

# **Contract Form and Technology Adoption in a Network Industry<sup>1</sup>**

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## Abstract

This paper investigates the relationship between transaction characteristics and contractual form as well as the role of technology adoption as a driver of variation in transaction characteristics. Our setting is the U.S. airline industry, where many large airlines have outsourcing relationships with smaller regional carriers. In the late 1990s, fixed price contracts began to replace revenue sharing agreements as the dominant contractual form in these relationships. Moreover, this change coincided with the diffusion and adoption of a new aircraft technology, the regional jet. We present evidence that the new aircraft technology changed the set of flights that airlines subcontracted to their regional partners and did so in a way that favored the use of fixed price rather than revenue sharing contracts. In particular, our results are consistent with the hypothesis that the new flights being subcontracted had characteristics that would have led to significant haggling costs under route-level revenue sharing.

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## **1. Introduction**

Organizational economists have long been interested in understanding how firms choose between alternative types of contracts. There is a large theoretical literature that analyzes the tradeoffs associated with different contractual forms. In addition, there is now a growing empirical literature that seeks to test many of the relationships identified in the theoretical work. For example, Crocker and Reynolds (1993), Banerjee and Duflo (2000), Bajari and Tadelis (2001), Corts and Singh (2004) and Kalnins and Mayer (2004) investigate how firms choose between fixed price and cost plus contracts. Other papers, especially in the areas of franchising and sharecropping, analyze the choice between fixed price and revenue sharing contracts (see, for example, Lafontaine 1992, Lafontaine and Shaw 1999 and Brickley 2002 and Akerberg and Botticini 2002). Most of this literature takes transactions and their characteristics as given and looks for a systematic relationship between the observed contractual form and transaction characteristics that affect the relative returns to that type of contract. However, to date, there has been little attention devoted to understanding what drives the variation in transaction characteristics that explains observed differences in contractual form.

In this paper, we use a novel empirical setting to investigate both the relationship between transaction characteristics and contractual form as well as the underlying source of variation in transaction characteristics. Our setting is the U.S. domestic airline industry. All major U.S. network airlines subcontract portions of their network to smaller regional carriers. These regionals may either be owned by the major or be independent and governed by contracts. Beginning in the late 1990s, there is a change in the predominant form of contract used in this industry. Revenue sharing contracts – under which the major and regional share ticket revenue from passengers who travel on both carriers – start to be replaced with what are known as capacity purchase agreements. These are a form of fixed price contract under which the regional receives a fixed amount per flight while the

major retains all ticket revenue. Between 1996 and 2001, the percentage of flights by independent regionals which were governed by capacity purchase contracts increased from 15% to 67%.

While this variation in contractual form is, on its own, interesting, what is perhaps even more interesting is the fact that it coincided with the adoption and diffusion of a new aircraft technology, the regional jet (RJ). RJs diffused rapidly during the late 1990s and early 2000s, and quickly replaced turboprops (TPs) as the dominant type of plane flown by regional carriers. During this period, newly negotiated capacity purchase contracts disproportionately covered regionals that operated RJs. By 2001, all RJ flights operated by an independent regional were governed by a capacity purchase contract while about 50% of turboprop flights remained under revenue sharing.

We hypothesize that the availability of the RJ changed the types of flights that could feasibly be outsourced to regional carriers. While RJs have a similar capacity to turboprops, they can fly at faster speeds and for longer distances. They are also perceived to be more comfortable than most turboprops. Thus, RJs provided majors with access to planes with a unique combination of attributes that may have allowed them to outsource flights on routes which could not previously be served by turboprop planes. By doing so, the adoption of the RJ may have resulted in changes in the characteristics of the transactions being outsourced. If these changes in transaction characteristics affected the relative returns to capacity purchase contracts over revenue sharing agreements, this could lead to a change in the optimal contractual form and could explain the observed correlation between technology adoption and contractual form in this setting.<sup>2</sup>

We begin by analyzing the tradeoffs that airlines face when choosing between contract types. Revenue sharing contracts incentivize a regional to exert effort to increase demand, but expose it to risk. Capacity purchase contracts insulate the regional from demand and (most) cost risk but provide limited incentives. In addition to this standard incentives-insurance tradeoff (see, for example,

Holmström 1979 and Hart and Holmström 1987), a second tradeoff arises in our setting resulting from the fact that the regional's and the major's flights are integrated into a common network. Because there are externalities across flights, the standalone profitability of a regional's flight will differ from the contribution of that flight to the overall profitability of the major's network. If a regional is compensated with a portion of flight-level revenue, this can lead to haggling between the major and the regional over route selection and scheduling decisions. Capacity purchase contracts will reduce this haggling because they make a regional indifferent as to where and when it operates its capacity.

We then present a collection of evidence which, taken together, suggests that RJs were used in systematically different ways than TPs and, in particular, used on routes where the haggling resulting from revenue sharing contracts was likely to be significant. Our empirical analysis begins by examining how the technological characteristics of a route affected the probability that an RJ would be adopted on that route, using detailed data which allow us to measure RJ adoption at the flight-quarter level. The results indicate that routes served with RJs were, in fact, systematically different than the routes that regionals were serving with turboprops. Relative to turboprops, RJs were more likely to be used on longer routes, on routes that connected to the major's hub, and on routes that involved congested airports. We also find some evidence that RJs were more likely than turboprops to operate on routes with more endpoint competition, especially from low-cost carriers (LCCs).

We then investigate descriptively whether these new uses of RJs are consistent with capacity purchase contracts replacing revenue sharing as the preferred contractual form. To do this, we use a novel, hand-collected dataset on the type of contract that governed almost every partnership between a major U.S. carrier and an independent regional between 1996 and 2001. We identify characteristics that should affect the relative returns to one contractual form over another and examine differences in

these over time and across turboprop and RJ flights. Specifically, we construct several proxies for the existence and magnitude of externalities across flights which we expect would have led to haggling between the major and regional. We also look at whether or not RJs more often connected to an endpoint at which the major itself operated flights since we expect that this would have increased the major's ability to monitor the regional. We find large and statistically significant differences between turboprop and RJ flights on all of these dimensions. Overall, the patterns are quite consistent with the widespread adoption of RJs changing the characteristics of the transactions that were carried out by regionals in a way that favored the use of capacity purchase contracts to incentivize regionals to serve routes that might not have been desirable under revenue sharing.

It is worth emphasizing that – for several reasons - our empirical setting does not lend itself to the common approach of regressing contractual form decisions on transaction characteristics. First, in our setting, the choice of contractual form is made at the partnership level rather than the transaction level. This means that the optimal contractual form must reflect some aggregation of the characteristics of the transactions included in the partnership but, without knowing what this aggregation is, a transaction level regression would likely lead to biased estimates. Second, much of our variation in contractual form arises from changes in the type of contract governing an existing relationship. Since the costs to changing contractual form are fixed and occur at the partnership level but the haggling costs associated with revenue sharing contracts occur at the route level, the initial RJ flights operated by a regional which has an ongoing contract with a major could be governed by the existing revenue-sharing agreements. These flights would appear to be sub-optimally governed at the transaction level but not necessarily at the partnership level. Third, the standard transaction-level regression implicitly assumes that firms are first endowed with transactions and then choose the optimal way to govern those transactions, given the transaction characteristics. However, because

variation in transaction characteristics in our setting results from the diffusion of the RJ and because this diffusion process is not entirely smooth (due, for example, to production lags at the RJ manufacturers), we expect that changes in contractual form at the partnership level could either follow changes in transaction characteristics or anticipate them.<sup>3</sup>

This paper is closely related to the empirical literature that analyzes variation in contractual forms. We contribute to this literature in several ways. First, we emphasize a novel source of transaction costs that may arise when revenue sharing contracts are used to govern outsourcing relationships in network industries. The franchising literature, as well as Nickerson and Silverman (2003), point out that, if there are spillovers across units, revenue sharing contracts will provide suboptimal incentives for effort and company ownership may be the optimal organizational form. However, in our setting, the existence of externalities from the regional's flights to the rest of the major's network implies that flight-level revenue sharing contracts may not only provide suboptimal incentives for effort but they may not even satisfy the regional's participation constraint.<sup>4</sup> Furthermore, majors have found a contractual form that provides some of the benefits of ownership – specifically, eliminating haggling over route selection and other scheduling decisions – but without the costs associated with ownership of a regional. As we discuss in Forbes and Lederman (2009), institutional features of this industry create costs of owning regionals that result from the difficulty of managing two distinct labor forces in a single organization.

