Airline Codeshare Alliances

Marketing Boon and Revenue Management Information Systems Challenge

Codeshare alliances are a popular instrument for airlines to grow profitably. This paper juxtaposes the challenges that they create for analytical information systems on the one hand and their motivation from a marketing perspective on the other. In this regard, revenue management systems as a central tool of the ticketing process are of particular interest. Complementary codesharing reduces alliance-wide revenues by up to 1 %. Losses disseminate over the whole network and increase with total demand and the degree of codeshare demand. Virtual codesharing causes losses of up to 1.5 % depending on the discount level offered by the marketing carrier and on the demand structure. Based on the findings, recommendations for airline management and future research are derived.

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1 Introduction

As competitive pressure increases, mergers and alliances are gaining popularity across all industries. A large and growing body of management research considers the topic; compare for example Ireland et al. (2002, pp. 413–446) for a discussion of the role of management in corporate alliances. At the same time, mergers and alliances provide new opportunities for information systems (IS) research: They pose challenges to communication and information consistency, and increase the size and complexity of decision support tasks, as discussed for example in Killing (1988, pp. 55–67).

Many industries regard alliances as the appropriate framework to build more efficient and profitable business networks. Airline codeshare alliances are a typical example. They enable carriers to cooperate when trade and ownership regulations make other forms of cooperation impossible (Park 1997, pp. 181–195). According to de la Torre (1999, pp. 60–75), the five main benefits of airline alliances are greater network reach, access to foreign markets, increased market penetration, higher traffic volumes and cost benefits due to synergy. From a marketing perspective, these benefits lead to potential gains through the extension of the product portfolio, improved customer relationship management, and the establishment of common sales policies across markets.

In 2010, the three large airline alliances – Star Alliance, One World and Sky Team – accounted for 54 members and a market share of almost 60 % of revenue passenger kilometers (Jain 2011, p. 24). Their popularity stems from the low margins prevalent in the industry: High competition and increasing costs combined with price-sensitive customers force airlines to collaborate with strategic partners.

Codesharing enables airlines to jointly market their capacity by assigning their designators to a common flight. For example, the Lufthansa flight LH430 from Frankfurt to Chicago is also marketed by United Airlines as flight UA8836, by Thai Airways as flight TG7708, by Air Canada (AC9457) and Air India (AI8637). While Lufthansa operates the flight (*operating carrier*), each codeshare partner may sell seats on it (*marketing carrier*). By means of this concept, the marketing carriers extend their product portfolio without requiring extra resources; they feed additional passengers into their own network and augment demand on major routes (Vinod 2005, pp. 66–82). Moreover, they can access new markets: In the example, Thai offers a flight that neither departs from nor arrives in its home market.

We collected data at Lufthansa German Airlines indicating an increase in alliance capacity of about 42 % from 2001 to 2011. The data also reveal that more than half of Lufthansa marketed flights are operated by allied carriers. Similarly, the majority of Lufthansa operated flights is marketed through at least one other airline. Overall, codesharing accounts for 6–8 % of Lufthansa bookings and has become a crucial factor in the airline's business strategy.

Alliances generate new challenges for the airline planning process and the analytical information systems supporting it. These include the increased complexity of the underlying decision support problems as well as the exchange of information and the coordination of joint decisions.

This paper contributes to information systems and airline alliance research in two ways: On the one hand, it provides a structured description of marketing benefits and information systems' challenges. On the other hand, the simulation results quantify the impact of decentralized codeshare control, thereby prompting to close the gap between theoretical research and the current practical implementation of alliance revenue management.

The rest of this article is organized as follows. We begin with an extensive literature review in Sects. 2 and 3. We consider the benefits of airline codeshare alliances as a marketing tool and cluster relevant literature accordingly. Following this overview, we outline the airline planning process under the aspect of implementing codeshare alliances. Subsequently, we critically consider the resulting challenges for analytical information systems. After introducing the simulation approach in Sect. 4, we use it to estimate the cost of codesharing on revenue management and to derive benchmarks for the performance of codeshare alliances in Sect. 5. The paper closes with a summary of the findings and recommendations toward further application oriented research.

2 Marketing Promises of Airline Codeshare Alliances

From a marketing perspective, three major promises render airline codeshare alliances attractive: synergy in customer relationship management, the extension of the product portfolio, and the establishment of common sales policies.

2.1 Customer Relationship Management

In airline alliances, cost efficient customer relationship management can be realized through infrastructure synergy and improved resource utilization. Examples for potentially shared resources are gates, lounges, and check-in facilities. Synergy arises by pooling ground and maintenance operations as well as purchasing and marketing activities (Morrish and Hamilton 2002, pp. 401–407).

Sharing each other's infrastructure also improves the service quality: For example, passengers obtain access to more lounges than could be efficiently maintained by a single carrier, and shared terminals reduce transfer times and distances between gates. Further quality aspects associated with alliances include safety, reliability, professionalism, and on board service. Along with a common logo and slogan, these factors establish the alliance as a brand, foster its recognition, and distinguish it from other airlines and alliances.

Alliance members often merge their frequent flyer programs, thereby strengthening the ties between the alliance and its customers (de la Torre 1999, p. 79). Passengers can earn and redeem miles within the entire alliance network; privileges of status customers, such as lounge access, priority boarding and late check-in, are globally recognized.

In addition to increased flight frequencies and a wider variety of connections, codesharing allows airlines to create seamless travel opportunities (Brueckner 2001, pp. 1475–1498). Seamless travel provides the impression of travelling on a single airline and is supported by common market interfaces and joint scheduling. The advantages of seamless travel include single ticketing, check-in and baggage drop-off.

2.2 Product Portfolio

Codeshare partners enrich their product portfolio by selling tickets for each other's flights. Oum et al. (1996, pp. 187–202) differentiate three types of codesharing: complementary, parallel, and virtual codesharing. For a *complementary codeshare*, flights operated by two or more airlines are combined to form a new route (Oum et al. 1996, pp. 187–202). In contrast, in a *parallel codeshare* each carrier also operates the route individually. *Virtual codeshares* refer to an airline offering a route while not operating any of the flights involved.

