Essays in Industrial Organization

by

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Dissertation submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in the Department of Economics
in the Graduate School of Duke University
2015
ABSTRACT

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Abstract

This dissertation extends the economics literature in industrial organization with three empirical essays on the strategic decisions of firms in imperfectly competitive markets. Using data from the U.S. airline industry, I combine reduced-form analysis with recent econometric advances in the estimation of dynamic games to examine the market-level and industry-level behavior of oligopolistic firms. The first essay presents a framework for sensitivity analysis in merger simulation. The second essay continues the market-level analysis of merger effects by examining how airline mergers influence price dispersion. The third essay shifts focus to industry-level investment behavior, examining the role played by bankruptcy policy in disciplining capital investment.
This dissertation is dedicated to my wife, Stephanie, for her support, her encouragement, and her smile.
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Empirical economic analysis of the airline industry is extensive, and for good reason. Air travel is economically critical, detailed data is plentiful, and industry profitability has been, until quite recently, uniquely terrible. Moreover, air travel in the U.S. has historically been dominated by a handful of large carriers. This feature is even more pronounced at the market level, that is, when considering the set of firms that compete on a given point-to-point (e.g. Chicago to Boston) market. As such, firms’ decisions, both at the market and industry levels, are very likely to be influenced by the expected actions of their opponents. The airline industry therefore provides fertile ground for asking and answering interesting and informative questions about the strategic decisions of firms in imperfectly competitive settings. Combining reduced-form analysis with recent econometric advances in the estimation of dynamic games, this dissertation extends the empirical economics literature in industrial organization.

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1 It’s no secret that U.S. airlines have been, on the whole, poor investments since industry deregulation in the late 1970s. A brief scan of recent literature corroborates the claim, with titles such as “Tracing the Woes” (Berry and Jia, 2010) and “Why Can’t U.S. Airlines Make Money?” (Borenstein, 2011). Even Warren Buffet, in his fiscal year 2007 Letter to Shareholders, explained, “The worst sort of investment is one that grows rapidly, requires significant capital to engender the growth, and then earns little to no money. Think airlines.” The letter is available online here: http://www.berkshirehathaway.com/letters/2007ltr.pdf
(I.O.) by addressing three such questions.

Chapter 2 asks how price effects predicted by merger simulation, a common numerical tool for understanding the potential implications of a merger, depend on particular assumptions about marginal costs. I present a framework for analyzing the sensitivity of these simulations to merger-related changes in the marginal costs of overlapping products. Chapter 3 continues the market-level analysis of merger effects by examining how airline mergers influence price dispersion. Joint work with Jimmy Roberts and Andrew Sweeting, this chapter presents evidence that mergers can have very different effects on the dispersion of airline ticket prices depending on the nature of the merging carriers. In Chapter 4, my analytical focus shifts from the market-level to the industry-level as I ask whether stricter bankruptcy laws can discipline capital investment, which in the context of airlines corresponds to growth in fleet size. First, I develop a theoretical model suggesting that higher Chapter 11 restructuring costs can rein in investment. Second, I employ a difference-in-differences analysis to show that a 2005 change to bankruptcy law is likely associated with restrained investment behavior in the U.S. airline industry. Finally, I estimate a structural model of investment and bankruptcy and simulate alternative policies to better understand how the treatment of long-term contracts in Chapter 11 influences firms’ investment behavior.

In the remainder of this chapter, I first provide some background on the U.S. commercial passenger airline industry. I then preview the content of each of my subsequent chapters.

1.1 The U.S. Airline Industry

The early development and regulatory history of the industry have played important roles in shaping the way airlines compete today, influencing market power, network structure, aircraft adoption, and other features of the competitive landscape. To
better understand the nature of competition among airlines, and to help explain the importance of some of the variables I will use in later chapters, I now present an overview of passenger air travel. Much of what follows regarding the history of the industry is largely due to Borenstein and Rose (2013).

Following World War I, military interest in a healthy aviation sector spurred subsidies for fledgling airlines. Early industry fragmentation sparked government concern over destructive competition, prompting indirect regulation aimed at promoting a network of large national carriers. The U.S. Post Office, by selectively awarding airmail contracts, was in fact the primary seat of indirect control. Direct regulation of the airline industry, including prices, entry, and merger decisions, began in 1938 with the creation of the Civil Aeronautics Board (CAB), which would eventually become the Federal Aviation Administration (FAA). The realized goal of the CAB was to develop and insulate a system of large national (“trunk” or “legacy”) carriers and to regulate entry by smaller airlines offering local service. In pursuit of that goal, prices were set comfortably above marginal cost. Regulated airlines did not enjoy the associated profits, however. Since price competition was restricted, airlines tended to compete on various dimensions of quality, including flight frequency and in-flight service. Moreover, airlines were frequently prohibited from charging lower fares for older planes, speeding industry-wide adoption of new aircraft. Both factors reduced capacity utilization (herein measured by load factor, the number of purchased seats divided by the number of available seats) and increased average cost per seat-mile. In short, airlines competed marginal costs up to the level of prices, dissipating the profits targeted by the CAB.

By the early 1970s, the CAB had developed a sufficiently negative reputation, and public dissatisfaction with regulation in general had grown sufficiently potent, that the U.S. Senate Judiciary Committee began hearings on airline deregulation. Further supported by Senate leaders, economists, and the leadership of the CAB
itself, the eventual result was the Airline Deregulation Act of 1978. The Act eliminated price and entry regulation and provided for the eventual closure of the CAB (by 1985), although the FAA continues to regulate operational and safety functions. The Essential Air Service program, which subsidizes and oversees service to small communities, also still exists.

Following deregulation, commercial air travel experienced a wave of entry into the industry by new carriers and expansion by existing regional airlines for several years until the recession of the early 1980s, which prompted a spate of bankruptcies and mergers. Market-level entry flourished as well, reducing concentration and competing down fares, especially on longer distance markets that could be served by many carriers offering a variety of connections. Reiss and Spiller (1989) estimate a static model of entry and fare competition on direct and indirect routes and find that competition from indirect routes can dramatically affect fare determination and entry on direct routes. Entry was shown to be even easier for airlines that already had a foothold at a given airport. Berry (1992) uses a static entry model to show that market share at the origin airport is a strong determinant of entry into other destination markets out of that airport. Along similar lines, Berry (1990) demonstrates the importance of an airline’s presence at the endpoint cities on both the demand and supply side.

As detailed in Borenstein (1992), deregulation also led to widespread adoption of hub-and-spoke operating networks, which allowed carriers to better utilize capacity and increase non-stop flight frequency to and from hub airports. The proportion of connecting service has consequently outpaced the growth in overall traffic. The prevalence of the hub-and-spoke system has prompted an abundance of research on its implications for competition. Borenstein (1989) and Borenstein (1991), among others, shows that carriers with dominant airport-level market shares tend to have increased market power on routes out of those airports, and higher market-level
shares are associated with higher markups. More recent work by Borenstein (2011) indicates that the price premium due to strong airport presence has declined in recent years. On the cost side, Brueckner et al. (1992) study the impact on airfares of economies of density in hub-and-spoke networks, while Mayer and Sinai (2003) study the effect of hubbing on air traffic congestion. Berry et al. (2006) find evidence of economies of density only on longer routes. They also shed further light on the demand side by estimating a model with customer heterogeneity, determining a hub carrier’s markup ability to be largely tied to price-inelastic business travelers. Another prominent outcome of deregulation was the substantial increase in load factors, which hovered around 55% at the height of regulatory oversight. Initially prodded upwards by cost competition, they continued steadily higher, fueled by advances in computerized ticketing and Internet sales, until reaching nearly 80% for some carriers in the mid-late 2000s. Dana and Orlov (2014) examine Internet penetration as a determinant of airline capacity utilization, hypothesizing that the availability of online information about price and product alternatives reduces friction in the market for air travel.

1.2 Dissertation Preview

1.2.1 Merger Simulation

Simulation based on economic models has become an increasingly important tool for antitrust authorities in predicting the price effects of a proposed merger. However, assessing the accuracy of this method has received relatively little attention. Although several studies have compared simulated to actual outcomes, few have examined the sensitivity of their predictions to underlying assumptions. In this chapter, I offer a straightforward approach for analyzing how merger predictions respond to various assumptions about marginal cost. I demonstrate my approach using price and quantity data for a merger between two large airlines, Delta and Northwest.
I find that the simulated price impact of the merger is relatively robust, owing to a narrow range of implied marginal costs for overlapping routes. The simulations tend to overestimate the price impact of the merger overall, predicting average price changes in the range of 5.1% to 6.1%, versus an actual change of 4.9%.

1.2.2 Price Dispersion in Mergers

A joint project with James Roberts and Andrew Sweeting, this chapter analyzes the price distribution effects of airline mergers. When evaluating a proposed merger, a primary concern for antitrust authorities is the potential for anticompetitive price outcomes, typically manifested in higher overall prices for consumers. In markets for differentiated products, however, the overall level of prices may not be the only concern. Changes in output, product variety, and price discrimination could all influence the effect of a merger on industry competitiveness. Using data on five mergers in the airline industry, we identify consistent changes in the distribution of fares, finding that prices rise more at the top of the fare distribution than at the bottom when the merger is between two legacy carriers, while the opposite effect is observed for the recent merger between Southwest and AirTran. We consider several explanations for this pattern.

1.2.3 Investment and Bankruptcy

This chapter asks whether stricter bankruptcy laws can discipline capital investment and is the first to analyze the link between reorganization and investment in a dynamic oligopoly setting. Models of capital investment in I.O. typically treat bankruptcy as an involuntary and final outcome, yet firms that file under Chapter 11 of the U.S. Bankruptcy Code often do so voluntarily and with the expectation that they will eventually emerge. One appeal of Chapter 11 from the firm’s perspective is its scope for canceling burdensome long-term contracts for labor and capital,
suggesting a non-financial influence of bankruptcy law on investment behavior. Understanding how this provision influences capital investment outside of bankruptcy has immediate implications for insolvency policy.

To study this link, I first develop a dynamic, game-theoretic model in continuous time that incorporates choices over investment and bankruptcy. I show that strengthening creditors’ bargaining power in bankruptcy proceedings can discipline capital investment behavior outside of bankruptcy, curbing investment in periods of high demand and spurring the sale of capital when demand is low. I test the implications of the model using over 30 years of daily aircraft-level data on the U.S. passenger airline industry and exploiting exogenous variation in creditor bargaining power due to the Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA) of 2005. I find evidence that the reform, which strengthened creditors’ bargaining power in Chapter 11, may have contributed to the widely acknowledged “capacity discipline” observed in the market since 2006.

Next, I simulate several alternative bankruptcy policies to better understand how the treatment of contracts in bankruptcy affects long-term investment and industry dynamics. Relative to current levels, I find that aggregate industry capacity would have been 5% higher in the absence of BAPCPA, while a complete revocation of Chapter 11’s non-financial provisions would have led to a 20% reduction in capacity.
2
Merger Simulation

2.1 Introduction

In an effort to protect consumer welfare, many nations have adopted policies that monitor or prohibit mergers and acquisitions that have the potential to substantially reduce competition. For example, the antitrust legislation in the United States relating particularly to mergers is Section 7 of the Clayton Antitrust Act of 1914, while the European Community’s merger activity is governed under Council Regulation (EC) No. 139/2004. In assessing the potential impacts of a proposed merger, antitrust enforcement agencies typically attempt to predict how the combination will change the level and balance of market power. To this end, simulation based on economic models has become an increasingly important tool. In the most recent version of their Horizontal Merger Guidelines, issued August 2010, the U.S. Department of Justice (DOJ) and the Federal Trade Commission (FTC) explicitly refer to the use of merger simulation methods as a means of quantifying the price effects of a proposed merger.\footnote{Horizontal Merger Guidelines, Section 6.1, available online here: \url{http://www.justice.gov/atr/public/guidelines/hmg-2010.html}}

Regarding its application, “The Agencies do not treat merger
simulation evidence as conclusive in itself, and they place more weight on whether their merger simulations consistently predict substantial price increases than on the precise prediction of any single simulation.” Budzinski and Ruhmer (2010) provide a helpful overview of merger simulation models, including discussions of some of the most important U.S. and European antitrust cases in which such methods have been employed.

Given the usefulness and growing application of merger simulation techniques, both in the academic and policy realms, a natural question arises as to how well simulations perform. While many authors have applied merger simulation methods to actual and hypothetical mergers in differentiated products markets, the literature assessing simulation performance is far more sparse. Nevo (2000) applies simulation techniques to the market for ready-to-eat cereal, examining three hypothetical mergers and two actual mergers, for which he provides an informal analysis of the comparison between actual and simulated results. Nevo also simulates outcomes assuming reductions in marginal cost that offset the price and welfare effects of the merger. The purpose of that analysis, however, is not to examine how simulations perform under a set of reasonable alternative assumptions, but to show the potential unreasonableness of the changes in marginal cost required to leave prices or welfare unchanged. Ivaldi and Verboven (2005) simulate the proposed (and rejected) European automotive merger between Volvo and Scania, and in the same volume, Hausman and Leonard (2005) test and reject the underlying assumptions of the former authors. In doing so, they provide several helpful robustness checks for merger simulation models. The most notable contribution is Peters (2006), which examines

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2 For example, Werden and Froeb (1994) apply merger simulation to a Bertrand model with differentiated products in order to predict the price and welfare implications of hypothetical mergers between existing carriers in the U.S. long-distance telephone service market. Hausman and Leonard (1997) provide a useful discussion of the DOJ’s merger analysis policies at the time and apply simulation methods to the Kimberly-Clark acquisition of Scott Paper Company. Pinkse and Slade (2004) look at the UK brewing industry.
the accuracy of merger simulation by directly comparing the predicted and actual prices resulting from five airline mergers that occurred in close succession during the 1980s. Peters uses counterfactual simulations, along with observed post-merger data, to break the predicted overall change in prices into its component effects. In particular, he separately evaluates the impact of a change in ownership (representing the baseline predictions), a change in product characteristics or market entry/exit, and a change in unobservable product quality. He attributes the remaining difference between actual and predicted price changes to unobservable supply-side effects, which under the Nash price-setting equilibrium assumption, amount simply to changes in marginal cost.\footnote{Since the effect of unobservable supply-side changes is just a residual term, it more generally includes changes to or misspecifications in firm conduct. In accounting for the difference between predicted and actual price outcomes, Peters considers deviations from the assumed model of firm conduct to be a more likely explanation than marginal cost changes.} While Peters does not simulate each merger under alternative cost assumptions, he does find that supply-side changes account for the majority of the difference between observed and predicted price effects, pointing to the important role played by marginal cost assumptions. Weinberg (2011) adds to this vein of the literature by comparing simulated and actual data from Proctor and Gamble’s 1997 acquisition of Tambrands. Finally, the study most relevant to my own is Brown and Gayle (2009), which looks at the Delta-Northwest merger prior to the integration of the two firms, and with particular emphasis on the role played by codeshares. The authors find that codeshare products have higher predicted prices, but they do not compare simulated and actual outcomes.

My goal in this chapter is to inform antitrust policy and add to the study of merger simulation by 1) examining the sensitivity of simulated post-merger prices with respect to reasonable alternative assumptions about post-merger marginal costs, and 2) extending the line of research comparing actual and simulated merger outcomes. The merger of interest is Delta’s 2008 acquisition of Northwest Airlines, which cre-
ated the largest U.S. passenger air carrier at the time. Employing ticket-level price and passenger data, I estimate a nested logit model of demand for air travel during the pre-merger period and use the demand estimates to simulate post-merger prices. I compare the predictions of my merger simulation model with actual post-merger prices and those that obtain under alternative marginal cost assumptions. Given the similarity in Delta’s and Northwest’s marginal costs for overlapping routes, the range of realistic alternative marginal cost assumptions is relatively small. As a consequence, simulation predictions are fairly consistent overall, tending to overestimate the price impact of the Delta-Northwest merger. I obtain aggregate weighted-average price changes of between 5.1% and 6.1%, versus an actual change of 4.9%. Average market-level outcomes take on a similar range of predictions. The most accurate simulation assumes the highest degree of cost synergies, taking the lower of the two marginal costs on an overlapping route, which may suggest that the merger in fact generated significant cost synergies. The remainder of this chapter proceeds as follows. Section 2.2 provides some background on the Delta-Northwest merger, while Section 2.3 lays out the primitives of the model I will estimate. I describe the data and discuss instrumental variables in Section 2.4, and in Section 2.5 I detail the estimation process. In Section 2.6 I provide and interpret my demand estimates and present results for four different merger simulations. Section 2.7 discusses limitations and extensions.

2.2 Background: The Delta-Northwest Merger

In September 2005, both Delta and Northwest filed for bankruptcy protection and in subsequent years reduced capacity. In the spring of 2007, only one month apart, both companies emerged from bankruptcy.\(^4\) Roughly one year later, Delta and Northwest

\(^4\) A CNN Money article gives some background on the road leading up to the merger and is available online here:
announced their intent to merge, pending regulatory and shareholder approval. Although the formal announcement took place on April 14, 2008, an article by CNN Money covering the merger suggested that the deal had been rumored since late 2007. In August 2008, the merger was approved by the European Commission, and in October 2008, upon approval by the DOJ, Delta completed the $2.8 billion acquisition of Northwest to create, at the time, the world’s largest airline. Not until January 2010 did the combined company begin flying as a single carrier.

Upon its approval, the DOJ’s Antitrust Division issued a statement regarding the proposed merger. The Division asserted that the merger was, “likely to produce substantial and credible efficiencies that will benefit U.S. consumers and is not likely to substantially lessen competition.” In addition to the anticipated benefits of improved service and a number of cost efficiencies due to the merger, one important factor in the DOJ’s approval was the pro-competitive presence of other legacy and low cost carriers on most of the routes where Delta and Northwest competed with each other. Unlike the failed combination of US Airways and United Airlines in 2000, in which a merger would have meant near-monopoly control of multiple airports, the overlap between Northwest’s and Delta’s routes was offset by competition from other firms. Since the merger of Delta and Northwest, the industry has seen three more behemoth deals. In May 2010, United Airlines and Continental Airlines an-


5 The article is available online here: http://money.cnn.com/2008/04/13/news/companies/delta_northwest/index.htm


7 The statement is available online here: http://www.justice.gov/opa/pr/2008/October/08-at-963.html

8 In a 2005 address to the Regional Airline Association, the Deputy Assistant Attorney General in charge of the DOJ’s Antitrust Division provided helpful insight into the Division’s policy with respect to airline mergers, including a summary of reasons for the DOJ’s rejection of the US Airways - United Airlines merger. The address is available online here: http://www.justice.gov/atr/public/speeches/217987.htm
nounced their merger, which created the world’s largest air carrier in a $3.2 billion deal. In September 2010, one month before the close of the United-Continental deal, Southwest Airlines announced its intent to acquire AirTran Holdings for $1.4 billion. Finally, in February 2013, US Airways and then-bankrupt American Airlines announced their $11 billion merger, creating the current largest airline.

2.3 Model

I consider a discrete choice model of air travel demand, consistent with much of the previous literature and bearing closest resemblance to the simpler of two models considered by Peters (2006). My setup is also closely related to the static equilibrium model of airline competition in Berry and Jia (2010), which itself draws heavily upon Berry et al. (2006). Both papers closely follow the framework and estimation methods described in Berry (1994) and Berry et al. (1995) and assume an interior, static, price-setting equilibrium in order to estimate marginal costs and markups. Using the estimated parameters, I compute the marginal costs implied by the first-order conditions for multi-product firms and use them to predict post-merger prices. I compare these predictions with the actual outcome of the merger, as well as with alternative predictions made under different assumptions about post-merger marginal costs.

2.3.1 Demand

Following Berry (1994), I estimate a nested logit model of demand in which individual i’s preferences for product j in market t can be represented by the utility function

\[ u_{ijt} = x_{jt} \beta + \xi_{jt} + \alpha \ln(p_{jt}) + \nu_i(\lambda) + \lambda \epsilon_{ijt}, \]

where \( x_{jt} \) are observable product characteristics, \( p_{jt} \) is price, and \( \xi_{jt} \) is unobserved product quality. Observable characteristics include things like the carrier and the
number of connections, while the unobservable accounts for characteristics like time of day or ticket restrictions, neither of which is available in the data I will be using.

The error term \( \nu_{it}(\lambda) + \lambda \epsilon_{ij} \) follows a mean-zero i.i.d. Type I Extreme Value, as does \( \epsilon_{ij} \), and \( \nu_{ij}(\lambda) \) follows the distribution described by Cardell (1997) that implies the nested logit form. The first nest contains the outside good of not flying, while the second nest contains all the flight products in a market. This setup allows some consumers to be driven out of the market for air travel if prices are too high. The parameter \( \lambda \) governs the degree of within-market substitutability. As \( \lambda \to 1 \), the correlation within a market becomes zero and the model approaches the standard multinomial logit setup in which products are independent. As \( \lambda \to 0 \), within-market correlation increases, implying that products within a market are more substitutable.

For the purposes of this chapter, I assume the mean utility of the outside good to be zero, and that consumers in all markets have the same values of \( \beta, \alpha, \) and \( \lambda \). In other words, flight characteristics, and flying in general relative to the outside good, are valued the same whether someone lives in Miami or Montana.

Individual \( i \) is allowed to make one choice in each quarter, selecting the product that maximizes utility. I define the mean utility of product \( j \) as

\[
\delta_j = x_j \beta + \xi_j + \alpha \ln(p_j),
\]

where product \( j = 0 \) is the outside good, with \( \delta_0 = 0 \). Finally, individuals’ choices are independent across quarters. The probability an individual chooses product \( j \) from the set of flight products \( 1, 2, ..., J \) is the same as the proportion of consumers choosing product \( j \), so the share of product \( j \) among the group of flight products is given by

\[
s_{j|g} = \frac{\exp(\delta_j)}{\sum_{k=1}^{J} \exp(\delta_k)}
\]

Similarly, the probability an individual chooses to fly is also the share of consumers
purchasing flights, \( s_g \). The shares for flying and for the outside good are therefore given by

\[
\frac{D^\lambda}{D^\lambda + 1}
\]

and

\[
s_0 = 1 - s_g = \frac{1}{D^\lambda + 1}
\]

respectively, where \( D \equiv \sum_{k=1}^{J} \exp(\frac{\delta_k}{\lambda}) \), which is just the denominator of \( s_{j|g} \). The overall share \( s_j \) of product \( j \) is then given by

\[
\frac{\exp(\frac{\delta_j}{\lambda})D^{\lambda-1}}{D^\lambda + 1} \text{ for } j \neq 0; \quad \frac{1}{D^\lambda + 1} \text{ for } j = 0.
\]

In order to equate the expressions above to observable shares, I follow Berry (1994):

\[
\frac{s_j}{s_0} = \frac{s_g s_{j|g}}{s_0} = \left( \frac{D^\lambda}{D^\lambda + 1} \right) \left( \frac{D^\lambda + 1}{1} \right) \left( \frac{\exp(\frac{\delta_j}{\lambda})}{D} \right)
\]

\[
= \left( \frac{D^\lambda}{1} \right) \left( \frac{\exp(\frac{\delta_j}{\lambda})}{D} \right)^\lambda \left( \frac{\exp(\frac{\delta_j}{\lambda})}{D} \right)^{1-\lambda}
\]

\[
= \left( \exp\left( \frac{\delta_j}{\lambda} \right) \right)^\lambda \left( s_{j|g} \right)^{1-\lambda}
\]

We can then express the estimating equation in log shares:

\[
\ln(s_j) - \ln(s_0) = x_j \beta + \alpha \ln(p_j) + \xi_j + (1 - \lambda) \ln(s_{j|g}),
\]

(2.1)

where \( \xi_j \) is treated as a random error term. Since \( \xi_j \) is sure to be correlated with prices (e.g. flights with refundable fares are typically more expensive) as well as group shares (e.g. flights with more leg room are more desirable), we need to instrument for both. I describe the instruments employed in Section 2.4.1.
2.3.2 Marginal Cost

I follow Berry and Jia (2010) and the previous literature on static demand estimation in calculating implied marginal costs. By assuming that firms play a static Bertrand-Nash price-setting game, we can use their first-order conditions for an interior equilibrium to compute markups, as in Berry et al. (1995). Suppose there are \( F \) firms, each producing some subset \( \mathcal{F}_f \) of the \( J \) different products. Firm \( f \)'s profit and corresponding first-order conditions for each of its products, \( j \in \mathcal{F}_f \) are given below:

\[
\pi_f = \sum_{j \in \mathcal{F}_f} (p_j - mc_j)s_j(x, \xi, p, \theta) M - C_f
\]

\[
\frac{\partial \pi_f}{\partial p_j} = s_j(p) + \sum_{r \in \mathcal{F}_f} (p_r - mc_r) \frac{\partial s_r(p)}{\partial p_j} = 0,
\]

where \( M \) is the overall market size, \( C_f \) are total fixed costs for firm \( f \), and \( mc_j \) is the (constant) marginal cost of product \( j \). The equilibrium markups for all products are therefore implied by this set of \( J \) first-order conditions. Define the matrix \( \Delta(p) \) such that \( \Delta_{jr}(p) = -\frac{\partial s_r(p)}{\partial p_j} \), and let the row-\( j \), column-\( r \) element\(^9\) of the pre-merger ownership matrix, \( \Omega^* \), be defined by

\[
\Omega^*_{jr} = \begin{cases} 
1, & \text{if } \exists f : \{j, r\} \subset \mathcal{F}_f \\
0, & \text{else}
\end{cases}
\]

Let \( \Omega^{pre} \) be the element-by-element product of \( \Delta \) and \( \Omega^* \), such that

\[
\Omega^{pre}_{jr}(p) = \begin{cases} 
\frac{\partial s_r(p)}{\partial p_j}, & \text{if } \exists f : \{j, r\} \subset \mathcal{F}_f \\
0, & \text{else}
\end{cases}
\]

\(^9\) Note that the partial derivative is of the column-\( r \) share with respect to the row-\( j \) price. Thus, if there are \( J = 5 \) products, of which firm 1 produces the first two, then the first row of \( \Omega \) is \(-\frac{\partial s_1(p)}{\partial p_1}, -\frac{\partial s_2(p)}{\partial p_1}, 0, 0, 0\), such that the first-order condition for product 1 becomes \( s_1(p) + (p_1 - mc_1) \frac{\partial s_1}{\partial p_1} + (p_2 - mc_2) \frac{\partial s_2}{\partial p_1} = 0 \).
which then allows us to write the set of first-order conditions in vector notation as

\[ 0 = s(p) - \Omega^{pre}(p)(p - mc). \]

The implied vector of marginal costs is then given by

\[ mc = p - \Omega^{pre}(p)^{-1}s(p), \tag{2.2} \]

where the second term represents the markups. Assuming firms face downward sloping demand curves, these markups will be positive. Given the nested logit form of \( s_j \), the equilibrium markups have analytical solutions.\(^\text{10}\)

2.3.3 Merger Simulation

Armed with an implied vector of marginal costs associated with the actual pre-merger ownership structure, we can simulate a merger by changing the ownership matrix and solving for the optimal prices set by firms in an interior price-setting equilibrium. Doing so, equation 2.2 becomes

\[ mc = p' - \Omega^{post}(p')^{-1}s(p'), \tag{2.3} \]

in which \( \Omega^{post} \) is the post-merger matrix defined as the element-by-element product of the new ownership matrix, \( \Omega' \), and \( \Delta(p') \), where \( p' \) is the vector of post-merger equilibrium prices. Using numerical methods, we can solve for the post-merger equilibrium price vector.

The standard approach taken is to leave marginal cost for each product at its pre-merger level, thereby simulating a merger with no cost synergies. Alternatively,

\(^\text{10}\) In particular, the partial derivatives defining \( \Omega^{pre} \) take the following form:

\[ \frac{\partial s_r}{\partial p_j} = \begin{cases} s_j s_{r|g} \left( \frac{\alpha}{p_j} \right) \left( 1 - s_g - \frac{1}{\lambda} \right) & \text{if } r \neq j \\ s_j \left( \frac{\alpha}{p_j} \right) \left( \frac{1}{\lambda} \left( 1 - s_{j|g} \right) + s_{j|g} \left( 1 - s_g \right) \right) & \text{if } r = j \end{cases} \]

17
one can solve for the level of post-merger cost synergies required to obtain pre-merger prices, as explained by Nevo (2000). The contribution of this chapter is to simulate price changes under several different assumptions on post-merger marginal cost, assessing the sensitivity of predicted prices to marginal cost assumptions and comparing the predictions to actual post-merger prices.

2.4 Data

Data on airline ticket prices and market shares are drawn from the Department of Transportation’s (DOT) Airline Origin & Destination Survey, known as Data Bank 1B (DB1B).\textsuperscript{11} DB1B is a quarterly 10% sample of all tickets issued for passenger air travel on domestic carriers. For the purposes of this chapter, I only consider tickets for travel originating, flying, and terminating within the contiguous United States.\textsuperscript{12} This is common in the empirical literature, since international travel involves additional considerations (e.g. customs clearance), and travel outside of the mainland U.S. typically involves specialty carriers and/or a niche customer segment that may not be representative of domestic travel in general.

In the DB1B data, a ticket represents a full trip itinerary, characterized by the sequence of airports visited (including the origin airport) and indicators for whether each visit represents a new destination or simply a connection on the way to the next airport. Each observation includes the ticket price (fare), the full itinerary, and the number of passengers flying that itinerary, along with segment-specific information such as the ticketing carrier (what airline sold the flight), the operating carrier (what

\textsuperscript{11} A wealth of air traffic information is publicly available for download from the Bureau of Transportation Statistics (http://www.transtats.bts.gov/). The DB1B data since 1993 are freely available here, and earlier years are available for purchase in hard copy.

\textsuperscript{12} The publicly available version of DB1B is already restricted to domestic flights, so this data cleaning step boils down to the elimination of trips to/from Hawaii and Alaska. It also entails dropping any itineraries that involve ground transportation. International segment data is available from the DOT with appropriate clearance, and to my knowledge, little to no analysis has incorporated it.
airline actually flew the flight), and the distance flown for each segment. For consistency in prices, I inflate/deflate fares to December 2009 levels using the Consumer Price Index (CPI) for the final month of each quarter,\textsuperscript{13} and drop tickets with extremely high or low fares (greater than $2,000 or less than $50).\textsuperscript{14} I further restrict my sample to round-trip tickets with at most one connection each way,\textsuperscript{15} and I exclude tickets for travel to multiple destinations.\textsuperscript{16} Both of these steps are commonly taken to simplify the analysis.

