universität wien

MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master‘s Thesis

„Merger Simulation Evaluation in the U.S. Airline Industry: A New Look“

verfasst von / submitted by

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angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien, 2023 / Vienna 2023

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	UA 066 913
Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet:	Masterstudium Volkswirtschaftslehre / Master's Programme Economics
Betreut von / Supervisor:	Univ.-Prof. Philipp Schmidt-Dengler, PhD

Merger Simulation Evaluation in the U.S. Airline Industry: A New Look *

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This Version: January 2023

Abstract

Over the past two decades, retrospective studies have focused on the methodology of standard merger simulations for predicting the price effects of horizontal mergers in a variety of industries with differentiated products, leaving the important question of whether conventional merger simulation techniques provide an accurate forecast for post-merger prices largely unanswered. Recent papers have begun to address this issue (see, e.g. Peters (2006)). This study investigates this issue for three airline mergers after the financial crisis in the year 2008. After estimating consumer demand using pre-merger data, pre-merger marginal costs are recovered under a maintained assumption about firm conduct and post-merger prices are predicted. The results from a comparison between the predicted price changes from merger simulation and the actual observed price changes following the consummated mergers show that *(i)* standard merger simulations do not yield accurate forecasts of a merger's overall effect, at least in the context of the airline industry, *(ii)* a decomposition of the observed price changes into individual component price effects can be useful in order to address the question of what accounts for the differences between the observed and simulated prices. The results obtained by incorporating post-merger data into the model indicate that *(i)* for each of the three mergers, the unobserved supply-side changes account for most of the difference between the observed and predicted price effects, *(ii)* an important focus in determining the impact of mergers on prices should, therefore, lie on the role of marginal costs and firm conduct, *(iii)* there is a need for richer models of firm conduct.

In den letzten zwei Jahrzehnten konzentrierten sich retrospektive Studien auf die Methodik von konventionellen Simulationen von Firmenzusammenschlüssen zur Vorhersage der Preiseffekte horizontaler Fusionen in einer Vielzahl von Branchen mit differenzierten Produkten, wobei die wichtige Frage, ob herkömmliche Fusionssimulationstechniken eine genaue Vorhersage für die Preise nach dem Zusammenschluss liefern, weitgehend unbeantwortet blieb. Neuere Arbeiten haben begonnen, sich mit diesem Thema zu befassen (siehe z.B. Peters (2006)). Diese Studie untersucht diese Fragestellung für drei Fusionen von Fluggesellschaften nach der Finanzkrise im Jahr 2008. Nach der Schätzung der Verbrauchernachfrage unter Verwendung von Daten vor der Fusion werden die Grenzkosten vor der Fusion unter einer beibehaltenen Annahme über das Verhalten der Unternehmen rückgewonnen und die Preise nach der Fusion prognostiziert. Die Ergebnisse eines Vergleichs zwischen den prognostizierten Preisänderungen aus der Fusionssimulation und den tatsächlich beobachteten Preisänderungen nach den vollzogenen Fusionen zeigen, dass *(i)* Standard-Fusionssimulationen keine genauen Vorhersagen über die Gesamtwirkung einer Fusion liefern, zumindest im Kontext der Luftfahrtindustrie, *(ii)* eine Zerlegung der beobachteten Preisänderungen in einzelne Komponentenpreiseffekte sinnvoll sein kann, um der Frage nachzugehen, was die Unterschiede zwischen den beobachteten und simulierten Preisen erklärt. Die Ergebnisse, die durch die Einbeziehung von Post-Fusions-Daten in das Modell erhalten wurden, zeigen, dass *(i)* für jede der drei Fusionen die unbeobachteten Änderungen auf der Angebotsseite für den größten Teil der Differenz zwischen den beobachteten und den vorhergesagten Preiseffekten verantwortlich sind, *(ii)* ein wichtiger Schwerpunkt bei der Bestimmung der Auswirkungen von Fusionen auf die Preise auf der Rolle der Grenzkosten und des Unternehmensverhaltens liegen sollte, *(iii)* ein Bedarf an flexibleren, reichhaltigeren Modellen des Unternehmensverhaltens besteht.

Keywords— merger simulation, airline industry, product differentiation, firm conduct

*I would especially like to thank my supervisor, Univ.-Prof. Philipp Schmidt-Dengler, PhD, who made this work possible. His guidance and advice carried me through all the stages of writing this thesis, as he has taught me the basics of empirical industrial organization and merger simulations as well as preliminaries on how to use the programming language R. Due to a need for more computational power for the simulation of post-merger prices, he also arranged a login on the Vienna Scientific Cluster (VSC). Hence, obtaining the computational results presented for the post-merger price predictions, which have been achieved in part using the VSC, is gratefully acknowledged. I am indebted to my fiancé for his support on learning how to use ssh connections, VPN, tmux and batch queues - as an IT Security student his technical knowledge complemented my economical and programming knowledge. I am grateful to my fellow students Alexander Fuchs, Philipp Hilmbauer-Hofmarcher, Jasmin Jöchle and Caroline Moreau, with whom I have had the pleasure to be with during both - the Bachelor's and Master's Programme Economics at the University of Vienna.

Contents

1 Introduction

This paper evaluates the performance of merger simulation in the U.S. airline industry – a topic related to the empirical industrial organization literature. In detail, the main goal of this study is to evaluate how accurate the simulated prices - offered as forecasts of post-merger outcomes - are. This is done by comparing the predicted price changes from merger simulation with the observed price changes following a consummated merger. One of the aims of this research is to contribute to Peters (2006) study about "Evaluating the Performance of Merger Simulations", where he analyses five airline mergers from the 1980s and finds that standard simulation methods do not generally provide an accurate forecast of a merger's overall effect, by examining more recent developments in the U.S. airline industry.

The main research question of this thesis is

"Do standard simulation methods, which measure the effect of the change in ownership due to a merger, provide an accurate forecast for post-merger prices?"

This question is addressed by using merger simulations to predict post-merger prices for three airline mergers, which all occurred after the financial crisis in the year 2008 – namely Delta-Northwest, Frontier-Midwest as well as United-Continental. Those have been some of the world's largest carriers at the time of merger.

The approach used in this paper follows Peters (2006) - it includes the usage of conventional merger simulation techniques, which consist of three components: the estimation of consumer demand using pre-merger data, the recovery of pre-merger marginal costs under a maintained assumption about firm conduct and the prediction of post-merger prices (under specific assumptions about what does and does not change as a result of the merger). These predictions will be compared with the observed price changes. Differences between the predicted and observed price changes raise then the question of what accounts for those differences. As a consequence, the observed price changes will be decomposed into individual components by incorporating post-merger data into the model.

But why is this research question such a relevant issue to study? As a potential motivation for such price comparisons serves the interest in evaluating the accuracy of price forecasts of post-merger outcomes gathered by the simulation. Furthermore, a comparison between predicted and observed price changes can also be viewed as a test of assumptions about the post-merger behavior of demand, costs and conduct - on which the simulation relies on. Hence, as Peters (2006, p.628) already pointed out, "if these assumptions are violated, it is more appropriate to interpret the simulated price changes as a measure of one component of the merger's effect on prices rather than as a forecast of the overall effect". Thus, a decomposition of the observed price changes into component price effects would be appropriate in order to find out what accounts for the differences.