Second, we document the process that gives rise to variation in transaction characteristics which, in this setting, results from the introduction of a new technology. Given this, the paper also builds on the work in Baker and Hubbard (2003, 2004) which show that the adoption of on-board computers in the U.S. trucking industry changed the optimal form of governance by lowering monitoring and coordination costs. We demonstrate an alternate channel through which technology

adoption can influence organizational decisions – namely, by changing the types of transactions that can be outsourced.

Finally, our setting highlights the fact that many firms make organizational form decisions at the relationship level, using a single organizational form to govern “bundles” of transactions with potentially heterogeneous characteristics. Furthermore, if transaction characteristics change over time – as they do in our setting – and if there are fixed costs to changing contractual form at the relationship level, then changes in contractual form may not immediately coincide with changes in transaction characteristics. Both of these factors imply that some individual transactions may appear to be misaligned. Recognizing these issues is important to understanding organizational form decisions in our context and is likely relevant in many other settings.

In addition to the empirical contracting literature, this paper is also related to the broader literature on the economics of technology adoption (see Stoneman 2002) and specifically Brueckner and Pai (2009) which is the only paper we know of that explicitly studies the introduction of the RJ. The results in that paper indirectly show that RJs allowed majors to use their regionals for flights that they had not previously been serving with turboprops. However, the paper does not consider the interaction of the RJ with airlines’ organizational form decisions.

The remainder of the paper is organized as follows. The next section provides relevant institutional background. Section III discusses incentives and contracts. Section IV describes our empirical approach and Section V describes our data and variables. We present our results in Section VI and follow that with a brief conclusion.

## **2. Institutional Background**

### *A. Regional Airlines<sup>5</sup>*

Regional airlines operate as subcontractors for major U.S. network carriers on low density short and medium-haul routes. These are routes which are most efficiently served with small aircraft. Majors subcontract these routes to regional airlines because regionals have a cost advantage in operating small planes, resulting from the substantially lower compensation that regional airline employees receive, relative to the major's own employees.<sup>6</sup> In fact, major network carriers do not operate any small aircraft themselves. Thus, a major's decision whether to use a regional to serve a particular flight is effectively a decision about the type of plane to use for that flight.

Regionals generally operate for majors under "codeshare agreements". Under these agreements, the regional operates flights on behalf of the major carrier, who markets and tickets the flights under its own flight designator code. In addition to using the major's code, the regional's flights also share the major's brand. For example, Delta's regional Comair operates under the name Delta Connection. Tickets on Comair's flights are sold by Delta through the same channels that Delta sells its own tickets. Comair's Delta Connection flights utilize Delta's trademarks and logos. To facilitate passenger connections between a major and its regional, their schedules, as well as check-in and baggage handling, may be coordinated.

Over the past 10 to 15 years, regional airlines have come to play an increasingly large role in the U.S. commercial airline industry. In 2008, regional airlines carried about one in every four domestic passengers. According to data provided by the Regional Airline Association, the number of passengers enplaned by regional airlines more than doubled and the number of available seat miles on regional carriers more than tripled between 1999 and 2008. Much of this growth can be attributed to the adoption and diffusion of the RJ. RJs are appealing because they combine capacity levels previously only available on turboprop planes with the range and speed of larger jets.

## *B. Organizational Forms and Contracts*

Codeshare relationships between majors and regionals are governed in one of two ways. Regionals are either wholly owned by the major with whom they partner (in which case, they do not generally contract with competing majors) or they are independently owned and work under contract for one or more major carriers. While our previous work has analyzed differences between owned and independent regionals (see Forbes and Lederman, 2009), this paper focuses on regionals which operate under contracts and examines variation in the types of contract used to govern these regionals.

Historically, contracts between majors and regionals took the form of *revenue sharing agreements* under which the major and the regional shared the revenue from passengers whose itineraries involved travel on both airlines. Passengers' fares would be split between the two carriers, typically based on the distance traveled on each airline. The regional would receive 100% of the revenue of passengers that travelled on only its planes. Beginning in the late 1990s, majors and regionals have increasingly used what are known as *capacity purchase agreements*. Under these agreements, the major pays the regional a fixed amount to cover the regional's operating costs on a block-hour or flight-hour basis.<sup>7</sup> All scheduling, pricing, reservations and marketing are carried out by the major. Under a capacity purchase agreement, the major carrier is effectively purchasing (or renting) the use of the regional's aircraft and flight crews.

Capacity purchase agreements usually take one of two forms. *Cost-based contracts* explicitly compensate the regional for specific costs it incurs as well as provide it with a profit margin. Costs that are thought to be under the control of the regional (e.g. crew wages) are compensated at a fixed rate that is set ex ante. Costs that are thought to be outside the control of the regional's control (e.g. fuel and landing fees) are fully reimbursed by the major. Cost-based contracts also include a profit

component based on the operational performance of the regional. *Fee-for-departure contracts* compensate the regional a fixed amount per departure. The rate is set to cover all of the regional's costs and provide it with a profit margin.<sup>8</sup> These contracts will usually also include incentive payments based on operational performance, passenger volumes and/or customer service. Table 1 summarizes the main differences between revenue sharing and capacity purchase contracts.

< Table 1 approximately here >

### *C. Changes in Organizational Forms and Technology*

Table 2 illustrates the changes in organizational forms and technology used by regional airlines between 1996 and the first quarter of 2001. The table includes domestic flights operated by independent regional partners of Continental, Delta, Northwest, United and US Airways.<sup>9</sup> Over this 5-year period, the percentage of flights operated by RJs tripled from 7% on average for the year 1996 to 21.4% in the first quarter of 2001. The use of capacity purchase agreements increased from 15% to 67% of all flights. When we decompose the use of capacity purchase contracts by plane type, we see that these contracts were disproportionately used for RJs, especially towards the end of the sample. While only 18% of RJ flights were under capacity purchase in 1999, this number jumped to 69% in 2000 and 100% by the beginning of 2001. The use of capacity purchase contracts increased for turboprops, too, but to a lesser degree. At the beginning of 2001, 41% of turboprops remained under revenue-sharing.

< Table 2 approximately here >

The increase in the fraction of flights under capacity purchase contracts results from several sources of variation. In the contract data that we have collected, we observe two existing revenue sharing relationships that are renegotiated as capacity purchase agreements (both in 2001), two new capacity purchase agreements covering entirely new partnerships (in 1997 and 2001) and three new capacity purchase agreements, all involving US Airways, that cover the RJ flights of existing regional partners who had been (and continue to be) operating turboprops under revenue sharing (in 1998, 1999, and 2000).<sup>10</sup> We never observe a turboprop-only relationship that is governed by a capacity purchase agreement and even those turboprop relationships that are initiated or renegotiated during our sample period are done so under revenue sharing.