To define the market participants, I first combine carriers owned by the same company.\textsuperscript{17} For example, Atlantic Southeast Airlines, which used to be a subsidiary of Delta, was sold to SkyWest Airlines in 2005. Atlantic Southeast is always grouped with its parent company, even though it may fly as its own brand. Codeshare agreements are treated similarly. A codeshare is an agreement under which one carrier operates a flight under another carrier’s name, or code. Codeshares are quite common, especially in international travel and short, regional domestic routes. As previously mentioned, Northwest and Delta were codeshare partners on a number of routes prior to their merger. The DB1B data provides both the ticketing and operating carrier codes for each flight segment, so I am able to differentiate between traditional and

\textsuperscript{13} CPI data are available here: ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt

\textsuperscript{14} Extremely low fares tend to indicate flights purchased with frequent flyer miles and other promotions. I also drop itineraries with fares deemed by the DOT not to be “credible.”

\textsuperscript{15} The standard in the literature is to drop one-way flights and focus on round trips, which tends to simplify things quite a bit. I intend to expand my sample in the future, however, to compare the characteristics of one-way travelers with those of round-trip travelers.

\textsuperscript{16} A multi-destination itinerary is one with more than two trip breaks, so for example, a sequence of non-stop flights from Baltimore (BWI) to Orlando (MCO) to Boston (BOS) and back to BWI would be excluded, since the stops along the way were in fact destinations. If instead the itinerary had been a non-stop flight from BWI to MCO, and then a flight from MCO to BWI that connected in BOS, it would have been included.

\textsuperscript{17} For company ownership over time, I compile available merger and acquisition data from numerous sources, including company Websites and news publications. The best starting point is Airlines for America’s unofficial list, available here: http://www.airlines.org/Economics/DataAnalysis/Pages/USAirlineMergersandAcquisitions.aspx
codeshare products. To simplify analysis, however, I assign ownership of codeshare flights to the ticketing carrier, the one that actually sells the flight. Since I need to assign each itinerary to a particular airline, I also drop any itineraries with multiple ticketing carriers.

I define a market as a directional origin-destination city pair in a particular quarter. For instance, a non-stop round-trip flight from Atlanta (ATL) to Detroit (DTW) appears as ATL-DTW-ATL, which I treat as a different market than DTW-ATL-DTW. The ATL-DTW city pair in 2007 Q2 is also different from ATL-DTW in 2007 Q3. Since some cities are served by multiple airports, I group these airports into the same city-level market, but treat the airport as a product characteristic. For example, flights from Raleigh-Durham (RDU) to Chicago’s Midway Airport (MDW) are in the same market as flights from RDU to Chicago’s O’Hare International Airport (ORD), but they are treated as different products. I consider only large markets, defined as those for which both the origin and destination airports service at least 1,000,000 passengers per quarter and are located in Census Metropolitan Statistical Areas (MSA) containing at least 850,000 residents, according to 2006 population estimates. I also eliminate any markets serving fewer than 90 passengers in a quarter, and I drop any observations for which a carrier serves fewer than 90 passengers or less than 1% of the market.

With quarterly markets defined by their origin-destination cities, products are

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18 While this has been the conventional treatment throughout most of the literature, and seems to make the most sense from the point of view of the consumer, nondirectional markets may be more appropriate when considering the price-setting strategies of firms.

19 The grouped airports are O’Hare and Midway in Chicago, IL; LaGuardia, Newark, and Kennedy in New York City, NY; National, Dulles, and Baltimore/Washington International in Washington, D.C.; San Francisco, Oakland, and San Jose in San Francisco, CA; Dallas-Fort Worth and Love Field in Dallas, TX; Hobby and George Bush Intercontinental in Houston, TX; and Los Angeles, Burbank, and Long Beach in Los Angeles, CA.

20 Consequently, I also drop any flights between airports that cannot be matched to an MSA. Census population estimates are available here: http://www.census.gov/popest/metro/CBSA-est2006-annual.html
defined by their sequence of airports (the route) and the ticketing carrier. For example, the following (fictitious) round-trip flights would all be different products for the same market:

Table 2.1: Example Routes

<table>
<thead>
<tr>
<th>Origin</th>
<th>Connection 1</th>
<th>Destination</th>
<th>Connection 2</th>
<th>Return</th>
<th>Carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATL</td>
<td>(non-stop)</td>
<td>ORD</td>
<td>(non-stop)</td>
<td>ATL</td>
<td>Delta</td>
</tr>
<tr>
<td>ATL</td>
<td>(non-stop)</td>
<td>MDW</td>
<td>(non-stop)</td>
<td>ATL</td>
<td>Delta</td>
</tr>
<tr>
<td>ATL</td>
<td>BOS</td>
<td>ORD</td>
<td>(non-stop)</td>
<td>ATL</td>
<td>Delta</td>
</tr>
<tr>
<td>ATL</td>
<td>BOS</td>
<td>ORD</td>
<td>BOS</td>
<td>ATL</td>
<td>Delta</td>
</tr>
<tr>
<td>ATL</td>
<td>CLT</td>
<td>ORD</td>
<td>BOS</td>
<td>ATL</td>
<td>Delta</td>
</tr>
<tr>
<td>ATL</td>
<td>BOS</td>
<td>ORD</td>
<td>(non-stop)</td>
<td>ATL</td>
<td>Northwest</td>
</tr>
<tr>
<td>ATL</td>
<td>BOS</td>
<td>MDW</td>
<td>(non-stop)</td>
<td>ATL</td>
<td>Northwest</td>
</tr>
<tr>
<td>ATL</td>
<td>(non-stop)</td>
<td>MDW</td>
<td>(non-stop)</td>
<td>ATL</td>
<td>Northwest</td>
</tr>
</tbody>
</table>

The same flights are often sold at several different prices, reflecting both unobserved ticket attributes and effective yield management by airlines. Following Peters (2006), Brown and Gayle (2009), and others, I aggregate observations up to the product level. As previously mentioned, a product is defined as a unique quarter-itinerary-carrier combination. I define the price of a product as the passenger-weighted average of all of its observed fares, and the quantity as the sum of the passengers at each fare level. In order to compute market shares for each product, and for the outside good, I must define the size of each city-pair market. Following convention, I use the geometric average population of the MSAs containing the two endpoint cities.

A few more variables warrant explanation. I include as a product attribute the number of slot-controlled airports through which an itinerary travels. In order to keep air traffic from overcoming the airport’s capacity to manage it, these airports have regulatory restrictions placed on the frequency of takeoffs and landings. Slot-controlled airports include Chicago O’Hare, New York LaGuardia, New York Kennedy, and Washington National. I also include indicators for whether a
route has asymmetric connections,\textsuperscript{21} and whether the flight is to a tourist destination (defined herein as Florida or Las Vegas).

2.4.1 Instruments

While the DB1B data are quite extensive, many important variables are not observed, such as flight time, in-flight service, flight restrictions (i.e. refund or flight change options), or date of purchase, all of which one might expect to be correlated with price and within-group share. The estimation method takes the endogeneity of price and market share with respect to these unobservable characteristics into account by employing instrumental variables.

The standard approach to instrumenting for price is to use input cost variables, since they are correlated with price but assumed not to be correlated with the (observed or unobserved) product characteristics that consumers value. Along these lines, I include the route-level distance and its square, which are directly associated with the marginal cost of operating a flight. The influence of distance on demand is likely to be confined to the number of connections and the degree to which those connections are “out of the way” with respect to a non-stop flight, and both of these characteristics are included as exogenous product attributes. Similar to Berry and Jia (2010), I also incorporate a measure of hub status for the carrier at the connecting airport. Hub status at connecting airports is likely to affect the marginal cost of a flight through traffic density, while it is unlikely to impact demand at the market level. Frequent flier programs and flight frequency, which are related to hub status of the origin and destination airports, are likely to influence demand. However, these features should be unrelated to the hub status of a connecting airport. To assign hub status, I supplement the DB1B data with the DOT’s T100 Traffic

\textsuperscript{21} This could be a trip that connects both ways, but at different airports each way, as well as a trip that is non-stop one direction and has a connection the other direction.
The T100 database provides monthly information on all domestic non-stop flights (including segments of connecting flights). Variables include operating carrier, cargo and passengers flown, seats available, aircraft type, and whether the flight was scheduled or unscheduled. While this data does not provide a one-to-one match with the DB1B’s origin and destination information, it does provide a more accurate measure of the total number of flights a carrier operates out of or into a given airport since it is not a sampled dataset. Following Mayer and Sinai (2003), I designate three levels of hub status according to the number of destinations served by an operating carrier out of a particular airport: small (21-40 destinations); medium (41-70 destinations); large (71 or more destinations).

As Berry (1994) explains, demand-side variables that influence markups (for example, the characteristics of competing firms) can also be used as instruments in product differentiation models with exogenous characteristics. A common instrument is the number of products in each market, which I include, along with its square. Also at the market level, I include the Herfindahl-Hirschman Index (HHI), which is a measure of market concentration, along with the total number of carriers competing in the market. In addition, I incorporate the number of non-participating potential entrants into the market, which I define as the set of carriers flying out of an origin or into a destination (or both) but not serving the market in question. As suggested by Goolsbee and Syverson (2008), Kwoka and Shumilkina (2010), and others, the threat of entry can suppress prices. I employ route-level characteristics as well, including the number of alternative routes in a market and the percentage

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22 For example, a direct round-trip flight from Newark (EWR) to St. Louis (STL) sold by American Airlines and operated by Chautauqua Airlines would appear in the T100 database as two segments (EWR-STL and STL-EWR) flown by Chautauqua. Their relationship to an American Airlines sale is not accounted for, and any differences between round-trip, one-way, or connecting passengers on each segment is lost.

23 Equal to the sum of the squared market shares of all firms in a given market. The value ranges from (almost) 0 to 10000
of those routes that are non-stop.

2.4.2 Sample Period

Following Peters (2006), I define the pre-merger period as the four quarters preceding the announcement of the merger, and the post-merger period as the four quarters following integration of both firms’ operations. Since Delta and Northwest formally announced their intent to merge in April of 2008, I define the pre-merger period as 2007 Q2 through 2008 Q1. This period seems to be conveniently representative of normal operations since both companies emerged from bankruptcy in the second quarter of 2007. The post-merger period is defined as the first four quarters in which all flights of the combined company flew under the DL carrier code: 2010 Q1 through 2010 Q4. While complete integration was still a long way off in 2010, two events in January suggest that my choice for the post-merger period is reasonable. First, the International Air Transport Association’s (IATA) retirement of the NW carrier code serves as official recognition of the merge. Second, all remaining Northwest bookings were canceled and transferred to new Delta flights in January 2010, reflecting a single entity to customers and marking the removal of Northwest from the carrier choice set. Table 2.2 provides summary statistics for the pre-merger period, which is used for demand estimation, while Table 2.3 refers to the post-merger period, which is used for comparison with the results of my merger simulations.

2.4.3 Overlapping Markets

Peters (2006) defines overlapping markets as those in which both carriers provided service in all four quarters of the pre-merger period, but excluding markets where

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24 For example, a recent NY Times article detailing the merger’s integration process explains that the last Northwest airplane was not repainted in Delta’s colors until spring 2011, and flight attendants still work under separate contracts due to pending mediation. The article is available online here:

http://www.nytimes.com/2011/05/19/business/19air.html?pagewanted=all
### Table 2.2: Pre-Merger Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fare</td>
<td>420.183</td>
<td>180.826</td>
<td>50.379</td>
<td>1998.299</td>
</tr>
<tr>
<td>Number of Connections</td>
<td>1.605</td>
<td>0.601</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Asymmetric Route</td>
<td>0.391</td>
<td>0.488</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Direct First Flight</td>
<td>0.2</td>
<td>0.4</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Distance (in hundreds of miles)</td>
<td>33.53</td>
<td>14.031</td>
<td>1.72</td>
<td>76.86</td>
</tr>
<tr>
<td>Measure of Itinerary Inconvenience</td>
<td>1.131</td>
<td>0.185</td>
<td>0.974</td>
<td>3.476</td>
</tr>
<tr>
<td>Tourist Destination (FL or Vegas)</td>
<td>0.298</td>
<td>0.458</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td># of Slot-Controlled Airports on Itinerary</td>
<td>0.383</td>
<td>0.714</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Origin Hub Level (1-3)</td>
<td>0.344</td>
<td>0.744</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Destination Hub Level (1-3)</td>
<td>0.334</td>
<td>0.731</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Sum of Connection Hub Levels (1-6)</td>
<td>2.655</td>
<td>1.983</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>HHI: Measure of Market Concentration</td>
<td>3931.901</td>
<td>1822.181</td>
<td>1347.888</td>
<td>10000</td>
</tr>
<tr>
<td>Average Population (in millions)</td>
<td>3.649</td>
<td>2.358</td>
<td>0.895</td>
<td>15.611</td>
</tr>
<tr>
<td>Non-Participating Potential Entrants</td>
<td>9.970</td>
<td>2.943</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Total Products in the Market</td>
<td>61.475</td>
<td>64.741</td>
<td>1</td>
<td>467</td>
</tr>
<tr>
<td>Total Carriers in the Market</td>
<td>5.432</td>
<td>1.936</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Number of Other Routes in the Market</td>
<td>55.758</td>
<td>60.282</td>
<td>0</td>
<td>445</td>
</tr>
<tr>
<td>Pct. Direct for Competing Routes</td>
<td>0.183</td>
<td>0.139</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>302099</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2.3: Post-Merger Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fare</td>
<td>411.246</td>
<td>170.224</td>
<td>50.248</td>
<td>1994.173</td>
</tr>
<tr>
<td>Number of Connections</td>
<td>1.619</td>
<td>0.586</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Asymmetric Route</td>
<td>0.433</td>
<td>0.495</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Direct First Flight</td>
<td>0.192</td>
<td>0.394</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Distance (in hundreds of miles)</td>
<td>33.121</td>
<td>13.563</td>
<td>1.8</td>
<td>79.239</td>
</tr>
<tr>
<td>Measure of Itinerary Inconvenience</td>
<td>1.15</td>
<td>0.198</td>
<td>0.974</td>
<td>3.797</td>
</tr>
<tr>
<td>Tourist Destination (FL or Vegas)</td>
<td>0.294</td>
<td>0.456</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td># of Slot-Controlled Airports on Itinerary</td>
<td>0.311</td>
<td>0.66</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Origin Hub Level (1-3)</td>
<td>0.336</td>
<td>0.725</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Destination Hub Level (1-3)</td>
<td>0.333</td>
<td>0.721</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Sum of Connection Hub Levels (1-6)</td>
<td>2.516</td>
<td>1.863</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>HHI: Measure of Market Concentration</td>
<td>3968.091</td>
<td>1839.896</td>
<td>0</td>
<td>10000</td>
</tr>
<tr>
<td>Average Population (in millions)</td>
<td>3.59</td>
<td>2.319</td>
<td>0.897</td>
<td>15.611</td>
</tr>
<tr>
<td>Non-Participating Potential Entrants</td>
<td>6.968</td>
<td>2.85</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Total Products in the Market</td>
<td>68.292</td>
<td>68.129</td>
<td>1</td>
<td>517</td>
</tr>
<tr>
<td>Total Carriers in the Market</td>
<td>5.025</td>
<td>1.741</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Number of Other Routes in the Market</td>
<td>62.309</td>
<td>62.493</td>
<td>0</td>
<td>471</td>
</tr>
<tr>
<td>Pct. Direct for Competing Routes</td>
<td>0.177</td>
<td>0.127</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>351579</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
a merger would be “unlikely to have adverse competitive effects” according to the DOJ’s Horizontal Merger Guidelines. In the most recent version of these guidelines, that stipulation amounts to any combination that 1) results in an “Unconcentrated Market” (defined as having HHI below 1500), or 2) involves a change in HHI\(^{25}\) of less than 100 points. Of the 350 markets served by both airlines during all pre-merger quarters, only 1 would be considered an unconcentrated market. Accounting for the change in HHI due to a merger, that market would become “Moderately Concentrated” (defined as having HHI between 1500 and 2500), so none of the overlapping markets satisfy the first condition. However, 85 of these overlapping markets would involve a relatively small change in concentration due to a merger and therefore satisfy the second condition. We are then left with 264 overlapping markets, which account for 17% of the markets served by Delta and 38% of the markets served by Northwest. The significant level of overlap due to Peters (2006)’s definitions may be misleading, however, given its low threshold for what constitutes market participation. I instead require an airline to carry at least 300 passengers in every quarter of the pre-merger period. This definition is roughly comparable to flying between 1 and 4 flights per month, depending on load factor and aircraft type, so it is still a relatively low hurdle. Nonetheless, I am left with 52 overlapping markets, which account for 6.5% of the markets served by Delta under this new definition, and 14.5% of those served by Northwest.

To examine how prices changed from the pre- to post-merger period, I calculate the total annual passenger-weighted average fare, as well as the percentage change from the pre- to post-merger period, for each directional city-pair market. In Table 2.4, I include the unweighted means and medians across all markets and overlapping markets. By this measure, fares changed very little over the period; the average

\(^{25}\)The resultant change in HHI is calculated as two times the product of the two firms’ market shares.
market-level increase was roughly 1% in real terms. Fares in overlapping markets, on the other hand, increased by about 3%. If instead I consider the weighted average fares across all markets and quarters during each period, the comparison is equally stark: Fares increased roughly 2.6% overall and 4.9% in overlapping markets. Finally, in the five markets where Delta and Northwest overlapped the most (Atlanta-Detroit, Atlanta-Minneapolis/St.Paul, Detroit-Atlanta, Memphis-Atlanta, Minneapolis/St. Paul-Atlanta), the mean and median percentage changes are 5.3% and 5.7%, respectively.

Table 2.4: Unweighted Means and Medians across Markets

<table>
<thead>
<tr>
<th></th>
<th>Pre-Merger Fares</th>
<th>Post-Merger Fares</th>
<th>Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Mean</td>
</tr>
<tr>
<td>All Markets</td>
<td>389.19</td>
<td>385.10</td>
<td>386.65</td>
</tr>
<tr>
<td>Overlapping Markets</td>
<td>410.50</td>
<td>429.92</td>
<td>421.22</td>
</tr>
</tbody>
</table>

All fares represented in December 2009 dollars

2.5 Estimation

I begin by estimating demand for passenger air travel following Berry (1994). Using the estimated demand parameters, I compute the marginal costs implied by multi-product firms’ first-order conditions and then simulate the Delta-Northwest merger under four different assumptions about post-merger marginal costs. I now describe each step in more detail.

2.5.1 Demand

I estimate demand using a nested logit framework with all flights in one nest and the outside good in another nest. The technique laid out in Berry (1994) allows for standard instrumental variables estimation of the linear equation 2.1, replicated
below, in which unobserved product quality \( \xi_j \) is treated as the error term.

\[
\ln(s_j) - \ln(s_0) = x_j \beta + \alpha \ln(p_j) + (1 - \lambda) \ln(s_{j|g}) + \xi_j
\]

Exogenous product characteristics affecting demand include the number of total connections, a measure of relative inconvenience (itinerary distance/non-stop distance), the hub status of the origin and destination airports for the ticketing carrier (large, medium, small, or not a hub), and the number of slot-controlled airports on the itinerary, as well as dummies for large ticketing carriers, dummies for origin and destination in multi-airport markets, and indicators for whether the flight is to a tourist destination (Las Vegas or Florida), has asymmetric connections, and has a direct flight for the first leg.

Endogenous product characteristics\(^{26}\) include the log of price and the log of within-group share. I instrument for these variables using the set of exogenous characteristics as well as variables affecting marginal costs and markups, which are assumed to be exogenous with respect to unobservable product quality. The set of market-level instruments includes distance and its square, the number of products in each market and its square, the total number of carriers in the market, HHI, and the number of non-participating potential entrants to the market and its square, while the set of route-level instruments includes the number of competing routes, the percentage of those routes that are direct, and the total hub status of (potentially) both connecting airports for the ticketing carrier.

### 2.5.2 Marginal Costs

After obtaining estimates of the demand parameters, I calculate implied marginal costs according to equation 2.3. In a typical merger simulation, these implied

\(^{26}\) Product characteristics, including unobserved ones, are treated as exogenous to the firm’s pricing decision. That is, things like flight time or seat comfort are determined in advance of pricing, so while price and within-group share are endogenous with respect to the error term (unobserved product quality), this is not due to a joint decision of provision and pricing of unobserved quality.
marginal costs are combined with the FOCs for an interior, price-setting Bertrand-Nash equilibrium to solve for the prices that would obtain in a simulated merger (i.e., changing the ownership matrix, Ω). Assuming that marginal costs remain constant after a merger reflects an absence of synergies, which is never the case according to the merging entities. However, arbitrarily assigning new marginal costs makes little sense. I simulate the merger between Delta and Northwest and solve for post-merger prices using the following four alternatives for marginal costs:

1. No marginal cost change, as in the standard approach

2. Lower of the two marginal costs for the same route in overlapping markets

3. Higher of the two marginal costs for the same route in overlapping markets

4. Average of the two marginal costs for the same route in overlapping markets

In order to consider the above adjustments to pre-merger marginal cost, I must also define overlapping products. I consider products to overlap if both Delta and Northwest are found to fly the same route (that is, the same sequence of origin, destination, and connecting airports) in a given quarter. Of the 52 overlapping markets according to my definition, 38 include overlapping products in at least one quarter.\textsuperscript{27}

\subsection*{2.6 Results and Conclusions}

\subsubsection*{2.6.1 Demand and Elasticity}

Table 2.5 provides the results of my demand estimation. All coefficients presented are statistically significant, as are virtually all coefficients on carrier, airport, and time dummies. The signs on each product characteristic are in line with what one

\textsuperscript{27} Of the 264 overlapping markets according to Peters (2006)’s definition, 121 include at least one overlapping product.
might expect. High prices are less attractive, and passengers derive less utility from connecting flights, especially those with more out-of-the-way connections or those that connect in different places. The hub status of the origin and destination airports are both preferred, and incrementally so according to the relative size of the hub. Direct flights are better than indirect ones, passengers slightly prefer tourist destinations, and the fewer slot-controlled airports on a trip, the better.

The coefficients on log fare and log of within-group share represent my estimates for $\alpha$ and $1 - \lambda$, respectively. Using these estimates, along with the observed shares, I calculate own- and cross-price elasticities for all products. The passenger-weighted average own-price elasticity for all markets is -3.65, and in overlapping markets the figure is -3.88, suggesting a higher degree of competition in overlapping markets. Presented in Table 2.6 is the elasticity matrix for a prominent overlap market. As the table illustrates, a 1% increase in the price of Delta’s non-stop flight results in a 3.4% reduction in the quantity sold of that product, coupled with about a 1% increase in the quantities of substitute products, including Northwest’s non-stop and connecting flights.

Table 2.6 highlights an unfortunate result of the simple nesting structure of my demand model: Substitution to other flight products does not vary by product characteristics. Rather, substitution away from any given product is governed by the market share of that product. This modeling disadvantage is also relevant for interpreting Table 2.7, which provides passenger-weighted means and medians of selected cross-price elasticities among markets with more than 1 product. Cross-price elasticities for each subset of the pre-merger sample are reasonable. Delta and Northwest

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28 As a robustness check, I estimate the model interacting log fare with the tourist dummy and find a very modest downward change in $\alpha$. The coefficient on the interaction is small and positive, suggesting that travelers to tourist destinations are less price sensitive, contrary to what one might expect. The most probably explanation is that my definition of tourist destinations does not define tourist travel. Florida and Las Vegas surely receive a great deal of business-related travel as well, which might explain the result.
Table 2.5: Demand Estimation, Second-Stage Results of 2SLS

<table>
<thead>
<tr>
<th></th>
<th>Coefficient (std error)</th>
<th>Origin is a Large Hub</th>
<th>Coefficient (std error)</th>
<th>Origin is a Medium Hub</th>
<th>Coefficient (std error)</th>
<th>Origin is a Small Hub</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Fare</td>
<td>-2.292*** (0.018)</td>
<td>0.209*** (0.007)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of Within-Group Share</td>
<td>0.481*** (0.002)</td>
<td>0.312*** (0.010)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measure of Inconvenience</td>
<td>-0.684*** (0.012)</td>
<td>0.728*** (0.015)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Connections</td>
<td>-0.387*** (0.006)</td>
<td>0.184*** (0.007)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymmetric Connections</td>
<td>-0.205*** (0.005)</td>
<td>0.248*** (0.009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct first flight</td>
<td>0.054*** (0.008)</td>
<td>0.191*** (0.013)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tourist Destination</td>
<td>0.158*** (0.005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Slot-Controlled Airports</td>
<td>-0.077*** (0.005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R-squared 0.502
Number of Observations 340,406

Coefficients on the constant and carrier, quarter, and airport dummies omitted for presentation and available upon request. Standard errors in parentheses. F-stats for first-stage regressions of log fare and log of within-group share are 638 and 4651, respectively. Full results available upon request.

*** statistically significant at the 1% level
** statistically significant at the 5% level
* statistically significant at the 1% level

products are indeed substitutes, though perhaps less so in markets where the two carriers directly compete. Cross-price elasticities among overlapping markets are generally only two-thirds as large as those across all markets. Much of this difference is surely due to the aforementioned relationship between substitution and market

31
Table 2.6: Estimated Elasticity Matrix for Memphis-Atlanta, 2007 Q3

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Number of Passengers</th>
<th>Weighted-Avg. Fare</th>
<th>Flight Type</th>
<th>Elasticities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta</td>
<td>4,480</td>
<td>312.15</td>
<td>Non-stop</td>
<td>-3.42 0.99 0.99 0.99</td>
</tr>
<tr>
<td>AirTran</td>
<td>2,510</td>
<td>238.60</td>
<td>Non-stop</td>
<td>0.56 -3.86 0.56 0.56</td>
</tr>
<tr>
<td>Northwest</td>
<td>2,600</td>
<td>293.12</td>
<td>Non-stop</td>
<td>0.58 0.58 -3.84 0.58</td>
</tr>
<tr>
<td>Northwest</td>
<td>10</td>
<td>562.43</td>
<td>Connecting</td>
<td>0.00 0.00 0.00 -4.41</td>
</tr>
</tbody>
</table>

All fares represented in December 2009 dollars. The row-$j$, column-$r$ element of the elasticity matrix signifies the percent change in the quantity sold of good $r$ for a 1% increase in the price of good $j$.

There tends to be both a greater variety of products and a larger number of carriers in overlapping markets, both of which work to reduce product-level market shares and, as a consequence, cross-price elasticities.

Table 2.7: Passenger-Weighted Mean and Median Cross-Price Elasticities

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Markets</td>
<td>0.75</td>
<td>0.64</td>
</tr>
<tr>
<td>Overlap Markets</td>
<td>0.53</td>
<td>0.44</td>
</tr>
<tr>
<td>All Delta Products</td>
<td>0.71</td>
<td>0.63</td>
</tr>
<tr>
<td>All Northwest Products</td>
<td>0.95</td>
<td>1.06</td>
</tr>
</tbody>
</table>

All costs represented in December 2009 dollars

2.6.2 Marginal Cost and Merger Simulation

Using the results of my demand estimation, I compute the marginal costs implied by firms’ FOCs as described in equation 2.3. Table 2.8 provides passenger-weighted

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29 To be specific, the weighted average number of products in overlapping markets was 66, while the overall weighted average was just 47. Moreover, the weighted average HHI in overlapping markets was 3451, while the overall weighted average was more than 4500.
means and medians for marginal cost and marginal cost per mile flown in all markets and overlapping markets. Implied marginal costs are generally higher in overlapping markets, although cost per mile tends to be lower. More importantly, gross margin is lower on average in overlapping markets, indicating that these markets tend to be more competitive, consistent with the interpretation of higher (in magnitude) estimates of own-price elasticity in overlapping markets.

Table 2.8: Passenger-Weighted Implied Marginal Cost and Margin

<table>
<thead>
<tr>
<th></th>
<th>Implied Marginal Cost</th>
<th>Implied Marginal Cost/Mile</th>
<th>Implied Gross Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Mean</td>
</tr>
<tr>
<td>All Markets</td>
<td>233.95</td>
<td>222.26</td>
<td>0.15</td>
</tr>
<tr>
<td>Overlapping Markets</td>
<td>281.89</td>
<td>253.41</td>
<td>0.13</td>
</tr>
</tbody>
</table>

All costs represented in December 2009 dollars

I simulate the Delta-Northwest merger by first modifying the ownership matrix to account for Delta’s ownership of Northwest’s products. Using the demand parameter estimates, observed product characteristics, and estimates of unobserved product quality, ξ, I then fix all components of mean utility except for price. Since the shares are functions of mean utilities, I can compute the new share derivative matrix, ∆(p'), for any arbitrary vector of prices p'. This allows me to calculate Ω\textsuperscript{post}(p'), as in equation 2.3, as the element-by-element product of ∆(p') and Ω', the new ownership matrix. Using a numerical equation solver, I recover the new vector of prices p' that satisfies the first-order conditions for price-setting oligopolists, taking into account my alternative assumptions about marginal cost for the merging firms.

To evaluate my results, I first calculate the actual weighted average post-merger fares for each overlapping market. I then calculate the weighted average marginal
costs, post-merger fare predictions, and percent increases for each overlapping market under all four assumptions. In the following tables, I present the unweighted means and medians, respectively, of those quantities across markets. As previously discussed, the baseline assumption makes no change to the marginal costs calculated from equation 2.3 and therefore reflects only the simulated effect of a change of ownership. The remaining three assumptions replace the marginal cost of an overlapping route with the lower, higher, or average of the marginal costs of Delta’s and Northwest’s products on that route.