The remainder of the study is organized as follows: Section 2 reviews the background literature and provides details on the contribution of this paper to the existing literature. Section 3 describes the data sources as well as the criteria for sample selection and restrictions. Section 4 presents the examined merging airlines. Section 5 provides the empirical model of the air travel market, constructs a set of instruments and reports model parameters as well as the estimated demand elasticities. Section 6 recovers marginal costs and firm conduct, while Section 7 simulates post-merger price changes and compares the predicted and actual post-merger outcomes. Section 8 decomposes the observed post-merger price change into its individual components. Section 9 discusses the results as well as potential shortcomings and Section 10 briefly concludes.

2 Literature Review & Contribution

This paper contributes to the existing literature in four ways.

2.1 Horizontal Mergers in Industries with Differentiated Products

First, it extends the literature on predicting the price effects of horizontal mergers in industries with differentiated products. By now, there have been many papers which study the price effects of hypothetical or actual mergers in a variety of industries. For example, Hausman, Leonard, and Zona (1994) applied a competitive analysis on merging firms in the beer industry by estimating demand models which take into account the pattern of consumer preferences as well as the fact that in differentiated product industries firms almost always tend to be multi-product firms which produce a number of competing products. Werden and Froeb (1994) simulated hypothetical mergers of U.S. long distance carriers by examining the price and welfare effects using a logit model. They highlighted the greater relevance to antitrust policy and the more reasonable assumption of a non-cooperative competition with differentiated products than with homogeneous products.[1] As the ready-to-eat cereal industry represents one example of an industry, where the non-cooperative competition assumption does not hold, Nevo (2000) used a model of post-merger conduct in order to investigate the competitive effects of mergers. Dubé (2005) discovered that in the carbonated soft drink industry the single unit purchase assumption relying on a discrete choice purchase behavior is inappropriate. Therefore, he used household-level scanner data to estimate demand.

This research has in common with the above stated literature that the price effects of an industry with differentiated products, as U.S. airlines offer a set of differentiated products in each of a large cross-section of origin-destination markets, are predicted.[2] However, this paper contributes to the literature on predicting the price effects of horizontal mergers in industries with differentiated products by comparing the predicted price changes from merger simulation with the observed price changes following actual consummated mergers.

2.2 Discrete-Choice Models

Second, this study contributes to the literature on discrete-choice models, such as logit and nested logit models, which model demand as a function of the characteristics of the available products.[3] Among one of the first pioneers on discrete choice is McFadden (1980), who established the multinomial logit (MNL) model[4] which is based on principles of utility maximization and can be derived from the random-utility model by assuming the utilities of the various alternatives to be independently distributed. As this property, known as the independence of irrelevant alternatives (IIA), does not always hold, he invented the generalized extreme value (GEV) model, which is a generalization of the nested logit model to permit patterns of "non-independence" of alternatives. The use of a discrete choice framework in the empirical industrial organization analysis has been mainly driven by Berry (1994), who proposed that prices are correlated with unobserved demand characteristics (endogeneity problem). With the use of traditional instrumental variables techniques and by inverting the market share equation, he reported that one could find the implied mean levels of utility for each good. By the term "mean utility" he denoted the component of utility that does not vary across consumers. Berry, Levinsohn, and Pakes (1995) provided an extension to the existing discrete-choice models by implementing the random-coefficients model, which takes consumer's preferences over products into account. An application of the GEV class of models represents the principles of differentiation (PD) generalized extreme value (GEV) model put forward by Bresnahan, Stern, and Trajtenberg (1996). This model allows for a potential source of market segmentation as the principles of differentiation (PD) define product similarity or product substitution patterns.

[1] The static non-cooperative oligopoly model is suitable for a variety of differentiated product industries, as the consumer product market. However, we are aware of the fact that in some industries the mode of competition might change after the merger, i.e. some sort of collusion might occur in those industries. In fact, this paper will suggest a need for richer models of firm conduct for the airline industry.

[2] See Section 3.1 for more detailed definitions of the terms "product" and "market" in the sense of the airline industry.

[3] For example, Peters (2006, pp.630-631) recommends the usage of discrete-choice models, as he finds functional-form models to be inappropriate for the demand estimation in airline markets. This is the case since there is only a short time series of quarterly airline data available and each airline industry market has an entirely different set of products, while typical consumer products industries offer a long time series of weekly data and the same group of products in numerous markets.

[4] See also Koppelman and Wen (1998) for a further discussion on alternative nested logit models and derivations of the demand model as well as own- and cross-price elasticities of the McFadden MNL model.

On the basis of these well-known discrete-choice models the results from three models - a logit, a nested logit and a 2-level nested logit model - will be compared. Some of the above stated models might have been more realistic or allow for more flexibility, but at a greater computational burden as the estimation procedure would have taken too long to converge.[5] This paper adds to the literature on discrete-choice models an overview of all needed mathematical derivations of demand models, market shares, own- and cross-price elasticities and substitution matrices, which are otherwise spread over diverse papers.

2.3 Performance Evaluation of Merger Simulation

Third, this paper adds to the literature on evaluating the performance of merger simulations. For instance, Weinberg and Hosken (2013) evaluated the efficacy of a static non-cooperative oligopoly model commonly used for merger simulation by exploring one motor oil and one syrup merger. They found over-estimated price simulations for the syrup merger. A recent study by Björnerstedt and Verboven (2016) also examined the question whether merger simulation works by analyzing the Swedish analgesics market. They over-predicted the price changes for the smaller firm and under-predicted the price changes for the outsiders. As possible supply-side explanations they provided a plausible cost increase after the merger and the possibility of partial collusion. Those supply-side modifications contributed to explaining the observed effects, however, some significant differences still remained.

This research has in common with the above stated literature that the performance of merger simulation will be evaluated based on static non-cooperative oligopoly models and it will be accounted for the differences between predicted and observed price changes. By incorporating post-merger data into the model one does not only allow for the possibility of unobserved supply-side changes but also for observed and unobserved demand-side changes. Moreover, while the focus of those papers lies on consumer product markets, this paper focuses on mergers in the airline industry.

2.4 Mergers in the Airline Industry

Forth, this thesis relates certainly to the literature on mergers in the airline industry. For example, Mazzeo (2003) explored potential connections between airline market concentration and flight delays and reported that routes with a lack of competition (where carriers enjoy market power) result in lower quality of service provided by the airline, i.e. in worse on-time performance. His study is among the first to quantify the link between competition and product quality, which will inform policy makers when evaluating potential mergers. Berry and Jia (2010) analyzed the impact of demand and supply changes on profitability for legacy carriers - those included, amongst others, Delta Airlines, Northwest Airlines, United Airlines and Continental Airlines - which reported large profit reductions in the early 2000's and went through major bankruptcies or mergers. Lee (2014) simulated the effect of the Delta-Northwest merger on prices, product characteristics and welfare and showed that the combined firm lowers the product quality - especially under strong market power - and tends to increase product differentiation, which reduces the firm's incentive to raise prices. Chen and Gayle (2019) also investigated the question of how mergers affect product quality for the Delta-Northwest and the United-Continental merger. In line with the previous studies on evaluating the relationship between merger and product quality, they found that a quality decrease follows in markets, where the merging airlines had pre-merger competition.

The last three papers include four of six merging carriers, which will be studied in this research. However, while the focus of those papers lies on changes in product characteristics or profits, this paper focuses on changes in prices and compares the predicted with the observed price changes.