#### *D. Regional Jet Usage*

Table 3 shows the distribution of newly introduced RJs across new and existing routes between 1996 and the first quarter of 2001. Routes that already use RJs in the first quarter of our sample are excluded. We distinguish four different uses for RJs: (1) replacing or supplementing existing turboprop service; (2) replacing or supplementing existing jet service; (3) entry into new routes; and (4) replacing turboprops or jets on routes previously served with a combination of jets and turboprops. What is clear from this table is that the majority of RJs are *not* being introduced on routes that were already being served by regionals with turboprops. Only 40% of the RJs introduced between 1996 and the first quarter of 2001 are onto routes that the regional previously served either entirely with turboprops (21%) or with a mix of turboprops and jets (19%). Thus, RJs were deployed on a large number of routes that the major had previously not outsourced to the regional or that had not been served at all. This provides preliminary evidence that the introduction of RJs may have changed the set of transactions being subcontracted to regionals.

< Table 3 approximately here >

### **3. Incentives and Contracts**

In this section, we explain how the two contractual forms address two incentive problems that may exist in the relationship between majors and independent regionals. The first incentive problem is a standard moral hazard problem; the second one relates to haggling over route selection and scheduling.<sup>11</sup> Outsourcing arrangements can be thought of as principal-agent relationships in which the agent (here, the regional) will exert suboptimal effort unless the principal uses incentive contracts or monitoring to get the agent to (or close to) the optimal effort level.<sup>12</sup> The set of activities allocated to the regional will vary both across partnerships as well as across airports, even for a given partnership. The regional will always be responsible for activities related to the operation and maintenance of the aircraft including in-flight service and will usually also be responsible for activities related to the on-time departure and arrival of an aircraft, such as loading/unloading of baggage. Depending on the size of the major's own operations at the airport, the regional may also carry out other activities such as check-in and ticket sales.

While the operation and maintenance of the aircraft is tightly regulated by the Federal Aviation Administration (and, thus, will likely not require additional monitoring), there are several other dimensions of quality that will be influenced by the regional and that vary both in terms the ease of monitoring by the major and the extent to which they affect demand. First, the regional provides in-flight service on the planes that it operates and we expect that this would be difficult for the major to monitor. The decisions by most U.S. airlines in recent years to significantly reduce some components of in-flight service - such as food and drinks - compared to previous levels suggest that

these components have a relatively weak effect on demand (compared to factors such as scheduling, on-time performance and frequent flier affiliation). However, other components of in-flight service - such as the friendliness of airline personnel - may still have an important effect on demand. Second, the regional's effort will affect quality dimensions such as on-time performance and baggage handling which continue to be important determinants of demand; however, relative to effort on in-flight service, the regional's effort on on-time performance may be easier for the major to monitor (since the leading cause of delays outside an airline's control is weather which is observable). Consistent with this, we observe that capacity purchase contracts often include incentive payments based on metrics such as on-time performance, cancellations and lost baggage. Finally, for other tasks that regionals may perform at certain airports – check-in, ticketing and other customer service functions – effort is likely hard to measure and we expect that the major's ability to monitor effort on these types of tasks and, in turn, the need for incentives to be provided through revenue-sharing will depend on the major's own presence at the airport.<sup>13</sup>

In addition to the standard insurance-incentives tradeoff, in our setting there is a second tradeoff between the two contractual forms that arises from potential haggling between the major and regional over route selection and scheduling. Under a revenue-sharing contract, a regional will prefer to serve the flights with the greatest stand-alone profitability. However, because of the externalities across flights, the overall contribution of a flight to the profitability of the major's network – which is what the major bases its scheduling decision on – can differ significantly from the standalone profitability of the flight. For example, the fact that an airline offers a 2 pm flight on a given route may increase consumers' willingness-to-pay for the airline's 5 pm flight because it gives consumers the option of taking an earlier flight if their travel plans change unexpectedly (see, for example, Berry and Jia 2010) but, on a typical day, the 2 pm flight may be quite empty. This can lead to haggling if

regionals are compensated with a portion of flight-level revenue. In contrast, under a capacity purchase contract, a regional's payment does not depend on flight-level revenues and, in fact, the contract is structured to make the regional indifferent between where and when it operates its capacity.<sup>14</sup> This eliminates disagreement over scheduling decisions and, consistent with this, the capacity purchase contracts that we have been able to look at explicitly give the major complete control over the scheduling and inventory decisions for the regional.

In theory, if there are differences across routes and/or flights in expected on-time performance, then the incentive payments incorporated into capacity purchase contracts could still result in haggling between majors and regionals over route selection as regionals will prefer not to operate flights that are expected to have worse on-time performance. We suspect that such haggling would be minimal at best since expected differences in on-time performance across flights can be – and typically are – built into a flight's scheduled departure and arrival times. In fact, at least one of the capacity purchase contracts we had access to explicitly stated that the departure and arrival times set for the regional's flights would be based on a "reliability factor" that was at least as high as the "reliability factor" used for scheduling the major's own flights. Thus, from the regional's perspective, the expected on-time performance of all flights should be the same and the incentive provisions included in capacity purchase contracts should not result in any haggling over flights and routes.

Finally, we would like to point out that we never observe a mix of revenue sharing and capacity purchase contracts covering the same technology for the same outsourcing relationship. Using a combination of the two contract types would give the regional incentives to move costs from routes that are covered by revenue sharing contracts to routes that are covered by capacity purchase contracts and to try to increase revenues on revenue sharing routes, possibly at the expense of routes

under capacity purchase. We do see a few cases in which different types of contracts are used to cover different technologies in the same outsourcing relationship but, as we discuss in section VI.B below, these are cases where the partnership has little overlap between RJs and turboprops at the same airports.

It is interesting to note that in trade press articles as well as in the interviews that we conducted, industry participants acknowledge the tradeoffs we discuss above. In describing the renegotiation of United Airlines and Atlantic Coast Airlines' revenue sharing contract as capacity purchase, Moorman (2000) highlights the greater control that these contracts provide to the major, stating that "the new pay scheme assures a better revenue stream for ACA and will mitigate earnings volatility due to external factors such as fuel prices and passenger yields. In exchange, United assumes complete control of seat inventory, fares, scheduling and selection of destinations. Possible plans to enhance ACA's small hub operation at Chicago's O'Hare International Airport will be made solely by United, if at all."

One industry participant we interviewed touched on precisely the haggling issue described above, explaining that the major is interested in optimizing its overall network and wants to avoid complaints from the regional about the routes it is serving. This individual also stated that elements of the network would be sub-optimized in the interests of the overall network. Interestingly, none of the trade press sources we collected, nor any of the interviewees, identified the loss of incentives provided by revenue sharing as a salient issue. This may be because the incentive clauses based on observable metrics like on-time performance that are included in capacity purchase contracts are effective or because competition between independent regionals and the ease of switching regionals act to discipline regionals. Finally, some of our interviewees believed that the change in contractual

form coincided with the adoption of the RJ because RJ routes were more similar to the major's routes than to routes served by turboprops.

#### **4. Empirical Approach**

As mentioned in the Introduction, there are two components to our empirical analysis. First, we investigate whether RJs did, in fact, change the transactions being subcontracted to regionals. Then, we investigate whether the change in transaction characteristics affected the relative returns to capacity purchase contracts. Since our data contain a large number of transactions (i.e., flights) but these transactions are carried out by a small number of firms who negotiate contracts at the partnership – rather than transaction - level, our analysis of RJ usage can be done with detailed regression analysis while our analysis of contractual form is done in a descriptive way.

We begin by estimating the effects of route-level characteristics on RJ adoption, focusing on what we call *technological characteristics*, such as distance and measures of route density, which are dependent on aircraft features such as range and size. We believe that these technological characteristics are the primary determinants of the choice to introduce an RJ on a given route. In our main specifications, we estimate multinomial logit models of the choice among the three different plane types: turboprops, RJs and jets. We also estimate hazard models of the RJ adoption decision for two subsamples: routes that had only turboprop service and routes that had only jet service at the beginning of our sample, respectively.