Complementary codesharing is prevalent in international alliances where individual networks rarely overlap: The main objective is to extend network reach and to access foreign markets. The airlines in the example above are suited for complementary codesharing as they have distinct home markets and only few shared routes.

Parallel codeshares can mostly be found in domestic markets. On the domestic level, airline networks tend to have more overlap: Partners focus on increasing market penetration and aim to reduce competition on jointly served routes. In international alliances, parallel codeshares typically occur on hub-to-hub routes, i.e., Chicago–Frankfurt as offered by United and Lufthansa.

Several authors use an economic perspective to demonstrate the effect of complementary and parallel codesharing on prices, traffic volumes, and social welfare. Adler and Smilowitz (2007, pp. 394–409), Brueckner and Whalen (2000, pp. 503–545) and others find that complementary codeshares positively affect prices, output and welfare. For parallel codesharing, the same contributions point out the prevalence of anti-competitive effects as prices increase while traffic volumes and welfare decrease.

Last but not least, virtual codesharing is predominantly a strategic marketing tool, as the marketing carrier does not supply capacity. Virtual codeshares occur in domestic as well as international markets and are described in further detail in Ito and Lee (2007, pp. 355–380) and Gayle (2007, pp. 17–18).

2.3 Sales Policies

Possibly the most ambivalent benefit of airline alliances is the potential to establish common sales policies. On the one hand, alignments can provide dependable standards for customers, increasing the perceived fairness of pricing and simplifying the purchasing process. On the other hand, they can easily catch the whiff of price fixing and cartel building.

The feasible extent of sales policy coordination depends on the alliance's legal situation. This may vary depending on the formal background – if the cooperation legally is a merger but the partners remain independent for organizational reasons, sales policy coordination can reach as far as desired. If the cooperation consists of agreements between economically separate and possibly competing airlines, it is strictly regulated by competition laws.

Using their partners' sales channels, airlines can increase their visibility in the global distribution systems (GDS). GDS form the largest distribution channel (followed by carriers' websites and third party providers) and are accessed by travel agencies (Boyd and Bilegan 2003, p. 1365). Higher visibility, for example through preference display, increases market penetration and purchase probability (Boyd and Bilegan 2003, pp. 1363–1386). Continuing the example, Lufthansa flight LH430 also appears as UA8836, TG7708, AC9457 and AI8637 in the GDS or on Internet travel sites, turning a single service into five different offers.

As another benefit, codeshare connections appear as online connections in the GDS and therefore take a more prominent position than genuine interline connections (Bamberger et al. 2004, p. 198). Similar to the display of search results on the Internet, the higher an offer is ranked, the more likely customers will choose it. Furthermore, empirical research by Bamberger et al. (2004, pp. 195–222) has shown that customers prefer online to interline connections: One reason is comparatively lower prices, but brand loyalty and perception of the marketing carrier also play a role.

Finally, online connections are easier to advertise: A carrier can independently tailor and communicate the offer. It can customize the tariffs as well as the marketing process to fit its brand perception and home market. As a result, airlines share marketing costs while benefitting from each other's regional competence and local market knowledge. Using their partners' existing sales channels, they can construct more effective and more efficient campaigns.

3 Airline Planning and Operations Systems in Codeshare Alliances

For more than forty years, airline planning and operations have been supported by analytical information systems. As described in Smith et al. (2001, pp. 37–55), this has allowed airlines to systematically include operations research principles and to adopt electronic business concepts early on. Alliance membership introduces additional complications to most information systems, and these are in the focus of the second part of the literature review presented in this section.

3.1 Alliance Impacts on Airline Planning Systems

As described by Belobaba (2009, pp. 153–181), the first part of the airline planning process includes fleet planning, route planning, and schedule development. The author refers to this as strategic planning. The task of assigning prices and allocating availabilities may be regarded as the second part and considered to be of tactical nature.

The first step of strategic planning, fleet planning, is generally not affected by alliances: While a homogeneous fleet might be more cost efficient, individual strategic factors take precedence. Alliance considerations first arise during route planning and flight scheduling. Both are often based on economic and revenue forecasts. The existence of complementing or parallel offers by alliance partners can influence these, affecting the expected performance on certain routes.

The development of flight schedules is also supported by operations research systems: Fleet assignment and aircraft rotations are optimized according to given conditions such as departure and arrival slots, available aircrafts, technical constraints and demand forecasts. Efficient schedules with regard to connection times and fleet utilization are hampered by codesharing complications. For example, not just connections to flights operated by the own airline, but also to those constituting complementary codeshares should be considered. On parallel routes, partners could avoid direct competition caused by wing-to-wing flights. Demand forecasts that form the basis of planning can be improved by including codeshare demand.

The tactical steps of crew scheduling, airport resource management and operations control are based on the results of flight scheduling. Here, only minimal considerations with regard to alliance partners are required: At most, the access to commonly used airport infrastructure such as lounges, gates or check-in facilities needs to be coordinated.

Information exchange plays a crucial role for the integration of codeshare alliances in the planning process. At least, the partners' plans with regard to routes and schedules should be exchanged; merged demand forecasts, however, will provide the best possible coordination.

In the tactical stage of airline planning concerned with price and inventory optimization, the role of information exchange becomes increasingly important. Whereas infrequent exchanges can support strategic planning, information about pricing and revenue management should be as current as possible. As will be shown in Sect. 3.2, alliance revenue management (RM) ideally asks for common demand forecasts, common pricing and consistent availability controls. As such a close cooperation may not be desired or admissible, the gap between the theoretical alliance-wide optimum and most practical implementations widens.

Finally, also the impact of alliances on sales and distribution is considerable. While GDS already enable codeshare offers, the airlines must adapt their internal ticketing processes and possibly other sales channels.