Finally, this thesis is mainly based on Peters (2006), who evaluated the performance of merger simulations for five airline mergers from the late 1980s and found that standard simulation methods do not generally provide an accurate forecast of a merger's overall effect. He instead found evidence that supply-side effects, such as changes in marginal costs and deviations from the assumed model of firm conduct, were important factors in post-merger price increases. The aim of this research is to contribute to his findings by examining more recent developments in the airline industry. Hence, this paper studies whether the results are similar, when using different airline mergers at a different time period.

[5] In fact, an application of a random-coefficients model to the airline industry by Armantier and Richard (2008, p.902) has shown that "the estimation procedure takes nearly a month to converge because of the relatively large sample size and high dimensional integrals involved in the market shares". In addition, Berry and Jia (2010, p.8) noted that "given the large size of the data sets [...], the simplicity of an analytical formula dramatically reduces the computational burden of the estimation" - "which is much simpler to evaluate than integrating the random coefficients with continuous distributions".

3 Data

3.1 Sources

This thesis required collecting airline data from a variety of sources (see Table 1). As the main data source serves the Airline Origin and Destination Survey Databank 1B (DB1B) provided by the U.S. Department of Transportation (DOT). The DB1B database is a 10 % random sample of airline passenger tickets from reporting carriers, produced on a quarterly basis. This study combines all three data tables of the DB1B: ticket, market and coupon. The relationship between those three data tables can be explained as follows: While the Ticket table contains summary characteristics of each *itinerary* (an ordered sequence of airports through which a passenger travels), such as the number of coupons, the origin airport along with the total fare price, the total distance traveled and an indicator specifying if the trip was a round-trip; the Market table contains directional market characteristics of each itinerary, such as the number of markets per ticket along with the number of coupons per market, detailed origin and destination airports and the total distance flown in each direction; and the Coupon table provides coupon-specific information for each itinerary, such as details about connection flights.[6]

The DB1B Market data table enabled to define, in analogy to Peters (2006, p.631), a *market* as an ordered origin-destination city-pair (OriginCity, DestCity), where a city is defined as a metropolitan statistical area (MSA)[7], possibly including more than one airport, a *product* as an airline-itinerary combination (TkCarrier[8], AirportGroup) as well as an *outside good*, which represents the option not to purchase any of the available itineraries. On the basis of the DB1B Market data table the observable product characteristics have been created further:

- price (P) - computed as a passenger-weighted average of all fares reported for a given product (MktFare, Passengers)
- airport presence (AptP) - defined as the airlines' share of all traffic at the origin airport (TkCarrier, Origin)
- (Direct) - specifies whether a change in aircraft is required, i.e. whether the itinerary is direct or connecting (MktCoupons)
- (Miles) - records the total distance flown (MktMilesFlown)

In addition, the T-100 Domestic Segment Databank - again provided by the DOT - has been used in order to construct flight frequency (Flights)[9], which proxies for the likelihood that a consumer will be able to find a flight close to her preferred time of departure.

Based on the U.S. Census Bureau's Population Estimates the data on the population of the metropolitan statistical areas (MSA) has been used in order to calculate market size, where the total market potential for each city-pair is assumed to be equal to the geometric mean of the populations of the two endpoint cities, and product j's market share (s_j) relative to potential market sales, where one divides the passengers per product by the market size (see, for example, Peters (2006, p.633)).

[6] Details on the databases, their contents and relationships have been gathered in part from CATSR (2014) as well as Airlab (2018).

[7] "An MSA consists of one or more counties that contain a city of 50,000 or more inhabitants or contain a Census Bureau-defined urbanized area and have a total population of at least 100,000." (U.S. Census Bureau, 2013, p.1)

[8] As in Berry and Jia (2010, pp.10-12) "ticketing carriers" instead of "operating" or "reporting carriers" have been used for the analysis.

[9] Following Berry and Jia (2010, p.12) among others, "departures scheduled" instead of "departures performed" have been used. However, in the airline literature several authors, including Mazzeo (2003) and Lee (2014), studied the airline industry with regard to product quality. This is why they focus on on-time performance as a proxy for service quality and as the most common category of customer complaints (whereas this study focuses on the change in prices solely without any information on customer satisfaction). Therefore, they include data on scheduled as well as actual departure/arrival times for a flight in their studies.

Table 1: Data Sources

Database	*Source*	*Variables*	*Level of Observation*	*Sample Period*
Airline O&D Survey (DB1B)[10]	U.S. DOT	Price, Airport Presence, Direct, Miles	Ticket / Market / Coupon	Q1-Q4 2008/11/13
T-100 Domestic Segment	U.S. DOT	Flight Frequency	Airline-Itinerary	Q1-Q4 2008/11/13
MSA Population[11]	U.S. Census Bureau	Market Size	MSA county, city	2008/11/13

[10]The data source (as of July 2022) for the Airline Origin and Destination Survey (DB1B) as well as the T-100 Domestic Segment (U.S. Carriers) Databank is:
https://www.transtats.bts.gov/DataIndex.asp

[11]The data source (as of July 2022) for the MSA population is:
https://www2.census.gov/programs-surveys/popest/datasets/2000-2009/metro/totals/

In order to match cities to counties and counties to MSA, the U.S. Cities Database (as of July 2022) has been used:
https://simplemaps.com/data/us-cities

3.2 Sample Selection & Restrictions

The criteria for sample selection has been following mainly Peters (2006), Berry and Jia (2010) and Lee (2014). In ticket level, the focus has been on round-trip itineraries. In coupon level, the sample has been restricted to coach-class travel. In market level, itineraries within the U.S. continent have been kept, i.e. only travel between a set of U.S. airports is considered, while any record that includes an airport outside the 50-state U.S. is excluded. In addition, records with more than 4 coupons have been excluded, i.e. only round-trips with at most four segments have been kept, allowing at most one connection in each direction. Tickets with multiple ticketing carriers have been eliminated, i.e. the focus lies on single ticketing carriers. City-pair markets with fewer than 50 passengers as well as products with fewer than five passengers in any quarter have been removed further, as they are likely to be non-regular services. Tickets with extremely low or high prices are removed, too - so tickets cheaper than $ 25 have been dropped in order to eliminate tickets purchased using frequent flyer miles or tickets higher than $ 5,000. Moreover, routes where an airline does not report at least five flights[12] during the quarter have been removed (see Table 2).

The data has been collapsed by product, such that in the collapsed data used for the analysis a product appears only once during a quarter. Then, the quarterly data has been combined to pre- and post-merger periods. As the merger discussions have already started and merger announcements have been made prior to the airlines' actual merger, the pre-merger period has been defined as the four quarters of the year 2008, while the post-merger period is defined as the first full year after the operations of the merged firms were fully integrated, which is typically later than the actual merger happened. Hence, in the case of the Delta-Northwest and the Frontier-Midwest mergers the sample period for post-merger analysis includes the four quarters of the year 2011, while for the United-Continental merger the four quarters of the year 2013 have been used as the post-merger period.[13]

Following Peters (2006), Lee (2014), Chen and Gayle (2019), and among others, the focus of this thesis lies on *overlap markets*, which consist of those origin-destination city-pairs, where both carriers provided service prior to the merger. The reason of focusing solely on overlap markets is that "the standard methods of merger simulation [...] capture only those price changes that stem from a loss of within-market competition. [Therefore, when evaluating the performance of standard simulation methods, it is appropriate to] focus on the set of markets where the two merging airlines faced significant competition from each other prior to the merger." (Peters, 2006, pp.639-640) As a consequence, for each of the three mergers of interest, the set of overlap markets has been defined as those city-pairs, where both carriers provided service during all four quarters of the pre- as well as the post-merger period. In addition, markets are excluded in which the merging carriers had less than 10 % market share (based on the mergers' share of passengers in the market)[14] in order to account for those markets where the merger would be considered as "unlikely to have adverse competitive consequences". (DOJ and FTC, 1997, pp.15-16)

Table 2: Sample Restrictions

round-trip
coach-class
U.S. carriers
at most one connection in each direction
single ticketing carriers
market passengers > 50
product passengers > 5
$\$25 <$ fare $< \$5,000$
flights > 5
airline passengers' share $> 10\%$

[12] Note that "flight frequency is measured as the geometric mean of the frequency for each outbound segment, for an itinerary with more than one outbound segment" (as in Peters (2006, p.631)).