Table 2.9: Means of Market-Level Passenger-Weighted Averages

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Marginal Cost</th>
<th>Pre-Merger Fare</th>
<th>Post-Merger Simulated Fare</th>
<th>% Post-Merger Increase</th>
<th>Post-Merger Actual Fare</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>298.58</td>
<td>410.50</td>
<td>432.95</td>
<td>5.3%</td>
<td>421.22</td>
<td>3.4%</td>
</tr>
<tr>
<td>Lower</td>
<td>296.43</td>
<td>410.50</td>
<td>432.40</td>
<td>5.1%</td>
<td>421.22</td>
<td>3.4%</td>
</tr>
<tr>
<td>Higher</td>
<td>301.11</td>
<td>410.50</td>
<td>436.27</td>
<td>6.2%</td>
<td>421.22</td>
<td>3.4%</td>
</tr>
<tr>
<td>Average</td>
<td>298.77</td>
<td>410.50</td>
<td>433.89</td>
<td>5.5%</td>
<td>421.22</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

All fares and costs represented in December 2009 dollars

Table 2.10: Medians of Market-Level Passenger-Weighted Averages

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Marginal Cost</th>
<th>Pre-Merger Fare</th>
<th>Post-Merger Simulated Fare</th>
<th>% Post-Merger Increase</th>
<th>Post-Merger Actual Fare</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>317.55</td>
<td>429.92</td>
<td>445.08</td>
<td>4.7%</td>
<td>438.12</td>
<td>2.6%</td>
</tr>
<tr>
<td>Lower</td>
<td>317.55</td>
<td>429.92</td>
<td>445.07</td>
<td>5.0%</td>
<td>438.12</td>
<td>2.6%</td>
</tr>
<tr>
<td>Higher</td>
<td>317.74</td>
<td>429.92</td>
<td>445.09</td>
<td>5.0%</td>
<td>438.12</td>
<td>2.6%</td>
</tr>
<tr>
<td>Average</td>
<td>317.55</td>
<td>429.92</td>
<td>445.08</td>
<td>5.3%</td>
<td>438.12</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

All fares and costs represented in December 2009 dollars

In terms of market-level accuracy, my simulations tend to overestimate the price impact of the Delta-Northwest merger overall. This is also true when looking at the
aggregate change in passenger-weighted average fares.

Table 2.11: Overall Passenger-Weighted Averages across Overlapping Markets

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Marginal Cost</th>
<th>Pre-Merger Fare</th>
<th>Post-Merger Simulated Fare</th>
<th>% Increase</th>
<th>Post-Merger Actual Fare</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>281.89</td>
<td>390.30</td>
<td>410.94</td>
<td>5.3%</td>
<td>409.39</td>
<td>4.9%</td>
</tr>
<tr>
<td>Lower</td>
<td>279.97</td>
<td>390.30</td>
<td>410.13</td>
<td>5.1%</td>
<td>409.39</td>
<td>4.9%</td>
</tr>
<tr>
<td>Higher</td>
<td>284.44</td>
<td>390.30</td>
<td>414.25</td>
<td>6.1%</td>
<td>409.39</td>
<td>4.9%</td>
</tr>
<tr>
<td>Average</td>
<td>282.21</td>
<td>390.30</td>
<td>411.89</td>
<td>5.5%</td>
<td>409.39</td>
<td>4.9%</td>
</tr>
</tbody>
</table>

All fares represented in December 2009 dollars

Consistent overestimation by all simulations and the fact that the lower marginal cost assumption was on average the most accurate may suggest that the merger indeed generated significant marginal cost savings, despite the long-run timeframe for complete integration. Overestimation may also point to the price-depressing effect of entry by other carriers into overlapping markets. In general, since taking the “higher of the two” marginal costs could raise the cost for the market leader or for the market laggard (or reduce cost for either player when taking the lower of the two), the overall outcome need not be consistent. Going forward, I would like to evaluate alternatives that are dependent on who is the market leader.

2.7 Limitations and Extensions

Potential improvements in both modeling and estimation are numerous. The first shortcoming, mentioned in the previous section, is the fact that substitution away from any good depends only on the share of that good, and not on the product characteristics of that good or potential substitutes. One remedy would be to upgrade the demand model to one with more flexibility. Peters (2006) estimates demand for air travel using both a nested logit and a principles-of-differentiation generalized extreme
value (PD-GEV) model that allows substitution to depend on overlapping product characteristics. Comparing results from the two models, he rejects the simpler nested logit specification, which is a special case of the PD-GEV model. Another way to enhance the demand model would be to allow for multiple types of consumers (e.g., business and leisure). Berry and Jia (2010) estimate such a model by employing a discrete-type version of the technique described in Berry et al. (1995). An extension of Berry and Jia’s model would be to match additional moments from aggregate data on travel decisions and demographics. The American Travel Survey of 1995 links demographic information with travel details, including origin, destination, mode, and purpose of travel.

Expanding the scope of the analysis is another improvement, and applying my analysis to other recent mergers is the obvious first step. I could also use the work in this chapter as a foundation for studying the behavior of firms in anticipation of industry consolidation. The recent round of merger activity in the airline industry, which began with the Delta-Northwest merger and continued with United-Continental, Southwest-AirTran, and American-US Airways, was anticipated by many who knew the industry well. For example, House Transportation Committee Chairman James Oberstar (D-MN), asserted

“This should not be and must not be considered as a standalone, individual transaction but rather as the trigger of what will surely be a cascade of subsequent mergers that will consolidate aviation in the United States and around the world into global, mega carriers.”

If Oberstar’s expectation was mirrored by airline industry executives, then perhaps a dynamic model that takes into account the probability of future consolidation

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30 Oberstar’s viewpoint is recounted in an article available online here: http://money.cnn.com/2008/05/14/news/companies/airline_merge/index.htm?postversion=2008051418
is more appropriate for merger simulation in this case. The airline industry also provides fertile ground for merger studies in which one party is bankrupt. The DOJ and FTC view distressed mergers in a more favorable light and are willing to tolerate greater anticompetitive effects in these situations. An interesting future research question is whether such a policy makes sense.

Beyond mergers, I am also interested in studying the capacity-setting decisions of airlines. While Chapter 4 models a capacity-setting game in the context of bankruptcy, it necessarily abstracts away from merger decisions. However, as explained in Peters (2006), the simulations herein reflect only one component of the overall impact of a merger. Changes in demand, firm conduct, and supply-side variables can be considerably more important. How firms change their product offering and shift or remove capacity in combining their fleets are sure to play crucial roles.

An ambitious extension of the demand estimation performed in this chapter would be to estimate a dynamic game of capacity- and price-setting. Snider (2009) serves as an aid in this respect. Relating a model of price and capacity competition to the airline industry, he develops a dynamic structural model in which cost asymmetries between large and small carriers lead to predatory behavior. The literature on methods of solving and estimating dynamic games has seen several recent advances, including a number of articles relevant to the airline industry (Ciliberto and Tamer, 2009; Aguirregabiria and Ho, 2010, for instance). More realistic models of price and capacity competition could provide new insights for the empirical analysis of mergers. I discuss the dynamic games literature in more detail in Chapter 4.
3.1 Introduction

It pays to shop around: Prices for very similar products often vary dramatically, a historically puzzling observation for economists. Not surprisingly, rationalizing the equilibrium dispersion of prices for homogeneous products has been the subject of considerable theoretical work. Explanations include, but are not limited to, consumer search costs, price discrimination, and demand uncertainty coupled with fixed capacity. The empirical literature, in addition to proving the prudence of price shopping, has established the legitimacy of each of these explanations. However, studies of their relative importance in real-world settings are more scarce. A common approach, exemplified by Borenstein and Rose (1994), is to evaluate competing theories on the basis of their comparative statics. One of the most pressing and controversial debates along these lines concerns the relationship between competition and price dispersion. Depending on its source, price dispersion can increase, decrease, remain the same, or even change non-monotonically with the arrival of an additional firm to an oligopolistic market. This chapter informs that debate with
conclusions drawn from empirical analysis of ticket prices in the U.S. airline industry. Exploiting the variation in market-level competition due to several large, national airline mergers, we isolate the relationship between competition and price dispersion with a set of difference-in-differences analyses of various statistics of the ticket price distribution. We find that price dispersion increased for mergers between two legacy carriers, while the merger between low-cost carriers Southwest and AirTran yielded the opposite result.

Our study has three main aims. First, we contribute to the literature on price dispersion and market concentration using variation in market-level prices due to national mergers. While cross-sectional studies can use variation in concentration across markets to provide some insight, the correlation between concentration and dispersion could very well be influenced by unobservable market-level characteristics. Panel studies partially solve the problem by controlling for market-specific effects, but unobserved factors could still drive the results. Merger analyses can more clearly isolate the effects of market power on dispersion, since the decision of two firms to merge is unlikely to be related to performance in a specific market. Second, the variation in consumer segmentation of the airline mergers in question provides a basis for thinking specifically about the role of price discrimination. Even considering only dispersion based on price discrimination, there is some debate over which direction market concentration should push dispersion. This chapter lays the groundwork for an articulated model of dispersion due to price discrimination and its relation to concentration. Finally, we extend the substantial literature analyzing

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1 For instance, it may be that some markets have more competitors because they are more conducive to price discrimination between leisure and business travelers. If so, price dispersion could seem to increase with competition.

2 For instance, market power may fall over time in markets that experience entry, but entry in those markets could be due to an influx of business travelers. If that change leads to more price discrimination, one might naively conclude that competition is associated with greater price dispersion.
merger effects by highlighting their role in affecting the distribution of fares. Most studies of merger effects, especially those done with antitrust concerns in mind, focus on the average price effect. However, there may be wide variation in a merger’s effect on prices across consumer segments, which could have implications for consumer welfare.

We identify consistent changes in the distribution of fares post-merger, namely, that prices rise more at the top of the fare distribution than at the bottom when the merger is between two legacy carriers (e.g. United and Continental). The opposite effect is observed for the merger between low-cost carriers Southwest and AirTran. We discuss possible explanations for the difference in outcomes, but further research is necessary to distinguish among the various effects at play. In the remainder of this chapter, I first provide some background on the sources of price dispersion before describing the literature most relevant to our study of price dispersion in the airline industry. Next, I briefly discuss how the data we use relates to that employed in Chapter 2 before presenting and describing results. Finally, I conclude with a summary and objectives for future research.

3.2 Background: Sources of Price Dispersion

This section briefly summarizes the primary explanations for equilibrium price dispersion that pertain to the airline industry, namely, price discrimination, costly search by consumers, and scarcity pricing, defined by demand uncertainty, capacity constraints, and perishable goods.

3.2.1 Price Discrimination

Price discrimination leads to price dispersion relative to a uniform price because, by definition, it involves setting different prices for the same good. The textbook treatment of price discrimination demonstrates that monopolists are able to price
discriminate, while perfectly competitive firms, assuming no other market frictions, are not. Imperfectly competitive markets, therefore, could be expected to fall somewhere in between these two extremes, suggesting that market power should be positively correlated with the price dispersion that arises due to discriminatory pricing. Indeed this is the case for Borenstein’s (1985) and Holmes’s (1989) models of monopolistically competitive price discrimination when sorting is based on consumers’ industry elasticity of demand. In other words, price discrimination based on consumers’ willingness to pay for air travel in general will tend to decrease with competition. However, in the presence of imperfect competition, cross-brand substitution is tremendously important. The aforementioned models demonstrate that price discrimination based on cross-brand elasticities (i.e. differences in customer loyalty) will actually tend to increase with competition.

Analyzing a duopoly model in which firms provide products that differ in quality, Corts (1998) shows that third-degree price discrimination, in which consumer segments are verifiable (e.g. senior citizen discounts), can lead to either higher or lower prices relative to a uniform price. Consumers fall into one of two observable groups, one that cares about quality (“choosy”) and one that does not (“cheap”). Resultant prices depend on how the firms rank the consumer segments. Relative to Holmes (1989), Corts (1998) allows for asymmetry in this ranking. In other words, the two firms may choose different consumer groups to target as their “strong” (i.e. more price inelastic) market, which can lead an environment of “all-out competition” in which prices are lower for both groups.

Cooper et al. (2005) review the antitrust implications of competitive spatial price discrimination, which unambiguously benefits consumers. This sort of price discrimination runs contrary to the motivation for the Robinson-Patman Act, which deters price discrimination in order to benefit consumers. Price discrimination of the type analyzed by Cooper et al. (2005) exhibits the best response asymmetry described...
in Corts (1998). This asymmetry leads firms to view different consumer segments
as strong, a common outcome when products are spatially differentiated and con-
sumers’ preferences over firm location can be observed. One possible outcome of this
asymmetry is Corts’s (1998) “all-out competition,” which as the name implies shifts
surplus from firms to consumers. This situation is in contrast to best response sym-
metry, in which firms agree on which customer segment represents the strong market
(e.g. business travelers), and price discrimination is aimed at attracting customers
into the market rather than stealing them from rivals.

Stole (2007) provides an excellent review of the literature on oligopolistic price dis-
crimination. As previously mentioned, under third-degree price discrimination, the
effect of competition on price dispersion depends on the nature of firms’ best-response
curves. In the case of best-response symmetry, price dispersion across consumer seg-
ments can increase when brand preferences are stronger in the strong market, such
that cross-price elasticities are lower. Under best-response asymmetry, the same re-
sult can arise, but so can all-out competition or all-out price increases. Theoretical
results are more scarce in the case of second-degree price discrimination, in which
sorting of unobservable consumer groups relies on their selecting the appropriate
product. Outcomes can depend on whether consumers buy from one or multiple
firms, as well as the relationship between quality preferences and brand preferences.
Spulber (1989) provides a tractable model in which consumers buy from only one
firm, and preferences for quality are identical to the strength of brand (location)
preferences. He finds that competition will only reduce the level of prices, while
quality allocations are equivalent to those of a monopolist operating multiple plants,
conditional on all consumers being served.

Rochet and Stole (2002) develop a model in which consumers have horizontal,
separable preferences over firms and quality. As the importance of firm preferences
increases, the incentive to discriminate based on quality is reduced, leading to cases
where quality distortion is reduced or eliminated. In some cases, duopoly competition would lead to lower price dispersion than under monopoly.

3.2.2 Consumer Search

In addition to price discrimination, informational frictions can also lead to dispersion in prices. Beginning with Stigler’s (1961) seminal paper, a number of models have demonstrated that consumer search can support equilibrium price dispersion for homogeneous products. Relating that dispersion directly to mergers, Janssen et al. (2007) consider the effect of a change in the number of firms in a homogeneous goods market with consumer search. Building on Stahl’s (1989) model of sequential search with perfect recall, the authors find that when search costs are high enough, mergers can lead to lower average prices. The lower prices lead to higher profits for the merging firms because they induce search among a contingent of consumers that previously did not participate in the market since price-shopping was not worthwhile. In earlier work, Janssen and Moraga-González (2004) employ a non-sequential search model. They find that when consumers search with low intensity, more competition leads to greater price dispersion. When search intensity is high, adding another firm will tend to lower prices if the number of competitors is low to begin with, but will tend to raise prices when the number of competitors is large. Arnold and Saliba (2011) demonstrate that price dispersion can persist when prices are known but there is costly search over product availability. The authors extend Arnold’s (2000) duopoly model by allowing asymmetric capacity constraints. In equilibrium, consumers are more likely to search at larger firms, despite their tendency to charge higher prices, because of the cost associated with visiting a store that has run out of a particular good. On the empirical side, Orlov (2011) finds that internet penetration,

3 See Reinganum (1979), Burdett and Judd (1983), and Stahl (1989) for widely known approaches and excellent reviews of earlier work.
by reducing search costs, increased intrafirm price dispersion while lowering average prices. For several other references to empirical tests of consumer search models, see Janssen et al. (2007).

3.2.3 Capacity Constraints and Uncertain Demand

Following the model of Prescott (1975), several papers have analyzed another explanation for price dispersion occurring when firms face capacity constraints and uncertain demand for a perishable good.\(^4\) Examples of such settings include hotels, cruises, and air travel. To maximize expected profits, they set low prices for some units to make sales if demand turns out to be low, but they reserve some high-priced capacity to take advantage of high demand, a strategy dubbed scarcity pricing. Dana (1999) presents a model with symmetric, capacity-constrained oligopolists who face uncertain demand and a marginal cost of capacity. In the context of the airline industry, firms choose a price schedule and a number of seats to offer at each price before observing the level of demand. The author shows that, while there is no pure strategy equilibrium for any single price, a unique pure strategy equilibrium exists in price distributions. Moreover, market competition enlarges the support of prices, although not necessarily measures of price dispersion such as the Gini coefficient. The model allows for only one type of consumer, eliminating the possibility of price dispersion based on price discrimination, but it demonstrates that dispersion based on scarcity pricing could increase with competition. Escobari and Gan (2007) support these predictions with data from the airline industry.

3.3 Price Dispersion in Airlines

Airline tickets are a popular subject in the literature on price dispersion. Not only is air travel an enormous and economically vital market, but airline tickets are also

\(^4\) See, for example, Eden (1990), Dana (1999), Dana (2001), and Gale and Holmes (1993)
known for their variety of prices and attributes. Fare restrictions/classes, departure times, connections, aircraft sizes, and more recently, aircraft and airport amenities each play a role in the price of a ticket. Thanks to airline revenue management (also known as yield management) programs, even tickets for identical products are often priced differently depending on the time and date of purchase. Indeed, Borenstein and Rose (2007) indicate that price dispersion has increased over time, coinciding with the advent of yield management systems. The literature on price dispersion in airlines can roughly be divided into two strands, one documenting features of dispersion, and another aimed at disentangling the underlying sources of dispersion. The second strand relates directly to the debate over the effect of concentration on price dispersion, which has received a great deal of attention due to conflicting results across studies. I summarize both strands below, before briefly covering work related to the price effects of airline mergers.

### 3.3.1 Describing Dispersion

Cho et al. (2008) uses a cross-sectional analysis of airline industry data to show how price dispersion varies with operational characteristics. The paper is also helpful for understanding the impact of revenue management on price dispersion. An important point made by the authors is that, because revenue management is aimed at maximizing revenue and not necessarily filling planes, price dispersion is likely to be negatively correlated with load factor and positively correlated with revenue. They find that higher capacity on a route increases load factors and price dispersion, but their analysis is limited in that it cannot control for carrier or route fixed effects. Mantin and Koo (2009) analyze intertemporal price dispersion using data from Farecast.com. The authors observe the lowest round-trip fares for a given route, beginning at 90 days prior to the flight. While the paper identifies key determinants of intertemporal price dispersion, including market-level measures of population, in-
come, and business travel, the analysis abstracts away from contemporaneous fare dispersion across fare types or carriers. Interestingly, the authors find that intertemporal price dispersion increases with the presence of low-cost carriers, while overall market concentration has no effect. Cornia et al. (2012) demonstrate that airline price dispersion is pro-cyclical, consistent with second-degree price discrimination. Lijsen and Voort (2010) consider price dispersion between carriers, not within, using a sample of European airline routes. They show that asymmetry in product differentiation leads to both price dispersion and market share inequality. As such, they argue that HHI should be decomposed into two components: asymmetry in market shares and the inverse of the number of firms. Using this decomposition, they show that price dispersion between firms decreases with competition (number of firms) and increases with market share asymmetry. Bachis and Piga (2011) identify internet sales as contributing to price dispersion.

3.3.2 Disentangling Dispersion

Borenstein and Rose (1994) document significant price dispersion in airline fares: Consumers purchasing tickets from the same carrier on the same route often pay vastly different prices. The authors aim to distinguish whether this dispersion is due to discriminatory pricing or underlying cost differences. Using a cross-section of routes in 1986, they show that dispersion varies by market, increasing on routes that are more competitive, and decreasing on routes with higher flight density or more tourist travel. These patterns could be explained by Borenstein’s (1985) or Holmes’s (1989) model of monopolistically competitive price discrimination. In addition to dispersion due to price discrimination, Borenstein and Rose (1994) find evidence of dispersion due to peak-load pricing (i.e. pricing to reduce congestion during peak times), models of which could also explain some of the patterns they attribute to price discrimination. As previously mentioned, the results of Borenstein and Rose (1994)
have been both confirmed and contested. For example, Gerardi and Shapiro (2009) examine how route-level price dispersion varies with market competition using panel data from 1993 to 2006. The authors find that competition reduces fare dispersion, a result more in line with the traditional treatments of price discrimination, and directly at odds with the findings of Borenstein and Rose (1994). A number of other papers contribute to this debate, also using airline data. For example, Stavins (2001) shows that price dispersion attributable to ticket restrictions increases as markets become more competitive, in line with Borenstein and Rose (1994). However, the author admits that her results should be treated with caution, since her data consists of a large sample of tickets on only 12 routes. Giaume and Guillou (2004) and Bilotkach (2006) also present results in agreement with Borenstein and Rose (1994). On the other hand, Gaggero and Piga (2011) and Evans et al. (1993) find evidence that price dispersion decreases with competition, in line with Gerardi and Shapiro (2009).

Dai et al. (2014) use airline data from 1993 to 2008 and find a non-monotonic effect of competition on price dispersion that accounts for the conflicting results in the literature. The authors find that more competition is related to more price dispersion in concentrated markets, but less price dispersion in competitive markets, a relationship that is consistent with an oligopolistic model of second-degree price discrimination. The inverse-U relationship is driven by two competing effects: one on prices, and another on qualities. The price effect causes prices for low-end products to decline (in percentage terms) faster with competition than prices for high-end products, leading to more dispersion. While this effect dominates in concentrated markets, the opposite effect obtains in competitive markets. Puller et al. (2009) uses data from an online computer reservation system to test whether airline ticket price dispersion at the carrier-route level is due to scarcity pricing or price discrimination. The authors find that, while scarcity pricing theories help explain differences in mean
fares, factors associated with second-degree price discrimination drive most of the variation in ticket prices at the carrier-route level. Along similar lines, Hayes and Ross (1998) argue that most dispersion is due to peak-load pricing rather than price discrimination.

Studies outside of the airline industry have also demonstrated mixed effects. For example, Busse and Rysman (2005) examine the effect of competition on price-size schedules for Yellow Pages advertising, finding that more competitive markets have not only lower prices overall, but differentially lower prices for larger ads, suggesting that competition increases quantity discounting. Using data on laundry detergent prices in six countries, Clerides and Michis (2006) find preliminary evidence of a non-monotonic relationship.

Given the potential importance of market power for price discrimination, significant sources of airline market power should be mentioned. Borenstein (1989) establishes the separate importance of route dominance and endpoint airport dominance for market power. He finds that while origin airport market share has a positive effect on fares, concentration at the origin airport matters very little, suggesting there is no “umbrella effect” of a given carrier’s dominance for other carriers’ markups. Borenstein (1991) finds strong evidence that origin airport market share increases route-level market share, although the effect is weakened on routes dominated by tourism. The analysis treats markets as directional, differencing out carrier-route effects. The pattern persists regardless of whether there is substantial difference in carriers’ prices.

3.3.3 Price Effects of Mergers

As highlighted earlier, national mergers provide an excellent opportunity for studying the effects of concentration on price dispersion. Given the appeal of merger analysis in this regard, there are surprisingly few studies relating mergers to price dispersion.
The most similar paper to this work is Dobson and Piga (2013), who examine two low-cost carrier mergers in Europe. Using an extensive sample of posted prices from 2002 to 2005, they find evidence that the acquiring firm imposed new intertemporal pricing policies, which increased fare dispersion. In particular, the authors report that prices for early bookers on the acquired routes fell, while very late bookers on those routes paid higher prices. A number of other papers examine the price effects of mergers without touching on distributional concerns. Luo (2014) looks at the price effect of the Delta/Northwest merger, as does Chapter 2 of this dissertation.

Outside the airline industry, two papers are most relevant to this chapter. Using data on mortgage rates, Allen et al. (2014) evaluate the distributional effect of a merger between two Canadian banks. They find that the merger reduces price dispersion by increasing prices more at the lower end of the rate distribution than at the higher end. The authors associate paying lower rates with having a higher ability to negotiate and/or search, such that consumers who are unwilling or unable to negotiate/search are the least affected by the merger. Consumers who choose to negotiate/search are the most affected, since they are less able shop around post-merger. Kalnins et al. (2010) use data on hotels to argue that mergers can increase output in revenue management industries, namely, those with short-term capacity constraints, perishable goods, and uncertain demand. They find that for a large set of hotel mergers, output rises after local mergers when average capacity utilization is high and demand is uncertain. In markets where demand is more predictable, output appears unchanged by the mergers, leading the authors to conclude that mergers reduce demand uncertainty, which reduces the likelihood that rooms will go unsold due to prices that are too high for low realizations of demand. They also claim that binding capacity constraints coupled with low demand uncertainty should imply little to no effect of a merger, since the firms will price to fill capacity before and after merging.
A related literature specific to the airline industry concerns the impact of codeshare agreements. Armantier and Richard (2008) apply a discrete choice model akin to Berry et al. (2006) to quantify the welfare consequences of the 1999 code-share agreement between Continental Airlines and Northwest Airlines. The authors find evidence that non-stop passengers suffered a loss of surplus, whereas the surplus of connecting passengers increased, amounting to a neutral effect on average, but suggesting that the code-share agreement allowed the airlines to better price discriminate. Important for welfare analysis is the finding that the welfare improvement due to price decreases was more than offset by welfare reductions due to changes in other product attributes. Gayle and Brown (2015) estimate the demand- and supply-side response to the Delta-Northwest-Continental alliance, finding evidence that the alliance increased demand for those carriers’ products without engendering collusion. The alliance was formed in 2003 and encountered a fair bit of concern regarding its potential for facilitating collusion on overlapping routes. In a related paper, Gayle (2008) showed that the alliance was associated with a slight price increase, but only on virtual codeshared flights. An increase in prices could point to collusion or simply to increased demand. There is reason to believe that alliances increase demand by giving frequent flyers more opportunities to use and earn miles. Gayle and Brown (2015) go a step further by estimating a model of supply and demand. They show that the alliance is associated with increased demand and statistically reject the hypothesis that the firms are pricing collusively. The paper only looks at flights with virtual, not traditional, codesharing.

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5 Traditional codesharing requires an interline ticket, so a passenger changes operating carriers at some point. For example, Northwest sells a flight in which it operates one of the segments, and Delta operates another. Virtual codesharing has no interline travel, so the passenger is always traveling on the same operating carrier’s planes, even though the ticketing carrier was someone else. For example, Northwest sells a flight entirely operated by Delta.
3.4 Data

The data used in this chapter is substantially the same as that used in Chapter 2. In each of the following analyses, the unit of observation is a summary statistic of the distribution of prices for a direct, round-trip ticket offered by a given carrier on given route observed in a particular quarter. A direct flight is one without any change-of-plane connections. A route is a directional origin-destination pair; for instance, LAX to JFK and JFK to LAX are different routes. As an example, suppose we observe $X$ sampled passengers flying from Raleigh-Durham (RDU) to Nashville (BNA) on Southwest Airlines during the second quarter of 2006. Those passengers paid $Y$ different fares, ranging from $A$ to $B$, with a median of $C$, and 10th and 90th percentiles of $D$ and $E$, respectively. Directional carrier-route observations are used even in specifications where we split the sample according to nondirectional route characteristics (i.e. the convenience of connecting substitutes and the index of business travel).

For all regressions, our focus is on what happens to the price distribution of routes with significant overlap by the merging carriers (“concern” routes) relative to routes where the merger poses little to no concern for raising market power. We include route-carrier fixed effects, time fixed effects (i.e. dummies for quarter), and the interactions of both distance and population with time fixed effects. For each merger, we designate a control group comprised of tickets of two other legacy carriers that did not have a merger during the sample period used. The mergers, their relevant timeframes, and their control groups are given in Table 3.1.
### Table 3.1: Mergers Analyzed

<table>
<thead>
<tr>
<th>Merging Carriers</th>
<th>Carrier Codes</th>
<th>Announced</th>
<th>Years Used</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southwest Airlines / AirTran Airways</td>
<td>WN/FL</td>
<td>September 2010</td>
<td>2006-2011</td>
<td>AA, US</td>
</tr>
</tbody>
</table>
3.5 Results

3.5.1 Baseline empirical specification

In the baseline empirical specification, post-merger price dispersion increased for the US/HP and UA/CO mergers, while the DL/NW merger was associated with only a temporary increase in dispersion. The DL/NW merger caused small decreases on low-price fares and small increases on high-price fares. The UA/CO merger led to increased prices at all price levels, with the strongest effects at higher price levels. The US/HP merger reduced fares for low-price tickets and increased fares for high-price tickets. In contrast, the WN/FL merger reduced price dispersion by increasing fares more for low-price tickets than for high-price tickets. The AA/TW merger exhibited no significant pattern.