After demonstrating in these regressions that the introduction of the RJ expanded regional service into a new and different set of routes, we analyze whether it also changed what we call the *incentive characteristics* of routes served by independent regionals. Building on the discussion in Section III, we identify flight and route characteristics that proxy for the two tradeoffs that majors

face when choosing between revenue sharing and capacity purchase contracts, the moral hazard problem and the haggling over route selection and scheduling. We then explore descriptively whether the expansion of regional service due to the technological characteristics of the RJ resulted in regionals carrying out transactions whose incentive characteristics are consistent with capacity purchase agreements replacing revenue sharing as the optimal contractual form. Specifically, we compare the incentive characteristics of RJ and turboprop flights both at the beginning and end of our sample.

## **5. Data and Variables**

Our analysis combines several sources of data. Our first data source is the Official Airlines Guide (OAG), from which we have obtained the complete flight schedule for all domestic airlines for a typical week within each quarter. Each observation in this data set corresponds to a particular flight by an airline on a day and includes information on the ticketing and operating carriers, the origin and destination airports, the scheduled departure and arrival times, and the aircraft type. These data allow us to identify - for each flight - whether it was operated by a regional and, if so, which regional. They also allow us to identify the exact type of aircraft used for the flight which we can then categorize as a turboprop, RJ or mainline jet. We also use the OAG data to construct various flight and route level characteristics.

For each year in our sample, we have assembled data on whether or not each of a major's regional partners is owned by that major and for regionals that are not owned, whether they operated under a revenue sharing or capacity purchase agreement. The data on ownership were obtained from the Regional Airline Association. There is no systematic source of data on contractual form for independent regionals and so we hand-collected these data using sources such as industry trade

presses, annual reports of the majors and of publicly traded regionals, various types of SEC filings, and press releases. The resulting data cover over 80% of the partnerships with independent regionals that we observe and 97% of the flights operated by these partnerships. For new relationships or new contracts, we generally have the month and year that these contracts came into effect. Where possible, we checked for consistency across different sources and also checked for consistency with what we observed in the OAG data.<sup>15</sup>

Since our objective is to understand the change in contractual form governing relationships between majors and independent regionals, all of our empirical analysis focuses on regionals that are not owned by a major airline. To create the sample used for our technology adoption regressions, we start with all flights within the continental U.S. operated by Continental, Delta, Northwest, United and US Airways or by any of their independently owned regional partners on a typical weekday.<sup>16</sup> We then drop routes with distances of more than 1300 miles because these are outside the range of RJs (as we observe it for our sample) and would thus automatically have to be served by jets. We also impose a minimum distance of 25 miles. Finally, we drop flights to and from LaGuardia Airport in New York City because changes in the takeoff and landing restrictions at this airport in 2000 and 2001 favored the use of regional planes for regulatory, rather than technological, reasons (see Forbes 2008 for more detail).

Table 4 provides descriptive statistics for the sample used in our regression analysis. The first three rows show the distribution of flights across the three technology types. 35% of all flights in our sample are operated by turboprops, 6% are by RJs, and the remaining flights are by jets. The remainder of the rows contain the variables that we use to explain airlines' choice of aircraft type at the flight level. We construct a measure of the distance of a route in miles and expect that longer routes are more likely to be served by RJs than turboprops but even more likely to be served by jets.

The mean distance in our sample is 418 miles. To proxy for route density, which should influence the optimal choice of plane size, we use U.S. Census data at the MSA-level to construct the population of each endpoint. In our sample, the mean population of the larger and smaller endpoints is 6.6 million and 2.2 million, respectively. To capture routes on which there is a taste for high frequency, we define “shuttle routes” as routes with 15 or more departures by the airline in the same direction per day. We define “tourist routes” as routes with at least one endpoint for which the ratio of MSA-level hotel revenues to manufacturing sales is 0.04 or greater.<sup>17</sup> Because the speed, comfort and frequency benefits of RJs are likely to be less highly valued by tourist travelers than business travelers, we expect that tourist routes will have a lower probability of being served by RJs.<sup>18</sup> We define “hub routes” as routes which have at least one endpoint that is the carrier’s own hub. Although there was initially much speculation that RJs would be used to bypass hubs and provide more point-to-point service, consistent with Brueckner and Pai (2009), our results show that hub routes have a higher probability of being served by RJs than non-hub routes.

< Table 4 approximately here >

The decision to substitute RJs for smaller turboprops or larger jets is likely to be influenced by the degree of congestion at the endpoint airports of a flight. In order to define a measure of airport congestion, we compute the number of daily departures (in hundreds) divided by the number of parallel runways at each endpoint and take the maximum of that across the two endpoints. We use the maximum because we believe that, all else equal, the more congested endpoint is more likely to influence how an airline trades off aircraft size and flight frequency. We expect that routes that

involve a more congested airport favor the use of aircraft with larger seat capacity (i.e. jets over RJs and turboprops but also RJs relative to turboprops).

Finally, we construct measures of competition from low-cost carriers. Because regionals provide majors with access to substantially lower labor costs, majors may have used RJs to compete with low-cost carriers. We construct a dummy variable that equals one if a route has direct competition from a low-cost carrier.<sup>19</sup> For routes that connect a spoke to a hub, competition at the smaller endpoint (to other hubs) may be more relevant than competition on the route and so we also construct a measure of whether there is LCC competition at the smaller endpoint of a route. During our sample, 26% of all routes have competition from a low-cost carrier on the route and 64% have a low-cost carrier that serves the smaller endpoint. We also control for the total number of competitors on the route and the total number of competitors serving the smaller endpoint.

## **6. Results**

### *A. Technology Regressions*

Table 5 shows multinomial logit estimates of the factors affecting an airline's choice to operate a given flight with a jet, RJ, or turboprop. We define turboprops as the base category. The coefficients are presented as relative risk ratios, or odds ratios, and standard errors are clustered at the airline level. Specifications (1) through (3) include flights on all routes, while specification (4) includes only flights on routes that are newly entered by a carrier during our sample and is restricted to the first quarter of entry to the new route. We begin in specification (1) with our pure technology measures and then in specifications (2) and (3) add measures of route-level competition and endpoint-level competition, respectively. All specifications we report are robust to including carrier fixed

effects. We do not include carrier fixed effects in the reported specifications because we believe that some of the interesting variation comes across carriers.

< Table 5 approximately here >

The coefficients on the year dummies capture the diffusion process of RJs. They indicate that, relative to turboprops and jets, the likelihood of observing flights operated by RJs increases over time. The coefficients on the distance variable indicate that both jets and RJs are more likely to serve longer routes than turboprops with the effect being larger for jets. The odds ratios of 2.5 and 2.09, respectively, mean that, as a flight's distance increases by 100 miles, it becomes 2.5 times more likely to be served with a jet and 2.09 times more likely to be served with an RJ, relative to a turboprop. Increasing the population of the larger endpoint lowers the likelihood of observing both jets and RJs relative to turboprops. This - perhaps counterintuitive - effect is driven by the fact that, during this time period, turboprops were frequently used to serve shuttle routes, including many routes to and from New York City and Los Angeles, the two metropolitan areas with the largest populations. Increasing the population of the smaller endpoint increases the likelihood of observing jets. In other words, jets are more likely to serve routes with more potential traffic between the endpoints than RJs and turboprops are.

We find weak evidence that shuttle routes are less likely to be served with RJs than with either jets or turboprops indicating that RJs were not commonly used to serve these types of very high frequency routes. We find no significant difference in the likelihood of using either RJ's or jets compared to turboprops on tourist routes. Whether or not a route connects to a hub has a very large effect on the type of aircraft chosen. The estimates in specification (1) imply that jets are 5.1 times

more likely to serve hub routes than turboprops are, and RJs are 4.5 times more likely than turboprops to serve hub routes. As expected, jets and RJs are also more likely to serve flights that involve a more congested endpoint airport, as measured by the number of daily departures per runway.

Overall, these results show that jets serve the longest and densest routes, while RJs serve long thin routes. Furthermore, most jet and RJ flights go to and from hubs.<sup>20</sup> Turboprops serve two types of routes: short and thin routes and shuttle routes that are too short or not dense enough to be economical for jet service.