As shown in **Fig. 1**, pricing and RM are among those steps of the planning process where the impact of codeshare alliances is strongest: Either the partners jointly exploit customers' willingness-to-pay or they underbid each other, accepting profit setbacks through cannibalization. In this area, the trade-off between potential marketing benefits and challenges to IS design is especially prominent. For this reason, our subsequent analysis focuses on the challenges for alliance revenue management systems.

3.2 Challenges for Alliance Revenue Management Systems

From an information systems perspective, alliances create two main challenges for airline planning. Both are most apparent in revenue management, but also apply to systems supporting the other steps of the planning process.

Separate and Heterogeneous Systems Most airlines operate complex and highly customized RM systems to optimize their individual performance. The market interface for codeshare itineraries needs to be managed across these separate systems. To exploit the full codesharing potential, it is essential to include information on such itineraries in each airline's calculations and to implement common control capabilities.

Incomplete Information As carriers in international alliances typically remain independent entities, antitrust laws restrict the exchange of information. Therefore, not all information necessary to optimally manage codeshare itineraries is available to all partners. This

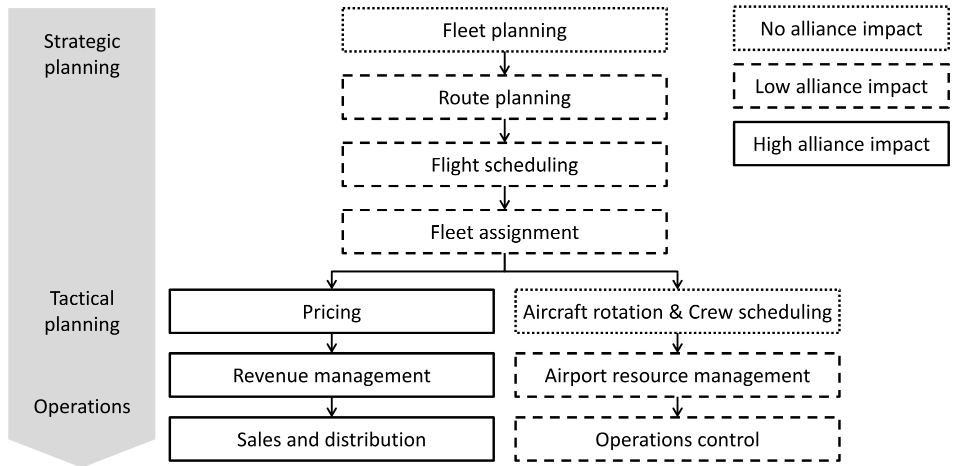


Fig. 1 The airline planning process and alliance considerations

includes prices, demand forecasts and product structures, and as far as possible booking data. Due to the restrictions on information exchange, potential benefits from joint planning become difficult to realize.

For the success and stability of an alliance it is crucial to overcome these challenges. With regard to RM, two central questions emerge: First, what is the most feasible way for alliance carriers to exchange availability information across their separate systems? And second, how should airlines forecast demand and optimize codeshare itineraries with only incomplete information?

Interviews with industry experts of Lufthansa have revealed that availability exchange is in practice mostly restricted to *availability status messages* (AVS). The operating carrier communicates local booking class availabilities to the marketing carrier (Vinod 2005, p. 69). The marketing carrier calculates the minimum availabilities across all operating carriers. A booking class becomes available if and only if all operating carriers offer it locally.

As flight level availabilities distort network controls and tend to be more restrictive (see Talluri and van Ryzin 2004, pp. 81–122), *bid price sharing* provides a network-based extension: Instead of exchanging booking class availabilities, the carriers exchange current bid prices – the marginal value of the next seat. Many carriers implementing network revenue management already use bid price controls and bid price sharing has been shown to increase revenue (Jain 2011, pp. 92–101). However, the exchange of bid prices requires partial antitrust immunity. Additionally, practitioners report that nowadays bid price sharing is rarely used in practice. Therefore, the computational study presented in this text implements AVS availability exchange. For discussions of the two methods refer to the contributions by Boyd (1998, pp. 1–7) and Vinod (2005, pp. 66–82).

Although some alliances have been granted partial immunity, practitioners further report no or little information exchange with regard to bookings and expected demand. While the marketing carrier knows the exact bookings and availabilities, the operating carriers may not be able to distinguish codeshare bookings from local bookings. This lack of information prevents airlines from explicitly forecasting and optimizing codeshare itineraries. Instead, they are forecasted and optimized together with local bookings.

Finally, the information asymmetry between operating and marketing carrier creates a moral hazard: The marketing carrier may use the additional information to independently maximize its revenue at the cost of its partners. However, this inequality balances out as all operating carriers usually offer a codeshare route.

3.3 Related Research on Airline Alliances

Having discussed the marketing benefits of codeshare alliances as well as their impact on information systems, let us also mention that there is a growing body of related research devoted to other aspects of airline alliances. As this paper focuses on the implications of current codeshare techniques applied in practice, this section provides only a brief overview of this literature.

Abdelghany et al. (2009, pp. 307–330) discuss the selection of codeshare flights in a hypothetical alliance network as one aspect of alliance formation. Their model explicitly considers the tradeoff between additional codeshare passengers and displaced local demand, but does not incorporate seat allocation decisions.

De la Torre (1999, pp. 1–215) provides a general introduction to codesharing and also highlights its impact on the revenue management process. Darot (2001, pp. 1–168), and more recently Jain (2011, pp. 1–142), present two large-scale simulation studies that evaluate the effect of various codeshare control approaches on alliance performance and traffic mix.

Wright et al. (2010, pp. 15–37), Topaloglu (2012, pp. 500–517) and Hu et al. (2013, pp. 1–38) provide a more theoretical perspective on alliance revenue management. Topaloglu proposes an improvement to decentralized codeshare availability control. The other papers focus on revenue sharing – the process of distributing codeshare revenues among the participating carriers – and demonstrate its impact on availability decisions. Wright et al. compare several static and dynamic schemes in terms of alliance revenues; Hu et al. develop a static scheme that implements the central solution in the local systems of the alliance partners.

