that $n^* < n^{so}$ when there is partial coverage of at least one market, while $n^* = n^{so}$ when the three markets are fully covered in both cases, that is for $v > 2t - \frac{3}{4c} + \mu$. It is also important to highlight that since optimal prices are smaller than monopoly ones, a lower frequence is required to fully cover a given market in the former case. Regarding the interval ordering it is important to note that we will assume that $\mu < \frac{t(4ct-3)}{4ct-1} < \frac{2t(8ct-3)}{8ct-1}$, that is we will ensure that partial covarage for all markets is an optimal and a market equilibrium for some values of the parameters. If this is the case then we can easily prove that the ranking in thresholds is $t - \frac{3}{4c} + \frac{\mu}{4ct} < t - \frac{3}{4c} + \mu < 2t - \frac{3}{4c} + \frac{\mu}{8ct} < 2t - \frac{3}{4c} + \mu$ since it occurs when $\mu < \frac{8ct^2}{8ct-1}$, where $\frac{t(4ct-3)}{4ct-1} < \frac{8ct^2}{8ct-1}$. This ranking meaning that it is optimal to fully cover the three markets when the monopolist at equilibrium only partially covers those markets. We find:

-a suboptimal underprovision of frequencies for $v < t - \frac{3}{4c} + \frac{\mu}{4ct}$ as $\frac{3v-\mu}{8ct-3} < \frac{3v-\mu}{4ct-3}$,

-for $t-\frac{3}{4c}+\frac{\mu}{4ct}<v<t-\frac{3}{4c}+\mu$, $\frac{v-\mu+2t}{4ct-1}>\frac{3v-\mu}{8ct-3}$ iff $v<4t-\frac{3}{2c}-\frac{2ct-1}{2ct}\mu$. But $t-\frac{3}{4c}+\mu<4t-\frac{3}{2c}-\frac{2ct-1}{2ct}\mu$ if $\mu<\frac{3}{2}t$. And noting that $\frac{t(4ct-3)}{4ct-1}<\frac{3}{2}t$ we conclude that there is a suboptimal underprovision of frequencies.

-for $t-\frac{3}{4c}+\mu<v<2t-\frac{3}{4c}+\frac{\mu}{8ct}$, we check when $\frac{3}{4c}>\frac{3v-\mu}{8ct-3}$. In fact, evaluating $\frac{3v-\mu}{8ct-3}$ at $v=2t-\frac{3}{4c}+\frac{\mu}{8ct}$, we find that $\frac{3}{4c}$ is always greater than $\frac{6t-\frac{9}{4c}+\frac{\mu}{8ct}-\mu}{8ct-3}$, then concluding that there is a suboptimal underprovision of frequencies.

-for $2t-\frac{3}{4c}+\frac{\mu}{8ct}<v<2t-\frac{3}{4c}+\mu$, the inequality to check is $\frac{3}{4c}>\frac{v-\mu+4t}{8ct-1}$. As before, evaluating $\frac{v-\mu+4t}{8ct-1}$ at $v=2t-\frac{3}{4c}+\mu$, we conclude that there is a suboptimal underprovision of frequencies.

Summarizing, if $\mu<\frac{t(4ct-3)}{4ct-1}<\frac{8ct^2}{8ct-1}$ *then there is a suboptimal underprovision of frequencies when* $\mu<v<2t-\frac{3}{4c}+\mu$. Otherwise the monopolist reaches the optimal frequency levels.

3.6.4 Proof of Proposition 7

Optimality

We compare the welfare obtained under each network and find the largest. Remind that the welfare levels for each network once $g=0$ are,

$$SW^{so}=\begin{cases} SW^p=\frac{3cv^2}{2ct-1} & \text{if } v<t-\frac{1}{2c} \\ SW^f=3v-\frac{3t}{2}+\frac{3}{4c} & \text{if } v>t-\frac{1}{2c} \end{cases}$$

$$\widehat{SW}^{so}=\begin{cases} \widehat{SW}^p=\frac{2ct(v-\mu)^2+4ctv^2-\mu^2}{t(4ct-3)} & \mu<v\leq t-\frac{3}{4c}+\frac{\mu}{4ct} \\ \widehat{SW}^d=\frac{2c(v-\mu)^2+t(8cv+3)-4ct^2-2\mu}{4ct-1} & t-\frac{3}{4c}+\frac{\mu}{4ct}<v\leq t-\frac{3}{4c}+\mu \\ \widehat{SW}^f=3v-\mu-\frac{3t}{2}+\frac{9}{8c} & v>t-\frac{3}{4c}+\mu \end{cases}$$

To be consistent we only make comparisons for $v>\mu$, which is the assumption made in the star network case; also from that scenario we have that parameter μ is assumed to belong to the interval $[0,\frac{t(4ct-3)}{4ct-1}]$. We also introduce some notation in the above expressions to simplify the presentation of the proof with superscripts $\{p,d,f\}$ for p partial coverage of markets, d partial coverage of only the indirect flight market and f for full coverage of any market. The first task to do is to obtain a full ranking for the thesholds in the SW expressions. Thus, two different cases are distinguished depending on the value of μ :

Case i) if $0<\mu<\frac{1}{4c}<\frac{t(4ct-3)}{4ct-1}$, then $\mu<t-\frac{3}{4c}+\frac{\mu}{4ct}<t-\frac{3}{4c}+\mu<t-\frac{1}{2c}$, meaning that

the disutility due to indirect flights is low and that there exists a range of v such that the star network fully covers all markets while the complete network does not.

Case ii) if $0 < \frac{1}{4c} < \mu < \frac{t(4ct-3)}{4ct-1}$, then $\mu < t - \frac{3}{4c} + \frac{\mu}{4ct} < t - \frac{1}{2c} < t - \frac{3}{4c} + \mu$, meaning now the opposite that there exists a range of v such that the complete network is fully covering the markets while the star network is not.

CASE i) $0 < \mu < \frac{1}{4c}$.

-i.a) Take $v > t - \frac{1}{2c}$, then both networks fully cover the markets and we compare SW^f to $\widehat{SW}^f$ finding that the star network is the one implying larger welfare since $\widehat{SW}^f - SW^f > 0$ iff $\mu < \frac{3}{8c}$ which is the case.

-i.b) Take now $t - \frac{3}{4c} + \mu < v < t - \frac{1}{2c}$, then the correct comparison is SW^p with $\widehat{SW}^f$. Note that $\widehat{SW}^f - SW^p$ is a quadratic and concave function in v with roots $r^- = t - \frac{1}{2c} - \frac{\sqrt{6(2ct-1)(3-8c\mu)}}{12c}$, $r^+ = t - \frac{1}{2c} + \frac{\sqrt{6(2ct-1)(3-8c\mu)}}{12c}$ (we are going to use in the sequel the notation r^- for the smallest root and r^+ for the largest). Direct inspection of the roots leads to the conclusion that when $\mu > \frac{3}{8c}$ the complete network is the one with greatest welfare level. However for $\mu < \frac{1}{4c}$ the roots are real and we check that $r^- < t - \frac{3}{4c} + \mu$ for all $\mu \in [0, \frac{1}{4c}]$ and similarly $r^+ > t - \frac{1}{2c}$. Therefore, the star network is the one with greatest welfare if $t - \frac{3}{4c} + \mu < v < t - \frac{1}{2c}$ and $0 < \mu < \frac{1}{4c}$.