The increased price dispersion of DL/NW, UA/CO, and US/HP may be attributable to greater scope for price discrimination between leisure and business travelers. The argument that greater market power leads to more price discrimination is consistent with Gerardi and Shapiro (2009) and to a lesser extent Borenstein and Rose (1994). The opposite result from the WN/FL merger lends further validation to the price discrimination story. Low-cost carriers WN and FL primarily target leisure travelers, and as a result, both have a fairly homogeneous consumer base. With less room for price discrimination, it’s not surprising that we would find a reduction in price dispersion.
### Table 3.2: DL/NW Baseline Results: Deciles

<table>
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<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
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<th>(9)</th>
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<td>(0.042)</td>
<td>(0.041)</td>
<td>(0.047)</td>
<td>(0.049)</td>
<td>(0.046)</td>
<td>(0.035)</td>
<td>(0.030)</td>
<td>(0.026)</td>
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<td>postDLNWconcern</td>
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<td>-0.041</td>
<td>-0.008</td>
<td>0.010</td>
<td>0.030</td>
<td>0.050</td>
<td>0.063</td>
<td>0.078</td>
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<td>(0.054)</td>
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<td>(0.039)</td>
<td>(0.047)</td>
<td>(0.045)</td>
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<td>(0.041)</td>
<td>(0.050)</td>
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<td>19,768</td>
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<td>19,768</td>
<td>19,768</td>
<td>19,768</td>
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</tr>
<tr>
<td>R-squared</td>
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<td>0.18</td>
<td>0.18</td>
<td>0.17</td>
<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
<td>0.13</td>
<td>0.11</td>
</tr>
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### Table 3.3: DL/NW Baseline Results: Dispersion

<table>
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<td>duringDLNWconcern</td>
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<td>postDLNWconcern</td>
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<td>(0.081)</td>
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<tr>
<td>Observations</td>
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<td>R-squared</td>
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<td>0.08</td>
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Table 3.4: UA/CO Baseline Results: Deciles

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<tr>
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<td>0.18</td>
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<td>0.17</td>
<td>0.16</td>
<td>0.15</td>
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.5: UA/CO Baseline Results: Dispersion

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<td>R-squared</td>
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
### Table 3.6: AA/TW Baseline Results: Deciles

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<td>duringAATWconcern</td>
<td>-0.086***</td>
<td>-0.032</td>
<td>-0.037</td>
<td>-0.032</td>
<td>-0.060***</td>
<td>-0.075***</td>
<td>-0.117***</td>
<td>-0.079*</td>
<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
<td>(0.024)</td>
<td>(0.035)</td>
<td>(0.032)</td>
<td>(0.019)</td>
<td>(0.024)</td>
<td>(0.036)</td>
<td>(0.036)</td>
<td>(0.067)</td>
</tr>
<tr>
<td>postAATWconcern</td>
<td>-0.022</td>
<td>-0.009</td>
<td>-0.011</td>
<td>-0.002</td>
<td>-0.020</td>
<td>-0.031</td>
<td>-0.075</td>
<td>-0.092</td>
<td>-0.034</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.029)</td>
<td>(0.048)</td>
<td>(0.060)</td>
<td>(0.049)</td>
<td>(0.046)</td>
<td>(0.065)</td>
<td>(0.095)</td>
<td>(0.091)</td>
</tr>
<tr>
<td>Observations</td>
<td>15,197</td>
<td>15,197</td>
<td>15,197</td>
<td>15,197</td>
<td>15,197</td>
<td>15,197</td>
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<td>15,197</td>
<td>15,197</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.17</td>
<td>0.17</td>
<td>0.16</td>
<td>0.16</td>
<td>0.18</td>
<td>0.19</td>
<td>0.19</td>
<td>0.20</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### Table 3.7: AA/TW Baseline Results: Dispersion

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>duringAATWconcern</td>
<td>0.043</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>(0.080)</td>
<td>(0.097)</td>
</tr>
<tr>
<td>postAATWconcern</td>
<td>0.005</td>
<td>-0.031</td>
</tr>
<tr>
<td></td>
<td>(0.105)</td>
<td>(0.143)</td>
</tr>
<tr>
<td>Observations</td>
<td>15,197</td>
<td>15,197</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.28</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Table 3.8: US/HP Baseline Results: Deciles

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>duringUSHPconcern</td>
<td>-0.158***</td>
<td>-0.148**</td>
<td>-0.114</td>
<td>-0.058</td>
<td>-0.024</td>
<td>-0.008</td>
<td>0.017</td>
<td>-0.057</td>
<td>-0.071</td>
</tr>
<tr>
<td>postUSHPconcern</td>
<td>-0.185***</td>
<td>-0.073</td>
<td>0.008</td>
<td>0.043</td>
<td>0.053*</td>
<td>0.056**</td>
<td>0.068*</td>
<td>0.038</td>
<td>-0.028</td>
</tr>
<tr>
<td>Observations</td>
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<td>13,092</td>
<td>13,092</td>
<td>13,092</td>
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<td>13,092</td>
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<td>13,092</td>
<td>13,092</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.19</td>
<td>0.18</td>
<td>0.18</td>
<td>0.16</td>
<td>0.14</td>
<td>0.13</td>
<td>0.12</td>
<td>0.11</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.9: US/HP Baseline Results: Dispersion

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gini_log</td>
<td>p90minusp10</td>
</tr>
<tr>
<td>duringUSHPconcern</td>
<td>0.173***</td>
<td>0.009</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.099)</td>
</tr>
<tr>
<td>postUSHPconcern</td>
<td>0.265***</td>
<td>0.120</td>
</tr>
<tr>
<td></td>
<td>(0.083)</td>
<td>(0.083)</td>
</tr>
<tr>
<td>Observations</td>
<td>13,114</td>
<td>13,114</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.12</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Table 3.10: WN/FL Baseline Results: Deciles

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>p10</td>
<td><strong>0.087</strong>*</td>
<td>0.104***</td>
<td>0.110***</td>
<td>0.102***</td>
<td>0.103***</td>
<td>0.102***</td>
<td>0.087***</td>
<td>0.068***</td>
<td>0.066**</td>
</tr>
<tr>
<td>p20</td>
<td>(0.022)</td>
<td>(0.021)</td>
<td>(0.019)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.015)</td>
<td>(0.014)</td>
<td>(0.021)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>p30</td>
<td><strong>0.170</strong>*</td>
<td>0.175***</td>
<td>0.157***</td>
<td>0.146***</td>
<td>0.124***</td>
<td>0.104***</td>
<td>0.074***</td>
<td>0.047</td>
<td>0.051</td>
</tr>
<tr>
<td>p40</td>
<td>(0.027)</td>
<td>(0.030)</td>
<td>(0.028)</td>
<td>(0.026)</td>
<td>(0.026)</td>
<td>(0.026)</td>
<td>(0.027)</td>
<td>(0.030)</td>
<td>(0.033)</td>
</tr>
<tr>
<td>p50</td>
<td>20,072</td>
<td>20,072</td>
<td>20,072</td>
<td>20,072</td>
<td>20,072</td>
<td>20,072</td>
<td>20,072</td>
<td>20,072</td>
<td></td>
</tr>
<tr>
<td>p60</td>
<td>0.17</td>
<td>0.18</td>
<td>0.18</td>
<td>0.17</td>
<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>p70</td>
<td>0.107</td>
<td>0.104</td>
<td>0.103</td>
<td>0.102</td>
<td>0.087</td>
<td>0.068</td>
<td>0.066</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p80</td>
<td>(0.021)</td>
<td>(0.021)</td>
<td>(0.019)</td>
<td>(0.018)</td>
<td>(0.018)</td>
<td>(0.015)</td>
<td>(0.014)</td>
<td>(0.021)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>p90</td>
<td><strong>0.170</strong>*</td>
<td>0.175***</td>
<td>0.157***</td>
<td>0.146***</td>
<td>0.124***</td>
<td>0.104***</td>
<td>0.074***</td>
<td>0.047</td>
<td>0.051</td>
</tr>
</tbody>
</table>

Observations: 20,072

R-squared: 0.17, 0.18, 0.18, 0.17, 0.16, 0.15, 0.14, 0.12, 0.11

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.11: WN/FL Baseline Results: Dispersion

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>gini_log</td>
<td>-0.007</td>
<td>0.037</td>
</tr>
<tr>
<td>p90minusp10</td>
<td>(0.023)</td>
<td>(0.033)</td>
</tr>
<tr>
<td>duringWNFLconcern</td>
<td>-0.157***</td>
<td>-0.074</td>
</tr>
<tr>
<td>(0.043)</td>
<td>(0.053)</td>
<td></td>
</tr>
<tr>
<td>postWNFLconcern</td>
<td>20,072</td>
<td>20,072</td>
</tr>
<tr>
<td>Observations</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.12</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1
3.5.2 Convenient vs. Inconvenient Connecting Substitutes

One possible explanation for prices rising more at the top of the fare distribution than at the bottom is simply the presence of greater competitive price pressures for lower quality tickets. To examine the validity of that explanation, we split the concern routes into two groups, based on how convenient are the connecting substitutes of other carriers on that concern route. We estimate the same regression on each group, maintaining the control group of AA/US direct tickets. DL/NW and UA/CO concern routes are pooled together, so that the number of concern routes in each group isn’t too small. The nondirectional metric used is (Best Connecting Travel Time)/(Direct Travel Time).

For UA/CO and DL/NW, we see very clear increases in price dispersion on routes with the most convenient connecting substitutes. This dispersion is primarily due to fares rising more for high-price tickets, while low-price tickets experience no change. The absence of a price increase for low-price tickets is not surprising if we consider convenient connecting flights to be suitable alternatives for leisure travelers, but not for business travelers. For routes with inconvenient connections, we see less of a merger-related increase in price dispersion relative to routes with convenient connections. Moreover, fares appear to rise at all price levels, and by a greater percentage relative to routes with convenient connections.
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>p10</th>
<th>p20</th>
<th>p30</th>
<th>p40</th>
<th>p50</th>
<th>p60</th>
<th>p70</th>
<th>p80</th>
<th>p90</th>
</tr>
</thead>
<tbody>
<tr>
<td>during_convenient_concern</td>
<td>-0.026</td>
<td>0.019</td>
<td>0.031</td>
<td>0.027</td>
<td>0.028</td>
<td>0.031</td>
<td>0.027</td>
<td>0.028</td>
<td>0.031</td>
</tr>
<tr>
<td>post_convenient_concern</td>
<td>0.042</td>
<td>-0.041</td>
<td>0.035</td>
<td>0.042</td>
<td>0.029</td>
<td>0.037</td>
<td>0.043</td>
<td>0.045</td>
<td>0.063</td>
</tr>
<tr>
<td>Observations</td>
<td>19,840</td>
<td>19,840</td>
<td>19,840</td>
<td>19,840</td>
<td>19,840</td>
<td>19,840</td>
<td>19,840</td>
<td>19,840</td>
<td>19,840</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.17</td>
<td>0.18</td>
<td>0.17</td>
<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
<td>0.13</td>
<td>0.14</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p < 0.01, ** p < 0.05, * p < 0.1

Table 3.13: UA/CO and DL/NW Pooled Results, High Convenience: Dispersion

<table>
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<th>VARIABLES</th>
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<th>p20</th>
<th>p30</th>
<th>p40</th>
<th>p50</th>
<th>p60</th>
<th>p70</th>
<th>p80</th>
<th>p90</th>
</tr>
</thead>
<tbody>
<tr>
<td>gini_logodds</td>
<td>0.181***</td>
<td>0.201***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p90_minus_p10</td>
<td>0.045***</td>
<td>0.068**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>19,840</td>
<td>19,840</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.12</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses

*** p < 0.01, ** p < 0.05, * p < 0.1
Table 3.14: UA/CO and DL/NW Pooled Results, Low Convenience: Deciles

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
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<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>p10</td>
<td>0.008</td>
<td>0.004</td>
<td>-0.001</td>
<td>0.003</td>
<td>-0.021</td>
<td>-0.022</td>
<td>0.024</td>
<td>0.081</td>
<td>0.111**</td>
</tr>
<tr>
<td>during_convenient_concern</td>
<td>(0.078)</td>
<td>(0.069)</td>
<td>(0.070)</td>
<td>(0.077)</td>
<td>(0.062)</td>
<td>(0.047)</td>
<td>(0.046)</td>
<td>(0.054)</td>
<td>(0.055)</td>
</tr>
<tr>
<td>post_convenient_concern</td>
<td>0.124*</td>
<td>0.089</td>
<td>0.106</td>
<td>0.109*</td>
<td>0.098*</td>
<td>0.095*</td>
<td>0.128**</td>
<td>0.155***</td>
<td>0.167***</td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
<td>(0.067)</td>
<td>(0.066)</td>
<td>(0.066)</td>
<td>(0.055)</td>
<td>(0.051)</td>
<td>(0.053)</td>
<td>(0.055)</td>
<td>(0.058)</td>
</tr>
<tr>
<td>Observations</td>
<td>19,784</td>
<td>19,784</td>
<td>19,784</td>
<td>19,784</td>
<td>19,784</td>
<td>19,784</td>
<td>19,784</td>
<td>19,784</td>
<td>19,784</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.17</td>
<td>0.18</td>
<td>0.18</td>
<td>0.17</td>
<td>0.16</td>
<td>0.16</td>
<td>0.15</td>
<td>0.13</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.15: UA/CO and DL/NW Pooled Results, Low Convenience: Dispersion

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gini_logodds</td>
<td>p90minusp10</td>
</tr>
<tr>
<td>during_convenient_concern</td>
<td>0.101</td>
<td>0.152</td>
</tr>
<tr>
<td></td>
<td>(0.106)</td>
<td>(0.099)</td>
</tr>
<tr>
<td>post_convenient_concern</td>
<td>0.075</td>
<td>0.200**</td>
</tr>
<tr>
<td></td>
<td>(0.096)</td>
<td>(0.094)</td>
</tr>
<tr>
<td>Observations</td>
<td>19,784</td>
<td>19,784</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.11</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
3.5.3 Business vs. Leisure Markets

We now split the concern routes based on a measure of market-level business travel. We construct nondirectional indices for all concern routes using Severin Borenstein’s city-level index. The market-level index is simply the product of the origin and destination indices. The same control group of AA/US direct flights is used in both groups.

We see greater increases in post-merger price dispersion for UA/CO and DL/NW routes that involve more business travelers. This difference is driven by the fact that low-price fares stay the same for business routes, but increase moderately for leisure routes. For the WN/FL merger, there is a much smaller difference between business and leisure routes. On DL/NW and UA/CO routes that are predominately business, increases in capacity that cater to the business travelers could also reduce costs for the leisure travelers. Low-end fares would then be kept low after the merger on business routes, but not on leisure routes. The results do not seem to support that travelers on leisure routes are more price-sensitive, or perhaps that this effect is outweighed by the cost-reduction explanation. Since WN and FL’s consumer base is mostly leisure regardless of whether the route has a higher or lower business index, this cost-reduction explanation would not hold for the WN/FL merger. Behavior of the price percentiles should be more similar between business and leisure routes in the low-cost merger.
Table 3.16: UA/CO and DL/NW Pooled Results, High Business: Deciles

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>during_convenient_concern</td>
<td>-0.034</td>
<td>-0.050</td>
<td>-0.056</td>
<td>-0.067</td>
<td>-0.076*</td>
<td>-0.062</td>
<td>-0.011</td>
<td>0.123**</td>
<td>0.145**</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.040)</td>
<td>(0.040)</td>
<td>(0.042)</td>
<td>(0.044)</td>
<td>(0.041)</td>
<td>(0.027)</td>
<td>(0.056)</td>
<td>(0.059)</td>
</tr>
<tr>
<td>post_convenient_concern</td>
<td>-0.000</td>
<td>-0.021</td>
<td>0.015</td>
<td>0.029</td>
<td>0.039</td>
<td>0.037</td>
<td>0.075*</td>
<td>0.146***</td>
<td>0.155***</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.029)</td>
<td>(0.041)</td>
<td>(0.050)</td>
<td>(0.049)</td>
<td>(0.049)</td>
<td>(0.043)</td>
<td>(0.054)</td>
<td>(0.053)</td>
</tr>
<tr>
<td>Observations</td>
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<td>19,720</td>
<td>19,720</td>
<td>19,720</td>
<td>19,720</td>
<td>19,720</td>
<td>19,720</td>
<td>19,720</td>
<td>19,720</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.17</td>
<td>0.18</td>
<td>0.17</td>
<td>0.17</td>
<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
<td>0.13</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.17: UA/CO and DL/NW Pooled Results, High Business: Dispersion

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>during_convenient_concern</td>
<td>0.220***</td>
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<tr>
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Table 3.18: UA/CO and DL/NW Pooled Results, Low Business: Deciles

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<td>(0.054)</td>
<td>(0.053)</td>
<td>(0.044)</td>
<td>(0.041)</td>
<td>(0.055)</td>
<td>(0.041)</td>
<td>(0.044)</td>
<td>(0.039)</td>
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<td>post_convenient</td>
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<td>0.142***</td>
<td>0.143*</td>
<td>0.161*</td>
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<td>concern</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.080)</td>
<td>(0.070)</td>
<td>(0.061)</td>
<td>(0.045)</td>
<td>(0.045)</td>
<td>(0.044)</td>
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<td>0.17</td>
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<td>0.16</td>
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<td>0.13</td>
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Robust standard errors in parentheses

*** p < 0.01, ** p < 0.05, * p < 0.1

Table 3.19: UA/CO and DL/NW Pooled Results, Low Business: Dispersion

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<td>0.213*</td>
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<td>concern</td>
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<td>R-squared</td>
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Robust standard errors in parentheses

*** p < 0.01, ** p < 0.05, * p < 0.1

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### Table 3.20: WN/FL Results, High Business: Deciles

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<tr>
<td></td>
<td>p10</td>
<td>p20</td>
<td>p30</td>
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<td>p50</td>
<td>p60</td>
<td>p70</td>
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<td>duringWNFLconcern</td>
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<td>0.081***</td>
<td>0.055**</td>
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<td>(0.071)</td>
<td>(0.077)</td>
<td>(0.063)</td>
<td>(0.035)</td>
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<td>0.114*</td>
<td>0.089</td>
<td>0.061</td>
<td>0.042</td>
</tr>
<tr>
<td></td>
<td>(0.110)</td>
<td>(0.116)</td>
<td>(0.104)</td>
<td>(0.079)</td>
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<td>(0.062)</td>
<td>(0.061)</td>
<td>(0.080)</td>
<td>(0.107)</td>
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<tr>
<td>R-squared</td>
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<td>0.16</td>
<td>0.15</td>
<td>0.14</td>
<td>0.12</td>
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### Table 3.21: WN/FL Results, High Business: Dispersion

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<td>(0.025)</td>
<td>(0.085)</td>
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<td>Observations</td>
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<td>20,144</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.12</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Table 3.22: WN/FL Results, Low Business: Deciles

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<td>0.105***</td>
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<td>0.084***</td>
<td>0.087***</td>
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<td>(0.017)</td>
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<td>(0.016)</td>
<td>(0.014)</td>
<td>(0.016)</td>
<td>(0.018)</td>
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<td>0.070**</td>
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<td>(0.030)</td>
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<td>0.18</td>
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<td>0.14</td>
<td>0.12</td>
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Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.23: WN/FL Results, Low Business: Dispersion

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<td>logodds</td>
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</tr>
<tr>
<td>p90minusp10</td>
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<td>-0.075</td>
</tr>
<tr>
<td></td>
<td>(0.052)</td>
<td>(0.061)</td>
</tr>
<tr>
<td>Observations</td>
<td>20,076</td>
<td>20,076</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.12</td>
<td>0.08</td>
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</tbody>
</table>

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
3.6 Conclusion

We have shown in this chapter that price dispersion tends to increase with market power after a merger when the merging firms both cater to a more heterogeneous consumer base that includes price-insensitive buyers. On the other hand, price dispersion decreases when the merging firms have a more homogeneously price sensitive set of customers.

Beyond informing the debate surrounding market power and price dispersion, these results have implications for antitrust evaluation of mergers. When examining a proposed merger, a primary concern for antitrust authorities is the potential for anticompetitive price outcomes, typically manifested in higher overall prices seen by consumers. While authorities like the U.S. Department of Justice will also consider mitigating factors, such as cost savings, increased product quality, and subsequent entry by new competitors, the central focus remains on long-run upward pricing pressure. In the airline industry, as in many markets, the overall level of prices is only part of the story. Quantity levels, product variety, and the degree of price discrimination could all play significant roles in evaluating the consumer welfare impacts of a merger. This chapter has demonstrated that prices tend to rise more at the high end of the fare distribution for a merger between carriers who are more likely to serve a heterogeneous set of consumers (i.e. business and leisure travelers). Given that antitrust authorities already have consumer welfare in mind, they may be interested to assess the welfare impacts of a merger on different consumer groups. The effects we’ve found suggest there may be a trade-off between squeezing a small number of price-insensitive travelers versus a wide swath of price-sensitive travelers. To the extent that these two groups have different valuations for travel, a particular outcome may be more valuable from a welfare standpoint.
4

Investment and Bankruptcy

4.1 Introduction

Since Arrow (1968), the industrial organization (I.O.) literature has acknowledged that investment irreversibility (a.k.a. “sunkness”) is a key determinant of the capital investment decision. One source of irreversibility is contractual investment, which effectively creates a cost to downsize. Given that reorganization under Chapter 11 of the U.S. Bankruptcy Code is a common setting for rescinding and/or renegotiating contracts, one would expect bankruptcy policy to play a significant role in investment models. Yet studies of capital investment in I.O. typically ignore bankruptcy entirely. Those that do allow for bankruptcy often view it as an involuntary and final outcome, tantamount to exit. However, most Chapter 11 filings are brought forth voluntarily, and two-thirds of public firms filing Chapter 11 eventually emerge from Bankruptcy Court protection. The corporate finance literature has adopted endogenous bankruptcy as the standard, beginning with Leland (1994) and Leland and Toft (1996), yet corporate finance models of capital investment and capital structure focus primarily on single-agent settings, leading one to ask, “What are the implica-
ations for jointly modeling investment and bankruptcy in the familiar I.O. context of strategic interaction?" 

This analysis is the first to show that making bankruptcy policy more creditor-friendly can discipline the investment behavior of non-bankrupt firms. Such “capacity discipline” takes the form of slower investment during periods of high demand coupled with faster disinvestment when demand is low. This new result arises from treating bankruptcy as a potentially non-final decision. Allowing firms to both enter and exit Chapter 11 reveals a previously unexplored investment-level impact of bankruptcy policy that is both significant and intuitive. I identify this effect as a potential cause of the recent capacity discipline observed in the airline industry. Using data on airline capacity, bankruptcy, and demand, I find support for the influence of bankruptcy policy on investment and evaluate the consequences of alternative bankruptcy policies.

Modeling bankruptcy as voluntary is reasonable given the appeal of Chapter 11 reorganization as a downsizing option. Chapter 11 gives malleability to many otherwise rigid contractual agreements. For example, financially distressed corporations can often renegotiate substantial portions of debt and other liabilities. On the non-financial side, Chapter 11 offers the potential to rescind or unilaterally alter many types of contracts. These non-financial protections can be especially important for companies with contractual commitments to utilize labor, capital, or materials because they open up cost-cutting options unavailable outside of bankruptcy. Among the more salient examples are pay cuts for unionized employees, renegotiated leasing terms, and pension benefit modifications.

To guide my analysis, I first develop a simple duopoly model that illustrates how stricter bankruptcy laws can lead to capacity discipline. In my model, the perceived cost of filing Chapter 11 (e.g. legal costs, expected repayments to creditors, risk of liquidation, etc.) increases in the creditor-friendliness of the bankruptcy regime.
Solving for equilibrium, I find that higher bankruptcy costs may tend to reduce firms’ incentive to invest during periods of high demand and increase their likelihood of disinvestment during periods of low demand. In other words, a more creditor-friendly bankruptcy policy may tend to rein in capacity investment behavior overall.

The airline industry presents the ideal context in which to test this link for three main reasons. First, the volatility of air travel demand and the prevalence of contractual labor and capital lease agreements in this industry make Chapter 11 especially appealing for distressed airlines. In other words, airlines satisfy the requirements of an industry that would benefit from Chapter 11: They heavily use long-term contracts, and they face volatile demand that sometimes necessitates breaching those contracts. Second, the prevalence of bankruptcy in the industry suggests it may be strategically used. To the extent that forward-looking firms internalize the reorganization option, they may tend to over-commit to long-term contracts, resulting in rampant bankruptcy when demand falls. The notorious insolvency of U.S. airlines fits this pattern. Third, anecdotal evidence suggests that an airline’s Chapter 11 filing can be strategically timed, indicating that bankruptcy is far from an exogenous event.

To test these implications empirically, I use data from the U.S. airline industry and exploit variation in the expected cost of reorganization due to the Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA) of 2005, which made significant changes to Chapter 11. In particular, BAPCPA reduced the amount of time allowed for a corporation to put forth an exclusive plan of reorganization, increased the amount and priority of wage and benefit claims, tightened the deadlines for accepting certain leases, and raised the priority and amount of a number of other claim categories. Legal scholars and practitioners both agree that the reform served to restrict debtor protection and reduce the likelihood of a successful reorganization,
particularly for the largest and most complex corporations.\textsuperscript{1} Indeed, under standard economic models of bargaining, such as Merlo and Wilson (1998), limiting the exclusivity period alone is enough to shift bargaining power to creditors.

My empirical approach to studying the link between bankruptcy and investment is three-fold. First, I perform a difference-in-differences analysis on airline industry data to determine whether BAPCPA had a disciplining effect on the investment behavior of large airlines. Second, I estimate a dynamic oligopoly model of investment and bankruptcy in order to measure BAPCPA’s impact on perceived Chapter 11 costs. Third, using the parameters estimated from the structural model, I simulate two counterfactual scenarios. In the first, I simulate equilibrium behavior as though BAPCPA had never been passed, finding an increase in industry capacity of about 5% relative to today’s levels. In the second scenario, I simulate a new equilibrium in which reorganization is prohibitively costly, allowing me to measure the overall effect of the Chapter 11 option on industry capacity. I find that eliminating Chapter 11 reduces total industry capacity by as much as 20%.

My analysis suggests that BAPCPA may have played a role in the capacity discipline recently observed in the airline industry. The phenomenon of capacity discipline has been well documented and discussed in the airline industry since 2006, yet explanations for its persistence have been little more than conjectures. Most observers cite airline consolidation, whereas others point to the disappearing emphasis on market share. Still others say competitors are just more rational nowadays, while most simply take the phenomenon as given. However, my theoretical model suggests a new mechanism: namely, an underlying change in bankruptcy law may have made holding capacity less desirable. My empirical results indicate that BAPCPA may indeed have been a contributing factor in disciplining airline capacity.

\textsuperscript{1} See, for example, Iverson (2012); Coelho (2010); Gilson (2010); Ayotte and Morrison (2009); Gottlieb et al. (2009); Selbst (2008); Herman (2007); Altman and Hotchkiss (2010); and Sprayregen et al. (2005).
The implications of my theoretical model can be extended to other industries. Understanding how airlines react to bankruptcy reform is valuable in its own right, yet my conceptual framework applies to any industry with heavily contractual investment and volatile demand. Steel, auto manufacturing, telecommunications, and even retail conform to this pattern. The capacity discipline engendered by a more creditor-friendly Chapter 11 should correlate positively with an industry’s degree of contract usage and demand volatility, and I hope to test these relationships in future research to better understand BAPCPA’s broader impact on investment.

In sum, this work and its extensions have important and timely implications for bankruptcy lawmakers around the world. Since 2011, the American Bankruptcy Institute’s Commission to Study the Reform of Chapter 11 has heard testimony from legal experts in a variety of fields regarding whether and how the current U.S. Bankruptcy Code should be amended. The Commission made its final report in December 2014. Congressional review of that report would greatly benefit from an understanding of how the non-financial provisions of bankruptcy law influence investment behavior outside of bankruptcy. Looking beyond the United States, Halliday and Carruthers (2007), in their study of the globalization of corporate insolvency regimes, document a convergence in bankruptcy law over the past two decades. The authors explain how international institutions, with significant U.S. support, have forged global norms, consequently influencing the lawmaking processes of transitional and developing countries. To the extent that U.S. practitioners and policymakers continue to contribute to global norm making, they must recognize how those norms may impact firm behavior, especially given the crucial role of capital investment for economic growth in developing economies.

The remainder of this chapter proceeds as follows: Section 4.2 reviews the relevant literature in industrial organization and corporate finance, while Section 4.3 provides background on bankruptcy law and the airline industry. Section 4.4 presents a simple
theoretical model linking reorganization and investment, and Section 4.5 overviews my three-part empirical strategy for analyzing that link. Section 4.6 describes the capacity, bankruptcy, and profit data I will use. Finally, I present and discuss my results in Section 4.7.

4.2 Literature Review

A number of studies have combined insights from corporate finance and industrial organization, yet none has shown how Chapter 11 can influence capital investment in a strategic environment. In this section I summarize relevant papers to show how my research combines the strategic interaction of industrial organization with the strategic role of bankruptcy in corporate finance. This chapter also augments the considerable body of work on airline competition by proposing a new mechanism for capacity discipline.

A rather extensive literature pertains to strategic capacity decisions, and capacity buildup is often described as an effective means of deterring entry. Eaton and Lipsey (1979) show that anticipated growth leads to buildup of capacity by incumbents that, when compared to the decisions of potential entrants, appears premature. Besanko et al. (2010) examines a dynamic model of discrete (“lumpy”) capacity investment, in which duopolists pre-commit to soft capacity constraints\(^2\) and then compete in a differentiated products market by setting prices subject to their respective constraints. They find that greater product homogeneity and capacity reversibility promote capacity preemption races. The authors also link excess capacity in the short run to capacity coordination in the long run, and show that capacity preemption races become more intense the more reversible is capital investment. This conclusion runs counter to the typical intuition that investment reversibility implies weaker commitment, such that the benefits of capacity leadership are transient. On the contrary,

\(^2\) “Soft” in this case means that the constraint can be violated at a high cost.
reversible investment encourages entry into the race to begin with by reducing the cost of committing to the race long-term. Hendricks et al. (1997) demonstrate another method of entry deterrence that is more particular to airlines. The authors show that operating a spoke market at a loss can be a dominant strategy for a hub carrier in response to entry by another firm into the spoke market. The network externalities inherent in a hub-and-spoke system therefore serve to deter entry. Aguirregabiria and Ho (2010) further this notion with their structural model of airline network competition. Takahashi (2011) estimates a continuous-time war of attrition among drive-in movie theaters. While the war of attrition model seems applicable to airlines’ choice of whether or not to file bankruptcy, Chapter 11 is usually filed as means of avoiding exit. The terminal nature of Takahashi’s model is therefore inappropriate for examining Chapter 11 reorganization.

Relating price and capacity competition in the airline industry, Snider (2009) develops a dynamic structural model in which cost asymmetries between large and small carriers lead to predatory behavior. He estimates the model to quantify the welfare implications of predation policy in a specific case: the Dallas-Ft. Worth (DFW) - Wichita (ICT) market, one of the four in which the U.S. Department of Justice alleged predatory conduct by American Airlines in 2000. The author’s main goal is to look at the implications of various static cost-based policies used by the courts in determining liability for predatory conduct. Unlike Besanko et al. (2010), Snider’s model treats market-level capacity adjustment as a continuous decision. However, a discrete treatment of capacity may be more appealing, since adding a single seat on a flight may necessitate adding an entire flight. Snider (2009) is one of the few papers I am aware of that combines capacity and price competition in the airline industry. Röller and Sickles (2000) is another, which measures market power using conjectural variation in the European airline industry. The authors employ a two-stage framework in which firms first purchase airplanes, and then compete in
prices. Unlike Snider (2009), Röller and Sickles (2000) define capacity in terms of fleet size, as will I.

Linking the financial structure of the firm to product market competition, Brander and Lewis (1988) and Brander and Lewis (1986) describe two effects. The limited liability effect captures the incentive a firm will have to pursue riskier product market strategies because equity holders do not share in downside risk below the point of bankruptcy. The strategic bankruptcy effect captures the incentive for a firm to pursue product market strategies that will increase the likelihood of competitor bankruptcy, which is contingent upon competitors’ financial structures. To isolate the linkages between financial markets and product markets, Brander and Lewis (1986) treat capital investment as fixed, allowing firms to choose their debt/equity ratios in the first stage of a two-stage duopoly model. The limited liability effect they describe is therefore solely due to short-run competition in output effected through changes in variable inputs. Linking capital structure to input decisions is Matsa (2010), which demonstrates how the presence of collective bargaining agreements can impact the choice of debt levels. This relationship is surely present in the airline industry, but it is beyond the scope of this work. Abstracting from the capital investment decision allows the aforementioned authors to focus on capital structure decisions and to avoid the additional effects of commitment, studied by Dixit (1979), Eaton and Lipsey (1980), Eaton and Eswaran (1984), Brander and Spencer (1983), and others. Whereas Brander and Lewis (1986) and Matsa (2010) linked the financial structure decision with output market strategies holding investment levels fixed, I will abstract from the capital structure decision and hold financial structure fixed, focusing on partially irreversible capacity investment.