Although this research proposes interesting enhancements to the codeshare process, most suggestions are not directly applicable to practice. This is due to practical limitations imposed by decentralization and incomplete information – the two aspects discussed in Sect. 3.2. Some authors acknowledge this and suggest heuristic approaches that satisfy more realistic but still not generally feasible conditions. The simulation results documented in Sect. 5 emphasize the need to fill this research gap.

4 The Simulation Approach

As the success of revenue management is difficult to measure due to such factors as changes in demand, competition, marketing campaigns and special offers, the computational study presented here relies on a simulation approach. By analyzing multiple simulation scenarios, we establish benchmarks for the cost of decentralized codeshare revenue management under conditions of incomplete information.

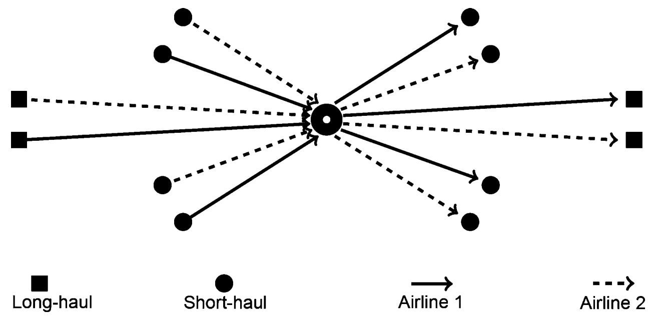


Fig. 2 Network with one hub and 12 spokes served by two airlines

4.1 The REMATE Simulation Environment

As described in Frank et al. (2008, pp. 7–16), simulation experiments are frequently used to evaluate the success of revenue management approaches. Simulations allow for ceteris paribus market conditions when comparing various strategies. Such an evaluation is not feasible in the real world, where changes in economic factors and competitor strategy may lead to diverging outcomes.

We use a web-based simulation system called REMATE which was developed by Lufthansa and several cooperating universities in 2009 (Cleophas 2012, pp. 163–170). REMATE is based on the recommendations for revenue management simulations listed in Frank et al. (2008, pp. 7–16) and implemented using Java. The affiliated universities use REMATE for application-driven theoretical research; at Lufthansa, the system supports strategic decisions and training.

4.2 Modeling Customers, Airlines and Revenue Management

The simulation model implemented in REMATE combines discrete-event-based and agent-based modeling: Airlines and customers are represented by agents, acquiring information from their environment and manipulating it through their decisions. Each action is scheduled as an event and realized sequentially. Stochastic elements include the variation of demand volume and customer characteristics.

Our customer model contains six customer types with varying sensitivity to prices and products. For the sake of simplicity, there are no cancellations, re-bookings nor repeated requests. The demand volume is given by a demand-to-capacity ratio. The *local or intraline demand* of a carrier includes all requests for routes exclusively served by that carrier. Requests for routes served jointly by both carriers are referred to as *codeshare demand*.

The airlines in this study operate distinct network revenue management systems, assume independent demand (Talluri and van Ryzin 2004, pp. 301–303) and use perfect forecasts as basis for revenue maximization. Optimization is realized through the Dynamic Programming Decomposition described in Talluri and van Ryzin (2004, p. 107), resulting in bid price controls. The available offers are displayed in a GDS, where customers book tickets. Based on the observed bookings, the airlines update their control decisions repeatedly during the booking period.

In the case of alliances, the airlines follow the setup described in Sect. 3.2: They operate distinct RM systems, do not explicitly forecast and optimize the codeshare itineraries, and use AVS to control the codeshare booking process. AVS information is exchanged each time a booking request arrives. The revenue of codeshare itineraries is shared based on the relative length of the individual flights (mileage proration).

4.3 Simulation Scenarios Implemented

The scenarios implemented for the computational study aim to be sufficiently small to provide traceable effects but realistic enough to generate meaningful findings. To this end, they model actual network constellations and were calibrated by means of Lufthansa booking data.

All scenarios contain 12 flights – four long-haul and eight short-haul flights. In the monopoly scenario, all flights are operated by a single airline; in the codeshare scenarios, two airlines operate half the flights each, as depicted in **Fig. 2**. The two sub-networks are symmetric and do not overlap, i.e., the distances between the hub and the spokes are the same, and spoke airports are served by exactly one airline. In its local network, each airline sells 15 intraline itineraries; 18 additional codeshare itineraries are created when the two networks are connected. Both carriers market all codeshare itineraries.

A capacity of 400 and 200 seats respectively per long-haul and short-haul flight is divided into two compartments (80 % Economy, 20 % Business). The business compartment includes three booking classes; the economy compartment includes eight booking classes. Each class has unique product restrictions. Prices are based on the distance flown and a class specific multiplier derived through regression over Lufthansa fare structures. The prices on complementary codeshare routes are the same for each airline.

For this study, five different supply scenarios are combined with seven demand clusters. Each scenario includes two airlines in different codeshare situations: In three scenarios, the carriers offer complementary codeshares created by connecting the two sub-networks in **Fig. 2**. Each incoming flight of one airline connects to every outgoing flight of the other airline. The results are compared to the optimal solution determined by monopolistically optimizing all flights and itineraries.