-i.c) Consider now $t - \frac{3}{4c} + \frac{\mu}{4ct} < v < t - \frac{3}{4c} + \mu$. Note that the difference $\widehat{SW}^d - SW^p$ is a quadratic and concave function in v with roots $r^{+,-} = \frac{2c(2ct-1)(2t-\mu) \pm \sqrt{c(2ct-1)(4ct-1)(\mu(3c\mu-1)+t(3-8c\mu))}}{c(8ct-1)}$. It is important to note that the discriminant in the roots is negative iff $\mu \in [\frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c}, \frac{4ct+1+\sqrt{(8ct-1)(2ct-1)}}{6c}]$, meaning that for μ in that interval the complete network implies higher welfare. Note that $\frac{1}{4c} < \frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c}$ always. Also $\frac{4ct+1+\sqrt{(8ct-1)(2ct-1)}}{6c}$ is greater than $\frac{t(4ct-3)}{4ct-1}$ when $ct > 1$ which is the case. Then for case i) the star network provides higher welfare if $v \in [r^-, r^+]$. And we prove that $r^- < t - \frac{3}{4c} + \frac{\mu}{4ct}$ and also that $t - \frac{3}{4c} + \mu < r^+$, thus concluding that the star network yields higher welfare than the complete network.

-i.d) Finally take $\mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$, the difference $\widehat{SW}^p - SW^p$ is a quadratic convex function in v with roots, $r^{+,-} = (\frac{2ct-1}{3ct})((2ct \pm \sqrt{ct(4ct-3)})\mu$. Therefore, the star network is welfare improving when $v \notin [r^-, r^+]$. Further note that $r^- < \mu$, then we conclude that for $\mu < v < r^+$ the complete network provides higher welfare whereas for $r^+ < v < t - \frac{3}{4c} + \frac{\mu}{4ct}$ it is the star network. Now we are ready to compare r^+ with $t - \frac{3}{4c} + \frac{\mu}{4ct}$ in order to find whether there are values of v in $\mu < v < t - \frac{3}{4c} + \frac{\mu}{4ct}$ that also satisfy $v < r^{+}$. We find that for all $\mu < \frac{3t(4ct-3)}{(4ct-3)(4ct+1)+4\sqrt{ct(4ct-3)}}$, $r^{+} < t - \frac{3}{4c} + \frac{\mu}{4ct}$, noting that $\frac{1}{4c} < \frac{3t(4ct-3)}{(4ct-3)(4ct+1)+4\sqrt{ct(4ct-3)}} < \frac{t(4ct-3)}{4ct-1}$. *Summarizing, for all* $0 < \mu < \frac{1}{4c}$, if $\mu < v < r^{+}$ *then the complete network is the one that attains highest welfare, while for all* $r^{+} < v < t - \frac{3}{4c} + \frac{\mu}{4ct}$ *it is the star one.*

CASE ii) $\frac{1}{4c} < \mu < \frac{t(4ct-3)}{4ct-1}$.

-ii.a) Take $v > t - \frac{3}{4c} + \mu$, then both networks fully cover the markets and we compare SW^{f} to $\widehat{SW}^{f}$ and as in case i) the star network is the one implying higher welfare iff $\mu < \frac{3}{8c}$.

-ii.b) Take now $t - \frac{1}{2c} < v < t - \frac{3}{4c} + \mu$, then the correct comparison is SW^{f} with $\widehat{SW}^{d}$. Note that $\widehat{SW}^{f} - SW^{d}$ is a quadratic and convex function in v with roots $r^{-} = t + \mu - \frac{3}{4c} - \frac{\sqrt{(4ct-1)(-3+8c\mu)}}{4c}$, $r^{+} = t + \mu - \frac{3}{4c} + \frac{\sqrt{6(2ct-1)(-3+8c\mu)}}{4c}$. Direct inspection of the roots leads to the conclusion that when $\mu < \frac{3}{8c}$ the star network is the one with largest welfare level. Besides note that $r^{+} > t - \frac{3}{4c} + \mu$, and $r^{-} < t - \frac{1}{2c}$. Therefore the complete network is the one with higher welfare if $\mu > \frac{3}{8c}$ and for all $v \in [t - \frac{1}{2c}, t - \frac{3}{4c} + \mu]$.

-ii.c) Consider now $t - \frac{3}{4c} + \frac{\mu}{4ct} < v < t - \frac{1}{2c}$. As in case i), $\widehat{SW}^{d} - SW^{p}$ is a quadratic and concave function in v with roots $r^{+,-} = \frac{2c(2ct-1)(2t-\mu)\pm\sqrt{c(2ct-1)(4ct-1)(2\mu(3c\mu-1)+t(8c\mu-3)}}{c(8ct-1)}$. Remind that if $\mu \in [\frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c}, \frac{4ct+1+\sqrt{(8ct-1)(2ct-1)}}{6c}]$, the complete network implies higher welfare for all v. Note that $\frac{1}{4c} < \frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c} < \frac{t(4ct-3)}{4ct-1} < \frac{4ct+1+\sqrt{(8ct-1)(2ct-1)}}{6c}$. Thus there are two possibilities: a) $\frac{1}{4c} < \mu < \frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c}$ then the star network attains higher welfare if $v \in [r^{-}, r^{+}]$; b) $\frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c} < \mu < \frac{t(4ct-3)}{4ct-1}$ where the complete network is the one that attains higher welfare for all $v \in [t - \frac{3}{4c} + \frac{\mu}{4ct}, t - \frac{1}{2c}]$.

ii.d) Finally for $\mu < v < t - \frac{3}{4c} + \frac{\mu}{4ct}$, the difference to be analysed is $\widehat{SW}^{f} - SW^{p}$ as happens in case i). Also remind that $\frac{1}{4c} < \frac{3t(4ct-3)}{(4ct-3)((4ct+1)+4(2ct-1)\sqrt{ct(4ct-3)}} < \frac{t(4ct-3)}{4ct-1}$, then we have two possible situations. Firstly, when $\mu < \frac{3t(4ct-3)}{(4ct-3)(4ct+1)+4(2ct-1)\sqrt{ct(4ct-3)}}$, we conclude that for $\mu < v < (\frac{2ct-1}{3ct})(2ct + \sqrt{ct(4ct-3)})\mu$ it is the complete network the one that attains higher welfare, while for all $(\frac{2ct-1}{3ct})(2ct + \sqrt{ct(4ct-3)})\mu < v < t - \frac{3}{4c} + \frac{\mu}{4ct}$ it is the star network. Secondly, for $\frac{3t(4ct-3)}{(4ct-3)(4ct+1)+4(2ct-1)\sqrt{ct(4ct-3)}} < \mu < \frac{t(4ct-3)}{4ct-1}$, it happens that $t - \frac{3}{4c} + \frac{\mu}{4ct} < r^{+}$ and therefore the complete network is the one that attains higher welfare for all $v \in [\mu, t - \frac{3}{4c} + \frac{\mu}{4ct}]$.

The sufficient condition.