[13] For further details on the airline merger's dates see Section 4.

[14] Market shares based on passengers have been used. However, very similar results are obtained when using market shares based on revenues.

4 Airline Mergers

In this thesis three airline mergers will be examined, which all occurred after the financial crisis in the year 2008.[15] The U.S. airline industry at this time offers an ideal opportunity to this research as the air travel market has experienced at least seven mergers between 2008 and 2012, where the operations of the merging firms have been already fully integrated. The three examined airline mergers are *Frontier Airlines - Midwest Airlines*, *Delta Air Lines - Northwest Airlines* and *United Airlines - Continental Airlines*.[16] In line with Peters (2006, p.628), other mergers that occurred in the same time period, but which had too few overlap markets to yield meaningful results, are excluded from the analysis - those include Southwest-ATA, Pinnacle-Mesaba, SkyWest-Atlantic Southeast-ExpressJet and Southwest-Airtran.[17]

Table 3 provides a short overview of the merging airlines.[18] While the pre-merger data stems from the last quarter of the year 2008, the post-merger data stems from the last quarter of the year after the operations of the merged firms were fully integrated. The reason why in this table the pre-merger period only includes the forth quarter is that the simulation sample consists only of the last quarter of the estimation sample, as the computational burden would have been too high, since the simulation time increases substantially with the number of markets and products. In order to eliminate seasonal differences in product characteristics, the post-merger period also only consists of the forth quarter. In the final sample there are 822 unique overlap markets and 3,700 unique products in the pre-merger and respectively 3,271 in the post-merger period.

As already pointed out in Peters (2006, p.628), despite the fact that the three airline mergers "occurr[ed] within the same time period and in the same industry, [they] also offer a range of *distinct characteristics*". The Delta-Northwest merger had - as the world's largest carrier at time of merger with 786 aircraft and an enterprise value of \$ 17.7 billion - a comparatively large number of overlap markets (753). Whereas, the Frontier-Midwest merger had a relatively small number of overlap markets (14). It has been a merger of brands only – as no Midwest aircraft was ever operated by Frontier, but instead by other Republic Airways subsidiaries. Republic Airways acquired both airlines in the year 2009. Moreover, the full integration of operations has taken longer for the United-Continental merger compared to the other mergers and both airlines have been reporting huge losses in the recession. The merger has combined the two airlines into the world's largest airline in revenue passenger miles and the third largest airline in terms of fleet size at the time of merger.[19] In fact, as Peters (2006) argues, these differences in characteristics will have an influence on the predicted price changes.

One can further notice that the number of observations and unique products (airline-itinerary combinations) declines from the pre-merger to the post-merger period. This results from airlines, which shared common hubs or itineraries (ordered sequence of airports through which a passenger travels) prior to the merger and now unite routes after the merger.

[15] One should also consider that during the financial crisis the merging airlines might have reported losses, bankruptcy or financial distress. As a consequence, a "survival of the fittest" phenomenon might have arisen as stronger airlines acquire weaker airlines and enhance their market position. (Simple Flying, 2021) Therefore, the financial crisis might have led to a lax antitrust enforcement or a "failing firm defense", where antitrust authorities may allow mergers, which involve a "failing" firm that fears to exit the market, to proceed despite apparent underlying competitive concerns, because it would be a greater loss to customers if the assets of the failing firm would exit the market completely than would occur if the merger were permitted (as assets stay in the market in the hands of the acquirer). (DOJ and FTC, 2010, p.32)

[16] Some authors have already examined the effects of some of those mergers. See, for example, Lee (2014) who studied the relationship between mergers and product quality for the Delta-Northwest merger as well as Chen and Gayle (2019) who investigated the same relationship for the Delta-Northwest and the United-Continental merger.

[17] Details on airline mergers and acquisitions in the U.S. around the observation period have been mainly gathered from A4A (2022).

[18] Note that from now onward the International Air Transport Association airport codes (IATA) - unique two-letter codes in order to identify airports - will be used in the output tables instead of full airline names. (See, for example, DOT (2019))

[19] Details on the Delta-Northwest merger have been mainly gathered from Simple Flying (2020) as well as the European Commission (2008), on the Frontier-Midwest merger from Airline Files (2022) and on the United-Continental merger from BBC News (2010) and the European Commission (2010).

Table 3: Overview of Airline Mergers

				pre-merger data			*post-merger data*				
merging airlines	IATA	merger	full integration	period	n	unique products	period	n	unique products	unique markets	unique markets per merger
Delta - Northwest	DL-NW	12-2009	01-2010			3,149	Q4 2011		3,011		753
Frontier – Midwest	F9-YX	11-2010	11-2010	Q4 2008	3,700	31	Q4 2011	3,271	29	822	14
United – Continental	UA-CO	10-2010	03-2012			520	Q4 2013		231		73

Notes: Due to the high computational burden, the simulation sample consists only of the last quarter of the estimation sample.

Table 4: Summary Statistics

	pre-merger data					*post-merger data*				
	n	mean	sd	min	max	n	mean	sd	min	max
DL-NW										
P		216	76	27	748		259	86	123	946
Flights		348	242	6	1,368		368	261	5	1,347
AptP	3,149	0.19	0.15	0.04	0.69	3,011	0.32	0.18	0.07	1
Direct		0.07	0.25	0	1		0.06	0.24	0	1
Miles		1,826	871	332	5,448		1,848	843	332	5,448
F9-YX										
P		165	17	139	202		155	22	113	213
Flights		241	150	12	482		254	156	10	461
AptP	31	0.07	0.09	0	0.28	29	0.12	0.09	0.03	0.24
Direct		0.45	0.51	0	1		0.41	0.5	0	1
Miles		1,385	318	680	1,829		1,369	323	680	1,799
UA-CO										
P		279	96	78	645		418	192	127	1,778
Flights		379	225	5	1,239		426	297	9	1,203
AptP	520	0.24	0.17	0.03	0.57	231	0.07	0.06	0	0.17
Direct		0.16	0.36	0	1		0.32	0.47	0	1
Miles		2,501	1,122	636	5,501		2,466	1,199	803	5,163

Notes: The simulation sample includes 3,700 airline-itinerary observations for mergers from the forth quarter of 2008 (pre-merger period) and 3,271 observations from the forth quarter of the post-merger period.