The first three scenarios differ by the distribution of demand between airlines. In scenario S demand is symmetric: The demand-to-capacity ratio as well as the traffic mix – the proportion of codeshare to local demand – is the same for every airline. In the other two scenarios, AS1 and AS2, the demand is asymmetric: In AS1, one carrier offers 25 % less capacity, but the demand remains unchanged. Hence, the share of codeshare demand is equal, but the demand-to-capacity ratio for this carrier is one third higher than that observed by the other carrier. In AS2, one carrier's capacity and local demand (but not the codeshare demand) are reduced by 25 %. As a result,

Table 1 Overview of scenarios

Scenario	Type of codeshare	Demand-to-capacity ratio	Traffic mix
S	Complementary	Symmetric	Symmetric
AS1	Complementary	Asymmetric	Symmetric
AS2	Complementary	Symmetric	Asymmetric
V25	Virtual	Symmetric	Symmetric
V50	Virtual	Symmetric	Symmetric

Table 2 Overview of demand clusters

Demand cluster	Demand-to-capacity ratio	Share of business demand	Willingness-to-pay
1	Low (1.22)	Very high (25 %)	High (9.64)
2	Medium (1.31)	High (22 %)	High (9.17)
3	Medium (1.35)	Medium (20 %)	Medium (8.38)
4	High (1.46)	Medium (19 %)	Medium (7.75)
5	Very high (1.58)	Very low (14 %)	Low (7.24)
6	Very high (1.62)	Medium (20 %)	Medium (8.38)
7	Very low (1.13)	Medium (20 %)	Medium (8.38)

the demand-to-capacity ratio for the local demand is the same, but the smaller carrier's share of codeshare passengers is higher.

Two further scenarios (V25 and V50) simulate virtual codesharing. We introduce a second, virtual airline to the monopoly scenario, which sells all itineraries without operating any flights. Note that in case of proper availability exchange and common product restrictions and prices, the marketing airline's offers would not deviate from the operating carrier's offers. However, in practice, this is usually not the case: First, the availability exchange method may not be consistent with the local availability control method of the respective carrier. Second, the marketing airline frequently offers different product restrictions or lower fares.

To simulate the cost of virtual codesharing, we use AVS for codeshare control, while implementing bid price controls in the carriers' local networks. Therefore the availabilities determined by the operating and the marketing carrier are likely to deviate. Furthermore, we reduce the fares of the virtual airline by two discount levels calculated in percent of the difference between two subsequent fares of the operating carrier. We copy every booking class of the operating carrier and subtract the discount between the price of this class and the next cheaper class. In V25, the discount percentage is 25 %; in V50 it is 50 %. The scenarios are summarized in Table 1.

The seven demand clusters differ in the demand-to-capacity ratio and in the distribution of demand across the customer types, inducing differences in the overall willingness-to-pay. Clusters 1 to 5 correspond to five typical demand situations on intercontinental routes as observed in the Lufthansa network. In all five clusters, demand exceeds capacity (ratios between 1.2 and 1.6), but the customer mix varies from high value business to high volume leisure. Clusters 6 and 7 present the same customer mix as Cluster 3 with an alteration of +/−20 % total demand, resulting in relatively high (Cluster 6) and low (Cluster 7) demand-to-capacity ratios. The share of codeshare demand is 30 % across all scenarios and clusters except for the small carrier in AS2, for which the share increases to 40 %. An overview of the seven clusters is provided in **Table 2**. Note that the willingness-to-pay factor needs to be multiplied with the square root of the distance of a specific itinerary in order to obtain the average willingness-to-pay on that itinerary.

5 Computational Study: Quantifying the Alliance Effect

This section presents the results of the simulation study outlined in the previous section. Each scenario is executed over 100 runs; the final results are the average over all runs with 95 % confidence.

Table 3 Bookings and revenue without codesharing in scenario S

	Bookings	Revenue
Cluster 1	76.83 %	66.82 %
Cluster 2	80.49 %	66.32 %
Cluster 3	81.52 %	66.21 %
Cluster 4	90.34 %	68.24 %
Cluster 5	92.55 %	68.70 %
Cluster 6	92.18 %	69.06 %
Cluster 7	68.66 %	66.82 %

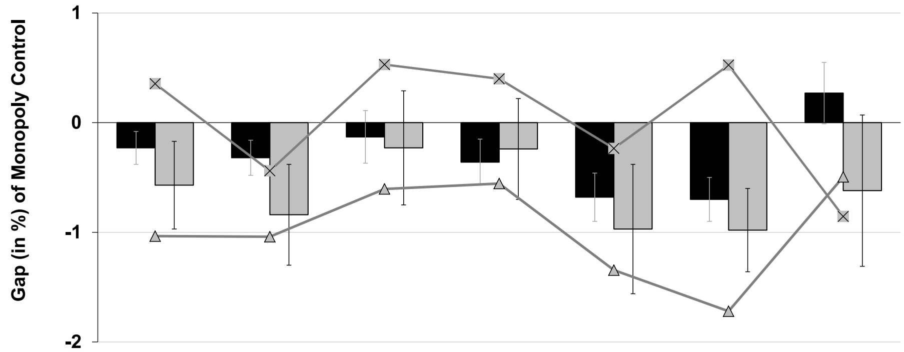
5.1 Market Extension through Complementing Codeshares

By means of codesharing complementary flights, carriers can access new markets and thus cater for 30 % of network-wide demand. **Table 3** depicts the aggregate revenue and bookings in Scenario S without the codeshare routes to show the market extension benefit. The results are stated as percentages of the monopoly outcome that a single airline is able to achieve across the entire network including codeshare demand.

Revenue in all clusters is about one third lower than the potential maximum, indicating that the carriers cannot compensate for revenue losses by local demand. In fact, they are losing even more revenue than demand, suggesting that codeshare demand is more valuable. In terms of bookings, we find that in Clusters 1 and 7 with low and very low demand-to-capacity ratios, the lost bookings correspond to the reduction in demand. In clusters with relatively high demand-to-capacity ratios, the majority of bookings can be compensated by local demand.