The suficient condition for *the* complete network to be socially preferred than the star comes from cases i.c) and ii.c) where for $\mu > \frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c}$ the complete network is preferred for a social planner for all v.

3.6.5 Proof of Proposition 8

Profitability

We now compare the monopolist profits obtained under each network and find the largest. Remind that the equilibrium profits for each network once $g = 0$ are given by

$$\Pi^* = \begin{cases} \Pi^p = \frac{3cv^2}{4ct-1} & \text{if } v < 2t - \frac{1}{2c} \\ \Pi^f = 3v - 3t + \frac{3}{4c} & \text{if } v > 2t - \frac{1}{2c} \end{cases}$$

$$\hat{\Pi}^* = \begin{cases} \hat{\Pi}^p = \frac{4ct((v-\mu)^2+2v^2)-\mu^2}{2t(8ct-3)} & \mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct} \\ \hat{\Pi}^d = 2(v-t) + \frac{(v-\mu)^2}{4t} + \frac{(v-\mu+4t)^2}{4t(8ct-1)} & 2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{3}{4c} + \mu \\ \hat{\Pi}^f = 3(v-t) - \mu + \frac{9}{8c} & v > 2t - \frac{3}{4c} + \mu \end{cases}$$

As occurs in the previous proposition, two different cases are distinguished depending on the value of μ :

Case i) if $0 < \mu < \frac{1}{4c} < \frac{t(4ct-3)}{4ct-1}$, then $\mu < 2t - \frac{3}{4c} + \frac{\mu}{8ct} < 2t - \frac{3}{4c} + \mu < 2t - \frac{1}{2c}$.

Case ii) if $0 < \frac{1}{4c} < \mu < \frac{t(4ct-3)}{4ct-1}$, then $\mu < 2t - \frac{3}{4c} + \frac{\mu}{8ct} < 2t - \frac{1}{2c} < 2t - \frac{3}{4c} + \mu$.

This similarity will allow us to follow the same logic as in the proof for optimality.

CASE i) $0 < \mu < \frac{1}{4c}$.

-i.a) Take $v > 2t - \frac{1}{2c}$, then both networks fully cover the markets and we compare Π^f to $\hat{\Pi}^f$ finding that t*he star network is the one implying higher profits* since $\hat{\Pi}^f - \Pi^f > 0$ iff $\mu < \frac{3}{8c}$ which is the case.

-i.b) Take now $2t - \frac{3}{4c} + \mu < v < 2t - \frac{1}{2c}$, then the correct comparison is Π^p with $\hat{\Pi}^f$. The difference $\hat{\Pi}^f - \Pi^p$ is a quadratic and concave function in v with roots $r^- = 2t - \frac{1}{2c} - \frac{\sqrt{6(4ct-1)(3-8c\mu)}}{12c}$, $r^+ = 2t - \frac{1}{2c} + \frac{\sqrt{6(4ct-1)(3-8c\mu)}}{12c}$. When $\mu > \frac{3}{8c}$ the complete network is the most protitable one, while for $\mu < \frac{1}{4c}$ the roots are real and we prove that $r^- < 2t - \frac{3}{4c} + \mu$ and $r^+ > 2t - \frac{1}{2c}$.for all $\mu \in [0, \frac{1}{4c}]$ Therefore, *the star network is the most profitable one if* $2t - \frac{3}{4c} + \mu < v < 2t - \frac{1}{2c}$ and $0 < \mu < \frac{1}{4c}$.

-i.c) Consider now $2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{3}{4c} + \mu$. Now the appropriate comparison is $\hat{\Pi}^d$ with Π^p. Note that $\hat{\Pi}^d - \Pi^p$ is a quadratic and concave function in v with roots $r^{+,-} = \frac{2c(4ct-1)(4t-\mu)\pm\sqrt{c(4ct-1)(8ct-1)(2\mu(3c\mu-1)+t(8c\mu-3))}}{c(16ct-1)}$. The discriminant in the roots is negative iff

$\mu \in [\frac{8ct+1-\sqrt{(16ct-1)(4ct-1)}}{6c}, \frac{8ct+1+\sqrt{(16ct-1)(4ct-1)}}{6c}]$, meaning that for μ in that interval the complete network is more profitable that the star network. Note that $\frac{1}{4c}$ is always smaller than $\frac{4ct+1-\sqrt{(8ct-1)(2ct-1)}}{6c}$ and also $\frac{4ct+1+\sqrt{(8ct-1)(2ct-1)}}{6c}$ is greater than $\frac{t(4ct-3)}{4ct-1}$ when $ct > 1$ which is the case. Then, for case i), that is $\mu < \frac{1}{4c}$, the star network delivers higher profits if $v \in [r^-, r^+]$. And we prove that $r^- < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$ and also that $2t - \frac{3}{4c} + \mu < r^+$, thus concluding that the *star network is more profitable than the complete network.*

-i.d) Finally take $\mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$, the difference $\hat{\Pi}^p - \Pi^p$ is a quadratic convex function in v with roots, $r^{+,-} = (\frac{4ct-1}{6ct})((4ct \pm \sqrt{2ct(8ct-3)})\mu$. Therefore, the star network is more profitable when $v \notin [r^-, r^+]$. Further note that $r^- < \mu$, then we conclude that for $\mu < v < r^+$ the complete network is more profitable while for $r^+ < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$, it is the star network. Now we are ready to compare r^+ with $2t - \frac{3}{4c} + \frac{\mu}{8ct}$ in order to find whether there are values of v in $\mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$ that also satisfy $v < r^+$. We find that for all $\mu < \frac{6t(8ct-3)}{(8ct-3)(8ct+1)+4(4ct-1)\sqrt{2ct(8ct-3)}}$, $r^+ < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$, noting that $\frac{1}{4c} < \frac{6t(8ct-3)}{(8ct-3)(8ct+1)+4(4ct-1)\sqrt{2ct(8ct-3)}} < \frac{t(4ct-3)}{4ct-1}$. Summarizing, for all $0 < \mu < \frac{1}{4c}$, if $\mu < v < r^+$ *the complete network is the most profitable one, while for all* $r^+ < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$ *it is the star network.*

CASE ii) $\frac{1}{4c} < \mu < \frac{t(4ct-3)}{4ct-1}$. The ranking that applies is $\mu < 2t - \frac{3}{4c} + \frac{\mu}{8ct} < 2t - \frac{1}{2c} < 2t - \frac{3}{4c} + \mu$.

-ii.a) For $v > 2t - \frac{3}{4c} + \mu$, both networks fully cover the markets and the profits comparison yields that t*he star network is more profitable iff* $\mu < \frac{3}{8c}$.

-ii.b) When $2t - \frac{1}{2c} < v < 2t - \frac{3}{4c} + \mu$, the correct comparison is Π^f with $\hat{\Pi}^d$. Noting that $\hat{\Pi}^f - \Pi^d$ is a quadratic and convex function in v with roots $r^- = 2t + \mu - \frac{3}{4c} - \frac{\sqrt{(8ct-1)(-3+8c\mu)}}{4c}$, $r^+ = 2t + \mu - \frac{3}{4c} + \frac{\sqrt{(8ct-1)(-3+8c\mu)}}{4c}$. Direct inspection of the roots leads to the conclusion that when $\mu < \frac{3}{8c}$ the star network is the one with higher profits. Besides note that $r^+ > 2t - \frac{3}{4c} + \mu$, and also $r^- < 2t - \frac{1}{2c}$ when $\mu > \frac{3}{8c}$. *Therefore the complete network is the one with higher profits if* $\mu > \frac{3}{8c}$ *and for all* $v \in [2t - \frac{1}{2c}, 2t - \frac{3}{4c} + \mu]$.