The second specification in Table 5 adds controls for route-level competition. We find that jets are most likely to serve routes with competition from low-cost carriers, followed by RJs. The effects are quite large with odds ratios of 3.9 and 2.4, respectively; however, the effect is not statistically significant for RJs in this sample. In results that are not included in the table, we have estimated this specification using only observations from the years 2000 and 2001. We do this because we suspect that, early in our sample, limited availability of RJs or contractual restrictions from their mainline pilots may have constrained airlines' ability to introduce RJs on all of the routes that they would like. If so, this would introduce noise into our estimates since we would observe routes whose characteristics would suggest they are well suited for RJs and yet not observe RJs on these routes. However, towards the end of our sample, airlines should be less constrained in their deployment of RJs. When we look only at 2000 and 2001, we find qualitatively similar results for the latter period with a statistically significant effect of competition from low-cost carriers on the likelihood of using an RJ.<sup>21</sup> Note that since competition on the route may be endogenous, we interpret these coefficients as being consistent with majors using RJs to compete with low-cost carriers but do not rule out the presence of unobservables that could lead both RJs and LCCs to serve the same types of routes. However, as we will discuss below, regardless of the direction of the

causality, the presence of low-cost carriers on routes served by RJs may affect the incentives of regionals to operate these flights if they are compensated with revenue sharing. The overall number of competitors on the same route has no significant effect on the choice of plane type. The effects of the other control variables are as in specification (1).

In specification (3), we show the effects of alternate measures of route competition. We find that jets, followed by RJs, are more likely to serve routes which have more competitors serving the smaller endpoint. In addition, RJs are more likely than either jets or turboprops to serve routes on which the smaller endpoint has any low-cost carrier service. While these measures of competition have the benefit of being less endogenous than realized competition, they have the drawback of potentially being correlated with route density. This is also likely the reason why some of the effects of the endpoint population variables are smaller in this specification, compared to specification (1).

Having established the basic relationships between route characteristics and aircraft type, we now attempt to provide a more nuanced sense of these relationships by exploring different subsamples of our data. We do this because the characteristics that affect the likelihood of RJ adoption could depend on the way in which the RJ is being used. We begin by looking at flights on routes that are newly entered by a carrier during our sample.<sup>22</sup> We estimate the multinomial logit model from specification (2) on a sample that includes only newly entered routes and only in the first quarter of entry. The results are presented in the final column of Table 5. We find that, for new routes, the effects of route distance are even larger than in the full sample, with odds ratios of 7.5 and 5.4 for jets and RJs, respectively. Most of the other control variables have very noisy coefficients, suggesting that these route characteristics have a less systematic effect on the choice of plane type for new routes than they had in the full sample. This may be because airlines often experiment with new routes without being certain whether demand is sufficient to justify sustained service. However, we

do find that congestion reduces the odds that jets are used for service on a new route. Since new routes are very rarely shuttle routes, we exclude the shuttle variable from this specification.

We also create two subsamples based on the type of aircraft that the major had used to serve a route prior to introducing RJs. The first subsample includes routes that were served exclusively with turboprops in 1996 and the second subsample includes routes that were served exclusively with jets in 1996. Since our interest here is the adoption of an RJ on the route, we estimate route-level hazard models. We assume a Weibull distribution and present the resulting hazard ratios in Table 6. As before, the standard errors are clustered at the carrier level. Our results here are consistent with our earlier findings and highlight interesting differences between the two subsamples. Among the routes which were initially served only by turboprops, distance, the presence of a hub endpoint and endpoint congestion increases the hazard of adopting RJs. In contrast, among the routes which were initially served only by jets, the hazard of adopting RJs decreases with the number of competitors and with LCC competition. On routes initially served by jets, distance has no significant effect on RJ adoption, but recall that we are limiting our sample to routes of less than 1300 miles (i.e. routes that are short enough for RJ service). Overall, these results suggest that RJs served the purpose of flying on routes with “intermediate” characteristics, between those typical of turboprop routes and of jet routes.

< Table 6 approximately here >

### *B. Resulting Changes in Transaction Characteristics*

In Section III, we identified two tradeoffs that majors face when choosing between a revenue sharing and capacity purchase contract. While revenue sharing contracts provide a regional with

incentives to exert effort to increase demand on its flights, they may lead to haggling over route selection by tightly linking the regional's incentive to serve a flight to the standalone revenue of that flight. In contrast, capacity purchase contracts provide a fixed payment to the regional, thus eliminating the incentive to haggle, but also providing no incentive to exert effort to increase revenues. Having analyzed the technological characteristics that drive RJ adoption, we now investigate whether these technology adoption decisions resulted in regionals carrying out transactions whose characteristics favored capacity purchase contracts over revenue sharing.

To do so, we identify variables (some of which were included in our earlier regressions) that proxy for either the ease of monitoring or the likelihood that, as a result of externalities elsewhere in the major's network, the regional and major will disagree over the relative desirability of a flight. In Table 7, we investigate whether turboprop and RJ flights operated by independent regionals differ on these characteristics. We compare four sets of flights: turboprop flights in the first and last quarter of our sample and RJ flights in the first and last quarter. Interestingly, we observe substantial differences in these characteristics across turboprop and RJ flights but, within aircraft type, the characteristics are remarkably stable over time even as the proportion of RJ flights increases over time (from 6.4% of all regional flights in the first quarter of 1996 to 21.4% of all regional flights in the first quarter of 2001).

< Table 7 approximately here >

The first variable we construct is a dummy that equals one for routes on which the major has no flights of its own at the smaller endpoint. We expect that when there is no overlap of the major and regional at the smaller airport, monitoring is more difficult for the major and, all else equal,

revenue sharing is more attractive. In addition, at airports at which the major has no flights of its own, the regional will likely be responsible for a greater set of activities and have more interaction with passengers and so its effort may have a larger impact on the major's profits. This may also increase the relative benefits of revenue sharing contracts. We observe that, both at the beginning and end of our sample, turboprops are significantly more likely than RJs to operate on a route on which the major has no presence at the smaller endpoint. At the end of our sample, 68% of turboprop flights connected to at least one endpoint with no flights by the major while only 40% of RJ flights did.

We use several variables to proxy for the extent to which a major and regional may haggle over the desirability of a particular flight. We construct a measure of whether a major and regional operate flights on the same route and call this "mixed service". If there are spillovers across flights on the route and, in particular, if the flights operated by the regional have low standalone revenue (for example, if they are at off-peak times of the day and mostly for the purpose of driving demand for the peak time flights), then these flights will not be very desirable to a regional compensated with revenue sharing. We observe a large and statistically significant difference in the share of flights on mixed routes between turboprops and RJs in 1996 as well as 2001. In both time periods, RJ flights are three times more likely than turboprop flights to operate on routes that the major also serves itself.

We also look at whether a regional flight connects to a major's hub. For these flights, the difference between the contribution to the profitability of the major's network and the standalone profitability may be large for two reasons. First, if many of the passengers on the regional connect to flights operated by the major, the major will be able to operate larger planes on the spokes that it serves itself, thus lowering its average cost on these flights (see Brueckner, Dyer and Spiller 1992, Brueckner and Spiller 1994, and Berry, Carnall and Spiller, 2006). However, this will of course not

be reflected in the profit that the regional earns from these passengers. Second, as has been well documented by Borenstein (1989) and Borenstein (1991), airlines benefit in several ways from dominating a particular airport. For example, airlines may be able to influence the allocation of scarce airport facilities, they can exploit economies of scale in things like advertising and airline frequent-flier programs create links between the size of an airline's network an airport and consumers' willingness-to-pay for tickets on any given flight in that network (see Lederman, 2007, for empirical evidence on this). If so, then hub carriers will have an incentive to offer or maintain service on spoke routes even if those routes are not, on their own, particularly profitable. Since this effect may be more pronounced at hubs at which there are two dominant carriers, we also look at whether or not a hub route involves an airport that serves as a hub to two majors. Consistent with what we would expect, we observe that RJs serve hub routes significantly more often than turboprops do. The table also indicates that RJs are significantly more likely than turboprops to serve shared hubs where a major's incentive to maintain unattractive spokes may be greatest.