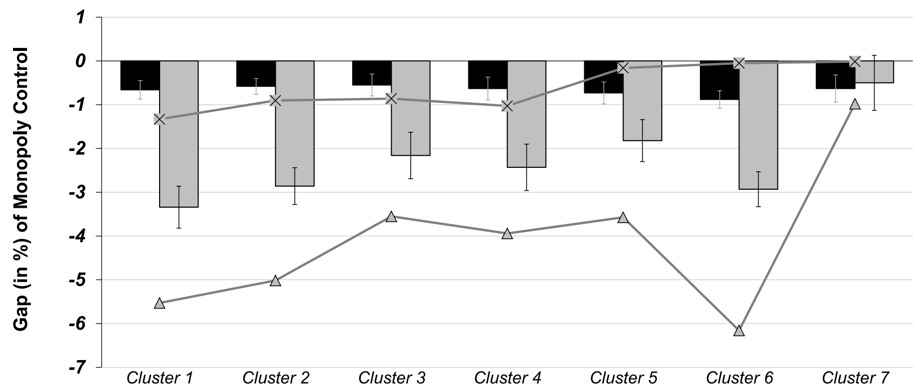
Symmetric Demand The impact of decentralized codeshare control with AVS under symmetric demand is shown in **Fig. 3**. As in the subsequent analyses, bookings and revenue are presented as bars illustrating the percentage change compared to monopolistic controls.

Bookings decrease slightly in four of seven clusters and significantly decrease by up to 0.7 % in the high demand Clusters 5 and 6. Only in Cluster 7 we see a small increase. Overall, codesharing has no strong impact on the resulting bookings.



	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
Bookings	-0.23	-0.32	-0.13	-0.36	-0.68	-0.7	0.27
Revenue	-0.57	-0.84	-0.23	-0.24	-0.97	-0.98	-0.62
Rev. Intraline	-1.04	-1.04	-0.61	-0.56	-1.35	-1.72	-0.50
Rev. Codeshare	0.36	-0.44	0.53	0.40	-0.24	0.53	-0.86

Fig. 3 Cost of complementary codesharing – scenario S



	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*Cluster 5*	*Cluster 6*	*Cluster 7*
Bookings	*-0.66*	*-0.58*	*-0.55*	*-0.63*	*-0.73*	*-0.88*	*-0.63*
Revenue	*-3.34*	*-2.86*	*-2.16*	*-2.43*	*-1.82*	*-2.93*	*-0.5*
Rev. Small C.	*-5.53*	*-5.02*	*-3.55*	*-3.94*	*-3.57*	*-6.16*	*-0.98*
Rev. Large C.	*-1.33*	*-0.90*	*-0.86*	*-1.03*	*-0.16*	*-0.05*	*-0.01*

Fig. 4 Cost of complementary codesharing – scenario AS1

With regard to revenue, we observe a drop across all clusters compared to the monopoly situation. The effect varies from −0.23 to −0.98 %, with the greatest losses occurring in clusters 5 and 6 (high demand-to-capacity ratios). This result can be attributed to the inefficiencies of AVS described in Sect. 3.2 as well as to effects of separate forecasting and optimization. Both aspects cause the availabilities to differ from the monopolistic optimum and thereby lead to sub-optimal control decisions.

As argued in Chap. 2, codesharing enables airlines to exploit new passenger streams. However, as capacity is restricted, displacement costs arise and new codeshare routes can harm the passenger flow on intraline itineraries. To analyze this, **Fig. 3** displays two lines presenting the revenue gap on codeshare and intraline itineraries respectively. We find that, except for Cluster 7, the impact on intraline itineraries is distinctly stronger. While the effect is ambiguous on codeshare itineraries – on average the performance is about the same as in the monopoly case – it is always negative on intraline itineraries. This can be explained by each airline forecasting and optimizing codeshare bookings on the local intraline itineraries. As a result, the intraline forecasts increase and revenue management controls become overly restrictive, leading to fewer bookings and less revenue.

Asymmetric Demand Since, so far, demand for both airlines was symmetric, both carriers had 50 % market share and the losses were distributed equally. In contrast, this section considers two scenarios with deviating demand situations. In AS1, the capacity of one carrier is reduced by 25 %, reducing overall capacity by 12.5 %, while demand remains constant. Thus, the carrier with the smaller capacity faces excess demand and its demand-to-capacity ratio increases to up to 2.4. The results compared to the monopoly situation with the same demand and capacity pattern are depicted in **Fig. 4**.

In AS2, we also reduce the local demand for the smaller carrier, leaving the codeshare demand unchanged. Consequently, the share of codeshare demand increases. The results are depicted in **Fig. 5**. Note that for both scenarios, we also display the change in individual carriers' revenue. To this end, results are compared to the monopoly results achieved exclusively from the flights assigned to this carrier. The revenue from multi-leg itineraries is prorated based on the relatively flown mileage.

First of all, we can note that in AS1 and AS2 the change in bookings is again rather small. Across both scenarios as well as all clusters, we find a consistent decrease of around −0.5 % in the total bookings (varying between −0.02 % to −0.88 %).

In terms of revenue, the effect is strictly negative, and with the exception of Cluster 7, the resulting losses are generally higher than in the symmetric case. This can be explained by the higher demand-to-capacity ratios: In line with our observation in S, the higher the demand-