-ii.c) Consider now $2t - \frac{3}{4c} + \frac{\mu}{8ct} < v < 2t - \frac{1}{2c}$. As in case i), $\hat{\Pi}^d - \Pi^p$ is a quadratic and concave function in v with roots $r^{+,-} = \frac{2c(4ct-1)(4t-\mu) \pm \sqrt{c(4ct-1)(8ct-1)(2\mu(3c\mu-1)+t(8c\mu-3))}}{c(16ct-1)}$. Remind that if $\mu \in [\frac{8ct+1-\sqrt{(16ct-1)(4ct-1)}}{6c}$, $\frac{8ct+1+\sqrt{(16ct-1)(4ct-1)}}{6c}]$, the complete network reaches higher profits for all v. Note that $\frac{1}{4c} < \frac{8ct+1-\sqrt{(16ct-1)(4ct-1)}}{6c} < \frac{t(4ct-3)}{4ct-1} < \frac{8ct+1+\sqrt{(16ct-1)(4ct-1)}}{6c}$. Two possibilities arise: either a)

$\frac{1}{4c} < \mu < \frac{8ct+1-\sqrt{(16ct-1)(4ct-1)}}{6c}$ *then the star network attains higher profits if* $v \in [r^-, r^+]$. Or b) $\frac{8ct+1-\sqrt{(16ct-1)(4ct-1)}}{6c} < \mu < \frac{t(4ct-3)}{4ct-1}$ where *the complete network is the with higher profits for all* $v \in [2t - \frac{3}{4c} + \frac{\mu}{8ct}, 2t - \frac{1}{2c}]$.

-ii.d) Finally for $\mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$, we study $\hat{\Pi}^f - \Pi^p$ as happens in case i). Remind that $\frac{1}{4c} < \frac{6t(8ct-3)}{(8ct-3)(8ct+1)+4(4ct-1)\sqrt{2ct(8ct-3)}} < \frac{t(4ct-3)}{4ct-1}$, then there are two possible situations. Firstly, when $\mu < \frac{6t(8ct-3)}{(8ct-3)(8ct+1)+4(4ct-1)\sqrt{2ct(8ct-3)}}$, we conclude that for $\mu < v < (\frac{4ct-1}{6ct})((4ct \pm \sqrt{2ct(8ct-3)})\mu$ it is the complete network the one preferred by the monopolist, while for all $(\frac{4ct-1}{6ct})((4ct \pm \sqrt{2ct(8ct-3)})\mu < v < 2t - \frac{3}{4c} + \frac{\mu}{8ct}$ it is the star network. Secondly, for $\frac{6t(8ct-3)}{(8ct-3)(8ct+1)+4(4ct-1)\sqrt{2ct(8ct-3)}} < \mu < \frac{t(4ct-3)}{4ct-1}$, it happens that $2t - \frac{3}{4c} + \frac{\mu}{8ct} < r^+$ and therefore the complete network is the one that attains higher profits for all $v \in [\mu, t - \frac{3}{4c} + \frac{\mu}{4ct}]$.

The suficient condition for *the* complete network to be more profitable than the star comes from cases i.c) and ii.c) where for $\mu > \frac{8ct+1-\sqrt{(16ct-1)(4ct-1)}}{6c}$ the complete network is preferred for the monopolist for all v.

3.6.6 Proof of Proposition 9

Remind that:

a) $(n_i^m)^* = \frac{9c^m t-1}{18c^I c^E t - c^I - c^E}$, for $m = I, E$, for the market equilibrium,

b)$(n_i^I)^{so} = \frac{2c^E t-1}{2(4c^I c^E t - c^I - c^E)}$ and $(n_i^E)^{so} = \frac{2c^I t-1}{2(4c^I c^E t - c^I - c^E)}$, for the social optimum case.

c) $n_i^{I**} = \frac{2c^E t-1}{4c^I c^E t - c^I - 2c^E}$, and $n_i^{E**} = \frac{c^I t-1}{4c^I c^E t - c^I - 2c^E}$ for the mixed equillibrium.

It is also important to remind that, t must be big enough in order to satisfy that all equilibrium frequncy levels are positive and the second order conditions. The specific condition is that $t > \max\{\frac{1}{c^I}, \frac{1}{2c^E}\}$, which imply two different situations: case a) if $c^I < 2c^E$, where $t > \frac{1}{c^I}$; and case b) if $c^I > 2c^E$, where $t > \frac{1}{2c^E}$

i) We first check $(n_i^I)^{so} = \frac{2c^E t-1}{2(4c^I c^E t - c^I - c^E)} < n_i^{I**} = \frac{2c^E t-1}{4c^I c^E t - c^I - 2c^E}$ and $(n_i^E)^{so} = \frac{2c^I t-1}{2(4c^I c^E t - c^I - c^E)} > n_i^{E**} = \frac{c^I t-1}{4c^I c^E t - c^I - 2c^E}$. The first inequality holds for $t > \frac{1}{4c^E}$ and the second for $t > \frac{1}{2c^E}$ which is always the case.

ii) Consider $c^I = c^E = c$, then t must be greater than $\frac{1}{c}$. We already know that $(n_i^I)^{so} < n_i^{I**}$ and $n_i^{E**} < (n_i^E)^{so}$. Then we firstly check when $(n_i^E)^* = \frac{9c^E t-1}{18c^I c^E t - c^I - c^E} > (n_i^E)^{so} = \frac{2c^I t-1}{2(4c^I c^E t - c^I - c^E)}$, or equivalently whether the expression $2c(2ct-1)(9ct-1)$ is positive. Since

$t > \frac{1}{c}$, it is always satified. Therefore $n_i^{E**} < (n_i^E)^{so} < n_i^{E*}$.

Next, note that $n_i^{I*} < n_i^{I**}$ if and only if $c(9ct - 1) > 0$ which always holds. Finally, $(n_i^I)^{so} < n_i^{I*}$ is alreary proven above since in case of symmetry $(n_i^I)^* = (n_i^E)^*$ and $(n_i^I)^{so} = (n_i^E)^{so}$. Therefore $(n_i^I)^{so} < n_i^{I*} < n_i^{I**}$.

iii) In this item we prove that $(n_i^I)^{so} < n_i^{I*}$ and $(n_{ij}^E)^{so} < n_{ij}^{E*}$ if and only if $0.546153 < \frac{c^I}{c^E} < 1.4766$.

First note that $(n_i^I)^{so} < n_i^{I*}$ if $c^E + c^I + 2((c^E)^2 - 3c^E c^I - 9(c^I)^2)t + 36c^E(2c^I - c^E)t^2 > 0$.

case a) $c^I < 2c^E$, where $t > \frac{1}{c^I}$.