The summary statistics of the sample in Table 4 reveals that the Delta-Northwest merger had in comparison to the other mergers the highest airport presence (the merger's share of all traffic at the origin airport had been on average 32 percent in the post-merger period), which is in line with the fact that the merged airline has been the world's largest carrier in terms of fleet size and enterprise value at the time of merger. Whereas, the Frontier-Midwest merger had the highest share of direct flights (41 percent of the merger's itineraries did not require a change in aircraft in the post-merger period), but also experienced a drop in price after the merger (from $ 165 in the pre-merger period to $ 155 in the post-merger period on average).

Which is untypical - as "the main economic concern from a merger is that prices to consumers will increase", if "the increase in market power which may occur if two competitors combine their operation is sufficiently large to outweigh production efficiency benefits". (Hausman, Leonard, & Zona, 1994, pp.173-174) Then the previous price constraining effects of the merging airlines will be eliminated, i.e. "the firm's incentive to keep prices low to avoid losing sales to rivals will diminish, [as the combined] firm will take into account the fact that some of the sales lost to a price increase will be diverted to its other products and hence will not represent a loss in overall profits". (Peters, 2006, pp.635-636) However, in this case the market power may not have risen enough since it has been a merger of brands only with a small number of overlap markets.

Lastly, the United-Continental merger had in comparison the highest price (on average $ 418 in the post-merger period) and the highest price increase[20], the highest flight frequency (426 average scheduled departures per quarter in the post-merger period) as well as the longest distances flown (on average 2,466 miles flown in the post-merger period), which is in line with the fact that the merged airline has been the world's largest airline in revenue passenger miles at the time of merger.

[20]Note that higher price increases due to the merger are consistent with financially distressed carriers prior to the merger (as shown by Peters (2006, p.642)). See, for example, Section 7.3 for further discussions on price changes based on merger's distinct characteristics.

5 The Empirical Model

This section presents the demand model in the air travel market. A model of airline oligopoly demand in the spirit of the literature on differentiated product markets following McFadden (1980), Berry (1994) and Verboven (1996) will be considered. The utility model is based on Peters (2006, pp.631-632).

The air travel demand model follows a discrete-choice framework[21], where each consumer derives utility from the five observable product characteristics: price (P), flight frequency (Flights), airport presence (AptP), whether the itinerary is direct or connecting (Direct) and the total distance flown (Miles), and unobserved components. The utility of consumer i from product j at time t adopted as a log-linear functional form is assumed to be

$$\begin{aligned} u_{ijt} &= \beta_P ln(P_{jt}) + \beta_F ln(Flights_{jt}) + \beta_A ln(AptP_{jt}) + \beta_D Direct_j + \beta_M ln(Miles_j) + \xi_{jt} + \epsilon_{ijt} \\ &= \delta_j + \epsilon_{ijt} \end{aligned} \tag{1}$$

where ξ_{jt} is the unobserved product quality and ϵ_{ijt} is the consumer-specific deviation from mean utility δ_j, the component of utility that does not vary across consumers (Berry, 1994).

$$\xi_{jt} = \alpha_A Airline_j + \alpha_Q Quarter_t + \alpha_M Market_j + \alpha_O OrigApt_j + \alpha_D DestApt_j + \nu_{jt} \tag{2}$$

The unobserved product quality ξ_{jt} includes fixed effects for airlines, quarters, markets and airports. ν_{jt} is the component of unobserved product quality that is not constant within significant subsets of the data.

In this thesis the results from three different discrete-choice demand models will be compared. The first one resembles a *multinomial logit (MNL) model*, following McFadden (1980, p.16), where product j's market share s_j can be calculated by dividing the number of passengers per product by the market size (the total market potential for each city-pair is assumed to be equal to the geometric mean of the populations of the two endpoint cities) and the market share for the outside option can be derived by

$$s_0 = 1 - \sum_j s_j \tag{3}$$

As Berry (1994, pp.248-250) considered the non-linearity problem of ξ_{jt} being correlated with prices, he suggested that the true model implies a one-to-one relationship between market share s_j and mean utility δ_j. Thus, the logit model implies a simple instrumental variables regression of differences in log market shares, i.e. one can obtain the mean utility from the differences in log market shares (see Table 5).

However, as the logit model produces unreasonable substitution patterns, the second considered demand model is a simple *nested logit model*, following Berry (1994, pp.252-253), which allows consumer tastes to be correlated across products j and thus, for more reasonable substitution patterns as compared to the simple logit model. In a nested logit model a potential passenger i in market m at time t faces a choice between $J+1$ alternatives - as there are $j = 1, ..., J$ differentiated air travel products as well as an outside good, $j = 0$. Hence, products are assumed to be organized into $G+1$ exhaustive mutually exclusive groups/nests, $g = 0, 1, ..., G$, in which the outside option is the only member of group 0 (see, for example, Berry (1994, pp.247+252) and Chen and Gayle (2019, pp.18-19)).

[21]See Section 2.2 for a discussion on why the usage of discrete-choice models is preferred over functional-form models.

In analogy to Peters (2006), in the case of the airline industry, all itineraries are placed in a single nest or group g within a market but separated from the outside good. The intuition is that "products with similar characteristics are closer substitutes than products with different characteristics", i.e. "different itineraries (inside goods) tend to be closer substitutes for each other than for the outside good" (namely to not choose any of the itineraries). (Peters, 2006, pp.632-633) In the nested logit model the market share of product j (belonging to group g) is the product of the "within-group" market share, $s_{j|g}$, and the market share of group g, s_g. In the derived demand model in Table 5 the parameter ρ indexes the extent to which different itineraries tend to be closer substitutes for each other than for the outside good.

The third demand model for comparison is the *2-level nested logit model*, a more sophisticated version of the simple nested logit model, following Verboven (1996). In the 2-level nested logit model each group $g = 1, ..., G$ is further partitioned into subgroups $s = 1, ..., S$. In the case of the airline industry, carriers correspond to a subnest s. Thus, the nested logit model allows an individual's preferences for a product j in market m to be correlated with other products from the same subgroup or group. The intuition is that itineraries from the same airline tend to be closer substitutes for each other than for rivals. In the 2-level nested logit model the market share of product j is the product of the "within-subgroup" market share of good j in subgroup s of group g, $s_{j|s}$, the "within-group" market share of subgroup s in group g, $s_{s|g}$, and the market share of group g, s_g, where I_s and I_g are the "inclusive values" of subgroup s or group g. (Verboven, 1996, p.250) In the demand model the "parameters ρ_s and ρ_g represent correlation of consumers' preferences between alternatives that belong, respectively, to the same subgroup s and to the same group g". (Razzolini, 2009, p.194)

Table 5: Market Shares & Demand Models

	Logit	**Nested Logit**	**2-Level Nested Logit**
$s_j =$	$\frac{exp(\delta_j)}{1+\sum exp(\delta_j)}$	$s_{j\|g} \cdot s_g =$ $\frac{exp(\delta_j/\rho)}{\sum_{l\in g} exp(\delta_l/\rho)} \cdot \frac{\sum_{l\in g} exp(\delta_l/\rho)^\rho}{\sum_g(\sum_{l\in g} exp(\delta_l/\rho))^\rho} =$ $\frac{exp(\delta_j/\rho)(\sum_{l\in g} exp(\delta_l/\rho))^{\rho-1}}{\sum_g(\sum_{l\in g} exp(\delta_l/\rho))^\rho}$	$s_{j\|s} \cdot s_{s\|g} \cdot s_g =$ $\frac{exp(\delta_j/(1-\rho_s))}{exp(I_s/(1-\rho_s))} \cdot \frac{exp(I_s/(1-\rho_g))}{exp(I_g/(1-\rho_g))}$ $\cdot \frac{exp(I_g)}{exp(I)}$ $I_s = (1-\rho_s) ln \sum_{l\in s} exp(\delta_l/(1-\rho_s))$ $I_g = (1-\rho_g) ln \sum_{l\in g} exp(I_s/(1-\rho_g))$ $I = ln(1+\sum_g exp(I_g))$
$s_0 =$	$\frac{1}{1+\sum exp(\delta_j)}$	$\frac{1}{\sum_g(\sum_{l\in g} exp(\delta_l/\rho))^\rho}$	
$ln(s_j) - ln(s_0) =$	δ_j	$\delta_j + (1-\rho) ln(s_{j\|g})$	$\delta_j + \rho_s ln(s_{j\|s}) + \rho_g ln(s_{s\|g})$