Pindyck (1986) demonstrates that irreversibility of investment reduces optimal

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3 The interested reader in corporate finance should review the citations within those two articles for foundational work on capital structure choice, and in particular, for exceptions to the Modigliani and Miller (1958) theorems.
capacity relative to an environment where investment decisions are reversible. This seminal paper identified the real option value associated with delaying such an investment when demand is uncertain. Jou and Lee (2008) extend earlier analyses in the real options literature to an oligopolistic industry. Their model incorporates choices over capital structure, investment scale and timing, and bankruptcy filing. By treating investments as fixed and bankruptcy as final, however, the authors necessarily abstract away from both the evolution of capital in the industry and the transient nature of bankruptcy. Beginning with Leland (1994) and Leland and Toft (1996), the corporate finance literature has recognized that the decision to liquidate is an endogenous one. Suo et al. (2013) and references therein provide a few examples. Broadie et al. (2007) extend these models of optimal capital structure by allowing for reorganization under Chapter 11 in addition to liquidation under Chapter 7. Hamoto and Correia (2012) provide a nice overview of the different models of default, liquidation, and bankruptcy, identifying Broadie et al. (2007) as the only paper to incorporate Chapter 11, although several authors separate the default and liquidation decisions. Even in papers where bankruptcy is endogenous, it is typically treated as a decision rule, optimized before other decisions are made, rather than a repeated choice. Jayanti and Jayanti (2011) show that an airline’s bankruptcy filing or a shutdown is good news for equity-holders of rival airlines, while emergence of a carrier from bankruptcy generally reduces rivals’ firm value. These findings together may suggest that a bankrupt carrier’s strategic changes are profitable for everyone, begging the question of why they weren’t made outside of bankruptcy. However, changes in rival firms’ value could simply reflect the market’s valuation of the expected change in earnings due to a competitor’s potential liquidation.

While many authors have examined market competition and entry in airlines, few have touched on capacity investment at the industry level. On the bankruptcy side, papers discussing the airline industry have tended to look exclusively at prod-
uct market competition (e.g. Borenstein and Rose (1995), Ciliberto and Schenone (2012), and Busse (2002)). One of the papers upon which I have drawn heavily for institutional details is Ciliberto and Schenone (2012). These authors examine the effect of bankruptcy on product market competition, concluding that bankrupt airlines reduce prices under bankruptcy protection and increase them after emerging from bankruptcy, while competitors’ prices do not change significantly. The authors also find that bankrupt airlines permanently prune overall route structures, reduce flight frequency and shed capacity. In particular, relative to pre-bankruptcy figures, routes, frequencies, and capacities fall by about 25% under bankruptcy protection, and by another 25% upon emergence from Chapter 11.

Regarding estimation, Snider (2009) focuses on Markov Perfect Equilibria (MPE), as will I, and employs the forward simulation estimator of Bajari et al. (2007). Ryan (2012) applies the same estimator to an investment game among regional cement plants. Another recent contribution to the estimation of games in the airline industry is Aguirregabiria and Ho (2010), who analyze a dynamic model of oligopolistic airline competition to identify factors influencing the adoption of hub-and-spoke networks. They find that the cost of entry on a route declines with the airline’s scale of operation at the endpoints of the route, and for large carriers, strategic entry deterrence is also an important factor. Ciliberto and Tamer (2009) develop a method for estimating payoff functions in static games of complete information and apply this method to the airline industry, examining the role played by heterogeneity in determining market structure. Finally, Roberts and Sweeting (2012) consider selective entry into airline markets in order to more accurately assess the impact of airline mergers.

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4 Busse (2002) also finds that firms in poor financial condition are more likely to reduce prices.
4.3 Background

In this section I present three elements of background information that together motivate the link between bankruptcy and capacity. First, I explain some of a firm’s key risks and rewards of filing for bankruptcy in the United States. Second, I describe the 2005 bankruptcy law reform in detail. Third, I demonstrate the appeal of Chapter 11 specific to airlines in the U.S., demonstrating that airline bankruptcy patterns are consistent with strategic use of Chapter 11.

4.3.1 Bankruptcy

The traditional economic justification\(^5\) for bankruptcy protection is as a solution to a collective action problem, namely, the allocation of an insolvent firm’s assets. In the United States, when a firm defaults\(^6\) on a debt obligation, the creditor whose claim is in default has the right to sue for relief in state court. Secured creditors have the additional right to seize the collateral underlying their claims. A financially distressed firm with many creditors is therefore liable to become a tragedy of the commons. When left to its individual legal rights, each creditor has incentive to secure as big a share of the firm’s assets as possible, as quickly as it can, to the detriment of the other creditors and the company’s chances for success. Much like a bank run, this kind of behavior can turn temporary insolvency into complete financial ruin. Bankruptcy law provides a way of collectivizing creditors’ behavior, with the goal of avoiding inefficient firm failures.

To this end, the United States Bankruptcy Code offers two forms of bankruptcy protection to business entities: liquidation under Chapter 7 and reorganization under Chapter 11. Both processes begin with an “automatic stay” that protects the firm

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\(^5\) See, for example, Jackson (1984).

\(^6\) Note that default need not be due to failure to make payments. Technical default occurs when one of the provisions of the debt agreement is violated (e.g. working capital, cash on hand, or liquidity ratios fall below pre-specified levels).
from legal action and asset seizure, but they differ in their subsequent treatment of insolvency. Chapter 7 is pursued (voluntarily or otherwise) when a company is unlikely to return to profitability, even with substantially reduced debt obligations. It provides for an orderly closure of the company, sale of assets, and repayment of claims. Chapter 11 is afforded to companies that have a reasonable chance of remaining a going concern, particularly if they renegotiate their obligations to creditors, vendors, employees, tax authorities, and other stakeholders. Under Chapter 11, a financially distressed corporation can typically negotiate away substantial portions of debt and other liabilities, sometimes on the order of cents on the dollar.

The courtroom is not the only place a firm’s financial distress can be resolved, of course. Litigation is costly, and most secured creditors would prefer to continue receiving debt payments than to own the underlying collateral. Consequently, debt renegotiations (called workouts) are common in the U.S. However, as White (2007) points out, the negotiation process is imperfect, and workouts can be easily derailed by hold-out creditor classes. In their study of 169 instances of financial distress among large public corporations in the 1980s, Gilson et al. (1990) find that slightly less than half (80) of firms successfully restructure their debt outside of bankruptcy. Success was more likely when firms had greater intangible assets, a higher proportion of bank debt, and fewer distinct creditor classes. The 89 unsuccessful firms in the study all filed for Chapter 11. In the remainder of this section, I briefly explain the overall process of Chapter 11 and Chapter 7 and describe the history of bankruptcy law in the United States. I then point out the most relevant provisions in the current Bankruptcy Code and describe how these and other rules were changed by BAPCPA.

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7 Debt restructuring outside of bankruptcy typically requires unanimous consent of all creditors whose claims are in default, so the likelihood that at least one creditor holds out increases in the number of creditors.
The Bankruptcy Process

As previously mentioned, business entities typically file under one of two chapters in the U.S. Bankruptcy Code: Chapter 7 (liquidation) and Chapter 11 (reorganization). Both procedures begin with an automatic stay to prevent asset seizure and litigation, but they have very different end goals. I now present a rough overview of both processes. For more thorough treatment, see White (2007), LoPucki (2012), and Branch et al. (2007).

Under Chapter 7, a court-appointed or elected trustee manages the orderly shutdown and liquidation of the company. The trustee’s goal is to convert the company’s assets to cash as quickly as possible, while seeking to maximize the value received for those assets. Since even distressed companies are typically worth more than the sum of their parts, sale of substantially all of the firm’s assets to a single party is not uncommon. The proceeds are then distributed to claimants according to the Absolute Priority Rule (APR). Also known as liquidation preference, the APR dictates the order in which unsecured claims are paid and stipulates that no class of creditor be paid until all more senior classes have been paid in full. In order of priority, the major divisions are as follows:

1. Administrative Claims (including legal fees)
2. Statutory Claims (including certain unpaid taxes, rents, wages, and benefits)
3. Unsecured Creditors’ Claims (including trade credit, bonds, and legal claims)
4. Post-filing Interest on Paid Claims
5. Equity

Secured creditors are notably absent from the APR ordering because their claims on particular assets remain valid in bankruptcy. Creditors with secured claims are
entitled to their collateral or its fair market value (usually replacement value) before any unsecured claims are paid.

Whereas Chapter 7 outlines the orderly paying of creditors’ claims, Chapter 11 provides an orderly way to renegotiate those claims. While the ultimate goal of Chapter 11 reorganization is reemergence from bankruptcy as a going concern, many firms are unsuccessful. Failure can take two forms, conversion or dismissal, each of which results from the bankruptcy judge’s approval of the specified motion. A motion to convert the case to Chapter 7 will, if granted, lead to liquidation. A motion to dismiss the case will, if granted, lift the automatic stay and remove the proceeding from Bankruptcy Court. In the case of dismissal, negotiations with creditors can continue, but as previously mentioned, creditors now have the option to seize collateral or sue the debtor in state court. Iverson (2012) and Morrison (2007) indicate that, in most cases, dismissal is tantamount to liquidation.

Chapter 11 centers on the firm’s reorganization plan, which outlines debt repayment and restructuring. The plan must also estimate firm value as a going concern and show that it exceeds liquidation value. Upon proposal, the judge must first approve the disclosure statement (the plan), before it can be voted on by creditors. If, at each level of seniority, at least 50% of creditors by number and 2/3 of creditors by value accept the plan, then it is deemed accepted by that class. Note that, in order to vote, a creditor must be impaired, in that it will receive less than 100% recovery under the plan. Even after creditors have voted on the plan, the judge still has the ability to approve or reject the plan. Most commonly, the judge may approve a plan that was voted down if he or she feels that doing so is in the best interest of the firm. Such a decision is known as a “cram-down” and requires that the plan be feasible, filed in good faith, and superior to liquidation in terms of creditors’ recovery.

A reorganization plan need not be approved on the first try (or the second or third, for that matter). The number of attempts is really only limited by the time
and patience of the bankruptcy judge. For the first 120 days of bankruptcy, the
debtor is given the exclusive right to file a reorganization plan. Often 120 days will
be far from enough time to formulate a plan that is agreeable to all parties, so a judge
may grant extensions of this exclusivity period if he or she sees fit. The scope of these
extensions is perhaps the most substantive change imposed by BAPCPA. Whereas
exclusivity was effectively indefinite before 2005, BAPCPA put a hard deadline at 18
months of exclusivity. Once this period expires, any creditor group or case trustee
may file an alternative plan and seek approval. Figure 4.1 illustrates the overall
bankruptcy process.
Bankruptcy Provisions of Interest

A number of sections in the Bankruptcy Code are of particular import in the context of the airline industry. Section 1110 affords special provisions to holders of leases and secured financings of aircraft and aircraft equipment. This section gives bankrupt airlines the right to make any outstanding payments within 60 days in order to keep the aircraft. If the airline fails to make those payments or renegotiate lease terms, the lessor has the exclusive right to repossess the aircraft, similar to a secured creditor’s position outside of bankruptcy. At first glance, this rule appears to favor the lessor. However, lease agreements are often far above market value for aircraft, and if a lessor repossesses the aircraft, it must then find another lessee in what is likely to be a down market. Repossession is therefore not a very attractive option for lessors. Moreover, should the lessor refuse the right to repossess the aircraft, the lease agreement is rescinded and becomes an unsecured claim on the airline, which takes a much lower priority for payment under bankruptcy protection. The lessor is therefore far less likely to be paid. Given the lessor’s grim options in the case of default, renegotiation of lease terms becomes very attractive. Renegotiating leases and secured financings of aircraft is a major source of cost-cutting by airlines in bankruptcy. Benmelech and Bergman (2008) show that renegotiation of aircraft leases is common practice for airlines in financial distress. Moreover, when redeployability of aircraft is low, as in an overall market downturn, lessors are able to negotiate for even greater concessions.

Section 1113 of the Bankruptcy Code relates to collective bargaining agreements (CBAs). This section of the Code was enacted in 1984, although bargaining power would have been similar before this time, given the contractual treatment of CBAs. Section 1113 stipulates that a company can unilaterally revise terms of a CBA if attempts to renegotiate with unions have failed. This rule gives airlines significant bargaining power in negotiating more favorable terms with unions, which typically
represent half of an airline’s workforce.

Section 1114 of the Bankruptcy Code deals with retiree benefits. Under bankruptcy protection, a carrier can renegotiate or cancel defined benefit pension obligations, thereby requiring the Federal Pension Benefit Guarantee Corporation (PBGC) to foot the bill. Such a decision must first be approved by the court, which requires 1) that the company first negotiate with representatives of the retirees, and 2) that the decision is necessary for the firm’s survival. Since defined benefit pension programs typically represent a huge burden on financially distressed carriers, renegotiating or canceling them in Chapter 11 can yield enormous cost savings.

History of Bankruptcy Reform

Several times throughout the 19th century, the U.S. Congress established and repealed bankruptcy legislation, but not until the Bankruptcy Act of 1898 did any set of rules gain permanence. Compared to its creditor-friendly predecessors, the 1898 Act clearly favored debtors, imposing no minimum payment to creditors and establishing debt forgiveness as standard procedure for consumer debtors. The 1898 Act permitted nonbusiness debtors to file voluntarily, while creditors could petition for involuntary bankruptcy against businesses. The 1898 Act also included provisions for an alternative to liquidation for bankrupt corporations, whereby, with the approval of creditors and the court, partial repayment of the corporation’s debt would discharge the entire debt. While bankruptcy law experienced minor changes in subsequent decades, the next major change was the Chandler Act of 1938, which, among other things, rewrote the reorganization provisions into distinct chapters, including chapter X for corporate reorganizations and chapter XI for rearrangements. The Bankruptcy Reform Act of 1978, aimed at streamlining administration and ensuring fairness among classes of creditors, was the last major overhaul of bankruptcy legis-

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8 This brief summary is largely due to Bak et al. (2008).
lation. Among its many changes were the combination of chapter X and chapter XI into chapter 11 for all corporate reorganizations and the removal of long-held caps on attorneys’ fees. The 1978 Act, commonly referred to as the Bankruptcy Code, was such a substantial change that its effect on filing rates has been the subject of considerable research.\textsuperscript{9} The Bankruptcy Amendments and Federal Judgeship Act of 1984 (BAFJA) made changes to the bankruptcy judiciary and added provisions to deter bankruptcy abuse by consumers. The Bankruptcy Reform Act of 1994 established a commission to review the Bankruptcy Code, and that commission eventually proposed BAPCPA, widely viewed as the most substantial change since 1978.

\subsection*{4.3.2 BAPCPA 2005}

In order to say whether or not bankruptcy law matters for investment, I need to observe the investment response to an exogenous change in bankruptcy law. To do so I exploit the Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA). This section summarizes the reform, providing evidence that it increased the expected cost of filing Chapter 11, especially for larger firms.

Although its primary target was consumer bankruptcy abuse, BAPCPA made a number of substantive changes to Chapter 11. A 2005 report by BBC News summarizes the common opinion that the changes were designed to prevent large corporations’ abuse of the bankruptcy option by making Chapter 11 filings more difficult. Coelho (2010) finds that the market response to public announcements of bankruptcy filing has been more severe since the reform relative to the pre-BAPCPA period, lending empirical validity to what Gilson (2010) and many other scholars had already agreed upon: the new Bankruptcy Code restricts debtor protection and reduces the likelihood of a successful reorganization. In support hereof, Coelho (2010)

\footnote{See, for example, Bhandari and Weiss (1993), Domowitz and Eovaldi (1993), White (1987), Boyes and Faith (1986), and Nelson (2000)}
cites Altman and Hotchkiss (2010); Gottlieb et al. (2009); and Ayotte and Morrison (2009) as well. Iverson’s (2012) conclusion that busy judges more often leave firms to their own devices agrees with the creditor-friendly perception of BAPCPA. Since bankruptcy court judges see both business and consumer cases, the drastic decline in consumer bankruptcy filings following BAPCPA substantially reduced judges’ overall caseloads. Iverson (2012) identifies this effect and suggests that judges with lighter caseloads are more inclined to dismiss or convert Chapter 11 cases, thereby increasing the probability of liquidation.\footnote{Note that Iverson agrees that BAPCPA likely had an impact on Chapter 11 filings, although the filing rate overall doesn’t appear to have been affected by the reform, at least not in his sample. This seems to conflict with the UCLA Lopucki database of large public filings.}

Even before the reform went into effect, it was commonly expected to shift bargaining power to creditors. While uncertainty surrounded the manner in which BAPCPA would eventually be implemented in the courts, the consensus among legal professionals was that BAPCPA would probably be bad for debtors, especially large ones and those with particular classes of assets. I now detail the reform components most relevant for large companies, relying collectively on Sprayregen et al. (2005), Herman (2007), Selbst (2008), and Levin (2005).

Changes of Interest

First, and perhaps most important, was the Act’s limitation of the exclusivity period for filing a plan of reorganization. The exclusivity period is the time during which the company has the sole right to put forth a plan of reorganization for consideration by stakeholders. Once the exclusivity period has expired, other parties, such as creditor committees or labor unions, can put forth alternative plans and call for a vote. Under the old regime, large corporations were regularly granted extensions lasting up to several years. United Airlines, for example, required three years before a reorganization plan was confirmed. The 2005 reform set a hard and fast limit of
18 months for exclusivity, and 20 months for acceptance of an exclusive plan. Selbst (2008) explains, “The change was aimed at curbing the perceived abuse of debtors spending too long in Chapter 11 and using exclusivity to coerce concessions from creditors.” This new limit increases the likelihood of losing exclusivity, especially for large companies. In a 2005 report by law firm Kirkland & Ellis, James Sprayregen\textsuperscript{11} and co-authors explained that, “...in many cases, changes in collective bargaining agreements and pension plans...and similar issues cannot be resolved in 20 months.”

Before the reform came into effect, airlines were about twice as likely as other firms to exceed the maximum threshold for acceptance of a plan.\textsuperscript{12} In other words, the BAPCPA’s change to exclusivity was likely to have a greater impact on airlines than on industry in general.

Coupled with the reduced exclusivity period is a slightly increased scope for dismissal or conversion of a bankruptcy case. By limiting the discretion of the bankruptcy judge, the Act made it more likely for courts to convert a reorganization into a liquidation if procedural requirements are not met. Firms are not only more likely to lose control of the reorganization process by losing exclusivity, but also more likely to lose reorganization as an option in the event of dismissal or conversion. Mitigating these changes was the relaxation of certain procedural requirements for prepackaged plans. However, prepackaging benefits are unlikely to change the net effect of these timing-related reforms.

The second key reform area is employee wages and benefits. One of the more prominent features of the Act was its limitation of key employee retention plans

\textsuperscript{11} Sprayregen’s relevant reorganization expertise includes representation of United Airlines, Japan Airlines, and Trans World Airlines (TWA).

\textsuperscript{12} Among similarly-sized public companies filing for Chapter 11 between 1980 and 2005 that eventually emerged from bankruptcy, 32\% of non-airline companies took longer than 608 days (the new statutory maximum) to confirm an exclusive plan of reorganization, versus 62\% of airline companies during this time. Median time spent in reorganization for airlines was also about twice that of non-airline bankruptcies. This qualitative observation is independent of firm size.
This measure was enacted to curb the abuse of such plans as a means of paying out insiders of the company before its coffers were empty. While it likely accomplishes that goal, the limitation is applied broadly to insider payments, which may have made it more difficult for large corporations to retain key employees. Related to the limitation on insider payments is an increase in the required payments to rank-and-file employees. Among other changes, BAPCPA doubled the maximum amount of priority wage and benefit claims per worker and the timeframe for recovery, from about $5,000 to $10,000 and from 90 days to 180 days, respectively. Given that labor costs represent about 1/3 of most airlines’ operating expenses, this change likely moved a large sum of money higher on the priority claims list. Another change to the handling of benefits was the Act’s permission to, at the request of stakeholders, unwind any modification made to retiree benefits in the 180 days prior to filing for Chapter 11, provided that the company was insolvent when the modification was made. This change essentially allows the court to reverse any reduction in benefits made before the company filed for bankruptcy. Important to note is that section 1114 permits unilateral modification (including wholesale cancellation) of retiree benefits if negotiations fall through and the court finds the modification to be necessary for the firm’s survival. BAPCPA essentially grants employees greater bargaining power under section 1114. An important change outside of BAPCPA in this regard is the Pension Protection Act of 2006 (PPA). While I do not cover it in any detail in this dissertation, PPA essentially increased the cost to the firm of both carrying and terminating underfunded pensions. The reform may very well have compounded the effects of BAPCPA.

The third major reform category is nonresidential property leases. In particular, the Act limits the timeframe for the assumption or rejection of such leases. Similar to its change in the exclusivity period, BAPCPA overrides the status quo of unlimited extensions by setting a 120-day limit with at most one 90-day extension. Any leases
not assumed by the end of this period are deemed rejected. For airlines, this provision applies directly to airport gates or terminals, forcing airlines to decide much sooner whether to remain at certain airports. It should be noted, however, that the Act simultaneously eliminated certain provisions pertaining to airport gate leases in the same section. For instance, the reform deleted the requirement to take all or none of the leased gates at an airport. It is unclear how important these deletions are relative to the overall change in the timeline for accepting leases.

Finally, BAPCPA raised priority for recovery of recently delivered goods, utility costs, and taxes. Both the amount and timeliness of these payments were substantially increased, placing a greater cash burden on companies during the bankruptcy process. Given the prevalence of fuel costs and taxes in the airline industry, it is possible that these changes reduced the likelihood of successfully exiting Chapter 11.

On the whole, the 2005 reform appears to have increased the probability of liquidation, thereby raising the expected cost of filing Chapter 11 from the firm’s perspective. I must point out, however, that sections 1110 and 1113, which represent the two biggest benefits of Chapter 11 to airlines, remain untouched. Nevertheless, the overall strengthening of creditors’ bargaining positions is generally accepted. In fact, even unintended consequences of the reform may have yielded a more creditor-friendly system. As mentioned earlier, Iverson (2012) associates the decline in consumer bankruptcy filings following BAPCPA with higher probability of dismissal or conversion for Chapter 11 cases. Finally, my own conversations with legal experts confirm that, at least for the largest of firms, BAPCPA’s curtailment of the exclusivity period turned the process of reorganization into almost assured liquidation.

Other, non-legislative changes are also worth noting. Bharath et al. (2014) identify an overall decline in absolute priority rule (APR) deviations from 10% of firm value to about 2% of firm value, or from 100% of the time to less than 20% of the time. A concomitant rise in the use of debtor-in-possession (DIP) financing and key
employee retention plans (KERP) is observed and found to be related to the decline in APR deviations. DIP financing, which came to prominence in the 1990s, tends to impose rigid restrictions on firm operations, thereby limiting the power of management, while KERPs often align management incentives with creditors. If BAPCPA did indeed enhance the bargaining position of creditors, then DIP financing terms are likely to be even more favorable to creditors. To the extent that KERPs serve as an alternative means of paying out management in reorganization, these two trends could very well have left management’s incentive to reorganize unchanged. Bharath et al. (2014) consider both innovations to have led to more creditor-friendly reorganizations. These authors also note that management turnover in bankruptcy has become more common, especially among managers with significant equity stakes. Yet another trend in Chapter 11 cases has been the increase in section 363 sales, in which the entire company is sold to an outside party. If we view managers as the ones making investment decisions, this trend coincides with the effects of BAPCPA. A shift of bargaining power toward creditors and an increased likelihood of acquisition under Chapter 11 will both increase a manager’s perceived cost of filing for bankruptcy.

4.3.3 Airline Bankruptcy

Airline bankruptcy and airline capacity are inextricably linked. Every legacy air carrier has undergone bankruptcy. Just in the past decade, United Airlines (UA), US Airways (US), Delta Air Lines (DL), Northwest Air Lines (NW), and American Airlines (AA) have filed for Chapter 11 protection, each time ranking among the top ten largest bankruptcies of the year by asset value.\footnote{Ciliberto and Schenone (2012), Benmelech and Bergman (2008), and others demonstrate that bankruptcy is a Top 20 largest public bankruptcies by year, available since 1995 at www.BankruptcyData.com/researchcenter2.htm}
common time to cut capacity and right-size the labor force. As previously discussed, a number of provisions in the Bankruptcy Code make Chapter 11 especially appealing for airlines looking to downsize. If abrogating contracts in Chapter 11 is less costly than breaching them outside of bankruptcy court, then firms will be more willing to sign those contracts in the first place (i.e. invest in capacity) relative to their behavior in a world without Chapter 11. The pattern of rapid investment followed by extensive bankruptcy that we would expect to find is clearly evident in the airline industry.

Not only is bankruptcy a valuable option, but there is evidence to suggest it may be strategically timed. In an interview with broadcast journalist Charlie Rose, former CEO of American Airlines Robert Crandall suggests that the company should have chosen to file for Chapter 11 during the earlier wave of bankruptcies by large legacy carriers.14 “I would have done it then because I knew that [the other major airlines] would emerge with a huge cost advantage,” he says. More than just a voluntary strategy for managing financial distress, the bankruptcy option can also be misused. Delaney (1992) details Continental Airlines’ 1983 bankruptcy filing, starkly illustrating its strategic intent and abusive nature. The more general case for bankruptcy’s strategic nature is debatable. Flynn and Farid (1991) and Tavakolian (1995) argue that bankruptcy has lost much of its previous stigma and grown into a viable business strategy for turning around failing companies. Moulton and Thomas (1993) provide empirical evidence that, if it is a deliberate strategy, it is not usually a successful one.15

Perhaps the best evidence for both the strategic timing of Chapter 11 filings and the potential impact of BAPCPA on bankruptcy costs is the fact that both Delta

14 http://www.charlierose.com/view/interview/12228
15 The interested reader is referred to Ciliberto and Schenone (2012) for additional evidence of the strategic use of bankruptcy in airlines.
Air Lines and Northwest Airlines independently filed for Chapter 11 in September of 2005, just one month before BAPCPA came into effect. Industry experts claim that BAPCPA played a key role in Northwest’s decision, and that Delta’s filing was long expected, suggesting the company had sufficient ability to time the decision.16

4.4 Theoretical Model

In this section I develop a simple dynamic duopoly model of investment and bankruptcy to show how equilibrium behavior changes with bankruptcy cost. The purpose of this exercise is to provide a transparent framework for thinking about how Chapter 11 influences capital investment in a dynamic, competitive environment. This simple model reveals two key insights. First, an exogenous change that makes bankruptcy more costly will limit capacity expansion when demand is high. Second, the same exogenous change will quicken capacity retraction when demand is low. While the intensity of each effect varies with the relative dominance of each firm, the overall implication lines up nicely with the capacity discipline that has been observed in the airline industry. In other words, as bankruptcy becomes more costly, firms will be less willing to invest when demand is good. At the same time, they’ll be more willing to get rid of capacity when demand is bad.

4.4.1 Duopoly Setup

Two firms compete for demand, which can be either high or low. The demand state evolves randomly according to two Poisson arrival processes. When demand is high, nature arrives at rate $\psi$ to reverse the demand state. When demand is low, nature arrives at rate $\psi'$ to reverse the demand state. Suppose firm $i$’s profit, conditional upon demand, can be given in reduced form by a function of $i$’s capital level, $n_i$, relative to its competitor. This relative level takes on one of 5 values, that

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16 See, for example, Maynard (2005) and Corridore (2005).
is, $n_i \in N \equiv \{-2, -1, 0, 1, 2\}$. Flow profit is given by

$$\Pi(n_i) \in \{\pi_{-2}, \pi_{-1}, \pi_0, \pi_1, \pi_2\}, \quad \pi_{n+1} > \pi_n \text{ when demand is high, and}$$

$$\Pi'(n_i) \in \{\pi'_{-2}, \pi'_{-1}, \pi'_0, \pi'_1, \pi'_2\}, \quad \pi_n > \pi_{n+1} \text{ when demand is low.}$$

In other words, having more capital relative to your opponent is profitable in high-demand states, but costly in low-demand states.\(^{17}\) Given this ordering, firms will want to increase their capital stock in good times, and decrease it in bad times. When demand is high each firm can increase its capital level by a Poisson investment process, which yields a unit increment to the capital stock at rate $x_i \geq 0$ and costs $\lambda x_i$. Similarly, when demand is low each firm can decrease its capital level at rate $y_i \geq 0$ at a cost of $\theta y_i$.

In each demand-capital state, default follows two Poisson processes, one yielding a single increment decrease in capital, and another resulting in a two-increment decrease. That is, firms never liquidate but are occasionally forced to downsize by one or two units, where applicable. The overall rate of default is held constant for a given demand and capital state, such that

$$D_{N_i} \equiv \begin{cases} 
  d_2 &= \gamma_2 d_2 + (1 - \gamma_2) d_2 \\
  d_1 &= \gamma_1 d_1 + (1 - \gamma_1) d_1 \\
  d_0 &= \gamma_0 d_0 + (1 - \gamma_0) d_0 \quad \text{when demand is high, and} \\
  d_{-1} &= d_{-1} \\
  d_{-2} &= 0
\end{cases}$$

$$B_{N_i} \equiv \begin{cases} 
  b_2 &= \phi_2 b_2 + (1 - \phi_2) b_2 \\
  b_1 &= \phi_1 b_1 + (1 - \phi_1) b_1 \\
  b_0 &= \phi_0 b_0 + (1 - \phi_0) b_0 \quad \text{when demand is low,} \\
  b_{-1} &= b_{-1} \\
  b_{-2} &= 0
\end{cases}$$

\(^{17}\) Large size could be costly in downturns if, for example, fixed costs are linear in capacity, while variable profits are concave. If the demand state shifts variable profit only, then fixed costs may very well dominate when demand is low.
where $\gamma_n$ and $\phi_n$ describe the probability that default will be of the two-increment type. Upon default, firms must pay a capital-dependent, one-time fee reflecting the cost of bankruptcy to equity holders. These restructuring costs, $R(n) \in \{R_{-1}, R_0, R_1, R_2\}$ are independent of both the demand state and the size of default, and they are not paid when firms transition to lower states of their own accord.