We focus on the subcase $\frac{c^E}{2} < c^I < 2c^E$ that implies that the coefficient of t^2 is positive and therefore the quadratic form is convex, which means that it is positive for all t outside the interval formed by the roots of the polynomial.

The roots of the polynomial are:

$$r^{+,-} = \frac{-(c^E)^2+3c^E c^I+9(c^I)^2 \pm \sqrt{(c^E)^4+30(c^E)^3 c^I-45(c^E)^2(c^I)^2-18c^E(c^I)^3+81(c^I)^4}}{36(2c^I-c^E)}$$

And it can be easily proven that $\frac{1}{c^I} > r^+$ if $0.546153c^E < c^I < 2c^E$, so we conclude that $(n_i^I)^{so} < n_i^{I*}$, for that interval.

Finally, $(n_{ij}^E)^{so} < n_{ij}^{E*}$ if $c^E + c^I - 2(9(c^E)^2 + 3c^E c^I - (c^I)^2)t + 36c^E(2c^E - c^I)t^2 > 0$. The coefficient of t^2 is positive for the interval $\frac{c^E}{2} < c^I < 2c^E$, so the quadratic polynomial is convex. It is easy to find that $\frac{1}{c^I} > r^+$ if $\frac{c^E}{2} < c^I < 1.4766c^E$. Therefore when $0.546153 < \frac{c^I}{c^E} < 1.4766$ it happens that both $(n_i^I)^{so} < n_i^{I*}$ and $(n_{ij}^E)^{so} < n_{ij}^{E*}$ are simultaneously satisfied.

Chapter 4

Customer Satisfaction and Behavioural Intentions: a passenger airline model of decision making about service quality

4.1 Introduction

The delivery of high service quality is a key strategy for firm success and survival in today's competitive framework. In this regard, the service quality required by customers needs to be determined to then develop the adequate strategies and meet their expectations (Parasuraman et al., 1985). The intensity of competition in the airline sector has increased especially since the emergence of low-cost carriers; this forces traditional carriers to reconsider their differentiation strategies thus questioning their positioning in the market. Differentiation in service quality reveals as one of the alternatives to the cost leadership strategy followed by such cheap flight suppliers, given that the monopolistic position enjoyed by flag carriers is coming to an end after the deregulation processes both in the USA and in Europe. Morash and Ozmet (1994) claim that service quality conditions influence firms' competitive advantage, retaining customer loyalty which leads to larger market share and, in the end, profitability. Also, Buzzel and Gale

(1987) assert that, normally, firms offering a better service quality achieve a higher market share growth.

Therefore, the motivation for the analysis in this chapter stems from the necessity of airlines to have deeper knowledge on how service quality offered to their passengers has an impact on their behavioral intentions. The deeper the knowledge about the importance and satisfaction of certain attributes, as well as their effect on recommendation and repurchase, the higher the suitability of resource allocation within the firm, and a sounder optimization of investment costs can be achieved in the book-keeping of an airline.

The chapter is structured as follows. Section 4.2 describes the concepts around service quality. Then section 4.3 examines different research models to set up the model developed in section 4.4. The empirical analysis is given in section 4.5, and results are presented and discussed in section 4.6. The chapter also provides conclusions (section 4.7), its weaknesses and future directions of research (section 4.8) as well as managerial implications (section 4.9).

4.2 Concepts around service quality

The early modern concept of quality refers to Total Quality Management (TQM), a Japanese philosophy originally from the manufacturing sector in the sense of producing “zero defects”, making things right from scratch (Parasuraman et al.,1985). Crosby (1979) defines quality as the "conformance to requirements” of the product. However, the product-based concept of quality is not appropriate to evaluate service quality, mainly because of characteristics such as its intangibility, short-living nature, inseparability and heterogeneity of the services industry.

The first concept that can be related with service quality is the customer’s expectation. There exist multiple cases in the literature on satisfaction about expectations interpreted as predictions on future events. At the same time, the literature on service quality associates expectations to operationally referring to standard norms and rules (Forbes et al., 1986; Tse and Wilton, 1988; Nicosia and Wilton,1986; Parasuraman et al., 1991). What is beyond question is that airlines need understand passenger expectations to deliver an improved service (Askoy et al., 2003). Also, the judgements about service quality and customer satisfaction involve comparisons between a customer’s previous expectation and the return of the service delivered

(Bagozzi, 1980, and Cronin and Taylor, 1992).

Secondly, the perception of the service and its interplay with expectations,gives rise to the concept of perceived service quality. In the model of Parasuraman et al. (1985), the globally perceived service quality for the consumer results from the comparison between perceptions and expectations on the different components of service quality. Boulding et al. (1993) assume that current perceptions are a blend of the prior expectations of what will and what should happen during the contact, and the service actually delivered during the service encounter.

Thirdly we find the concept of satisfaction intimately linked with perceived quality. In such a link Boulding et al. (1993) connect satisfaction with consumer perceptions in a particular transaction, whereas perceived service quality emphasizes the accumulation of that service perceptions. Hunt (1977) defines satisfaction as the evaluation of an emotion. Rust and Oliver (1994) suggest that satisfaction reflects the degree to which the consumer believes that the possession and/or use of a service evokes positive feelings.

Fourthly, the concept of service value appears as one more link between satisfaction and perception, to a point that Hallowell (1996) says that satisfaction is the outcome of a customer's perception over perceived value. Zeithaml (1988) evaluates the exchanges in service and defines value as the global evaluation of a product based on the perceptions about what is received and what is given. The concept of service value is also associated with whatever is given up. Hart et al. (1990) and Zeithaml (1988) present it as that which is foregone to acquire a particular service, a multidimensional construct. The items representing consumer perceptions about monetary and non-monetary prices associated with the purchase of a product or a service are employed as constructs for that sacrifice.

And fifthly, as a consequence of providing service quality, we may talk about customers' behavioural intentions. To increase customer loyalty and/or diminish the ratio of customer drop-outs stand as two of the most important capacities to generate profit. Zeithaml et al. (1996) suggest that favourable behavioural intentions are connected with the ability of a service supplier to make customers (1) tell positive things about the supplier, (2) stay loyal, (3) recommend the supplier to others, (4) spend more on the firm and (5) pay premium prices.

There certainly exists further literature on the concepts of service quality and models developed from their interaction. In spite of this, from a managerial perspective simplicity and clear focus on their decision models are greatly required; this is particularly so when pressed for time. The analysis that follows has these features; it is simple, useful and efficient to directly focus on the concepts of i) satisfaction with service quality (as per its attributes) and ii) passenger behavioural intentions regarding repurchase and recommendation. The model applied to the case-study is based on these premises; expectations, perceived quality and service value are left out for future research.

4.3 Models that measure service quality

A number of papers exist on the measurement of service quality. Some focus on the antecedent-mediator-consequent approach. Bagozzi (1992) suggests that the initial assessment of a service produces an emotional reaction leading later behaviour. Boulding et al. (1993) define three processes to articulate their conceptualization: (1) the process by which customers form and update their expectations, (2) the process by which customers develop perceptions of the quality of specific and global aspects of the service delivery system and (3) the relationship between perceptions of overall service quality and intended behaviours.