Notes: The analytical solution for the utility models, as the difference in log market shares, is given in the Appendix A. The market share for the outside option, s_0, for the 2-level nested logit model can be derived in analogy to the other two models - however, it is much more complex.

5.1 Instruments

As in the above demand models the unobserved product quality, ξ_{jt}, induces endogeneity, one has to account for a potential correlation between the observed and unobserved characteristics. It calls for the construction of a set of instruments, as in this case not only price P but also flight frequency $Flights$ and airport presence $AptP$ are likely to be endogenous. The strategy of constructing optimal instruments relies on Bresnahan, Stern, and Trajtenberg (1996) as well as Peters (2006).

Following Peters (2006, p.634), as instruments for flight frequency $Flights$ and airport presence $AptP$ serve the overlaps between itineraries in different markets:

- number of distinct itineraries that include a segment
- average population of the endpoint cities across all itineraries that include a segment
- number of itineraries offered by the airline out of the origin airport
- number of itineraries offered by rival airlines out of the origin airport
- fraction of the airline's itineraries that are direct at the origin airport
- fraction of rival's itineraries that are direct at the origin airport

As noted by Peters (2006, p.634), the intuition is that an airline's flight frequency will increase for segments, "where connections to many different endpoints will be available", and an airline's airport presence will "increase with the total number of itineraries" as well as the percentage of direct routes offered by the airline. Since flight frequency and airport presence are themselves endogenous, the means of their corresponding instruments are used.

In the spirit of Bresnahan, Stern, and Trajtenberg (1996, p.21), the number of products and the means of product characteristics within markets and for products with similar characteristics serve as instruments for price P:

- number of products within markets (sharing nest g with product j)
- means of product characteristics within markets (sharing nest g with product j)
- number of products offered by the airline (sharing subnest s with product j)
- means of product characteristics offered by the airline (sharing subnest s with product j)
- number of products sharing both market and airline (sharing nest g and subnest s with product j)
- means of product characteristics sharing both market and airline (sharing nest g and subnest s with product j)

As pointed out by Peters (2006, p.634), the intuition is that the "price will tend to fall with an increase in the number of alternative products, the number of relatively close substitutes, or the attractiveness of those alternatives' characteristics."

5.2 Estimates from Demand Equation

The estimated coefficients from the demand models, β_P, β_F, β_A, β_D and β_M, represent consumer taste parameters (marginal utilities) associated with the measured product characteristics. The expected signs of the marginal utility parameters are: $\beta_P < 0$, $\beta_F > 0$, $\beta_A > 0$, $\beta_D > 0$ and $\beta_M < 0$ (see, for example, Chen and Gayle (2019, p.19)). As shown in Table 6, all parameters are highly significant with the expected sign (except for the airport presence), as consumers will generally prefer lower prices, a higher flight frequency, direct over connecting itineraries, and to travel over shorter distances (in analogy to Peters (2006, p.631)).

Table 6: Demand Estimation

	Logit	Nested Logit	2-Level NL
log(P)	-1.33^{***}	-0.56^{***}	-0.22^{**}
	(0.06)	(0.04)	(0.07)
log(Flights)	0.87^{***}	0.46^{***}	0.43^{***}
	(0.01)	(0.01)	(0.01)
log(AptP)	-0.03^{***}	-0.02^{***}	-0.02^{***}
	(0.01)	(0.00)	(0.00)
Direct	3.61^{***}	1.98^{***}	1.92^{***}
	(0.01)	(0.04)	(0.04)
log(Miles)	-2.52^{***}	-1.40^{***}	-1.43^{***}
	(0.02)	(0.03)	(0.03)
$\log(s_{j\|g})$		0.45^{***}	
		(0.01)	
$\log(s_{j\|s})$			0.48^{***}
			(0.01)
$\log(s_{s\|g})$			0.45^{***}
			(0.01)
Num. obs.	110,924	110,924	110,924
R^2	0.72	0.91	0.92
Adj. R^2	0.70	0.91	0.91
Num. airlines	19	19	19
Num. quarters	4	4	4
Num. markets	6,578	6,578	6,578
Num. origins	165	165	165
Num. dests	205	205	205

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Notes: The estimation sample consists of 110,924 airline-itinerary-quarter observations for mergers and rivals from all four quarters of the year 2008 (pre-merger period), which includes 6,578 unique markets and 36,052 unique products. Figures in parentheses are standard errors.

As the multinomial logit model assumes independence of ξ across alternatives, i.e. alternatives must be dissimilar, one can test the Independence of Irrelevant Alternatives Assumption (IIA), known by McFadden (1980, p.16), by estimating the nested logit model and testing the null hypothesis:

$$H_0 : \rho = 1 \tag{4}$$

The idea behind this is that if $\rho = 1$, then the nested logit model would reduce to a simple multinomial logit model. However, as the coefficient estimate of the log of the "within group" market share, $(1 - \rho)$, is significantly different from zero, i.e. ρ is significantly different from 1, one can reject the null hypothesis of conditional independence across nests. This means that the logit model is rejected, as the necessary restriction for the nested logit model is satisfied, namely that ρ, which "measures the correlation of the consumer's utility across products belonging to the same group", is bounded between 0 and 1. (Chen & Gayle, 2019, p.19)

Or in other words, as Lee (2014, p.9) argued, "ρ is the nested logit parameter, which represents the degree of product differentiation between inside goods. It varies between 0 and 1. If $\rho = 1$ [...], each airline product is perfectly differentiated. In this case, there will be no need to set an outside option and demand specification becomes a multinomial logit model. If $\rho = 0$, all airline services are perfectly substitutable." Hence, according to Berry (1994, p.252), the following inequality must hold for the nested logit model:

$$\begin{aligned} 0 \leq 1 - \rho < 1 \\ 0 < \rho \leq 1 \\ 0 < 0.55 \leq 1 \end{aligned} \tag{5}$$

In order to satisfy the conditions for consistency with random-utility maximization, invented by McFadden (1980) and shown by Verboven (1996, p.251) as well as Razzolini (2009, p.194), the following inequality must hold for the 2-level nested logit model:

$$\begin{aligned} 0 \leq \rho_g \leq \rho_s \leq 1 \\ 0 \leq 0.45 \leq 0.48 \leq 1 \end{aligned} \tag{6}$$

As Verboven (1996, p.251) pointed out, "if both ρ_g and ρ_s are 0, an individual's preferences would be uncorrelated across [all products] in market m, resulting in the simple logit model with symmetric (non-localized) competition across [products] in market m. If only ρ_s is positive and ρ_g is 0, individual preferences are only correlated across [products] from the same subgroup s, resulting in localized competition between [products] from the same subgroup. If in addition ρ_g is positive, individual preferences are also correlated across [products] from a different subgroup s within the same group g. If ρ_g approaches ρ_s, preferences are equally correlated across all [products] belonging to the same group g. If ρ_s approaches 1, [products] in the same subgroup s become perfect substitutes. If in addition ρ_g approaches 1, [products] in the same group g become perfect substitutes."