Finally, all else equal, routes with more competition, especially from low-cost carriers, may be unattractive to regionals compensated under revenue sharing because they provide lower and potentially more variable revenue. However, they may still be attractive to the major if they connect to an important hub, if these routes carry passengers who connect onto high yield routes (for example, long-haul international flights) or if the major, for strategic reasons, does not want to cede the route to a competitor. Therefore, we look at the presence of low-cost carrier competition on the route and, for hub routes, the number of competitors serving the spoke endpoint. The data in Table 7 show that RJs are significantly more likely than turboprops to serve routes that face direct competition from at least one low-cost carrier and also more likely to serve hub routes with more competitors at the spoke endpoint. Overall, the patterns in Table 7 suggest that RJs serve routes which would involve

substantial haggling between the major and regional if revenue sharing contracts were used to govern these transactions. Furthermore, the table also indicates that the greater overlap between majors and regionals (both on a route and at the endpoint airports) might facilitate monitoring for RJ flights.

It is interesting to note that this descriptive analysis indicates the early RJ flights – which as Table 2 indicates were governed by the existing revenue sharing contract that the major and regional had in place – had incentive characteristics that were similar to the later RJ flights. This observation is consistent with majors trading off the route level haggling costs associated with revenue sharing contracts with the fixed costs of changing contractual form at the partnership level. Majors are likely to have switched to capacity purchase contracts when RJs became important enough that the total costs of haggling over route allocation exceeded the costs of switching to the new contractual form.<sup>23</sup> On the other hand, as mentioned earlier, newly negotiated RJ partnerships – where the fixed cost of changing contractual form would not have to be borne – were always governed by capacity purchase contracts.

We conclude this section with a short discussion of turboprop relationships. As Table 2 indicates, turboprop flights also became increasingly likely to be governed by capacity purchase contracts though not to the same degree as RJs. If, as we have hypothesized, the switch to capacity purchase contracts results from regionals using RJs to expand into new routes, this begs the question of why we observe turboprop flights under the new contractual form. A possible explanation for this is that, in all three of the turboprop relationships that were governed by capacity purchase at the end of our sample (Delta and SkyWest, United and SkyWest and United and ACA), the regionals operated both turboprops and RJs for the major and often at the same airport. Specifically, 56% of the turboprop flights operated in these three relationships in the first quarter of 2001 departed from or arrived at an airport at which the regional also operated RJs for the major. Also, 14% of the

turboprop flights were on routes on which the regional also operated RJs for the major. Having a regional's turboprop flights operate under revenue sharing while its RJ flights at the same airport or on the same route operate under capacity purchase could create numerous incentive problems. For example, the regional would clearly have an incentive to substitute effort towards increasing demand on the revenue sharing flights at the expense of effort on the capacity purchase flights.

In contrast, regionals that fly only turboprops are never governed by capacity purchase during our sample. US Airways has regionals that fly both turboprops and RJs on its behalf and, unlike the partnerships above, governs its turboprop flights with revenue sharing and its RJ flights with capacity purchase. However, there is much less overlap between its turboprop and its RJ flights. In particular, for US Airways' regionals that operate both turboprops and RJs, only 28% of their turboprop flights depart from or arrive at airports at which the regional also operates RJs and they never overlap on the same route.

### *C. Alternative Explanations*

We discuss two possible alternative explanations for the correlation between the adoption of RJs and the switch to capacity purchase contracts. In both explanations, it is the technology itself – as opposed to the way in which the technology is used – which could change the optimal contractual form. First, a correlation between RJ adoption and capacity purchase contracts could arise if RJs themselves improve a major's ability to monitor its regional. While neither the trade presses nor any of our interviewees identified a relationship between plane type and monitoring, one could imagine several channels through which RJs might better allow a major to observe its regional's effort on certain types of tasks. First, by virtue of being newer, RJs might have a lower risk of mechanical problems. Second, because RJs fly at higher altitudes than turboprops, they are less likely to be

affected by certain types of bad weather. Both of these factors could reduce the amount of noise in the relationship between a regional's effort on on-time performance and its realized on-time performance. On the other hand, it is hard to imagine any channel through which RJs would affect the monitoring of effort on in-flight service or customer service-related activities at an airport. To the extent that RJs do improve monitoring, they could lead majors and regionals to use capacity purchase contracts since incentive provision through revenue sharing would be less important. We view this possible explanation as complementary to the one that we have investigated.

The second alternative explanation relates to financial considerations. The adoption of RJs required regionals to acquire new and more expensive aircraft. In order to take on the debt associated with the new aircraft, regionals may have wanted a less variable revenue stream, and capacity purchase contracts provide this. Alternatively, the new contracts may have been preferred by the lessors of the aircraft. While we cannot rule out this explanation, we note that airplanes are highly mobile and airplane financing risk tends to be relatively insensitive to revenue risk because the collateral is highly valuable.<sup>24</sup>

## **7. Conclusion**

This paper is motivated by two empirical facts. First, there has been a change in the predominant form of contract used to govern airlines' outsourcing relationships with their regional partners. Second, this change is highly correlated with the adoption and diffusion of the RJ. We have hypothesized that the adoption of the new aircraft type changed the ways in which majors could use their regional partners and, in turn, changed the characteristics of the transactions being subcontracted to regionals in a way that favored the new contractual form. Our empirical analysis has provided several pieces of evidence that support this hypothesis. First, we have shown that, at the flight level,

RJ adoption is driven by characteristics that influence whether the flight is well suited for the technological features of an RJ, such as its range and size. The results of our regression analysis suggest that RJs act as a hybrid between turboprops and jets. Relative to turboprops, the routes served by RJs are longer, more likely to connect to a hub and involve airports at which landing slots are in higher demand. Relative to jets, the routes served by RJs are thinner but otherwise quite similar. Overall, these results indicate that RJs did result in majors subcontracting new types of routes to their regional partners and indeed the raw data indicate that more than half of the RJs adopted during our sample period were placed on routes that were not previously being served by a regional. The second part of our empirical analysis explored whether these new uses of regionals are consistent with capacity purchase replacing revenue sharing as the optimal contractual form. Our descriptive analysis suggests that they are. Specifically, the data indicate that, compared to turboprop flights, RJ flights are more likely to involve externalities elsewhere in the major's network and, because of their greater overlap with the major's flights, RJ flights may be easier to monitor.

While some of the analysis in the paper is descriptive in nature, we believe that this paper has three important contributions. First, building on our earlier work on this industry, we again highlight transaction costs that can arise when firms operating in a network industry attempt to outsource a portion of their network. In our previous work, we focus on incentive problems that can arise when contracts are incomplete and majors and regionals haggle over real-time adaptation decisions. Here, we emphasize that the existence of externalities across flights in the major's network can lead to differences between the standalone profitability of a flight and the overall contribution of that flight to the profitability of the major's network. When revenue sharing arrangements are used, this can lead to haggling between majors and regionals over route selection and scheduling as the major seeks to optimize its overall network while the regional is concerned only with the set of flights that it

operates. In our setting, firms use fixed fee contracts in order to eliminate the incentive for this type of haggling while avoiding the costs associated with common ownership.

Second, other than Baker and Hubbard's work on the trucking industry, we believe that we are one of the only other papers to document and analyze a clear relationship between technology adoption and organizational form decisions. While Baker and Hubbard find that the new technology changes the contracting environment but not the types of transactions being contracted out, we find that the new technology changes the set of transactions that can be outsourced which was previously constrained by the limits of the existing technology. We believe we are one of the only papers to document the underlying process that gives rise to heterogeneity in transaction characteristics.