Finally, suppose the common rate of time preference is given by $r > 0$. Given this set of incentives and processes, let $V$ represent value functions in good states and $W$ represent value functions in bad states. We can then define firm values recursively as follows

$$
rV_2 = \pi_2 + x_{-2}[V_1 - V_2] + (1 - \gamma_2)d_2[V_1 - V_2 - R_2] + \gamma_2d_2[V_0 - V_2 - R_2] + \psi[W_2 - V_2]
$$

$$
rV_1 = \max_{x_1 \geq 0} \left\{ \pi_1 - \lambda x_1 + [x_1 + d_{-1}][V_2 - V_1] + x_{-1}[V_0 - V_1] + ... + (1 - \gamma_1)d_1[V_0 - V_1 - R_1] + \gamma_1d_1[V_{-1} - V_1 - R_1] + \psi[W_1 - V_1] \right\}
$$

$$
rV_0 = \max_{x_0 \geq 0} \left\{ \pi_0 - \lambda x_0 + [x_0 + (1 - \gamma_0)d_0][V_1 - V_0] + x'_0[V_{-1} - V_0] + ... + (1 - \gamma_0)d_0[V_{-1} - V_0 - R_0] + \gamma_0d_0[(V_2 - V_0) + (V_{-2} - V_0 - R_0)] + \psi[W_0 - V_0] \right\}
$$

$$
rV_{-1} = \max_{x_{-1} \geq 0} \left\{ \pi_{-1} - \lambda x_{-1} + [x_{-1} + (1 - \gamma_1)d_1][V_0 - V_{-1}] + x_1[V_{-2} - V_{-1}] + ... + d_{-1}[V_{-2} - V_{-1} - R_{-1}] + \gamma_1d_1[V_{-1} - V_{-1}] + \psi[W_{-1} - V_{-1}] \right\}
$$

$$
rV_{-2} = \max_{x_{-2} \geq 0} \left\{ \pi_{-2} - \lambda x_{-2} + [x_{-2} + (1 - \gamma_2)d_2][V_{-1} - V_{-2}] + \gamma_2d_2[V_0 - V_{-2}] + \psi[W_{-2} - V_{-2}] \right\}
$$

$$
rW_2 = \max_{y_2 \geq 0} \left\{ \pi'_2 - \theta y_2 + y_2[W_1 - W_2] + (1 - \phi_2)b_2[W_1 - W_2 - R_2] + ... + \phi_2b_2[W_0 - W_2 - R_2] + \psi'[V_2 - W_2] \right\}
$$

$$
rW_1 = \max_{y_1 \geq 0} \left\{ \pi'_1 - \theta y_1 + y_1[W_0 - W_1] + (1 - \phi_1)b_1[W_0 - W_1 - R_1] + ... + \phi_1b_1[W_{-1} - W_1 - R_1] + [y_{-1} + b_{-1}][W_2 - W_1] + \psi'[V_1 - W_1] \right\}
$$

$$
rW_0 = \max_{y_0 \geq 0} \left\{ \pi'_0 - \theta y_0 + y_0[W_{-1} - W_0] + (1 - \phi_0)b_0[W_{-1} - W_0 - R_0] + ... + [y_0' + (1 - \phi_0)b_0][W_{-1} - W_0] + \phi_0b_0[(W_2 - W_0) + (W_{-2} - W_0 - R_0)] + \psi'[V_0 - W_0] \right\}
$$

$$
rW_{-1} = \max_{y_{-1} \geq 0} \left\{ \pi'_{-1} - \theta y_{-1} + y_{-1}[W_{-2} - W_{-1}] + b_{-1}[W_{-2} - W_{-1} - R_{-1}] + ... + [y_{-1} + (1 - \phi_1)b_1][W_0 - W_{-1}] + \phi_1b_1[W_1 - W_{-1}] + \psi'[V_{-1} - W_{-1}] \right\}
$$

$$
rW_{-2} = \pi'_{-2} + [y_2 + (1 - \phi_2)b_2][W_{-1} - W_{-2}] + \phi_2b_2[W_0 - W_{-2}] + \psi'[V_{-2} - W_{-2}]$$
The left-hand side of each equation represents the rate of appreciation of the firm’s value. On the right-hand side of each equation, the first term is flow profit. For equations with maximization, the second term is the cost of (dis)investment. The remaining terms give the probabilities of each possible state change multiplied by their associated changes in continuation value. Note that restructuring costs are one-time values, which is why they appear only when continuation values change due to default. We assume that default rates are not so large as to make (dis)investment unappealing.
Solving for equilibrium investment and disinvestment intensities yields the following.\(^{18}\)

\[
x_{-2}^* &= \max \left\{ 0, \frac{\pi_2 - \pi_{-2} - R_2 d_2 - 49\psi}{\lambda} - (4(r + \psi) + 2(1 + \gamma_2)d_2) \right\}
\]

\[
x_{-1}^* &= \max \left\{ 0, \frac{\pi_1 - \pi_{-2} - R_1 d_1 - 39\psi}{\lambda} - (3(r + \psi) + (1 + \gamma_2)d_2 + (1 + \gamma_1)d_1 - d_{-1}) \right\}
\]

\[
x_0^* &= \max \left\{ 0, \frac{\pi_0 - \pi_{-2} - R_0 d_0 - 29\psi}{\lambda} - (2(r + \psi) + (1 + \gamma_2)d_2) \right\}
\]

\[
x_1^* &= \max \left\{ 0, \frac{\pi_{-1} - \pi_{-2} - R_{-1} d_{-1} - \theta\psi}{\lambda} - ((r + \psi) + (1 + \gamma_2)d_2 - (1 + \gamma_1)d_1 + d_{-1}) \right\}
\]

\[
x_2^* = 0
\]

\[
y_{-2}^* = 0
\]

\[
y_{-1}^* &= \max \left\{ 0, \frac{\pi_1' - \pi_2' + R_2 b_2 - R_{1} b_{1} - \lambda\psi'}{\theta} - ((r + \psi') + (1 + \phi_2)b_2 - (1 + \phi_1)b_1 + b_{-1}) \right\}
\]

\[
y_0^* &= \max \left\{ 0, \frac{\pi_0' - \pi_2' + R_2 b_2 - R_0 b_0 - 2\lambda\psi'}{\theta} - (2(r + \psi') + (1 + \phi_2)b_2) \right\}
\]

\[
y_1^* &= \max \left\{ 0, \frac{\pi_{-1}' - \pi_2' + R_2 b_2 - R_{-1} b_{-1} - 3\lambda\psi'}{\theta} - (3(r + \psi') + (1 + \phi_2)b_2 + (1 + \phi_1)b_1 - b_{-1}) \right\}
\]

\[
y_2^* &= \max \left\{ 0, \frac{\pi_{-2}' - \pi_2' + R_2 b_2 - 4\lambda\psi'}{\theta} - (4(r + \psi') + 2(1 + \phi_2)b_2) \right\}
\]

### 4.4.2 Duopoly Implications

Solving for equilibrium investment and disinvestment strategies reveals the two key features of capacity discipline at work: Higher bankruptcy costs slow investment in high-demand states and speed disinvestment in low-demand states. Intuitively, higher bankruptcy costs make disinvestment more expensive overall, increasing the

\(^{18}\) See Appendix C for additional details on the solution.
risk of being large in a down market, thereby reducing the incentive to invest. At the same time, disinvestment outside of bankruptcy becomes less expensive relative to bankruptcy, leading to quicker retraction outside of bankruptcy. The magnitude of each effect depends on the nature of competition between the duopolists. In particular, the disinvestment effect is stronger for more dominant firms, while the investment effect is stronger for weaker firms.\(^\text{19}\)

The previous equations give explicit expressions for optimal investment/disinvestment, which we can analyze to determine the impact of a change in bankruptcy policy. I view BAPCPA as increasing the cost of reorganization conditional upon filing, which is best proxied by an increase in the one-time restructuring costs \(\{R_n\}\). The first and most intuitive effect of such a change is to reduce investment intensity during high-demand periods, as seen by \(\frac{\partial x^*_n}{\partial R_{-n}} < 0\). A greater reluctance to invest in upturns is one component of the capacity discipline observed in the market since 2005. This effect is stronger when investment costs are smaller and when the arrival rate of default is higher. Based on the changes it makes to the Bankruptcy Code, BAPCPA is expected to have greater impact on the expected restructuring costs of the largest firms. If we further suppose that BAPCPA has a larger impact on larger firms, such that \(\Delta R_n > \Delta R_{n-1}\), we should expect the investment effect to be strongest for small firms and weakest for large firms.

The other component of capacity discipline is greater eagerness to disinvest during downturns, which we find in \(\frac{\partial y^*_n}{\partial R_{-n}} > 0\). However, this effect is tempered by the restructuring cost change at lower levels. If we again assume that \(\Delta R_n > \Delta R_{n-1}\), then the overall effect of BAPCPA will indeed be faster disinvestment. Moreover, the effect will be stronger the larger the firm. A few more intuitive observations:

\(^{19}\) While these effects do not account for BAPCPA’s impact on steady-state equilibrium industry structure, Appendix C shows that the qualitative implications of this section continue to hold when we weight intensities by long-run probabilities.
• investment in good times decreases with the arrival rate of bad times, while disinvestment in bad times falls with the arrival rate of good times.

• investment in good times falls with the price of investment, while disinvestment in bad times falls with the cost of disinvestment.

• disinvestment in bad times falls with the arrival rate of default for the largest firm, as well as with the probability of “big” default for the largest firm.

Finally, capacity discipline could be further amplified through the ancillary effects of restructuring cost on negotiation with labor groups. That is, if the bankruptcy change leads to greater likelihood of liquidation, union members may be more inclined to agree to pay cuts to avoid losing their jobs. BAPCPA certainly did plenty to enhance bargaining power of employees relative to equity holders, which suggests the opposite effect. However, the reform may have done so much to help creditors that the pie split amongst equity holders and employees is much smaller.

4.5 Empirical Strategy

My empirical approach to studying the link between bankruptcy and investment is three-fold. First, I perform a difference-in-differences analysis of airline data to test whether investment behavior changed following a 2005 bankruptcy law reform. Second, I estimate a dynamic, structural model of investment, competition, and bankruptcy to measure the incremental firm-level cost due to that reform. Finally, I use the estimated parameters to simulate two counterfactual scenarios in which 1) BAPCPA was never enacted, and 2) Chapter 11 reorganization is effectively prohibited.
4.5.1 Difference-in-Differences Model

The comparative statics of my theoretical model suggest that an increase in bankruptcy cost will reduce overall investment. In Section 4.6.1, I show that investment has fallen since BAPCPA was enacted. While this pattern is consistent with the theoretical model’s predictions, further analysis is necessary if we are to attribute the decline to an increase in bankruptcy cost. To separate the effect of a bankruptcy cost change from the effects of time, demand, or other macroeconomic variables, we would like to compare BAPCPA’s effect on investment behavior across two groups of airlines - one that was affected by the change, and one that was not. Here I describe my preliminary difference-in-differences approach to test that implication by comparing large and small airlines before and after BAPCPA.

The specifics of the BAPCPA reform suggest that its effects will have been felt most by highly complex firms. Legal experts agree that the new limit on the exclusivity period makes successful reorganization virtually impossible for the largest and most complex corporations. Intuitively, the more parties with which a firm must negotiate, the slower it will expect to gain consensus, the more likely is the exclusivity period restriction to bind. Given the shift of bargaining power to creditors upon termination of exclusivity, firms will expect to face a harsher bankruptcy regime if the new restriction binds. I use firm size\textsuperscript{20} as a proxy for complexity, based on the observation that larger entities tend to have more creditors, more bankruptcy committees, more entities filing joint bankruptcy petitions, and so forth.\textsuperscript{21} I verify that firm size is correlated with bankruptcy duration using Lynn LoPucki’s database of public firm filings and outcomes. In Section 4.7, I present the results of my difference-in-differences analysis. After controlling for demand, seasonality, and firm type, I

\textsuperscript{20} I measure size as the number of available aircraft seats in the fourth quarter of 2004.

\textsuperscript{21} One might also consider the number of unions, the number of outstanding debt classes, etc. as proxies.
find evidence that larger firms reduced investment more than smaller firms during the post-BAPCPA era.

4.5.2 Structural Model

In this section I describe the structural model that will be used to perform counterfactual simulations. The model benefits my analysis in three critical ways. First, the continuous-time approach is both intuitive and computationally tractable to solve. Second, the model produces numerical comparative statics that line up with the theoretical model of Section 4.4. Finally, the model lends itself well to estimation using conditional choice probability (CCP) methods, which greatly expedite computation while also resolving some equilibrium selection issues.

To empirically analyze the relationship between BAPCPA and airline investment behavior, only a dynamic model is suitable. Most structural dynamic models in the airline literature describe market-level decisions, which are complicated in their own right, but in this case I must look at the industry as a whole. The number of players in my model is therefore necessarily large, making the computation of Markov Perfect Equilibria (MPE) for a traditional discrete-time, simultaneous-move model (i.e. an Ericson and Pakes (1995)-style (EP) model) somewhat difficult. One way to ease the computational burden is to assume that firms make decisions based on less (or less precise) information. For example, Aguirregabiria and Ho (2012) examine industry-wide route network decisions by making assumptions to simplify the set of payoff-relevant variables for each of 22 airlines. A similar concept is used more generally by Weintraub et al. (2008), who introduce the concept of oblivious equilibrium to approximate EP models when many firms are involved. The more popular approach, pioneered by Hotz and Miller (1993) and Hotz et al. (1994) and adapted to the I.O. context by Bajari et al. (2007) and others, has been to estimate

22 Pakes et al. (2007), Pesendorfer and Schmidt-Dengler (2008), Ryan (2012), Dunne et al. (2013),
players’ actual choice probabilities from the data, incorporating them into a single-agent dynamic programming framework. The model I employ combines this second approach with a continuous-time model, further expediting computation.

Setup: Discrete Choices in Continuous Time

A continuous-time, discrete-choice model is an intuitive and computationally tractable way to model interaction among a relatively large number of firms. I now lay down the foundations of this model, following Arcidiacono et al. (2013), henceforth referred to as ABBE (2013).

Consider a continuous-time, infinite-horizon game following ABBE (2013), in which $N$ firms compete in capacity levels with the option to file for bankruptcy. At any given time, a firm is fully represented by a capacity level $q_i \in Q$ and a bankruptcy state $b_i$, which equals 1 if the firm is under Chapter 11 protection and 0 otherwise. The state of the game is characterized by the set of all players’ states as well as the demand state, $\alpha \in \{\alpha_{lo}, \alpha_{hi}\}$, and a state governing the bankruptcy regime, $\phi$, equal to 0 before the BAPCPA reform and 1 after the reform takes effect on 10/17/2005. Let $\theta \in \Theta$ represent the vector of economic states and $x \in X$ represent the vector of firms’ states. Flow profit for firm $i$ is $u_i = u (x_i, x_{-i}; \theta)$.

As in ABBE (2013), the state evolves according to a number of independent, continuous-time processes governing the arrival of move opportunities for nature and for all $N$ players. Nature flips the demand state whenever the opportunity arises, and those opportunities follow a Poisson process with parameter $\gamma$. Firm capacity and bankruptcy adjustment opportunities follow separate Poisson processes with parameters $\lambda_a$ and $\lambda_b$, respectively. When a capacity adjustment opportunity arrives, a firm may choose to remain in its current state, increase capacity by one increment, decrease capacity by one increment, or exit. Exit and entry are accounted for by

and Aguirregabiria and Mira (2007), to name a few.
adjustment to and from a level of zero capacity. If the firm changes capacity levels, it incurs a potentially asymmetric adjustment cost that depends on whether or not the firm is currently in bankruptcy. When a bankruptcy adjustment opportunity arrives, the firm may choose to remain in its current state or change its bankruptcy status. A firm filing for Chapter 11 incurs no explicit cost to transition into bankruptcy, but a firm exiting bankruptcy incurs an explicit cost to adjust its capital structure via court approval of a plan of reorganization. This cost reflects the bargaining power of creditors and is therefore conditional upon the bankruptcy regime. For example, if bankruptcy is more creditor-friendly, then the firm must sacrifice more of its equity upon exit, making reemergence from Chapter 11 more costly.

The structural parameters of interest are the capacity adjustment costs and bankruptcy exit costs, which together make up the set of state transition costs, $\psi_{j,k}$, to transition to state $j$ from state $k$. Firms maximize expected lifetime profits, discounting at continuous rate of time preference $\rho$ and taking their opponents’ strategies (conditional choice probabilities) as given. The value to player $i$ of being in state $k$ can be written as

$$V_{i,k} = \frac{1}{\rho + N\lambda_a + N\lambda_b + \gamma} \left\{ u_{i,k} + \gamma V_{i,l(demand,k)} + \lambda_a \mathbb{E}[V_{i,l(i,k;a)}] + \lambda_b \mathbb{E}[V_{i,l(i,k;b)}] + \sum_{i' \neq i} \lambda_a \mathbb{E}[V_{i,l(i',k;a)}] + \sum_{i' \neq i} \lambda_b \mathbb{E}[V_{i,l(i',k;b)}] \right\}$$

where

$$\mathbb{E}[V_{i,l(i,k;r)}] = \mathbb{E} \max_{j \in J_{i,k,r}} \{ V_{i,l(i,j,k)} + \psi_{j,k} + \epsilon_{ij} \}$$
and

$$\mathbb{E} \left[ V_{i,l(i',k,r)} \right] = \sum_{j \in J_{i',k,r}} \sigma_{i',j,k} \mathbb{E} \left[ V_{i,l(i',j,k)} \right]$$

and where \( r \in \{a, b\} \) is the type of move opportunity, and \( J_{r,k} \) is the corresponding choice set. When a move opportunity arrives, agents receive a Type I Extreme Value shock, \( \epsilon_{ij} \), to the value of each possible choice, such that the probability of player \( i \) making a particular choice \( j \) from state \( k \) when the move arrival type is \( r \) takes the familiar logit form:

$$\sigma_{ijkr} = \frac{\exp(V_{i,l(i,j,k)} + \psi_{jk})}{\sum_{j' \in J_r} \exp(V_{i,l(i,j',k)} + \psi_{j'k})}$$

**Empirical Model Implications**

While the theoretical model provided a framework simple enough to generate comparative statics, its simplicity came at the expense of realism. The empirical model is by no means an accurate depiction of reality, but it incorporates many features the theoretical model could not. To verify that both models generate the same set of predictions, I now present some numerical comparative statics from the empirical model.

I calibrate the empirical model as a duopoly with three possible capacity levels: exit (0), low (1), and high (2). Low demand is set to make a player indifferent between exiting and remaining in the market when he is the only incumbent and has low capacity. High demand is set to ensure that both firms earn a profit even when both are at high capacity. Nature’s move arrival rate is set to 0.25, implying a change every 4 years on average and roughly reflecting the macroeconomic cycle. Players’ move arrival rates are 2, implying 2 choices per year on average, for each choice type. I set the flow cost of holding a unit of capacity to 2, and the flow cost
of being in bankruptcy is set to 0.25. Increasing capacity outside of bankruptcy or decreasing capacity under bankruptcy protection are costless, while the cost of decreasing capacity outside of bankruptcy or increasing capacity within bankruptcy is set to 4. The continuous rate of time preference is set to 10%.

In Figure 4.2 I present conditional probabilities of increasing and decreasing capacity based on this intuitive calibration. The probability of increasing capacity is conditional on having low capacity when demand is good, while the probability of decreasing capacity is conditional on having high capacity when demand is bad. These two probabilities represent the two sides of capacity discipline: caution on the upswing and quickness in downturns. Since the probability of filing for bankruptcy falls with bankruptcy emergence cost, the probabilities of both investment and disinvestment rise. Therefore, to compare the relative appeal of investment and disinvestment, the numbers presented in Figure 4.2 are conditional on choosing not to file for bankruptcy. Finally, the first panel of the figure presents equilibrium strategies when the firm is the only incumbent, while the second panel shows how the effect of bankruptcy emergence cost is amplified upon the entry of a low-capacity opponent.

23 According to AMR Corporation’s 2010 10-K filing, the company’s aircraft rental expense of $580 million was distributed over a fleet of 241 aircraft under operating lease, suggesting a cost of $2.4 million per aircraft. If we interpret the flow cost of bankruptcy along the same lines, a $250k figure per year seems overly reasonable. However, this conservatism is meant to highlight the role of bankruptcy emergence cost, which I allow to vary from 0 to 10.

24 I interpret time in annual units, so a flow cost of \( c \) generalizes to a rate of \( c \) per year in the absence of discounting. Firms discount at continuous rate of time preference \( \rho \), such that a flow cost of \( c \) yields an annualized cost of \( \int_0^1 c e^{-\rho t} dt = c \frac{1-e^{-\rho}}{\rho} \). A flow cost of 1 for one year when \( \rho = 0.1 \) therefore has a present value of about 0.95.

25 Again using AMR Corporation’s 2010 10-K filing, we can estimate an early lease termination fee of about $10 million per aircraft, based on a $94 million charge for grounding 9 Airbus A300s prior to lease expiration. This value roughly amounts to completion of a 5-year lease term, and more than half of AMR’s leased fleet had remaining lease terms of 5 years or more. However, a given airline is unlikely to rent more than 50% of its fleet. Setting the adjustment cost to twice the annual lease term is therefore a somewhat conservative figure. Setting the upward adjustment cost under bankruptcy protection to be the same value simple eases explanation of the calibration.
Estimation Using Conditional Choice Probabilities

As previously mentioned, CCP (or “two-step”) methods begin by estimating players’ state-specific choice probabilities directly from the data. The Type I Extreme Value assumption for the distribution of the choice-specific error term then allows me to combine the estimated CCPs with a guess of the structural parameters to construct the value function. Representing the value function in this way eliminates the computationally costly value function iteration loop characteristic of full-solution methods, speeding estimation by orders of magnitude. Moreover, CCPs provide a reasonable equilibrium selection criterion by assuming the relevant equilibrium is the one played in the data. In what follows I explain how to implement this method.

The normal algorithm for nested-fixed-point estimation is

1. guess parameters

2. converge to value function

3. compute likelihood using the CCPs associated with that value function and the parameter guess

4. maximize the likelihood by changing the guess

Figure 4.2: Investment and Disinvestment Probabilities
CCP estimation allows me to skip step 2 of the process, replacing it with a step 0, in which I estimate the empirical CCPs from the data. This step is performed only once, outside the maximum likelihood loop. Armed with empirical CCPs, the new algorithm is

1. guess parameters

2. converge to value function

3. compute likelihood using estimated CCPs and the parameter guess

4. maximize likelihood function by changing the guess

The empirical CCPs are estimated as flexibly as possible and can be thought of as a kind of interpolation in which we use the data to tell us the probabilities with which agents will make every relevant choice at every observed node in the state space, even if such choices or their resultant states never occur in the data. I estimate conditional choice probabilities using a linear-in-parameters multinomial logit specification. For instance, the contribution to the log likelihood of capacity choice $j' \in J_a$ from state $k$ is

$$l_{kj'} = \log \left( \frac{\exp(X_k\beta_{j'})}{\sum_{j \in J_a} \exp(X_k\beta_j)} \right) - \tau N \lambda_a \sum_{j_a \neq 0} \left( \frac{\exp(X_k\beta_{j_a})}{\sum_{j \in J_a} \exp(X_k\beta_j)} \right)$$

where $\lambda_a$ is a chosen value of the capacity move arrival rate, $\tau$ is the duration in state $k$, and $N$ is the number of firms. $X_k$ is a matrix of regressors specific to state $k$, and $\beta_j$ is the $j$th column of $\beta$, a matrix of coefficients for which the column associated with the continuation choice is normalized to zero. The set of regressors includes own capacity and its square, the sum of opponents’ capacities and its interaction with own capacity, own bankruptcy state and its interaction with all of the above.

---

26 This expression is not actually the log likelihood, but its argmax in $\beta$ is the same as the argmax of the underlying log likelihood.
the demand state and its interaction with all of the above, and an indicator for the implementation of BAPCPA and its interaction with all of the above. I also assume that I know the common, continuous rate of time preference, $\rho$.

**Constructing the Likelihood**

In order to write the likelihood of the data as a function of only the empirical CCPs and structural parameters requires the presence of either a terminal state or some sort of finite dependence. I use firm exit as a terminal state in order to take advantage of CCP methods. Suppose I observe every non-continuation choice $j > 0$ for each player, and that I observe all changes in market demand (high or low). I now derive the likelihood, using ABBE (2013) as a guide. What we observe is a series of events and their points in time. Let the state space be indexed by $k = \{1, \ldots, K\}$, and let $Q_0$ be the $K \times K$ intensity matrix governing exogenous state transitions. Let $Q_N$ be the intensity matrix governing agent-related state transitions. An intensity matrix characterizes a finite-state Markov jump process, in which the elements of $Q$ represent the rates at which the possible transitions occur. For example, if $K = 3$, we have intensity matrix

\[
Q = \begin{pmatrix}
q_{11} & q_{12} & q_{13} \\
q_{21} & q_{22} & q_{23} \\
q_{31} & q_{32} & q_{33}
\end{pmatrix}
\]

For $l \neq k$, $q_{kl}$ is the hazard rate for transitions from state $k$ to state $l$, that is,

\[
q_{kl} = \lim_{h \to 0} \frac{\mathbb{P}[X_{t+h} = l | X_t = k]}{h}
\]

For $l = k$, $q_{kk}$ is the overall rate at which the process leaves state $k$ and is defined as a negative number.
\[ q_{kk} = - \sum_{l \neq k} q_{kl} \]
such that the sum across any given row is always zero. The intensity matrix tells us everything we need to know about the transition process. In particular, we know that the duration in state \( k \) has an exponential distribution with parameter \(-q_{kk}\). That is,

\[
F_k(t) = 1 - \exp(-t \sum_{l \neq k} q_{kl})
\]

and

\[
f_k(t) = \left( \sum_{l \neq k} q_{kl} \right) \exp(-t \sum_{l \neq k} q_{kl})
\]

Conditional on a jump occurring, the probability of transitioning to state \( l \) from state \( k \) is \( \frac{q_{kl}}{\sum_{l' \neq k} q_{kl'}} \). Therefore, the joint likelihood of a jump occurring at time \( \tau \) from state \( k \) to state \( l \) is

\[
L_{k,l,\tau} = \left( \sum_{l \neq k} q_{kl} \right) \exp(-\tau \sum_{l \neq k} q_{kl}) \times \frac{q_{kl}}{\sum_{l' \neq k} q_{kl'}} = q_{kl} \exp(-\tau \sum_{l \neq k} q_{kl})
\]

Putting this back into the terms of the model, where \( Q_N \) governs players and \( Q_0 \) governs nature, we can write the likelihood separately for nature’s moves and players’ moves. Let choice \( j = 0 \) be a player’s continuation choice, such that the state does not change. Then the likelihood that the next state change occurs after time \( \tau \) and is the result of player \( i \) making capacity choice \( j > 0 \) is given by

\[
\lambda_a \sigma_{ijk} \exp \left[ -\tau \left( \sum_{l \neq k} q_{kl}^0 + \sum_i \lambda_a \sum_{j \neq 0} \sigma_{aijk} + \sum_i \lambda_b \sum_{j \neq 0} \sigma_{bijk} \right) \right]
\]
which can be written

$$\lambda_a \sigma_{ijk} \exp \left[ -\tau \left( \sum_{l \neq k} q^0_{kl} + \sum_{r \in \{a, b\}} \lambda_r \sum_i (1 - \sigma_{rikt}) \right) \right]$$

Similarly, the likelihood that the next state change occurs after time $\tau$ and is the result of nature changing the state from $k$ to $l$ is

$$q^0_{kl} \exp \left[ -\tau \left( \sum_{l \neq k} q^0_{kl} + \sum_{r \in \{a, b\}} \lambda_r \sum_i (1 - \sigma_{rikt}) \right) \right]$$

Given data on $T$ observations of a change in the state and associated length of time, $\tau$, since the last state change, we construct the likelihood of the data as follows:

$$L(Q_0, \lambda_a, \lambda_b, \theta) = \prod_{t=1}^{T} \left\{ q^0_{kt} \exp \left[ -\tau_t \left( \sum_{l \neq k} q^0_{kl} + \sum_{r \in \{a, b\}} \lambda_r \sum_i (1 - \sigma_{rikt}) \right) \right] \right\}^{d_t} \times \left\{ \lambda_b \sigma_{bijkt} \exp \left[ -\tau_t \left( \sum_{l \neq k} q^0_{kl} + \sum_{r \in \{a, b\}} \lambda_r \sum_i (1 - \sigma_{rikt}) \right) \right] \right\}^{(1-d_t)b_t} \times \left\{ \lambda_a \sigma_{aijkt} \exp \left[ -\tau_t \left( \sum_{l \neq k} q^0_{kl} + \sum_{r \in \{a, b\}} \lambda_r \sum_i (1 - \sigma_{rikt}) \right) \right] \right\}^{(1-d_t)(1-b_t)}$$

where $d_t$ indicates a demand move, and $b_t$ indicates a bankruptcy move. Noting that $q^0_{kl} = \gamma$ and taking logs, we can write the log-likelihood function as follows:

$$l(\psi; \gamma, \lambda_a, \lambda_b, \rho, \hat{\sigma}, \hat{\beta}, \hat{\alpha}) = \sum_{t=1}^{T} \left\{ d_t \log (\gamma) + (1 - d_t) b_t \log (\lambda_b \hat{\sigma}_{bijkt}) + (1 - d_t)(1 - b_t) \log (\lambda_a \hat{\sigma}_{aijkt}) - \tau_t \left( \gamma + \sum_{r \in \{a, b\}} \lambda_r \sum_i (1 - \hat{\sigma}_{rikt}) \right) \right\}$$
Maximizing the log-likelihood yields estimates for the structural parameters. Identification follows from Blevins (2014).

**Flow Profit Estimation**

A key element of the state-specific value function is the flow profit, $u_{ik}$, in that state. Given the highly complex nature of network-level competition in the airline industry, I refrain from explicitly modeling network choice. Instead, I model flow profit in the domestic U.S. market as a reduced-form function of state variables such as the carrier’s capacity, the aggregate capacity in the market, and consumer demand. One of the many advantages of analyzing the U.S. airline industry is the abundance of data, including quarterly line-item-level accounting data. I proxy for flow profits using a carrier’s inflation-adjusted EBITDA. To estimate flow profit as a function of the state, I regress the set of carrier-quarter EBITDA values on the associated time-weighted average values of each state variable for each carrier-quarter. Estimating flow profit in this way allows me to abstract away from modeling utilization or network effects.