As the necessary restriction for the 2-level nested logit model holds, while the restrictions of the nested logit model, according to Peters (2006, p.633), namely:

$$\begin{aligned} 1 - \rho = \rho_g = \rho_s \\ 0.45 = 0.45 \neq 0.48 \end{aligned} \tag{7}$$

is just rejected, it only indicates a minor importance of allowing for closer substitution between itineraries with similar characteristics, i.e. within the same airline.

Besides the rejection of the logit model through the necessary restrictions of the ρ parameters, the importance of allowing for closer substitution between itineraries with similar characteristics is further suggested by the higher R^2 for the nested logit models compared to the simple logit model.

The plausibility of the estimated demand parameters can be further checked by the implied aggregate demand elasticity, which - as Peters (2006, p.637) argues - approximately equals β_P, as the outside good's share s_0 will usually be close to 1 if the market size is defined as proportional to market population. The 2-level nested logit estimates ($\beta_P = -0.22$) imply a considerably less elastic aggregate demand than the nested logit ($\beta_P = -0.56$) and the logit estimates ($\beta_P = -1.33$). This low aggregate demand elasticity is, however, not consistent with prior beliefs about air travel demand elasticity - as Brander and Zhang (1990, p.577) assumed a more elastic air travel demand with a range of -1.2 to -2.0. Demand estimates imply inelastic demand curves (elasticities between 0 and -1), i.e. a change in price causes a smaller percentage change in demand. This is often the case in markets where there are few substitutes. The interval $[-1, 0]$ includes cases of unit elasticity, where a change in price is exactly cancelled by the market share response, until cases of perfect inelasticity, where market shares do not respond at all to a price change.

5.3 Estimated Demand Elasticities

In merger simulation, however, one is typically more interested in the demand elasticities, which measure how responsive the market share is when the price of goods - for markets in which the merging firms competed with each other (overlap markets) prior to the merger - changes. While the extent to which consumers are willing to switch to alternatives after a marginal price increase is measured by the *own-price elasticities*, the degree of substitution between products of the merging firms is measured by the *cross-price elasticities*.

The estimated demand elasticities, as shown in Table 7, have been retrieved from Koppelman and Wen (1998, p.293), amongst others, for the multinomial logit model as well as the nested logit model and from Verboven (1996, p.265) for the 2-level nested logit model. In the nested logit model the own-price elasticities are differentiated between alternatives which are or are not in a nest and the cross-price elasticities are differentiated between competing pairs of alternatives, offered by the merging carriers, which are or are not in a common nest. The 2-level nested logit model differentiates further between alternatives or pairs of alternatives belonging to the same subgroup, to a different subgroup within the same group and to a different group.

Table 7: Price Elasticities

Logit	$\frac{\partial s_i}{\partial P_j}\frac{P_j}{s_i} = \begin{cases} \beta_P P_i(1-s_i) & \text{... if } j=i \text{ ... own-price elasticity} \\ -\beta_P P_j s_j & \text{... if } j \neq i \text{ ... cross-price elasticity} \end{cases}$
Nested Logit	$\frac{\partial s_i}{\partial P_j}\frac{P_j}{s_i} = \begin{cases} \beta_P P_i[(1-s_i)+(1/\rho-1)(1-s_{i\|g})D_g] & \text{... if } j=i \\ -\beta_P P_j[s_j+(1/\rho-1)s_{j\|g}D_g] & \text{... if } j \neq i \end{cases}$ $D_g = 1$ ... if j and i in same nest g
2-Level Nested Logit	$\frac{\partial s_i}{\partial P_j}\frac{P_j}{s_i} = \beta_P P_j \left[\frac{1}{1-\rho_s}D_j - \left(\frac{1}{1-\rho_s}-\frac{1}{1-\rho_g}\right)s_{j\|s}D_s - \frac{\rho_g}{1-\rho_g}s_{j\|g}D_g - s_j\right]$ $D_j = 1$ ... if $j=i$ $D_s = 1$ ... if j and i in same subnest s $D_g = 1$ ... if j and i in same nest g

As the multinomial logit model has been clearly rejected, Table 8 compares the own- and cross-price elasticities for the merging carriers in overlap markets for the nested and the 2-level nested logit model.

A comparison between the models shows that the 2-level nested logit model implies smaller own-price elasticities (in absolute value) as well as smaller cross-price elasticities compared to the nested logit model. This means, that after a marginal price increase under the 2-level nested logit model fewer consumers are willing to switch to alternatives, but at the same time fewer consumers choose other flights in the same market, as the product's substitution for each other in the same market is lower. The estimated demand elasticities are consistent with the 2-level nested logit model's implying a lower aggregate elasticity, i.e. a lower β_P in absolute value as derived in Section 5.2.

A comparison between the mergers shows that the Frontier-Midwest merger has lower own-price (in absolute value) and higher cross-price elasticities compared to the competing products offered by other pairs of merging carriers. The latter means that their products were often particularly close substitutes for each other. As a consequence, the post-merger price increases predicted by merger simulation will tend to be higher for this merger.

Table 8: Own- and Cross-Price Elasticities

	Number of Products	*Average Own-Price Elasticities*		*Average Cross-Price Elasticities*	
		Nested Logit	2-Level NL	Nested Logit	2-Level NL
DL-NW	3,149	-5.18	-2.09	0.31	0.13
F9-YX	31	-4.71	-1.86	0.55	0.22
UA-CO	520	-5.48	-2.24	0.28	0.12

Notes: Estimated demand elasticities are based on 3,700 airline-itinerary observations for mergers in an overlap market from the forth quarter of the year 2008 (pre-merger period), which includes 882 unique markets. Own-price elasticities are calculated for each product, offered by one of the merging carriers, in an overlap market, while cross-price elasticities are calculated for each competing pair of alternatives, offered by the merging carriers, in an overlap market. Figures reported are unweighted means.

6 Recovery of Marginal Costs & Firm Conduct

In order to recover marginal costs, *static Nash-Bertrand conduct* is assumed - the standard approach in the literature on merger simulation - where firms choose prices non-cooperatively. This assumption is mainly used in merger simulations for reasons of mathematical simplicity and the belief that alternative assumptions about firm behavior, such as Cournot or collusive conduct[22], are less appropriate in markets with differentiated products.[23] (see, for example, Peters (2006, pp.634-635))

As in Berry, Levinsohn, and Pakes (1995, pp.853-854), each profit-maximizing firm has to choose prices, P_i, such that the first-order conditions

$$s_j + \sum_{i \in S_j} (P_i - c_i) \frac{\partial s_i(P)}{\partial P_j} = 0 \tag{8}$$

$$\vec{s} - \Delta(\vec{P} - \vec{c}) = 0$$

$$\vec{P} - \vec{c} = \Delta^{-1} \vec{s}$$

$$\vec{c} = \vec{P} - \Delta^{-1} \vec{s}$$

$$\vec{c} = \vec{P} - \vec{b}$$

are satisfied. For a market with J products, this yields then a system of J linear equations, which can easily be solved for the marginal costs, $\vec{c}$, as the difference between observed prices, $\vec{P}$, and estimated price-cost-markups, $\vec{b}$. Hence, to obtain the implied price-cost markups, $\vec{b}$, by the J first-order conditions, one has to define a J-by-J substitution matrix, $\Delta_{j,i}$, whose (j, i) element is given by

$$\Delta_{j,i} = \begin{cases} \frac{-\partial s_i}{\partial P_j} & \text{... if } i \in S_j \\ 0 & \text{... o/w} \end{cases} \tag{9}$$

where S_j is the set of all products produced by the same firm as product j.