Finally, our setting highlights the fact that many firms make organizational form decisions at the relationship level, using a single organizational form to govern bundles of transactions with potentially heterogeneous characteristics. Furthermore, if transaction characteristics change over time – as they do in our setting – and if there are fixed costs to changing contractual form at the relationship level, then changes in contractual form may not immediately coincide with changes in transaction characteristics. Both of these factors imply that some individual transactions may appear to be misaligned. Better understanding these issues and how they relate to the transaction level analysis that is typically used in this literature would appear to be another important avenue for future research.

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**Table 1**  
**Comparison of Revenue Sharing and Capacity Purchase Contracts**

	<b>Revenue Sharing</b>	<b>Capacity Purchase</b>
Major's Revenues	Pro-rated portion (by distance) of ticket revenue from connecting passengers	All passenger and cargo revenue
Regional's Revenues	Pro-rated portion of ticket revenue from connecting passengers  100% of revenue from local passengers	Fixed payment per flight  Some incentive compensation based on metrics like cancellations and on-time performance
Regional's Costs	Regional pays	"Controllable Costs" (e.g. labor) reimbursed based on estimates  "Non-controllable Costs" (e.g. fuel, landing fees) directly reimbursed
Regional's Profits	Difference between Revenue and Costs	Target profit margin set by contract  Residual claimant on controllable costs  Some incentive pay
Schedules and Inventory	Coordinated between major and regional	Set by major

**Table 2**  
**Organizational Forms and Technology**  
**Independent Regionals, 1996-2001 (Q1)**

	1996	1997	1998	1999	2000	2001 (Q1)
Percent Flights by RJs	7%	10%	15%	23%	21%	21%
Percent Flights under Capacity Purchase	15%	19%	29%	35%	52%	67%
Percent RJ Flights under Capacity Purchase	0%	3%	11%	18%	69%	100%
Percent TP Flights under Capacity Purchase	17%	21%	33%	41%	48%	59%
Number of Flights	5,805	5,588	5,684	5,301	3,464	4,561

RJ: Regional Jet; TP: Turboprop. Data is based on regional flights by independent regional partners of Continental, Delta, Northwest, United and US Airways on a typical weekday. The construction of the sample is described in Section V.

**Table 3**  
**RJ Usage in Quarter of Introduction**  
**1996-2001 (Q1)**

Number of RJ Introductions	750
<i>Purpose of RJ Introduction (%):</i>	
TP Replacement or Supplement	21
Jet Replacement or Supplement	35
New Route	23
Mixed	19
Other	2
<i>Survival (%)</i>	
Serving Route Four Quarters Later	69

“TP Replacement or Supplement” includes RJ introductions to routes that were served exclusively by TPs before and served either exclusively by RJs or by a combination of RJs and TPs afterwards. “Jet Replacement or Supplement” includes RJ introductions to routes that were served exclusively by jets before and either exclusively served by RJs or by a combination of jets and RJs afterwards. “New Route” refers to routes that were not previously served (within our sample) by the major with any kind of aircraft. “Mixed” refers to RJ introductions to routes that were served by a combination of jets and TPs before RJs are introduced. “Other” includes RJ introductions that do not fit into any of the above categories.

**Table 4**  
**Summary Statistics - Regression Sample**

	<b>Mean</b>	<b>St Dev</b>	<b>Min</b>	<b>Max</b>
Turboprop	0.35	0.48	0	1
Regional Jet	0.06	0.24	0	1
Jet	0.60	0.49	0	1
Distance (in hundreds)	4.18	2.93	0.29	12.95
Population at Larger Endpoint (in millions)	6.64	5.53	0.07	21.20
Population at Smaller Endpoint (in millions)	2.16	2.62	0.07	21.20
Shuttle Route	0.11	0.31	0	1
Tourist Route	0.19	0.39	0	1
Hub	0.78	0.41	0	1
Congestion	2.37	1.14	0.07	5.63
Number of Competitors Serving Route	0.73	1.07	0	8
Number of Competitors Serving Smaller Endpoint	6.72	3.31	0	15
Low-cost Carrier Serves Route	0.26	0.44	0	1
Low-cost Carrier Serves Smaller Endpoint	0.64	0.48	0	1
Year=1997	0.20	0.40	0	1
Year=1998	0.20	0.40	0	1
Year=1999	0.19	0.39	0	1
Year=2000	0.16	0.37	0	1
Year=2001	0.04	0.20	0	1

See definition of regression sample on p.17. The number of observations is 266,017.

**Table 5**  
**Flight Characteristics and Choice of Aircraft Type**  
**Multinomial Logit Models (Relative Risk Ratios; Base Category: Turboprop Flights)**

	All routes		All routes		All routes		New Routes	
	Jets	RJs	Jets	RJs	Jets	RJs	Jets	RJs
	(1)		(2)		(3)		(4)	
Year=1997	1.00 (0.08)	1.34* (0.18)	0.95 (0.09)	1.30+ (0.20)	0.99 (0.08)	1.33* (0.18)		
Year=1998	0.87 (0.16)	2.03** (0.36)	0.79 (0.15)	1.92** (0.39)	0.84 (0.17)	1.96** (0.37)	2.02 (2.80)	128.53+ (329.49)
Year=1999	0.95 (0.22)	3.23** (0.62)	0.87 (0.22)	3.08** (0.68)	0.92 (0.23)	3.19** (0.59)	1.13 (1.52)	52.51+ (121.81)
Year=2000	1.34 (0.54)	3.05* (1.45)	1.25 (0.54)	2.95* (1.34)	1.35 (0.54)	3.12* (1.40)	3.82 (4.38)	87.33+ (229.51)
Year=2001	1.02 (0.42)	3.12* (1.66)	0.95 (0.42)	2.98* (1.52)	1.07 (0.45)	3.36* (1.72)	0.02** (0.01)	4.56 (12.76)
Distance	2.50** (0.22)	2.09** (0.21)	2.37** (0.14)	1.99** (0.18)	2.25** (0.17)	1.96** (0.17)	7.53** (1.80)	5.41** (1.42)
Log(Pop at Larger Endpoint)	0.59* (0.12)	0.45* (0.16)	0.56* (0.15)	0.45* (0.15)	0.51** (0.12)	0.41* (0.16)	0.70 (0.44)	0.49* (0.14)
Log(Pop at Smaller Endpoint)	1.58** (0.07)	0.99 (0.14)	1.49** (0.10)	0.98 (0.12)	1.07 (0.07)	0.85+ (0.08)	1.77 (0.83)	0.98 (0.09)
Shuttle Route	1.34 (0.43)	0.43 (0.24)	1.05 (0.40)	0.42 (0.25)	0.72 (0.23)	0.30* (0.17)		
Tourist Route	1.71 (0.76)	0.73 (0.44)	1.24 (0.50)	0.58 (0.34)	1.15 (0.42)	0.60 (0.31)	1.71 (2.63)	0.69 (0.92)
Hub Route	5.08** (1.45)	4.51** (0.47)	5.91** (1.69)	4.55** (0.59)	7.42** (1.84)	6.08** (0.61)	1.08 (0.58)	1.84 (1.10)
Congestion	1.50** (0.14)	1.52* (0.29)	1.44** (0.17)	1.48* (0.28)	1.42** (0.14)	1.44** (0.20)	0.36** (0.09)	1.12 (0.38)
Number of Competitors Serving Route			0.98 (0.08)	0.89 (0.33)			1.43+ (0.27)	0.66 (0.35)
LCC Serves Route			3.85** (1.63)	2.38 (1.43)			4.10 (3.53)	0.82 (0.78)
Number of Competitors Serving Smaller Endpoint					1.41** (0.03)	1.17** (0.06)		
LCC Serves Smaller Endpoint					1.19 (0.27)	1.41+ (0.27)		
Observations	266,017		266,017		266,017		1,760	
Pseudo R2	0.3561		0.3710		0.4138		0.7061	