4.5.3 **Counterfactual Equilibria**

Armed with structural parameter estimates, I can solve for equilibria under alternative assumptions and measure the corresponding industry statistics. To examine just how much the bankruptcy option influences overall capacity levels in the industry, my counterfactual equilibrium of interest makes bankruptcy prohibitively costly. This section explains how to solve for such an equilibrium.

For a given set of parameters $\theta$, I can solve for a symmetric, anonymous Markov Perfect Equilibrium (MPE) using value function iteration. Existence of equilibrium

---

27 The interested reader will find a host of articles tackling that challenge, beginning with the basic entry model of Berry (1992) and stretching to the more complex models of Aguirregabiria and Ho (2010) and Ciliberto and Tamer (2009).
is shown in ABBE (2013). The solution process can take some time, especially for large games, which is why full-solution estimation can be extremely time-consuming. As previously discussed, CCP methods allow me to avoid solving for equilibrium during estimation, but doing so is necessary for simulating data from the model.

The number of possible states for each bankruptcy regime is \(2(2Q)^N\), representing a severe curse of dimensionality. To make the state space more manageable, I take advantage of exchangeability (a.k.a. anonymity) to reduce the number of payoff-relevant states over which the value function must be computed.\(^{28}\) This approach results in a much smaller state space of size \(S = 4Q(\frac{2Q+N-2}{N-1})\). To understand how this helps, consider that a 7-player game with 5 capacity choices has 20 million basic states, but only 100,100 anonymous states. The value function iteration program proceeds as follows:

1. Guess \(V\), an \(S \times 1\) vector

2. Compute firm 1’s expected value of a move arrival

   (a) Compute the normalized choice-specific values (including adjustment costs)

   (b) Expected value of moving is the inclusive value term (the log-sum)

3. Compute conditional choice probabilities (CCPs) for other players

4. Compute firm 1’s expected value of each opponent’s move arrival\(^{29}\)

5. Update \(V\) according to the updating equation

\(^{28}\) An alternative is the Pakes and McGuire (2001) algorithm, which iterates over the value of recurrent states only. The algorithm also conserves memory in computing the value function at each iteration because it considers only the set of states that can be visited in the next move, rather than the full set of possible states, some of which will not be reachable for at least two moves.

\(^{29}\) This is just the sum of the values (from firm 1’s perspective) associated with each possible choice for each possible opponent, weighted by the corresponding CCP.
We repeat this process until $V$ converges.\(^{30}\) The updating equation is

\[
V_{i,k} = \frac{1}{\rho + N\lambda_a + N\lambda_b + \gamma} \left\{ u_{i,k} + \gamma V_{i,l(demand,k)} + \lambda_a \mathbb{E} [V_{i,l(i,k;a)}] + \lambda_b \mathbb{E} [V_{i,l(i,k;b)}] + \sum_{i' \neq i} \lambda_a \mathbb{E} [V_{i,l(i',k;a)}] + \sum_{i' \neq i} \lambda_b \mathbb{E} [V_{i,l(i',k;b)}] \right\}
\]

where $i$ indexes the firm, $k$ indexes the current state, and $l$ indexes the future state. The value function can be described more intuitively using asset pricing terms. Let us first re-write it this way

\[
\rho V_{i,k} = u_{i,k} + \gamma \left( V_{i,l(demand,k)} - V_{i,k} \right) + \lambda_a \left( \mathbb{E} [V_{i,l(i,k;a)}] - V_{i,k} \right) + \lambda_b \left( \mathbb{E} [V_{i,l(i,k;b)}] - V_{i,k} \right) + \sum_{i' \neq i} \lambda_a \left( \mathbb{E} [V_{i,l(i',k;a)}] - V_{i,k} \right) + \sum_{i' \neq i} \lambda_b \left( \mathbb{E} [V_{i,l(i',k;b)}] - V_{i,k} \right)
\]

The formulation above indicates that the instantaneous opportunity cost of holding an asset ($\rho V$), should be equal to the dividend flow received from that asset ($u$) plus the capital gain realized when a change in value occurs ($V' - V$), weighted by the chance of that gain being realized ($\lambda_a, \lambda_b$, or $\gamma$). We can simplify the value function expression by substituting the following:

\[
\mathbb{E} [V_{i,l(i,k;r)}] = \mathbb{E} \max_{j \in X_{i,k,r}} \left\{ V_{i,l(i,j,k)} + \psi_{j,k} + \epsilon_{ij} \right\}
\]

\[
\mathbb{E} [V_{i,l(i',k;r)}] = \sum_{j \in X_{i',k,r}} \sigma_{i',j,k} \mathbb{E} [V_{i,l(i',j,k)}]
\]

\(^{30}\) Convergence is not guaranteed for a multi-player game, but when estimating the model, opponents’ CCPs are fixed, reducing the process to a single-player dynamic programming problem, which is guaranteed to converge.
where \( r \in \{a, b\} \) is the type of move opportunity, and \( X_{r,k} \) is the corresponding choice set. Firms’ strategies/CCPs are given in \( \sigma \), and instantaneous payoffs are given in \( \psi_{jk} \). Instantaneous payoffs are the capacity adjustment costs and bankruptcy exit costs. The key benefit of continuous-time modeling is that only one event can occur at a time. Firms’ state transitions are therefore deterministic conditional upon their choices, such that \( \mathbb{E}[V_{i,l(i',j,k)}] = V_{i,l(i',j,k)} \). Finally, our assumption on the error structure allows us to write the inclusive value term, \( \mathbb{E}_{j \in X_{i,k}; r} \{V_{i,l(i,j,k)} + \psi_{jk} + \epsilon_{ij}\} \), as

\[
\gamma_{eul} + \log \sum_{j \in X_{i,k}; r} \exp \left( V_{i,l(i,j,k)} + \psi_{jk} \right)
\]

where \( \gamma_{eul} \) is Euler’s constant.

4.6 Data

I employ three data sets, which together allow me to match capacity and bankruptcy decisions with firm profitability over time. The first is the Ascend Online Fleets database, maintained by Ascend Advisory,\(^{31}\) which contains ownership and technical data on over 200,000 aircraft worldwide. I aggregate Ascend’s daily aircraft-level data to measure airlines’ fleet size. The second data set includes the timing and outcome of all bankruptcy filings in the U.S. airline industry. The third is a set of publicly available databases maintained by the U.S. Department of Transportation (DOT). Data on quantities and prices for commercial passenger air travel come primarily from the Airline Origin & Destination Survey, known as Data Bank 1B (DB1B).\(^{32}\) I supplement the DB1B data with the Form 41 Traffic database (T100) and the Form

\(^{31}\) I am grateful to the Duke Economics Department and Andrew Sweeting for helping me purchase this data. More details can be found at the company’s Website:
http://www.ascendworldwide.com

\(^{32}\) A wealth of air traffic information is publicly available for download from the Bureau of Transportation Statistics (http://www.transtats.bts.gov/). The DB1B data since 1993 are freely available here, and earlier years are available for purchase in hard copy.
Financial database. I now describe each data set in further detail.

4.6.1 *Daily Fleet Data*

Capacity is defined as the number of seats in a carrier’s aircraft fleet, grouped into a number of bins. Daily fleet data comes from the Ascend Online Fleets data base, which was purchased from Flightglobal, a division of U.K.-based Reed Business Information. This data set works well with a continuous-time modeling approach because it provides a daily snapshot of aircraft ownership and usage. Each observation covers all passenger aircraft operated in North America, including their registration and serial numbers, owners and operators (indicating leased vs. owned), aircraft and engine types and manufacturers, and status (in storage, on order, in service, etc.), among other details. I aggregate this data into daily fleet snapshots for all domestic passenger air carriers. Fluctuations in operating fleet serve as a key indicator of capacity investment. However, I must account for the fact that many aircraft are purchased years ahead of time. The fleet database provides each aircraft’s build year, order date, and delivery date, so I know when each aircraft was ordered, at least for brand new planes. Another concern is that the aircraft fleet is not partitioned into regional subcategories, posing a challenge when analyzing domestic data only. Following Severin Borenstein’s lead, I can restrict the analysis to narrow-body jets, since wide-body jets are more often used to fly over-ocean routes. Another key piece of data is the financier, if present, for each aircraft, which allows me to measure how many parties (either lessors or secured creditors) with which a given carrier is contracted. Figures 4.3-4.5 demonstrate that fleet investment has fallen since BAPCPA was enacted, and demand for passenger air travel fails to explain the trend.
Figure 4.3: Median % Fleet Additions

Figure 4.4: Median Net % Change in Fleet Size

Figure 4.5: Median % Fleet Additions and Implied Demand
Table 4.1 summarizes daily aircraft fleets for several large carriers.

Table 4.1: Capacity Statistics

<table>
<thead>
<tr>
<th>Player</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>American (AA)</td>
<td>99.8</td>
<td>105.4</td>
</tr>
<tr>
<td>Continental (CO)</td>
<td>46.8</td>
<td>47.1</td>
</tr>
<tr>
<td>Delta (DL)</td>
<td>87.5</td>
<td>92.0</td>
</tr>
<tr>
<td>Northwest (NW)</td>
<td>61.0</td>
<td>69.5</td>
</tr>
<tr>
<td>United (UA)</td>
<td>85.0</td>
<td>88.2</td>
</tr>
<tr>
<td>US Airways (US)</td>
<td>46.3</td>
<td>52.3</td>
</tr>
<tr>
<td>Southwest (WN)</td>
<td>45.9</td>
<td>42.7</td>
</tr>
<tr>
<td>America West (HP)</td>
<td>59.7</td>
<td>36.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>66.8</strong></td>
<td><strong>66.4</strong></td>
</tr>
<tr>
<td><strong>Observations</strong></td>
<td>98,448 carrier-days</td>
<td></td>
</tr>
</tbody>
</table>

4.6.2 Bankruptcy Events

Evaluating firms’ decisions to enter and exit bankruptcy requires data on the timing and circumstances of these decisions. I extend and cross-check Ciliberto and Schenone’s (2012) list of pre-2008 bankruptcies using news and trade journal reports, court dockets, Lynn LoPucki’s (UCLA) Bankruptcy Research Database, and data from Airlines for America (A4A), the U.S. airline industry’s primary trade organization. While nearly 200 airline cases have been filed since 1978, many of those involved small and/or cargo carriers. I focus on the filings of passenger airlines with at least 20 aircraft who provide service on their own routes, as opposed to regional carriers who primarily operate as feeder airlines to larger companies. After imposing those restrictions and combining mutually owned companies, I end up with 41 bankruptcy filings matched to capacity data. If that figure seems a bit small, recall that the model is not just estimated off of transitions between states. Every daily observation of a firm’s bankruptcy state provides information on the hazard of state
transition, so knowing that American Airlines was bankrupt on January 1, 2013 is just as important as knowing that the firm was not bankrupt on March 3, 2005, for example. Figures 4.6 and 4.7 show no discernible trend in overall bankruptcy filings but suggest that firms nearing insolvency chose to file under the pre-BAPCPA rules.\textsuperscript{33}

\textsuperscript{33} Data include all airline filings, not just those that are matched with capacity data.
4.6.3 Demand and Flow Profit

Airline demand is typically estimated using publicly available price and quantity data. I used quarterly data from the Department of Transportation to construct such a measure and found that it was no better at predicting profit or investment than a measure of real GDP growth. Moreover, using real GDP allows me to credibly treat my demand measure as exogenous, while also sidestepping the need to account for demand estimation error when reporting final results. Therefore, I measure industry demand using year-over-year quarterly growth in real GDP. I define the demand state as good if growth was above the linear trend, and bad otherwise. This definition amounts to about 20 demand changes over the course of my data, consistent in both number and direction with results from estimating demand with price and quantity data.

As mentioned in Section 4.5.2, the abundance of airline data is a boon for estimation. The Department of Transportation’s Form 41 Financial Data, Schedule P-1.2 provides an abundant source of financial information, including operating revenue and expense data for reporting carriers in the U.S. Several expense categories are even broken into detailed subcategories. More importantly, this data set breaks down each accounting category by region, which is not always done in SEC filings for publicly traded airlines. As such, I am able to link domestic operating profits to domestic demand. In order to convert accounting data into economic profits, I assume that operating cash flow is proportional to economic profit. I measure operating cash flow as earnings before interest, taxes, depreciation, and amortization, or EBITDA. Table 4.2 summarizes this value for several large carriers.
4.7 Results

I now present the results of each empirical analysis: My difference-in-differences test shows that an increase in bankruptcy cost tends to discipline capital investment; my structural estimation quantifies the effect of BAPCPA; and my counterfactual simulations demonstrate that rescinding BAPCPA would increase industry capacity by about 5%, while completely eliminating the reorganization option would reduce industry capacity levels by as much as 20%.

4.7.1 Difference-in-Differences Results

As mentioned previously, the changes made by BAPCPA were more likely to affect the behavior of the most complex firms, for which Chapter 11 typically represents a multi-year process. Following the empirical literature on bankruptcy, I proxy for complexity using firm size. I measure firm size as the average number of seats available in the fleet during the quarter, and I split the sample in half by size as of the fourth quarter of 2004, using 5,000 seats as the cutoff. Investment is the percent

Table 4.2: Profit Statistics

<table>
<thead>
<tr>
<th>Player</th>
<th>Mean</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>American (AA)</td>
<td>1274</td>
<td>1551</td>
<td>-4509</td>
<td>4267</td>
</tr>
<tr>
<td>Continental (CO)</td>
<td>548</td>
<td>538</td>
<td>-1467</td>
<td>2104</td>
</tr>
<tr>
<td>Delta (DL)</td>
<td>1486</td>
<td>1169</td>
<td>-1475</td>
<td>6111</td>
</tr>
<tr>
<td>Northwest (NW)</td>
<td>801</td>
<td>879</td>
<td>-1348</td>
<td>3132</td>
</tr>
<tr>
<td>United (UA)</td>
<td>1019</td>
<td>1186</td>
<td>-4307</td>
<td>4638</td>
</tr>
<tr>
<td>US Airways (US)</td>
<td>255</td>
<td>255</td>
<td>-3646</td>
<td>2349</td>
</tr>
<tr>
<td>Southwest (WN)</td>
<td>1000</td>
<td>960</td>
<td>62</td>
<td>2253</td>
</tr>
<tr>
<td>America West (HP)</td>
<td>377</td>
<td>393</td>
<td>-2499</td>
<td>1529</td>
</tr>
<tr>
<td>Overall</td>
<td>846</td>
<td>737</td>
<td>-4509</td>
<td>6111</td>
</tr>
<tr>
<td>Observations</td>
<td>696 carrier-quarters</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observations: 696 carrier-quarters
change in fleet size from the same quarter of the previous year. Table 4.3 shows that BAPCPA reduced overall investment of sufficiently large firms by 60% relative to small airlines.

Table 4.3: Difference-in-Differences Results

<table>
<thead>
<tr>
<th>Dependent Variable = Year-over-Year % Change in Fleet Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Post BAPCPA</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Large X Post BAPCPA</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Moving Average of Demand Growth</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Seasonal Fixed Effects</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type-Specific Fixed Effects (LEG, LCC, Other)</td>
<td>Yes</td>
</tr>
<tr>
<td>Type-Specific Linear Time Trend</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>4,192</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.10
4.7.2 Structural Model Estimates: Flow Profit Estimates

Table 4.4 presents results from an ordinary least squares regression of annualized free cash flows on capacity, demand, and a number of other state variables. As one might expect, demand and own capacity tend to improve performance, while opponents’ capacity reduces profitability when demand is high. These results provide the basis for the flow profit function used in the second stage of the estimation.

Table 4.4: Flow Profit Estimation

<table>
<thead>
<tr>
<th>Dependent Variable = Annualized Quarterly EBITDA (in millions of $2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Demand</td>
</tr>
<tr>
<td>Sum of Opponents’ Capacity</td>
</tr>
<tr>
<td>Own Capacity</td>
</tr>
<tr>
<td>OwnCap X OppCap</td>
</tr>
<tr>
<td>HighDem X OwnCap</td>
</tr>
<tr>
<td>HighDem X OppCap</td>
</tr>
<tr>
<td>HighDem X OppCap X OwnCap</td>
</tr>
<tr>
<td>Seasonal Fixed Effects</td>
</tr>
<tr>
<td>Number of Observations</td>
</tr>
</tbody>
</table>

Significance based on robust standard errors clustered at the player level.
*** p<0.01, ** p<0.05, * p<0.10
4.7.3 Structural Model Estimates: Second Stage

Table 4.5 illustrates that BAPCPA more than doubled the cost of emerging from Chapter 11, raising it from $799 million to $906 million. Upward adjustment costs are estimated to be around $170 million outside of bankruptcy and $631 under bankruptcy protection. Downward adjustment costs are about $1 billion outside of bankruptcy and $145 million under bankruptcy protection. Put in context, the median annualized cash flow across carriers is about $700 million. Adjustment costs are based on a change of between 20 and 40 aircraft. The ballpark value for a new Boeing 737 is $50 million,\(^{34}\) while a rough estimate\(^{35}\) of early lease cancellation fees amounts to $10 million per aircraft.

\(^{34}\) [Website URL]

\(^{35}\) Based on AMR Corporation’s 2010 10-K
Table 4.5: Structural Parameter Estimates

(costs in millions of $2009)

<table>
<thead>
<tr>
<th>Parameter Description</th>
<th>Estimate</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Bankruptcy Emergence Cost</td>
<td>799 **</td>
<td>(345)</td>
</tr>
<tr>
<td>BAPCPA Incremental Bankruptcy Emergence Cost</td>
<td>906 **</td>
<td>(330)</td>
</tr>
<tr>
<td>Upward Adjustment Cost, Non-Bankruptcy</td>
<td>170</td>
<td>(260)</td>
</tr>
<tr>
<td>Downward Adjustment Cost, Non-Bankruptcy</td>
<td>1061 ***</td>
<td>(285)</td>
</tr>
<tr>
<td>Upward Adjustment Cost, Bankruptcy</td>
<td>631 *</td>
<td>(305)</td>
</tr>
<tr>
<td>Downward Adjustment Cost, Bankruptcy</td>
<td>145</td>
<td>(523)</td>
</tr>
<tr>
<td>Scale Parameter</td>
<td>0.47</td>
<td>(2.6)</td>
</tr>
<tr>
<td>Number of Observed Events</td>
<td>1184</td>
<td></td>
</tr>
</tbody>
</table>

Bootstrapped standard errors in parentheses.

4.7.4 Counterfactual Simulation

Using the structural model estimates, I now solve for two counterfactual equilibria. In the first, I simulate industry evolution as though the expected cost of Chapter 11 is infinite, effectively precluding reorganization as a downsizing option. As a result, I find that eliminating the Chapter 11 option reduces overall capacity by as much as 20% relative to its actual level, suggesting that the malleability of contracts in bankruptcy has a significant inflationary effect on capacity. This result is not entirely surprising given the steep adjustment cost associated with downsizing outside of bankruptcy.

The second counterfactual simulates what would have happened had BAPCPA never been passed. In that scenario, I find a modest increase in industry capacity of about 5%, representing an estimate of the contribution of BAPCPA to observed
capacity discipline. Though small in magnitude, the presence of any effect at all should give pause to bankruptcy law reformers. In his recent testimony before the American Bankruptcy Institute’s Commission to Study the Reform of Chapter 11, bankruptcy expert and law professor Daniel Keating stressed policymakers to respect the potential for unintended consequences from tweaking the U.S. Bankruptcy Code.\textsuperscript{36} As Congress reviews the Commission’s final report, the influence of Chapter 11’s non-financial provisions on investment behavior should be considered.

4.7.5 Conclusion

The key takeaway of this chapter is that bankruptcy law, specifically Chapter 11, can influence oligopoly investment behavior. I have presented a straightforward theoretical model that predicts capacity discipline as an outcome of stricter bankruptcy policy, and I have provided support for that prediction with rigorous, multi-faceted empirical analysis. As the first analysis to link the investment and reorganization decisions in a strategic setting, this work has a number of interesting extensions in both the corporate finance and industrial organization literatures. Moreover, the predictions of the theoretical model generalize to any industry with heavy contractual investment and volatile demand, suggesting an important and heretofore undiscussed consideration for bankruptcy law reform, both in the United States and abroad.

Appendix A

Overview of Distributions

The following is meant as a refresher on the PDFs and CDFs of Poisson and exponential distributions. Poisson is a discrete distribution with PMF

\[ P(x) = \frac{\exp(-\mu)\mu^x}{x!} \]

where \( x = 0, 1, 2, ... \) and the mean and variance are both \( \mu \). Exponential is a continuous distribution with PDF

\[ f(t) = \lambda \exp(-\lambda t) \]

where \( t \geq 0 \) and the mean and variance are both \( \frac{1}{\lambda} \). The exponential CDF is

\[ F(t) = 1 - \exp(-\lambda t) \]

If the Poisson describes the number of occurrences per unit of time, then the exponential describes the duration between occurrences. That is, the Poisson rate describes how many events should occur, on average, per unit of time. If \( \lambda t \) events occur in \( t \) units of time, then the probability that no events occur in an interval of \( t \) is

\[ P(0; \mu = \lambda t) = \frac{\exp(-\lambda t)(\lambda t)^0}{0!} = \exp(-\lambda t) \]

125
Therefore, the probability that an event has not occurred after \( t \) time has passed is 
\[ 1 - \exp(-\lambda t) = F(t). \]

Finally, let’s match the exponential distribution to the intensity matrix of a Markov jump process. Following Chapter 3 of Hoel et al. (1986), a jump process is a sequence \( X(t) \) that describes the state of a system at time \( t \) in the following way:

\[
X(t) = \begin{cases} 
x_0, & 0 \leq t < \tau_1 \\
x_1, & \tau_1 \leq t < \tau_2 \\
x_2, & \tau_2 \leq t < \tau_3 \\
\vdots
\end{cases}
\]

A pure jump process is one that is non-explosive, that is, one for which \( \lim_{n \to \infty} \tau_n = \infty \). The jump times and associated states are random. If the process reaches an absorbing state, it remains there forever, whereas if the process reaches a non-absorbing state \( k \), it remains there for some length of time \( t \), which is distributed according to \( F_k(t) \). After \( t \) elapses, the process jumps from state \( k \) to state \( l \) with probability \( Q_{kl} \) (define \( Q_{kk} = 0 \)). Moreover, the time and state events are independent. Hence, if we consider a pure jump process beginning in state \( k \) at time 0, then

\[
P_x[\tau_1 \leq t, \ X(\tau_1) = l \mid x_0 = k] = F_k(t)Q_{kl}
\]

Referencing Chapter 5 of Hoel et al. (1971), Hoel et al. (1986) points out that a pure jump process is Markovian if and only if \( F_x(t) \) is exponential for every non-absorbing state \( x \). Let \( P_x \) denote the probability of an event conditional on the current state being \( x \). Then the Markov property means

\[
P_x[\tau_1 > t + s, \ | \ \tau_1 > s] = P_x[\tau_1 > t]
\]

Further, let \( P_{xy}(t) \) denote the probability that a process beginning in state \( x \) is in state \( y \) at time \( t \), and let \( P_{xy}(0) = \delta_{xy} \), where

\[
\delta_{xy} = \begin{cases} 
1, & y = x \\
0, & y \neq x
\end{cases}
\]

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Then the Markov property also implies

\[ P_{xy}(t + s) = \sum_z P_{xz}(t)P_{zy}(s) \]

To relate all of this to the intensity matrix I use in 4, let \( q_x \) be the parameter that defines the exponential distribution \( F_x \). Since I always have to be reminded, that means

\[ F_x(t) = 1 - \exp(-q_xt) \]

and

\[ P_x[\tau_1 \geq t] = 1 - F_x(t) = \exp(-q_xt) \]

We can describe \( P_{xy}(t) \) as the integral over all possible jumps from time from 0 to \( t \) that take the process from state \( x \) to state \( z \), each weighted by the probability of thereafter transitioning from state \( z \) to state \( y \). This yields the Chapman-Kolmogorov equation.

\[
P_{xy}(t) = \delta_{xy}(1 - F_x(t)) + \int_0^t f_x(s) \left( \sum_{z \neq x} Q_{xz}P_{zy}(t-s) \right) ds
\]

\[
= \delta_{xy} \exp(-q_xt) + \int_0^t q_x \exp(-q_xt) \left( \sum_{z \neq x} Q_{xz}P_{zy}(t-s) \right) ds
\]

To get the infinitesimal parameters of the intensity matrix, first replace \( s \) with \( t - s \)
\[ P_{xy}(t) = \delta_{xy} \exp(-q_x t) + \int_0^t q_x \exp(-q_x s) \left( \sum_{z \neq x} Q_{xz} p_{zy}(s) \right) ds \]

\[ = \delta_{xy} \exp(-q_x t) + q_x \exp(-q_x t) \int_0^t \exp(q_x s) \left( \sum_{z \neq x} Q_{xz} p_{zy}(s) \right) ds \]

and then differentiate with respect to \( t \) to get

\[ P_{xy}'(t) = -q_x \delta_{xy} \exp(-q_x t) - q_x^2 \exp(-q_x t) \int_0^t \exp(q_x s) \left( \sum_{z \neq x} Q_{xz} p_{zy}(s) \right) ds + q_x \exp(-q_x t) \left[ \exp(q_x t) \left( \sum_{z \neq x} Q_{xz} p_{zy}(t) \right) \right] \]

\[ = -q_x P_{xy}(t) + q_x \left( \sum_{z \neq x} Q_{xz} p_{zy}(t) \right) \]

which at \( t = 0 \) reduces to

\[ P_{xy}'(0) = -q_x \delta_{xy} + q_x Q_{xy} \]

Define \( q_{xy} \equiv P_{xy}'(0) \), and we can write the elements of the intensity matrix in a familiar way

\[ q_{xy} = \begin{cases} 
-q_x, & y = x \\
q_x Q_{xy}, & y \neq x 
\end{cases} \]

and since \( \sum_y Q_{xy} = 1 \), we know that \( \sum_y q_{xy} = q_x = -q_{xx} \). Recall that each non-diagonal element of the intensity matrix is the instantaneous probability (hazard rate) of transitioning from one state to another:

\[ q_{kl} = \lim_{h \to 0} \frac{\Pr[X_{t+h} = l | X_t = k]}{h} \]

1 Use Liebniz rule:

\[ \frac{\partial}{\partial t} \left( \int_{a(t)}^{b(t)} f(t, s) ds \right) = f(t, b(t))b'(t) - f(t, a(t))a'(t) + \int_{a(t)}^{b(t)} f_t(t, s) ds \]

In this case, \( a(t) = 0 \) and \( b(t) = t \)
and the sum of these probabilities represents the rate at which the process leaves state \( k \). Therefore, the CDF of the duration spent in state \( x \) is given by

\[
F_x(t) = 1 - \exp(-t \sum_y q_{xy})
\]
Appendix B

CCP Representation

B.1 Overview

To apply the two-step procedure requires us to find a way to represent the analytical CCPs as explicit functions of the structural parameters and the empirical CCPs. Consider again the ex ante value function for firm $i$ in state $k$:

$$V_{i,k} = \frac{1}{\rho + N\lambda_a + N\lambda_b + \gamma} \left( \mu_{i,k} + \gamma V_{i,l(demand,k)} + \lambda_a \mathbb{E} \left[ V_{i,l(i,k:a)} \right] + \lambda_b \mathbb{E} \left[ V_{i,l(i,k:b)} \right] ight)$$

$$+ \sum_{i' \neq i} \lambda_a \mathbb{E} \left[ V_{i,l(i',k:a)} \right] + \sum_{i' \neq i} \lambda_b \mathbb{E} \left[ V_{i,l(i',k:b)} \right]$$

and apply what we know of the expectation terms

$$\mathbb{E} \left[ V_{i,l(i,k;r)} \right] = \mathbb{E} \max_{j \in X_{i,k,r}} \{ V_{i,l(i,j,k)} + \psi_{jk} + \epsilon_{ij} \}$$

$$\mathbb{E} \left[ V_{i,l(i',k;r)} \right] = \sum_{j \in X_{i',k,r}} \sigma_{i',j,k} V_{i,l(i',j,k)}$$

to arrive at

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\[ V_{i,k} = \frac{1}{\rho + N\lambda_a + N\lambda_b + \gamma} \left( u_{i,k} + \gamma V_{i,l(demand,k)} \right) \]  

\[ + \sum_{r \in \{a,b\}} \lambda_r \left( \mathbb{E} \max_{j \in X_{i,k,r}} \{ V_{i,l(i,j,k)} + \psi_{jk} + \epsilon_{ij} \} + \sum_{i' \neq i} \sum_{j \in X_{i',k,r}} \sigma_{i',j,k} V_{i,l(i',j,k)} \right) \]  

(B.1)

B.2 Incumbents

Applying Proposition 2 of ABBE (2013), we can write the Emax term as follows:

\[ \mathbb{E} \max_{j \in X_{i,k,r}} \{ V_{i,l(i,j,k)} + \psi_{jk} + \epsilon_{ij} \} = \gamma_{eul} + \psi_{j',k} + V_{i,l(i,j',k)} - \log(\sigma_{j',k}) \]

for any choice \( j' \in X_{i,k,r} \). For incumbents facing a capacity adjustment opportunity, we can choose \( j' = \text{exit} \) and normalize the continuation value of \( \text{exit} \) to 0,\(^1\) giving us

\[ \mathbb{E} \max_{j \in X_{i,k,a}} \{ V_{i,l(i,j,k)} + \psi_{jk} + \epsilon_{ij} \} = \gamma_{eul} + \psi_{\text{exit},k} - \log(\sigma_{\text{exit},k}) \]  

(B.2)

The same proposition allows us to compare the value functions of different states, as reflected in Proposition 1 of ABBE (2013) below:

\[ \gamma_{eul} + \psi_{j,k} + V_{i,l(i,j,k)} - \log(\sigma_{j,k}) = \gamma_{eul} + \psi_{j',k} + V_{i,l(i,j',k)} - \log(\sigma_{j',k}) \]

\[ V_{i,l(i,j,k)} = V_{i,l(i,j',k)} + \psi_{j',k} - \psi_{j,k} + \log(\sigma_{j,k}) - \log(\sigma_{j',k}) \]

where \( j \) and \( j' \) are elements of the same choice set \( X_{i,k,r} \). To compare value functions across choice sets, suppose that player \( i \) in state \( k \) will always have a continuation choice, \( j^* \), that does not change the state. In other words, players can always choose