Every managerial strategy has, among its main objectives, to secure the viability of the firm through its profitability. Differentiation through service quality is no different from any other strategy since the lack of profit over time leads to shut-down. The relationship between service quality and profitability is neither a simple nor a direct one; this is why the intermediate stages need to be studied, as in the example of service quality and behavioural intentions (Zahorik and Rust, 1992). These authors distinguish five tasks to model the impact of service quality on profit: (1) identify the key attributes in a service to be included in the model, (2) select the most important attributes, (3) model the link between service programmes and customers' attitudes towards them, (4) model the behavioral response to such programmes and (5) model the impact of these programmes on profit.

Research on satisfaction, value and perceived quality, as in Hallowell (1996), treats customer satisfaction as the result of customer perception about the delivered value. Also Fornell et al. (1996) conclude that the main determinant aspect regarding global satisfaction is perceived quality followed by perceived value. Athanasspopoulos (2000) shows that customer satisfaction is highly correlated with value and a variety of quality attributes, the price among them. Rust and Oliver (1994) conclude that favourable perceptions of service quality carry improvements in attributes related with value and satisfaction.

Focusing on the relationship between satisfaction and behavioural intentions, numerous papers find evidence on their positive relation such as with recommendation and repurchase. For example, Reichheld (1996) determines that more satisfied customers are six times more likely to repurchase Xerox products than less satisfied ones. Cronin and Taylor (1992) find a positive correlation between service quality and behavioural intentions. Woodside et al. (1989) provide evidence on a significant association between patients' global satisfaction and the purpose of choosing the same hospital again. Berry et al. (1988a) and Zeithaml et al. (1996) investigate whether a positive and significant relation exists between perceived service quality and customers' propensity to recommend purchase as well as their intentions to purchase again.

The lack of consensus on the constructs of perceived value reinforces the research question posed in this chapter and earlier advanced. We shall center on the relation between customer satisfaction and behavioural intentions. Therefore, the model of decision making will be as simple as possible to highlight the importance of certain quality attributes to further study their impact on customers' future intentions regarding repurchase and recommendation of service.

4.4 Case-study: conceptual framework

As already noted, the concepts around service quality are wide and varied within the service cycle. In addition, the variety of existing models would lead a manager, who takes decisions under incomplete information and pressed by time, to pick the simplest model offering quick answers with a high probability of success. If the information available were complete then the manager would not be needed at all. If time were not a constraint then more elaborate models could be developed with higher probability of making successful decisions. Unfortunately this is not the case of the air transport sector, where the dynamics of competition are constantly compelling managers to take swift decisions always with a lack of information. For these reasons we wish to set up a model in terms of its usability for the actual management of an airline company.

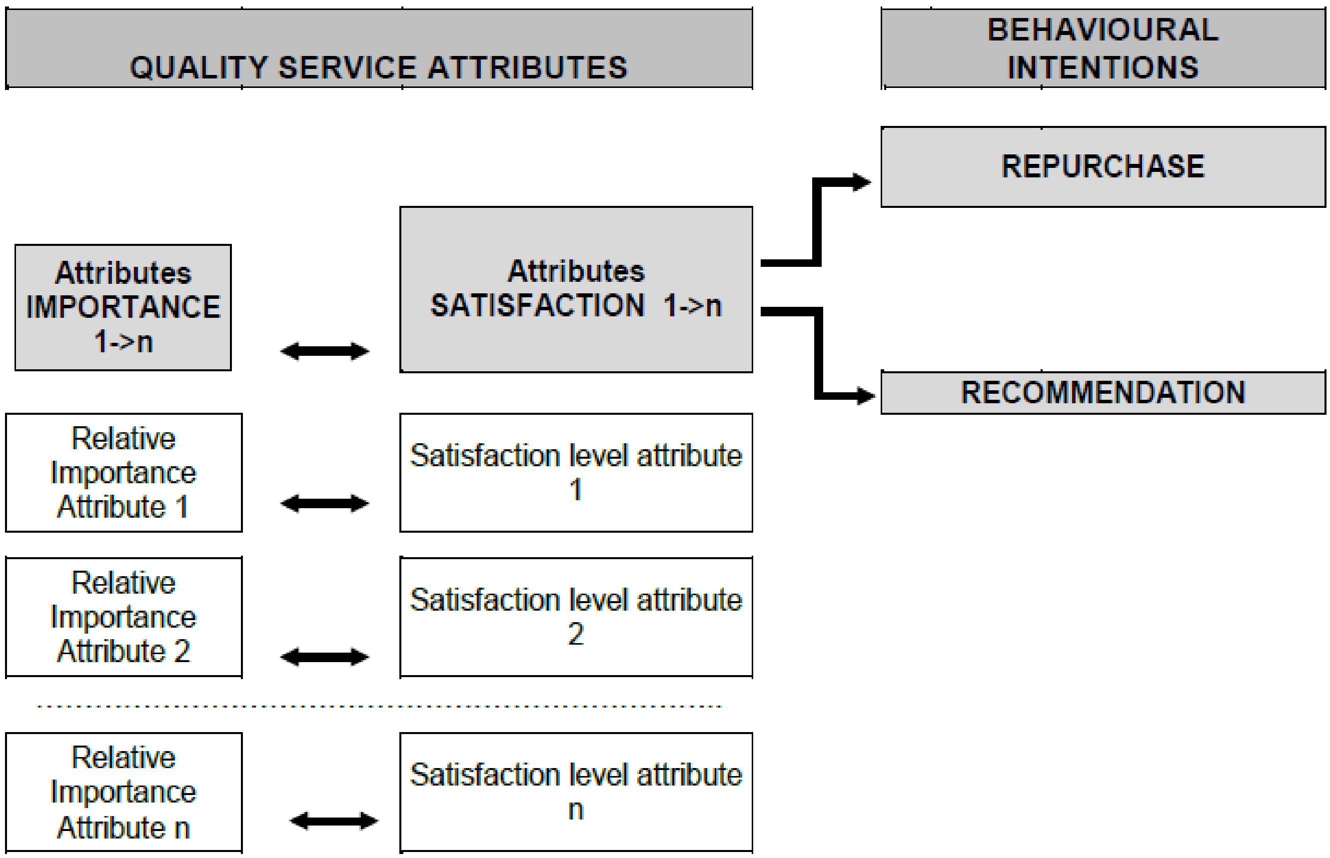

Figure 4.1: Conceptual Framework

The model is thus based on an information system and analysis about customer satisfaction in service quality attributes, and on customers' behavioural intentions about recommendation and repurchase. The goal is to integrate such information system as an input for strategic decision making, above all in terms of investment and resource allocation.

As can be seen in its graphical representation, service quality is composed of a series of n attributes. The variables that are measured for every attribute are their relative importance as well as their satisfaction level. The behavioural intentions considered are customer repurchase and recommendation. The information conveyed by the model is of three types: how important is every attribute to a passenger, which is the passenger's satisfaction level per attribute, and finally whether he/she would repurchase and/or recommend flying with the airline in question. The interaction among these types of information allows us to establish the hypotheses to be tested as to the relationship between importance and satisfaction on an attribute and repurchase/recommendation of service.

In the first part, we obtain information about passenger importance and satisfaction regarding the number of attributes in which service quality has been divided for the model analyzed. This information permits the construction of a positioning matrix by measuring the level of importance in the vertical axis and level of satisfaction in the horizontal axis. This provides a first snapshot within which decisions are taken, with regard to the priorities of passengers.