Standard errors are clustered by carrier and appear in parentheses. \*\* p<0.01, \* p<0.05, + p<0.1

**Table 6**  
**Route-Level RJ Adoption, by Technology Used at the Beginning of the Sample**  
**Hazard Models**

	Initially Served by TPs	Initially Served by Jets
	(1)	(2)
Distance	1.75** (0.27)	1.01 (0.09)
Log(Pop at Larger Endpoint)	0.87 (0.30)	1.35 (0.39)
Log(Pop at Smaller Endpoint)	0.99 (0.12)	0.96 (0.26)
Tourist Route	0.93 (0.66)	0.48 (0.46)
Hub Route	4.95** (1.81)	0.52 (0.58)
Congestion	1.21** (0.08)	1.00 (0.15)
Number of Competitors Serving Route	1.03 (0.21)	0.48* (0.16)
LCC Serves Route	1.03 (0.80)	0.35* (0.14)
Observations	12,238	27,752
Log pseudo likelihood	-244.75	-169.19

Table presents hazard ratios. Standard errors are clustered by carrier and appear in parentheses. \*\* p<0.01, \* p<0.05, + p<0.1

**Table 7**  
**Changes in Characteristics of Transactions Subcontracted to Independent Regionals**

	(1) TP Flights 1996 q1	(2) RJ Flights 1996 q1	(3) TP Flights 2001 q1	(4) RJ Flights 2001 q1	Difference between (1) and (2) statistically significant	Difference between (3) and (4) statistically significant
Major Has No Presence at Smaller Endpoint	0.50 (0.50)	0.44 (0.50)	0.68 (0.46)	0.40 (0.49)	yes	yes
Mixed Route	0.13 (0.33)	0.36 (0.48)	0.10 (0.30)	0.30 (0.46)	yes	yes
Hub Route	0.51 (0.50)	0.87 (0.33)	0.66 (0.47)	0.85 (0.35)	yes	yes
Fraction that Involve a Shared Hub (Hub Routes Only)	0.09 (0.29)	0.15 (0.35)	0.06 (0.25)	0.21 (0.41)	yes	yes
Number of Competitors Serving Spoke (Hub Routes Only)	3.97 (2.73)	5.26 (3.06)	3.18 (3.16)	5.73 (2.75)	yes	yes
LCC Competition on Route	0.07 (0.25)	0.18 (0.39)	0.06 (0.25)	0.21 (0.41)	yes	yes
Number of Observations	5,471	374	3,584	977		

Table reports variable means. Standard deviations are in parentheses. Significance tests are at 5% level.

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<sup>2</sup> Alternatively, changes in contracting could have led to the introduction of the new technology. We discuss this and another alternative explanation for the correlation between RJs and capacity purchase contracts at the end of Section VI.

<sup>3</sup> All three of these issues also prevent us from doing an analysis that would estimate the timing of contract changes as a function of system-wide route characteristics.

<sup>4</sup> This does not necessarily mean that the major is asking its regional to serve a route with negative profits (though we do not rule this out). Rather, it means that the major is asking the regional to serve a route that generates a lower payoff for the regional than it would receive if it moved its assets to their next best use. Because assets are so easily redeployed in this industry, it is natural for a regional to compare its payoff to the payoff it would earn from alternate flights it could be operating.

<sup>5</sup> See Forbes and Lederman (2007, 2009) for more on the role of regional airlines.

<sup>6</sup> Forbes and Lederman (2009, 2010) provide more detail on the source and magnitude of these labor costs differences.

<sup>7</sup> Block time is calculated as the time between the start of the engines at the departure airport and the shut off of the engines at the arrival airport. Flight time is calculated as the time between takeoff and landing. Thus, block time includes taxi-out and taxi-in time.

<sup>8</sup> Fee-for-departure contracts may be either annual or long term. Based on our reading of the trade press and annual reports, it is our understanding that long term contracts may be adjusted annually to account for changes in operating costs.

<sup>9</sup> American Airlines has only wholly-owned regional partners during this period. We exclude the seventh-largest carrier, TWA, from our analysis because it was acquired by American during the sample period. The entries for each year are based on a typical weekday schedule for these regional airlines in that year.

<sup>10</sup> We also observe three acquisitions of independent regionals that had previously been operating under revenue sharing contracts.

<sup>11</sup> There is a third incentive problem – arising from the need for real-time schedule disruptions – which is the focus of Forbes and Lederman (2009, 2010). We do not focus on this incentive issue here because, as we explain in those pieces, we do not believe that either contractual form can replicate the incentives provided by ownership of a regional.

<sup>12</sup> One could also think of this situation as a two-sided moral hazard problem because (i) some connecting passengers fly both on the regional's and the major's planes, and (ii) the major's effort on things like advertising as well as its quality on its own flights can affect consumers' willingness to pay even on the regional's direct flights. Unfortunately, our

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data contain no information that would allow us to learn about the nature of the two-sided moral hazard problem. Battacharya and Lafontaine (1995) consider optimal contracts in the presence of two-sided moral hazard.

<sup>13</sup> It is worth noting that while revenue sharing contracts provide the regionals with greater incentives to exert effort to increase demand than capacity purchase contracts, these incentives are suboptimal. This is not only because the regional only captures a portion of the revenue generated by the (connecting) passengers it carries but also because the regional, like a franchisee, will not internalize the impact that its effort has on demand elsewhere in the major's network.

<sup>14</sup> In theory, an alternative way to reduce this haggling would be to offset a regional's low revenue routes with high revenue routes and thus satisfy the regional's participation constraint at the partnership rather than route level. The fact that we observe majors use capacity purchase contracts which explicitly offer the regional a guaranteed payment per route suggests that the route is the relevant level for the participation constraint or that aggregating expected revenue across more and less attractive routes was not sufficient to resolve the haggling problem.

<sup>15</sup> We encountered one difficulty in matching the ownership and contract data to the OAG data. For reasons unknown to us, in the first three years of our data, the OAG gives all of US Airways' regionals the same code ("USE" for US Airways Express). Therefore, we are unable to distinguish the multiple regionals that operate under the US Airways Express name and match them to their ownership/contract information.

<sup>16</sup> We keep Monday flights. More than 99% of these flights also operate on Tuesday through Friday.

<sup>17</sup> These endpoints are primarily located in Florida, Nevada and coastal California.

<sup>18</sup> We attempted to construct a measure of routes that involve significant business travel. However, most of the endpoint airports that are associated with business travel are also hubs. This prevented us from identifying a business travel effect separately from the hub effect.

<sup>19</sup> Our group of low-cost carriers includes Southwest Airlines, JetBlue Airways, Frontier Airlines, Midwest Express, AirTran Airways, American Trans Air, Vanguard Airlines, Sun Country Airlines, Spirit Airlines, and ValuJet Airlines. We define low-cost carrier competition at the city level, including service to and from secondary airports in the same city.

<sup>20</sup> This is also what we see in the raw data: 90% of jet and RJ flights have hub endpoints, compared to 57% for turboprop flights. Routes that do not connect to a hub are rare and those that exist are disproportionately served by turboprops.

<sup>21</sup> The results are available from the authors upon request.

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<sup>22</sup> Our group of low-cost carriers includes Southwest Airlines, JetBlue Airways, Frontier Airlines, Midwest Express, AirTran Airways, American Trans Air, Vanguard Airlines, Sun Country Airlines, Spirit Airlines, and ValuJet Airlines. We define low-cost carrier competition at the city level, including service to and from secondary airports in the same city.

<sup>23</sup> The exact timing of the contract change was likely influenced by when individual existing contracts expired or were up for renewal.

<sup>24</sup> We thank an anonymous referee for suggesting this point.