\(^1\) Note that the adjustment cost of exit is state-specific, so while leaving the industry is worth zero going forward, the context in which a carrier exits (e.g. liquidation, merger, etc.) is allowed to matter.
to do nothing, regardless of the type of move opportunity that arrives. Combining this expression with the continuation choice gives us the following two equalities:

\[ V_{i,l}(i,j_a^*, k) = V_{i,l}(i,j_a, k) + \psi_{ja,k} - \psi_{j_a^*, k} + \log(\sigma_{j_a^*,k}) - \log(\sigma_{ja,k}) \]

\[ V_{i,l}(i,j_b^*, k) = V_{i,l}(i,j_b, k) + \psi_{jb,k} - \psi_{j_b^*, k} + \log(\sigma_{j_b^*,k}) - \log(\sigma_{jb,k}) \]

where the \( j \) choices have subscripts to indicate their relevant choice sets. Recognizing that \( V_{i,l}(i,j_a^*, k) = V_{i,l}(i,j_b^*, k) \), we can write

\[ V_{i,l}(i,j_a, k) + \psi_{ja,k} - \psi_{j_a^*, k} + \log(\sigma_{j_a^*,k}) - \log(\sigma_{ja,k}) = V_{i,l}(i,j_b, k) + \psi_{jb,k} - \psi_{j_b^*, k} + \log(\sigma_{j_b^*,k}) - \log(\sigma_{jb,k}) \]

which, assuming there is no instantaneous cost to choosing the status quo, simplifies to

\[ V_{i,l}(i,j_b, k) = V_{i,l}(i,j_a, k) + \psi_{ja,k} + \log(\sigma_{j_a^*,k}) - \log(\sigma_{ja,k}) - \psi_{jb,k} - \log(\sigma_{j_b^*,k}) + \log(\sigma_{jb,k}). \]

If we set \( j_a = exit \) and apply the the normalization of equation B.2, we get

\[ V_{i,l}(i,j_b, k) = \psi_{exit,k} + \log(\sigma_{j_a^*,k}) - \log(\sigma_{exit,k}) - \psi_{jb,k} - \log(\sigma_{j_b^*,k}) + \log(\sigma_{jb,k}). \]

For an incumbent facing a bankruptcy adjustment opportunity, we can substitute this expression into Proposition 1 and cancel terms to arrive at

\[
\mathbb{E} \max_{j \in \mathcal{X}_{i,k,b}} \left\{ V_{i,l}(i,j,k) + \psi_{jk} + \epsilon_{ij} \right\} = \gamma_{\text{eul}} + \psi_{exit,k} + \log(\sigma_{j_a^*,k}) - \log(\sigma_{exit,k}) - \log(\sigma_{j_b^*,k}) + \log(\sigma_{jb,k}). \] (B.3)

Next consider the value to player \( i \) of an opponent’s choice, which moves the state from \( k \) to \( k' \equiv l(i',j,k) \). Note that the value to player \( i \) of being in state \( k' \)
does not depend on how player $i$ arrived in that state. Therefore, if we again let $j^*$ represent a continuation choice for player $i$, such that $l(i, j^*, k') = k'$, then we have $V_{i,l(i', j, k)} = V_{i,k'} = V_{i,l(i,j^*, k')}$. Proposition 3 of ABBE (2013) applies this equivalence, allowing us to re-write Proposition 1 as follows:

$$V_{i,l(i', j, k)} = V_{i,l(i,j^*, k')} = V_{i,l(i,j^*, k')} + \psi_{j^*,k'} - \psi_{j^*, k'} + \log(\sigma_{j^*,k'}) - \log(\sigma_{j', k'})$$

where $j'$ is any of player $i$'s choices in state $k'$, and we can again set $\psi_{j^*,k'} = 0$. In addition, whenever player $i$'s choice set in state $k'$ includes both exit and a continuation choice $j^*$ (i.e. for a capacity adjustment decision), we can substitute $V_{i,l(i, exit, k')} = 0$ for $V_{i,l(i,j', k')}$ to get an even tidier result:

$$V_{i,l(i', j, k)} = \psi_{exit,l(i', j, k)} + \log(\sigma_{j^*,l(i', j, k)}) - \log(\sigma_{exit,l(i', j, k)})$$

(B.4)

where I have applied $k' \equiv l(i', j, k)$ to make it clear that we still have an opponent’s move in view. The same expression applies to moves by nature. Expressions B.2-B.4 will be valid for all states in which player $i$ is an incumbent. Substituting them into B.1 expresses each value function in terms of CCPs and parameters.

$$V_{i,k} (\rho + N\lambda_a + N\lambda_b + \gamma) = u_{i,k}$$

$$+ \gamma \left[ \psi_{exit,l(demand, k)} - \log(\sigma_{exit,l(demand, k)}) + \log(\sigma_{j^*,l(demand, k)}) \right]$$

$$+ \lambda_a \left[ \gamma_{eul} + \psi_{exit,k} - \log(\sigma_{exit,k}) \right]$$

$$+ \lambda_b \left[ \gamma_{eul} + \psi_{exit,k} - \log(\sigma_{exit,k}) + \log(\sigma_{j^*,k}) - \log(\sigma_{j^*,k}) \right]$$

$$+ \sum_{r \in \{a,b\}} \lambda_r \left( \sum_{i' \neq i} \sum_{j \in X_{i',k,r}} \sigma_{i',j,k} \nu_{i',j,k} \right)$$

where $\nu_{i',j,k} = \psi_{exit,l(i', j, k)} - \log(\sigma_{exit,l(i', j, k)}) + \log(\sigma_{j^*,l(i', j, k)})$.

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B.3 Potential Entrants

For potential entrants, \textit{exit} is not an option, so we must apply another substitution in order to eliminate value functions on the right-hand side. As before, apply Proposition 2 to get

$$\mathbb{E} \max_{j \in X_{i,k}} \{V_{i,l(i,j,k)} + \psi_{jk} + \epsilon_{ij}\} = \gamma_{eul} + \psi_{j',k} + V_{i,l(i,j',k)} - \log(\sigma_{j',k})$$

but now let \( j' = 1 \), the choice to enter with the lowest possible capacity, and define \( k^* \equiv l(i, 1, k) \). Then, since player \( i \) is an incumbent in state \( k^* \), simply apply equation B.4 to \( V_{i,l(i,j',k)} \) to get an expression for the future value of player \( i \)'s move:

$$\mathbb{E} \max_{j \in X_{i,k}} \{V_{i,l(i,j,k)} + \psi_{jk} + \epsilon_{ij}\} = \gamma_{eul} + \psi_{1,k} + \left[\psi_{\text{exit},k^*} + \log(\sigma_{j^*,k^*}) - \log(\sigma_{\text{exit},k^*})\right] - \log(\sigma_{1,k})$$

(B.5)

To represent the future values of opponents’ moves, apply Proposition 1 as before:

$$V_{i,l(i',j,k)} = V_{i,l(i,j^*,k')} = V_{i,l(i,j',k')} + \psi_{j',k'} - \psi_{j^*,k'} + \log(\sigma_{j^*,k'}) - \log(\sigma_{j',k'})$$

Choose \( j' = 1 \) and apply equation B.4 again to get

$$V_{i,l(i',j,k)} = \left[\psi_{\text{exit},l(i,1,k')} + \log(\sigma_{j^*,l(i,1,k')}) - \log(\sigma_{\text{exit},l(i,1,k')})\right] + \psi_{1,k'} + \log(\sigma_{j^*,k'}) - \log(\sigma_{1,k'})$$

(B.6)

Substitute B.5 and B.6 into B.1 to get expressions for each value function.
\[ V_{i,k} (\rho + N \lambda_a + (N - 1) \lambda_b + \gamma) = \]

\[ u_{i,k} + \gamma \left[ \psi_{\text{exit},l(i,1,k^\prime')} + \log(\sigma_{j^\prime, l(i,1,k^\prime')} - \log(\sigma_{\text{exit},l(i,1,k^\prime')}) \right] \]

\[ + \psi_{1,k^\prime} + \log(\sigma_{j^\prime, k^\prime}) - \log(\sigma_{1,k^\prime}) \]

\[ + \lambda_a \left[ \gamma_{\text{cut}} + \psi_{1,k} + \left[ \psi_{\text{exit},k^\prime} + \log(\sigma_{j^\prime, k^\prime}) - \log(\sigma_{\text{exit},k^\prime}) \right] - \log(\sigma_{1,k}) \right] \]

\[ + \sum_{r \in \{a,b\}} \lambda_r \left( \sum_{i' \neq i} \sum_{j \in X_{i',k,r}} \sigma_{i',j,k} \left[ \nu_{i',j,k} + \psi_{1,k^\prime} \right. \right. \]

\[ + \log(\sigma_{j^\prime, k^\prime}) - \log(\sigma_{1,k^\prime}) \left. \right] \right) \]

where \( \nu = \psi_{\text{exit},l(i,1,k^\prime')} + \log(\sigma_{j^\prime, l(i,1,k^\prime')} - \log(\sigma_{\text{exit},l(i,1,k^\prime')}) \), \( k^\prime \equiv l(\text{demand}, k) \), \( k' \equiv l(i', j, k) \), and I have prohibited potential entrants from filing for bankruptcy.
Appendix C

Duopoly Model

C.1 Solution

Recall from Section 4.4.1 that firms’ value functions are recursively defined as follows:

\[ rV_2 = \pi_2 + x_2 \left( V_1 - V_2 \right) + \left( 1 - \gamma_2 \right) d_2 \left( V_1 - V_2 - R_2 \right) + \gamma_2 d_2 \left( V_0 - V_2 - R_2 \right) + \psi \left[ W_2 - V_2 \right] \] (C.1)

\[ rV_1 = \max_{x_1 \geq 0} \left\{ \pi_1 - \lambda x_1 + \left[ x_1 + d_{-1} \right] \left( V_2 - V_1 \right) + x_{-1} \left( V_0 - V_1 \right) + \ldots \right\} + \left( 1 - \gamma_1 \right) d_1 \left( V_0 - V_1 - R_1 \right) + \gamma_1 d_1 \left( V_{-1} - V_1 - R_1 \right) + \psi \left[ W_1 - V_1 \right] \] (C.2)

\[ rV_0 = \max_{x_0 \geq 0} \left\{ \pi_0 - \lambda x_0 + \left[ x_0 + \left( 1 - \gamma_0 \right) d_0 \right] \left( V_1 - V_0 \right) + x_0 \left[ V_{-1} - V_0 \right] + \ldots \right\} + \left( 1 - \gamma_0 \right) d_0 \left( V_{-1} - V_0 - R_0 \right) + \gamma_0 d_0 \left( V_{-2} - V_0 - R_0 \right) + \psi \left[ W_0 - V_0 \right] \] (C.3)

\[ rV_{-1} = \max_{x_{-1} \geq 0} \left\{ \pi_{-1} - \lambda x_{-1} + \left[ x_{-1} + \left( 1 - \gamma_{-1} \right) d_{-1} \right] \left( V_{0} - V_{-1} \right) + x_{-1} \left[ V_{-2} - V_{-1} \right] + \ldots \right\} + \left( 1 - \gamma_{-1} \right) d_{-1} \left( V_{-1} - V_{-1} - R_{-1} \right) + \gamma_{-1} d_{-1} \left( V_{-1} - V_{-1} \right) + \psi \left[ W_{-1} - V_{-1} \right] \] (C.4)

\[ rV_{-2} = \max_{x_{-2} \geq 0} \left\{ \pi_{-2} - \lambda x_{-2} + \left[ x_{-2} + \left( 1 - \gamma_{-2} \right) d_{-2} \right] \left( V_{-1} - V_{-2} \right) + \gamma_{-2} d_{-2} \left( V_{0} - V_{-2} \right) + \psi \left[ W_{-2} - V_{-2} \right] \right\} \] (C.5)
According to C.11 and C.12, we know that

\[ V_{n+1} - V_n = \lambda \text{ for } n \in \{-2, -1, 0, 1\} \tag{C.11} \]

while any non-zero disinvestment level must satisfy

\[ W_n - W_{n+1} = \theta \text{ for } n \in \{-1, 0, 1, 2\} \tag{C.12} \]

per the first-order conditions for each optimization problem. Combining C.11 and C.5 gives

\[ V_{-2} = \frac{\pi_{-2} + \lambda (1 + \gamma_2) d_2 + \psi W_{-2}}{r + \psi} \]

Similarly, combining C.12 and C.6 yields

\[ W_2 = \frac{\pi_2 + \theta (1 + \phi_2) b_2 + \psi' V_2 - R_2 b_2}{r + \psi'} \]

According to C.11 and C.12, we know that \( V_2 = V_{-2} + 4\lambda \) and \( W_{-2} = W_2 + 4\theta \). These
conditions give us a solvable system of two equations:

\[
V_2 = \frac{\pi_{-2} + \lambda(1 + \gamma_2)d_2}{r + \psi} + 4\lambda + \frac{\psi W_2}{r + \psi}
\]

\[
W_{-2} = \frac{\pi'_2 + \theta(1 + \phi_2)b_2 - R_2b_2}{r + \psi'} + 4\theta + \frac{\psi' V_2}{r + \psi'}
\]

It turns out we don’t even need to solve the system, though. We can use everything we have so far to get expressions for optimal investment in each state. First, combine C.11 with C.1-C.4 and C.12 with C.7-C.10 to get expressions in terms of value functions, assuming investment and disinvestment are always positive.

\[
x^{*}_{-2} = \frac{\pi_2 - R_2d_2 - \lambda(1 + \gamma_2)d_2 + \psi W_2 - (r + \psi)V_2}{\lambda}
\]

\[
x^{*}_{-1} = \frac{\pi_1 - R_1d_1 + \lambda d_{-1} - \lambda(1 + \gamma_1)d_1 + \psi W_1 - (r + \psi)V_1}{\lambda}
\]

\[
x^*_0 = \frac{\pi_0 - R_0d_0 + \psi W_0 - (r + \psi)V_0}{\lambda}
\]

\[
x^*_1 = \frac{\pi_{-1} - R_{-1}d_{-1} + \lambda(1 + \gamma_1)d_1 - \lambda d_{-1} + \psi W_{-1} - (r + \psi)V_{-1}}{\lambda}
\]

\[
x^*_2 = 0
\]

\[
y^{*}_{-2} = 0
\]

\[
y^{*}_{-1} = \frac{\pi'_1 - R_1b_1 + \theta(1 + \phi_1)b_1 - \theta b_{-1} + \psi' V_1 - (r + \psi')W_1}{\theta}
\]

\[
y^*_0 = \frac{\pi'_0 - R_0b_0 + \psi' V_0 - (r + \psi')W_0}{\theta}
\]

\[
y^*_1 = \frac{\pi'_{-1} - R_{-1}b_{-1} + \theta b_{-1} - \theta(1 + \phi_1)b_1 + \psi' V_{-1} - (r + \psi')W_{-1}}{\theta}
\]

\[
y^*_2 = \frac{\pi'_{-2} - \theta(1 + \phi_2)b_2 + \psi' V_{-2} - (r + \psi')W_{-2}}{\theta}
\]
Next, rewrite C.13 and C.14 as follows

\[ \psi W_{-2} - (r + \psi)V_2 = - (\pi_{-2} + \lambda(1 + \gamma_2)d_2 + (r + \psi)4\lambda) \]
\[ \psi'V_2 - (r + \psi')W_{-2} = - (\pi'_{2} + \theta(1 + \phi_2)b_2 - R_2b_2 + (r + \psi')4\theta) \]

and recall that

\[ W_{-2} = W_{-1} + \theta = W_0 + 2\theta = W_1 + 3\theta = W_2 + 4\theta \]
\[ V_2 = V_1 + \lambda = V_0 + 2\lambda = V_{-1} + 3\lambda = V_{-2} + 4\lambda \]

Then we need not even solve explicitly for either value function. We can simply substitute the expressions above into C.15-C.24.
Starting from the top, let’s sub in for investment intensities:

\[ x^*_2 = \frac{\pi_2 - R_2d_2 - \lambda(1 + \gamma_2)d_2 + \psi W_2 - (r + \psi)V_2}{\lambda} \]
\[ = \frac{\pi_2 - R_2d_2 - \lambda(1 + \gamma_2)d_2 + \psi(W_{-2} - 4\theta) - (r + \psi)V_2}{\lambda} \]
\[ = \frac{\pi_2 - R_2d_2 - \lambda(1 + \gamma_2)d_2 - (\pi_{-2} + \lambda(1 + \gamma_2)d_2 + (r + \psi)4\lambda) - \psi 4\theta}{\lambda} \]
\[ = \frac{\pi_2 - \pi_{-2} - R_2d_2 - 4\theta \psi}{\lambda} - (4(r + \psi) + 2(1 + \gamma_2)d_2) \]

\[ x^*_1 = \frac{\pi_1 - R_1d_1 + \lambda d_{-1} - \lambda(1 + \gamma_1)d_1 + \psi W_1 - (r + \psi)V_1}{\lambda} \]
\[ = \frac{\pi_1 - R_1d_1 + \lambda d_{-1} - \lambda(1 + \gamma_1)d_1 + \psi(W_{-2} - 3\theta) - (r + \psi)(V_2 - \lambda)}{\lambda} \]
\[ = \frac{\pi_1 - R_1d_1 + \lambda d_{-1} - \lambda(1 + \gamma_1)d_1 - (\pi_{-2} + \lambda(1 + \gamma_2)d_2 + (r + \psi)4\lambda) - \psi 3\theta + \lambda(r + \psi)}{\lambda} \]
\[ = \frac{\pi_1 - \pi_{-2} - R_1d_1 - 3\theta \psi}{\lambda} - (3(r + \psi) + (1 + \gamma_2)d_2 + (1 + \gamma_1)d_1 - d_{-1}) \]

\[ x^*_0 = \frac{\pi_0 - R_0d_0 + \psi W_0 - (r + \psi)V_0}{\lambda} \]
\[ = \frac{\pi_0 - R_0d_0 + \psi(W_{-2} - 2\theta) - (r + \psi)(V_2 - 2\lambda)}{\lambda} \]
\[ = \frac{\pi_0 - R_0d_0 - (\pi_{-2} + \lambda(1 + \gamma_2)d_2 + (r + \psi)4\lambda) - \psi 2\theta + 2\lambda(r + \psi)}{\lambda} \]
\[ = \frac{\pi_0 - \pi_{-2} - R_0d_0 - 2\theta \psi}{\lambda} - (2(r + \psi) + (1 + \gamma_2)d_2) \]

\[ x^*_1 = \frac{\pi_{-1} - R_{-1}d_{-1} + \lambda(1 + \gamma_1)d_1 - \lambda d_{-1} + \psi W_{-1} - (r + \psi)V_{-1}}{\lambda} \]
\[ = \frac{\pi_{-1} - R_{-1}d_{-1} + \lambda(1 + \gamma_1)d_1 - \lambda d_{-1} + \psi(W_{-2} - \theta) - (r + \psi)(V_2 - 3\lambda)}{\lambda} \]
\[ = \frac{\pi_{-1} - R_{-1}d_{-1} + \lambda(1 + \gamma_1)d_1 - \lambda d_{-1} - (\pi_{-2} + \lambda(1 + \gamma_2)d_2 + (r + \psi)4\lambda) - \psi \theta + 3\lambda(r + \psi)}{\lambda} \]
\[ = \frac{\pi_{-1} - \pi_{-2} - R_{-1}d_{-1} - \theta \psi}{\lambda} - ((r + \psi) + (1 + \gamma_2)d_2 - (1 + \gamma_1)d_1 + d_{-1}) \]
And now, disinvestment intensities:

\[
y_{-1}^* = \frac{\pi_1' - R_1b_1 + \theta(1 + \phi_1)b_1 - \theta b_{-1} + \psi'V_1 - (r + \psi')W_1}{\theta}
\]

\[
y_{-2}^* = \frac{\pi_1' - R_1b_1 + \theta(1 + \phi_1)b_1 - \theta b_{-1} + \psi'(V_2 - \lambda) - (r + \psi')(W_{-2} - 3\theta)}{\theta}
\]

\[
y_{-1}^* = \frac{\pi_1' - R_1b_1 + \theta(1 + \phi_1)b_1 - \theta b_{-1} - (\pi_2' + \theta(1 + \phi_2)b_2 - R_2b_2 + (r + \psi')4\theta) - \lambda \psi' + (r + \psi')3\theta}{\theta}
\]

\[
y_{0}^* = \frac{\pi_1' - \pi_2' + R_2b_2 - R_1b_1 - \lambda \psi'}{\theta} - ((r + \psi') + (1 + \phi_2)b_2 - (1 + \phi_1)b_1 + b_{-1})
\]

\[
y_{0}^* = \frac{\pi_0' - R_0b_0 + \psi'V_0 - (r + \psi')W_0}{\theta}
\]

\[
y_{0}^* = \frac{\pi_0' - R_0b_0 + \psi'(V_2 - 2\lambda) - (r + \psi')(W_{-2} - 2\theta)}{\theta}
\]

\[
y_{0}^* = \frac{\pi_0' - R_0b_0 - (\pi_2' + \theta(1 + \phi_2)b_2 - R_2b_2 + (r + \psi')4\theta) - 2\lambda \psi' + (r + \psi')2\theta}{\theta}
\]

\[
y_{0}^* = \frac{\pi_0' - \pi_2' + R_2b_2 - R_0b_0 - 2\lambda \psi'}{\theta} - 2(r + \psi') + (1 + \phi_2)b_2
\]

\[
y_{1}^* = \frac{\pi_1' - R_{-1}b_{-1} + \theta b_{-1} - \theta(1 + \phi_1)b_1 + \psi'V_{-1} - (r + \psi')W_{-1}}{\theta}
\]

\[
y_{1}^* = \frac{\pi_1' - R_{-1}b_{-1} + \theta b_{-1} - \theta(1 + \phi_1)b_1 + \psi'(V_2 - 3\lambda) - (r + \psi')(W_{-2} - \theta)}{\theta}
\]

\[
y_{1}^* = \frac{\pi_1' - R_{-1}b_{-1} + \theta b_{-1} - \theta(1 + \phi_1)b_1 - (\pi_2' + \theta(1 + \phi_2)b_2 - R_2b_2 + (r + \psi')4\theta) - 3\lambda \psi' + (r + \psi')\theta}{\theta}
\]

\[
y_{1}^* = \frac{\pi_1' - \pi_2' + R_2b_2 - R_{-1}b_{-1} - 3\lambda \psi'}{\theta} - (3(r + \psi') + (1 + \phi_2)b_2 + (1 + \phi_1)b_1 + b_{-1})
\]

\[
y_{2}^* = \frac{\pi_2' - \theta(1 + \phi_2)b_2 + \psi'V_{-2} - (r + \psi')W_{-2}}{\theta}
\]

\[
y_{2}^* = \frac{\pi_2' - \theta(1 + \phi_2)b_2 + \psi'(V_2 - 4\lambda) - (r + \psi')W_{-2}}{\theta}
\]

\[
y_{2}^* = \frac{\pi_2' - \theta(1 + \phi_2)b_2 - (\pi_2' + \theta(1 + \phi_2)b_2 - R_2b_2 + (r + \psi')4\theta) - 4\lambda \psi'}{\theta}
\]

\[
y_{2}^* = \frac{\pi_2' - \pi_2' + R_2b_2 - 4\lambda \psi'}{\theta} - (4(r + \psi') + 2(1 + \phi_2)b_2)
\]
Summarizing, the set of investment and disinvestment intensities is as follows:

\[
x^*_{-2} = \max \left\{ 0, \frac{\pi_2 - \pi_{-2} - R_2 d_2 - 4\theta \psi}{\lambda} - (4(r + \psi) + 2(1 + \gamma_2)d_2) \right\}
\]

\[
x^*_{-1} = \max \left\{ 0, \frac{\pi_1 - \pi_{-2} - R_1 d_1 - 3\theta \psi}{\lambda} - (3(r + \psi) + (1 + \gamma_2)d_2 + (1 + \gamma_1)d_1 - d_{-1}) \right\}
\]

\[
x^*_0 = \max \left\{ 0, \frac{\pi_0 - \pi_{-2} - R_0 d_0 - 2\theta \psi}{\lambda} - (2(r + \psi) + (1 + \gamma_2)d_2) \right\}
\]

\[
x^*_1 = \max \left\{ 0, \frac{\pi_{-1} - \pi_{-2} - R_{-1} d_{-1} - \theta \psi}{\lambda} - ((r + \psi) + (1 + \gamma_2)d_2 - (1 + \gamma_1)d_1 + d_{-1}) \right\}
\]

\[
x^*_2 = 0
\]

\[
y^*_{-2} = 0
\]

\[
y^*_{-1} = \max \left\{ 0, \frac{\pi'_1 - \pi'_2 + R_2 b_2 - R_1 b_1 - \lambda \psi'}{\theta} - ((r + \psi') + (1 + \phi_2)b_2 - (1 + \phi_1)b_1 + b_{-1}) \right\}
\]

\[
y^*_0 = \max \left\{ 0, \frac{\pi'_1 - \pi'_2 + R_2 b_2 - R_0 b_0 - 2\lambda \psi'}{\theta} - (2(r + \psi') + (1 + \phi_2)b_2) \right\}
\]

\[
y^*_1 = \max \left\{ 0, \frac{\pi'_{-1} - \pi'_2 + R_2 b_2 - R_{-1} b_{-1} - 3\lambda \psi'}{\theta} - ((r + \psi') + (1 + \phi_2)b_2 + (1 + \phi_1)b_1 - b_{-1}) \right\}
\]

\[
y^*_2 = \max \left\{ 0, \frac{\pi'_{-2} - \pi'_2 + R_2 b_2 - 4\lambda \psi'}{\theta} - (4(r + \psi') + 2(1 + \phi_2)b_2) \right\}
\]

C.2 Implications: Steady-State

While investment rates are informative, they do not tell the whole story. The distribution of industry structures in equilibrium may change when $R_n$ changes. Therefore, we compute the steady-state distribution, $\mu$, a vector of long-run probabilities. The long-run rate at which the process leaves state $i$ must equal the sum of the long-run
rates at which the process enters state $i$. The steady-state vector $\mu$ is a solution to

$$\mu'Q = 0$$

$$\sum_i \mu_i = 1$$

where $Q$ is the infinitesimal generator, or the intensity matrix, of the continuous-time Markov process and has elements $q_{ij}$. The matrix $Q$ corresponds to the matrix $P - I$ in discrete-time Markov processes. The row sums in $Q$ are zero, such that

$$q_{ii} \equiv \sum_{j=1,j\neq i}^N -q_{ij}$$

Given our equilibrium (dis)investment intensities, we can construct $Q$ as follows:

$$Q = \begin{pmatrix}
  q_{11} & d_2(1 - \gamma_2) + x_{-2} & d_2 \gamma_2 & \psi & 0 & 0 \\
  x_1 + d_{-1} & 2\gamma_0 d_0 & 2(x_0 + (1 - \gamma_0)d_0) & q_{22} & x_{-1} + (1 - \gamma_1)d_1 & 0 \\
  \psi' & 0 & 0 & q_{33} & 0 & 0 \\
  0 & \psi' & 0 & 0 & y_{-1} + b_{-1} & 0 \\
  0 & 0 & \psi' & 2\phi_0 b_0 & 2(y_0 + (1 - \phi_0)b_0) & q_{44} \\
  0 & 0 & 0 & 0 & 0 & q_{55} \\
  0 & 0 & 0 & 0 & 0 & q_{66}
\end{pmatrix}$$

The condition $\mu'Q = 0$ yields the balance equations

$$\mu_i q_i = \sum_{j=1,j\neq i}^N \mu_j q_{ji}$$

which we express in long form as

$$u_2 (x_1 + d_{-1}) + u_3 2\gamma_0 d_0 + u_4 \psi' = u_1 (d_2 + x_{-2} + \psi)$$  \hspace{1cm} (C.25)

$$u_1 (d_2(1 - \gamma_2) + x_{-2}) + u_3 2(x_0 + (1 - \gamma_0)d_0) + u_5 \psi' = u_2 (x_1 + d_{-1} + x_{-1} + (1 - \gamma_1)d_1 + \psi)$$  \hspace{1cm} (C.26)

$$u_1 d_2 \gamma_2 + u_2 (x_{-1} + (1 - \gamma_1)d_1) + u_6 \psi' = u_3 (2x_0 + 2d_0 + \psi)$$  \hspace{1cm} (C.27)

$$u_5 (y_{-1} + b_{-1}) + u_6 2\phi_0 b_0 + u_1 \psi = u_4 (b_2 + y_2 + \psi')$$  \hspace{1cm} (C.28)

$$u_4 (b_2(1 - \phi_2) + y_2) + u_6 2(y_0 + (1 - \phi_0)b_0) + u_3 \psi = u_5 (y_{-1} + b_{-1} + y_1 + (1 - \phi_1)b_1 + \psi')$$  \hspace{1cm} (C.29)

$$u_4 b_2 \phi_2 + u_5 (y_1 + (1 - \phi_1)b_1) + u_3 \psi = u_6 (2y_0 + 2b_0 + \psi')$$  \hspace{1cm} (C.30)

$$u_1 + u_2 + u_3 + u_4 + u_5 + u_6 = 1$$  \hspace{1cm} (C.31)
The system can be solved for $\mu$ when constraint C.31 is substituted in, but the expression is many pages long. Absent a simplified expression, I parameterized the model in MATLAB and verified that changes in $R_n$ have the same effect in steady-state as they do on the intensities for a given level. In particular, steady-state investment in upturns falls with $R$, while steady-state disinvestment in downturns rises with $R$. To illustrate, the following figure presents the steady-state distribution of investment and disinvestment intensities as functions of reorganization cost for a parameterization of the theoretical model.
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Biography

Lawrence Joseph Mazur II, more commonly known as Joe Mazur, was born in Indiana in 1984. He attended Indiana University, where he earned a B.A. in Economics and a B.S. in Business. Thereafter, he worked for Houlihan Lokey in Chicago as a corporate financial analyst focusing on sell-side mergers and acquisitions. Joe has an M.A. in Economics and a Ph.D. in Economics from Duke University. In the fall of 2015, he will join the Purdue University faculty as an Assistant Professor in the Department of Economics, part of the Krannert School of Management. A follower of Jesus Christ, Joe is also a devoted husband, a loving father, and an avid musician.