Fig. 5 Cost of complementary codesharing – scenario AS2

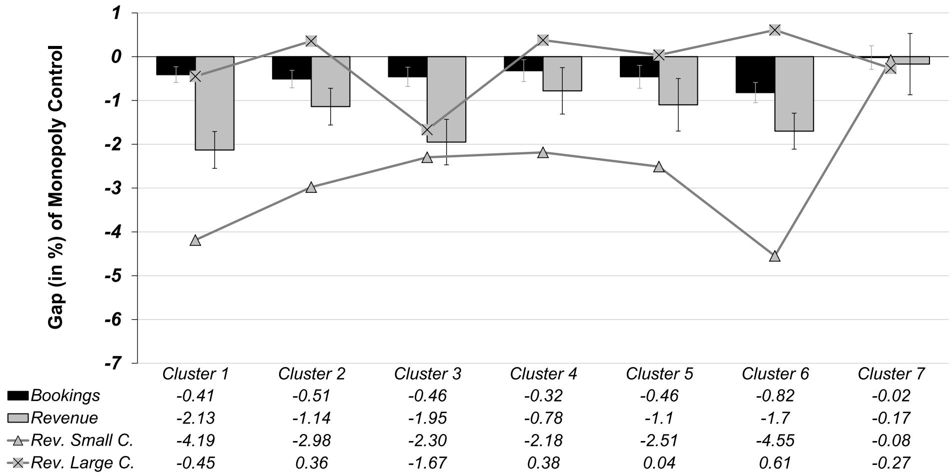
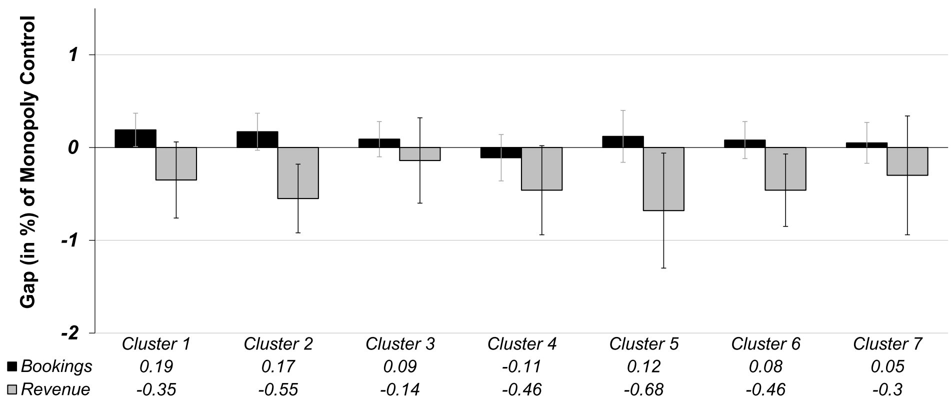


Fig. 6 Cost of virtual codesharing – scenario V25



to-capacity ratio, the higher the losses caused by inefficient codeshare revenue management. In AS1, the revenue gap amounts to −0.5 % to −3.34 %. In AS2, the revenue gap is smaller than in AS1, as the demand is lower. Yet it is still larger than in S, due to the incremental codeshare demand. It varies between −0.17 % and −2.13 %.

The performance of the individual carriers holds greater interest. As can be seen from the two lines for the small and the large carrier, the one with the reduced capacity consistently suffers higher revenue losses. In AS1, these amount to up to −6 %. In AS2, they approach −4.5 %. The performance of the carrier with regular capacity in AS1 is only slightly worse than in S, while in AS2, the losses are about the same, and sometimes even small gains occur.

In both cases, the highest losses occur in the clusters including many high value passengers. First, in AS1, there is generally more demand and therefore inefficient codeshare revenue management incurs a higher risk: Suboptimal codeshare control is more likely to displace high value passengers. Second, in AS2, while the overall demand is not much higher, the larger share of codeshare demand increases the impact of suboptimal acceptance decision taken by AVS. As critical decisions are more likely when codeshare demand is high, the probability to displace high value demand also increases.

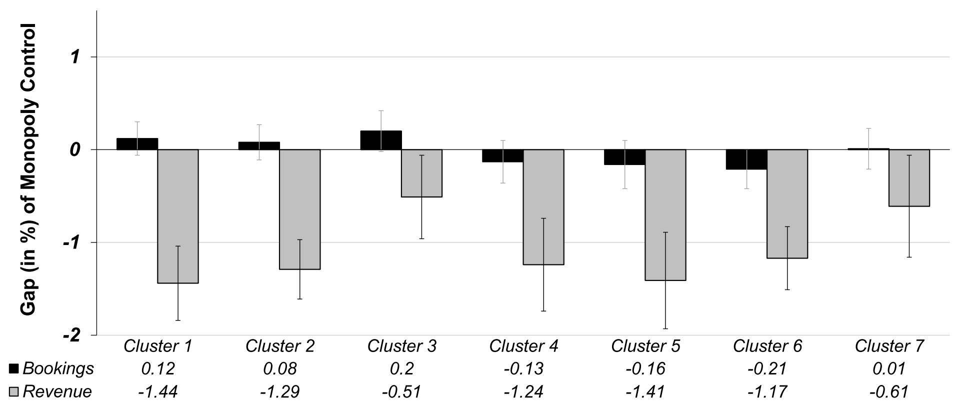
5.2 The Cost of Virtual Codeshares

This section analyzes how virtual codesharing affects the performance of the alliance. We introduce a virtual airline that does not operate flights and solely markets the other carrier's itineraries. The fares of the virtual airline undercut those offered by the operating carrier by 25 % of the difference to the next cheaper booking class in V25 and by 50 % in V50. In the monopoly scenario, a single carrier controls all classes, both the 11 original ones and the 11 discounted classes. The respective results are presented in **Figs.** 6 and 7.

We find that introducing an additional marketing carrier with lower fares slightly increases the number of bookings in most clusters, particularly in those with low and medium demand-to-capacity ratios. Once more, the change in bookings is relatively small compared to the effect on revenue: The latter is consistently negative across both scenarios and all seven clusters. Given the moderate discount of 25 %, the effect varies between −0.14 % and −0.68 %. With the higher discount, the effect becomes more pronounced and revenue declines by between −0.51 % and −1.44 %.

The losses can be explained by the monopoly airline jointly controlling the regular and the discounted booking classes. Thus it has full control over all offers, while in the codeshare case it cannot directly control the availability of the virtual codeshare classes. Instead, their availability is determined by the sum of the AVS availabilities on the respective flights. On the one hand, this tends to be more restrictive. On the other hand, virtual classes that become available underbid the regular offers and customers buy the lower fare, causing revenue losses.

Fig. 7 Cost of virtual codesharing – scenario V50



6 Concluding Remarks

The contribution of this paper is twofold. On the one hand, we cluster the benefits of airline alliances into three groups of marketing promises and examine the impact of codesharing on each step of the airline planning process. The former constitutes codeshare alliances as marketing tool. The latter serves as guideline to researchers as well as practitioners on how to implement codeshare alliances throughout the planning process.