Then, two hypotheses are specified. They refer to which attributes and by how much do they increase passenger behavioural intentions about repurchase and recommendation. The hypotheses to be verified are the following:

- Hypothesis H1: The level of satisfaction of every attribute of service quality influences the probability of repurchase of the service.
- Hypothesis H2: The level of satisfaction of every attribute of service quality influences the probability of recommendation of the service.

4.5 Measurement tool: passenger surveys

The survey was carried out in 2006 through a total of 3.000 questionnaires circulated to passengers in three European airports. The percentage of valid responses was 72% totalling a number of 2.162 questionnaires completed. The questionnaire was designed as follows:

- The attributes of service quality were determined by means of a focalized work group of five passengers with an annual flight frequency greater than or equal to six (ensuring a minimum of one flight every two months). The attributes were chosen on the basis of the Servqual model on measurement of service quality (Parasaruman et al. 1988). Their disposition and final choice was made so as to have them as customized as possible with the necessities and actual expectations of actual air transport passengers. The final list included:

Attributes of Service Quality
Boarding
Check-in
Fares
Luggage
Press on board
Info at airport
Timetable and frequency
Languages by crew
Punctuality
Comfort on board
Crew attention
Food & beverages on board

Table 4.1: Attributes of Service Quality

- How satisfied is a passenger with every attribute was measured by a Likert scale, from 1 to 4, as an increasing degree of satisfaction. The main reason for choosing an even number is the practical criterion of their usefulness for manager decision taking. An even scale forces the pollee not to stay in the middle and to opt for a positive or a negative opinion about satisfaction, which is indeed the information he/she reveals when taking a decision.

- To measure the relative importance of attributes for passengers, the method chosen was to ask them to rank just the most relevant attributes. To this end the questionnaire asked about the three most important attributes and passengers were told to rank them with 3 points to the most important one, 2 points to the next in importance, and 1 point to the third more important.

- Two measures have been used to evaluate passenger behavioural intentions, repurchase and recommendation, in a yes/no scale.

- The profile of the passenger in the survey is shown in the next Table 4.2:

Age	
under 18	0,5%
18 to 24	5,5%
25 to 35	34,0%
36 to 50	41,5%
over 50	18,6%
Trip Reason	
business	53,3%
leisure	21,7%
visit friends&relatives	21,9%
Annual Trip Frequency	
less than 6 times a year	58,6%
6 to 12 times	21,1%
13 to 24 times	10,8%
over 25 times	9,5%

Table 4.2: Passenger Profiles

4.6 Empirical results analysis

This section presents the empirical analysis outlined in earlier sections. Firstly, the analysis considers the matrix of importance and how it can be used by managers. Secondly, the results for testing hypotheses H1 and H2 are given.

4.6.1 Descriptive analysis of relative importance of attributes: their influence in the management of service quality satisfaction

The relative importance of every attribute and its average level of satisfaction are shown below in Table 4.3.

Items	Relative importance	Average satisfaction
Punctuality	37,8%	3,21
Fares	24,0%	2,48
Timetable/Frequency	9,7%	2,99
Crew attention	8,9%	3,74
Comfort	6,1%	3,09
Info at airport	4,1%	3,19
Check-in	3,9%	3,36
Boarding	2,2%	3,28
Luggage	1,4%	3,20
Food/beverages	1,1%	3,22
Languages	0,5%	3,29
Press	0,3%	3,27

Table 4.3: Relative Importance and Average Satisfaction

The results reveal that higher levels of customer satisfaction can be achieved with actions on those attributes with greater relative importance and with greater potential growth. Thus, decisions targeted to punctuality, fares, timetable/frequency, crew attention and comfort should be given priority by managers. Also the Table shows that there is further scope for improvement in fares, timetable/frequency and comfort rather than in crew attention, where passengers are very satisfied. Strategic investment decisions in actions to improve satisfaction should therefore consider matrices similar to the above one. More precise information regarding this type of actions is given next with the quantitative analysis of the variables involved. This together with a report on the viability of the investment (economic, physical, etc...) will help in further focusing on adequate resource allocation.

4.6.2 Testing hypotheses H1-H2: The level of satisfaction of an attribute influences the probability of repurchase/recommendation

We now have a dichotomic dependent variable (yes/no) for the repurchase and recommendation decision which is a function of a change in a number of attributes of service quality, these are qualitative explanatory variables (from 1 to 2, from 2 to 3, from 3 to 4). The model is thus estimated with a logit regression analysis, where the independent variables are ordered. In addition, marginal effects are taken into account in the estimation. The initial regression has been carried out with 12 explanatory attributes. Table 4.4 below shows the results. The following comments are in order.

- 4 attributes out of 12 are found significant: an increase of a one-point level of satisfaction translates to an increase in the probability of repurchase and recommendation. These attributes are punctuality, fares, cabin comfort and food/beverages. The attribute with a greater impact on the increase in such probability is cabin comfort, 25,94% and 27,96% for repurchase and recommendation, respectively. It is followed by food/beverages (19,33% and 19,81%, respectively, although the former is significant at 90%).

- Besides, timetable/frequency and check-in are significant at the 90% level only regarding recommendation, their probabilities of increase being 8,51% and 18,41%, respectively.

- Of the 4 statistically significant attributes, cabin comfort stands as the one that supposes the highest increase in the probability of repurchase, followed by food/beverages, fares and punctuality. Regarding the probability of reccommendation, punctuality comes before fares. Besides, "timetable/ frequency" is significant in recommendation and is 3^{rd} in importance. Crew attention, though important (it ranks 4^{th}), does not appear as significant for the increase in probability of repurchase and recommendation. Additionally, food/beverages, despite it ranking 10^{th} in relative importance terms, does lead to a considerable increase in the probability of repurchase and recommendation. This finding reinforces the initial exploration of the information contained in the matrix importance/satisfaction in the sense that the relevance of attributes must be taken into account when taking decisions.

- Of the 4 statistically significant attributes, cabin comfort is shown the attribute which substantially increases the probability of repurchase, followed by food/beverages, fares and punctuality. The latter two attributes exchange their order regarding the probability of recommendation.

- The increase in the probabiilty of repurchase is greater than in that of recommendation for punctuality, when increasing by one the level of satisfaction. For fares and cabin comfort the opposite holds.

- Regarding passenger type (business vs others), the estimates show that this variable is non-significant.