On the other hand, we quantify the effect of decentralized booking control in three typical codeshare situations. Our model uses separate revenue management systems and assumes limited information exchange, as currently applied in the industry. We find significant losses due to suboptimal booking control. They are the result of the information asymmetry (moral hazard) among the alliance partners: Only the marketing carrier has full information about the request and makes the acceptance decision on behalf of the operating carrier. In addition, neither carrier can verify whether the partners act in their mutual best interest. The operating carrier cannot control the marketing carrier's decision, while the marketing carrier cannot observe the correctness of the availabilities provided by the operating carrier. In the economics literature, this situation is described by the principal-agent problem. As the revenue gap between the alliance and the monopoly turns out to be significant in our simulations, it is in the interest of all members to implement mechanisms that align the alliance decisions. In Sect. 6.1, we continue this discussion and derive four managerial implications from our findings.

6.1 Managerial Implications

First, we found that in the symmetric scenario, revenue losses are not limited to codeshare routes, but propagate through the whole network, also affecting intraline itineraries. In fact, our results clearly indicate that with the given revenue management setup, intraline itineraries bear the most severe losses. This can be attributed to skewed local forecasts and to suboptimal codeshare controls displacing more valuable local passengers. This observation supports the need for separate codeshare forecasting and optimization. Also, management needs to consider these effects when evaluating the performance of the alliance or that of individual routes.

Second, our results show that airlines with higher demand on intraline routes or a higher share of codeshare demand face an increased risk from suboptimal codeshare management. Given an increase of about one third, the respective carrier loses an additional 2 % to 3.5 % of its revenue. Hence, this carrier's management needs to be more restrictive when picking partners and routes for codesharing. Furthermore, as a carrier in this situation faces a higher risk, it may want to negotiate an incentive scheme guaranteeing a larger share of the resulting revenue.

Third, we observed that virtual codesharing with underbidding causes revenue losses of up to 1.5 % (depending on the discount level) when compared to the case of monopoly. This indicates that it is better for an airline to control all its offers singlehandedly. Consequently, partners and routes for virtual codesharing should be chosen with care; a regular evaluation of the marketing benefits from the additional sales channel in relation to the loss of control seems highly recommendable. In this context, aspects of trust and financial dependency are particularly important: Close partners or financially dependent carriers may have fewer incentives to underbid or harm their allies.

Last, we observe that across all scenarios, the volume of bookings is little affected by codesharing. Changes in revenue are explained by shifts in the distribution of bookings across booking classes. Furthermore, losses in revenue usually exceed the change in bookings, thereby reducing the yield and suggesting that primarily high value bookings are affected.

6.2 Summary and Outlook

In this paper, we analyzed the impact of airline codeshare alliances under two aspects: We contrasted the promises from a marketing perspective with the challenges arising for airline planning supported by information systems. Focusing on revenue management systems as the area in which the contrast between the two aspects is clearest, we quantified the effect of decentralized codeshare control using stochastic simulations. Finally, we highlighted four managerial recommendations for codeshare revenue management as taken from the simulation results.

The findings established in Sect. 5 are based on large-scale stochastic simulations and were validated across seven typical demand constellations. The scenarios cover several connecting flights, different traffic flows, and realistic price and product structures. Possible extensions could include a closed-loop revenue management model with adaptive forecasts, the integration of competition, and the comparison of alternative RM approaches. The first two points were neglected as we expected a distortion of the effects of codesharing: The performance of the alliance might be influenced by the quality of the forecast as well as by the decisions of the competitor. Nevertheless, both aspects and in particular the comparison of alternative RM systems provide opportunities for ongoing research. Possible variations may include protection levels for availability control as well as forecast and optimization algorithms assuming dependent demand or incorporating customer choice behavior.

We also note that our model is motivated by current industry practice. As mentioned in Sect. 3.3, recent research has introduced a number of theoretical advances. Implementing these features would most likely reduce the observed effects. However, the intention of this paper is to highlight the necessity to close the gap between the new, theoretical approaches and the application-driven implementations observed in practice.

Further research may extend our work in several ways. First of all, we have not considered parallel codeshares as a marketing tool and therefore have not included them in our investigation. A similar study could be conducted to determine the cost of suboptimal parallel codesharing.

The impact of codeshare alliances may be further studied in context of innovative pricing and revenue management approaches. For example, Post and Spann (2012, pp. 329–338) provide an analysis of variable opaque products on the airline market. Codesharing can be seen as a variant of opaque products, as the customer may not directly observe which alliance carrier operates the flight, and the service level may vary between consecutive flights.

In view of our results, alternative approaches to codeshare revenue management may attempt to minimize the effect on the individual partners and routes and could be evaluated based on the criteria in this article. Additionally, incentive schemes could base their allocation decisions on the market environment to compensate for the different risks that the partners face. Similar schemes may also be used to govern virtual codeshares and to avoid underbidding.

Finally, although we pointed out that pricing and revenue management pose the greatest challenges, other areas of planning and operations should not be neglected. Especially joint airport resource planning as well as joint operations control provide new opportunities for future research and should be systematically considered.

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Abstract

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Airline Codeshare Alliances

Marketing Boon and Revenue Management Information Systems Challenge

The paper juxtaposes the challenges that airline codeshare alliances create for analytical information systems on the one hand and their motivation from a marketing perspective on the other. The authors review the state-of-the-art literature on potential marketing benefits and analyze the impact on airline planning systems. In this regard, revenue management systems are of particular interest. Based on a simulation study, the authors infer a severe impact of decentralized codeshare controls as currently widely implemented in the industry on revenue management performance. In the scenarios examined, complementary codesharing reduces alliance-wide revenues by up to 1 %. Losses increase when a carrier experiences high local demand or a high degree of codeshare demand, and disseminate over the whole network. Virtual codeshares also cause losses of 0.3 % to 1.5 % depending on the discount level offered by the marketing carrier and on the demand structure. Finally, the authors formulate a set of managerial implications based on these findings.

Keywords: Revenue management, Information systems, Airline alliances, Codesharing, Simulation, Marketing

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