Relative Importance	Variable	Likelihood Increment [a]			
		Repurchase		Recommendation	
		Likelihood	P value	Likelihood	P value
1º	**punctuality**	10.89%	0.046**	18.80%	0.001**
2º	**fares**	14.63%	0.000***	8.54%	0.002**
3º	timetable	7.67%	0.169	8.51%	0.068*
4º	crewatt	19.65%	0.617	38.39%	0.295
5º	**comfort**	25.94%	0.011**	27.56%	0.007***
6º	luggage	6.09%	0.956	-0.71%	0.941
7º	**checkin**	11.79%	0.240	18.41%	0.052*
8º	boarding	12.83%	0.190	14.49%	0.138
9º	info	14.81%	0.829	-5.22%	0.378
10º	**food**	19.33%	0.089*	19.81%	0.088*
11º	press	4.91%	0.554	4.98%	0.509
12º	language	14.88%	0.395	15.05%	0.324
Business Passengers		-1.55%	0.281	-0.96%	0.497

*** Significant 99% (p value < 0.01)
** Significant 95% (p value < 0.05)
* Significant 90% (p value < 0.10)

[a] Likelihood increment of repurchase / recommendation due to an increase of 1 satisfaction level (1-->2; 2-->3 or 3-->4) in the corresponding attribute for all the passengers, except those with the maximum level of satisfaction (4)

Table 4.4: Ordered Logit Regression

To test for the robustness of our results several estimations have been carried out, beginning with considering the five most important attributes. Out of these estimates, three statistically significant attibutes were selected, and then attributes have been added two by two until completing the analysis. The robustness results are shown in Table 4.5 in the Appendix; they confirm the results presented in the main text. Table 4.5 in the appendix is constructed by taking groups of five attributes ordered by relative importance. There, it can be seen that the range of increases in the probability of repurchase/recommendation is 23,9%-34,7% for comfort; 10,1-22,0% for punctuality, and 8,1%-16,3% for fares.This happens for all groupings. The attribute food/beveradges is found significant only as to repurchase - see test 5 of Table 4.5.

4.7 Conclusions

The strong and dynamic competition brought about by the emergence of low-cost carriers in the airline sector has pushed their boards of managers to set a higher pace and good judgement in their strategic decisions at all levels. The strategy of differentiation through service quality is a possible alternative to the strategy of cost leadership. The knowledge of passenger satisfaction about service quality offered by an airline, as well as how it impacts on passenger behavioural intentions, are very relevant for the investments and resource allocation that managers have to undertake in an agile way.

The model proposed in the case study is aimed at making managerial decisions easier regarding an airline's positioning of service quality. Such model is based on an information system centered on how passengers define the attributes of service quality, how important is every attribute, and how the level of satisfaction in every attribute is perceived with service experience. The information system is integrated in the model of decision taking by first building a ranking of importance and satisfaction level to learn the priorities of taking actions per attribute – regarding the relative importance of every attribute and also the potential to improve its level of satisfaction. Secondly, the ordered logit regression analysis permits a quantitative assessment regarding how increasing the level of satisfaction in an attribute affects behavioural intentions on repurchase and recommendation.

The hypotheses tested confirm that the relative importance and level of satisfaction of attributes prioritizes those on which to take decisions. In the sample, the five out of twelve most important attributes (punctuality, fares, timetable/frequency, crew attention and cabin comfort) show different levels of satisfaction, being punctuality, fares and cabin comfort the ones on which decisions on investment and resource allocation should be targeted as these also have a greater potential for improvement. The findings derived from the regression analysis show that only four out of twelve attributes are statistically significant to increase the probability of repurchase/recommendation by increasing their level of satisfaction. These are punctuality, fares, cabin comfort and food/beverages, where cabin comfort is found to have the stronger impact, followed by food/beveradge, fares and punctuality - for the probability of repurchase. Two more attributes are significant just regarding the probability of recommendation - check-in and food/beverages**.** Passenger type is found non-significant neither for repurchase nor recommendation. However, business passenger type adds two attributes that increase the probability of recommendation: boarding and languages. Therefore, the model developed, and supported by a case study, lends itself as a simple and useful information system for strategic decision making regarding service quality in airline management.

4.8 Deficiencies and future research

From the viewpoint of marketing and market research, where the models proposed are exhaustive and detailed, the current model is prone to improvement, although its guidance for quick decisions in investment/resource allocation directly based on customer information leaves any refinements of the model for future analysis. Also the development of current research on service value and its relationships with satisfaction and behavioural intentions manifest the inclusion of the latter dimension in the model.

4.9 Managerial implications

The complexity, dinamism and strong competition in the passenger airline sector put strong pressure on managers, who have to take decisions with lack of information and with time constraints. The decisions on investment and optimal resource allocation must be, at all strategic levels, targeted at profit and loss statements and based on customer decisions. The simple model proposed and its operative results reveals useful information as to strategic decisions regarding service quality.

It reinforces managers in their application and improvement of airline performance; it also enhances customer target. With these, managers will enjoy a more precise knowledge of market segmentation in the decisions per attribute of service quality, not only as to an ordering of importance but also as to the potential for improvement in satisfaction and, consequently, as to their impact on repurchase and recommendation intentions. This will certainly complement the cost-benefit analysis of investments and resource allocation in a simple and agile manner.

4.10 Appendix.

4.10.1 Robustness

	Relative Importance	Variable	Likelihood Increment [a]			
			Repurchase		Recommendation	
			Likelihood	p value	Likelihood	p value
TEST 1	1º	punct	0.1227	0.007***	0.1991	0.000***
	2º	fares	0.1616	0.000***	0.1004	0.000***
	3º	timetable	0.0663	0.229	0.0648	0,152
	4º	crewatt	0.1884	0.494	0.2774	0.373
	5º	comfort	0.3031	0.002***	0.3113	0.002***
	Business passenger		-0.0147	0.287	-0.0016	0.890
TEST 2	1º	Punct	0.1470	0.002***	0.2199	0.000***
	2º	Fares	0.1563	0.000***	0.1164	0.000***
	3º	checkin	0.1001	0.368	0.1035	0.316
	4º	luggage	0.1463	0.107	0.1658	0.052*
	5º	comfort	0.2576	0.006***	0.2358	0.008***
	Business passenger		-0.0250	0.071	-0.0106	0.357
TEST 3	1º	punct	0.1012	0.035**	0.1797	0.000***
	2º	fares	0.1586	0.000***	0.1115	0.000***
	3º	boarding	0.1574	0.079 *	0.1611	0.171
	4º	info	0.0357	0.571	0.1047	0.849
	5º	comfort	0.3204	0.001***	0.2573	0.003 ***
	Business passenger		-0,0211	0.123	-0.0086	0.445
TEST 4	1º	punct	0.1319	0.004***	0.2017	0.000***
	2º	fares	0.1568	0.000***	0.0895	0.000***
	3º	food	0.1955	0.076*	0.1730	0.094*
	4º	press	0.2307	0.755	0.2852	0.678
	5º	comfort	0.3231	0.001***	0.2562	0.076 *
	Business passenger		-0.0242	0.076	-0.0157	0.161
TEST 5	1º	punct	0.1530	0.002***	0.2063	0.000***
	2º	fares	0.1581	0.000***	0.0958	0.001***
	3º	food	0.1900	0.081*	0.1690	0.111
	4º	language	0.1917	0.277	0.2051	0.213
	5º	comfort	0.3486	0.000***	0.2861	0.003***
	Business passenger		-0.0165	0.242	-0.0065	0.584

*** Significant 99% (p value < 0.01)
** Significant 95% (p value < 0.05)
* Significant 90% (p value < 0.10)

[a] Likelihood increment of repurchase / recommendation due to an increase of 1 satisfaction level (1-->2; 2-->3 or 3-->4) in the corresponding attribute for all the passengers, except those with the maximum level of satisfaction (4)

Table 4.5: Robustness test: groups of 5 variables (ordered by relative importance and significance)

Part III

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