The specifications of the substitution matrices, $\Delta_{j,i}$, for the compared models are shown in Table 9.

Under the assumption that marginal costs are constant in output and linear in product characteristics, as in Berry (1994, p.255) and Berry, Levinsohn, and Pakes (1995, p.854), one can estimate the marginal costs[24] as a function of the product characteristics

$$\begin{aligned} ln(c_{jt}) &= \vec{w_{jt}} \vec{\gamma} + \omega_{jt} \\ &= \gamma_F ln(Flights_{jt}) + \gamma_A ln(AptP_{jt}) + \gamma_D Direct_j + \gamma_M ln(Miles_j) + \omega_{jt} \end{aligned} \tag{10}$$

where ω_{jt} is the product j specific unobserved cost shifter, which is assumed to be independent of $\vec{w_{jt}}$, i.e. the observed product characteristics for product j.

Table 10 reveals that in the 2-level nested logit model specification marginal costs are decreasing in flight frequency, airport presence as well as the share of direct flights and increasing in the total distance flown.

[22] On one end of the spectrum of the identification of the mode of competition, is Bertrand, where the conduct parameters are equal to 0, as prices are determined independently; in the middle lies Cournot, where the conduct parameters take up some positive values in markets with differentiated substitutable products where companies compete in price; and on the other end lies Collusion, where the conduct parameters are equal to 1, as prices are determined jointly. (See, for example, Kawaguchi, Kohei (2022) for a detailed description on the identification of conduct.)

[23] Beyond the scope of this research is taking into account alternative assumptions about firm conduct or the idea that the mode of competition might change after the merger, as, for example, tacit collusion might become easier. However, as this paper will suggest the possibility of a misspecified conduct, in Section 8 post-merger data will be incorporated into the model, in order to account for differences between predicted and observed price changes.

[24] Note that Peters (2006, p.635) refers to c_{jt} as the "supply-side residual rather than as marginal cost, as the estimated markup relies heavily on the assumption of static Nash Bertrand conduct." Thus, he considers prediction errors due to misspecified conduct.

Table 9: Substitution Matrix

Logit	$\Delta_{j,i} = \begin{cases} \frac{-\partial s_i}{\partial P_j} = \begin{cases} -\beta_P(1-s_i)s_i & \text{... if } j=i \\ \beta_P s_j s_i & \text{... if } j \neq i \end{cases} \\ 0 & \text{... o/w} \end{cases}$
Nested Logit	$\Delta_{j,i} = \begin{cases} \frac{-\partial s_i}{\partial P_j} = \begin{cases} -\beta_P[(1-s_i)+(1/\rho-1)(1-s_{i\mid g})D_g]s_i & \text{... if } j=i \\ \beta_P[s_j+(1/\rho-1)s_{j\mid g}D_g]s_i & \text{... if } j \neq i \end{cases} \\ 0 & \text{... o/w} \end{cases}$ $D_g = 1$ ... if j and i in same nest g
2-Level Nested Logit	$\Delta_{j,i} = \begin{cases} \frac{-\partial s_i}{\partial P_j} = -\beta_P\left[\frac{1}{1-\rho_s}D_j - \left(\frac{1}{1-\rho_s}-\frac{1}{1-\rho_g}\right)s_{j\mid s}D_s - \frac{\rho_g}{1-\rho_g}s_{j\mid g}D_g - s_j\right]s_i \\ 0 \quad \text{... o/w} \end{cases}$ $D_j = 1$ ... if $j=i$ $D_s = 1$ ... if j and i in same subnest s $D_g = 1$ ... if j and i in same nest g

Table 10: Estimation of Marginal Costs

	Nested Logit	2-Level NL
log(Flights)	0.054***	−0.041***
	(0.005)	(0.008)
log(AptP)	−0.029***	−0.176***
	(0.007)	(0.010)
Direct	−0.083***	−0.548***
	(0.017)	(0.026)
log(Miles)	0.516***	0.316***
	(0.004)	(0.007)
Observations	3,700	3,700

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Notes: Estimated marginal costs are based on 3,700 airline-itinerary observations for mergers in an overlap market from the forth quarter of the year 2008 (pre-merger period), which includes 882 unique markets.

7 Post-Merger Price Changes

7.1 Post-Merger Simulation

As argued in Hausman, Leonard, and Zona (1994, p.173) "merger analysis attempts to determine whether the increase in market power which may occur if two competitors combine their operation is sufficiently large to outweigh production efficiency benefits which may also arise from a merger". The main economic concern from mergers is that consumers will be confronted with an increase in price as a profit-maximizing multi-product firm will take into account the fact that some of the lost sales will go to other products which represent substitutes for this product - now produced by the merging airlines. Hence, it does no longer represent a loss in a firm's overall profits and the firm's previous price constraining effect - of keeping prices low in order to avoid losing sales to rivals - will be reduced. (Hausman, Leonard, & Zona, 1994, p.174; Peters, 2006, p.636)

If a merger takes place, the ownership structure changes. Thus, using the demand estimates and the recovered marginal costs, one can predict the post-merger equilibrium prices by simply changing the ownership structure, while holding all variables (except the price P and quantity), including ξ (unobserved characteristics) and c (marginal costs), constant. In analogy to Peters (2006, p.636), for each market, the first-order conditions shown in the previous Section 6, together with the estimated demand function, define a system of non-linear equations in price

$$\vec{P}_{post} = \vec{c} + \Delta_{post}(\vec{P}_{post})^{-1}\vec{s}(\vec{P}_{post}) \tag{11}$$
$$\%\Delta\vec{P} = \frac{\vec{P}_{post} - \vec{P}_{pre}}{\vec{P}_{pre}}$$

where the relative price change is calculated as the difference between the predicted post-merger price and the actual pre-merger price relative to the pre-merger price.

According to Peters (2006, pp.639-640), "as standard methods of merger simulation [...] capture only those price changes that stem from a loss of within-market competition", the focus of this study lies on markets in which the "merging airlines faced significant competition from each other prior to the merger (overlap markets)", as already highlighted in Section 3.2.

7.2 Observed Post-Merger Prices

In the spirit of Peters (2006, pp.640-641), as a benchmark for comparison serve the post-merger prices which are actually observed in the post-merger data.[25] Hence, the relative price change for each market is calculated as the difference between the observed percentage price change (i.e. the relative difference in the average passenger-weighted post-merger fare $\bar{P}$ for each of the overlap markets for each merger) and an average industry-wide percentage price change (i.e. the relative difference in the predicted value from univariate log-linear regressions of price on distance, $\hat{P}$)

$$\%\Delta\vec{P} = \frac{\bar{P}_{post} - \bar{P}_{pre}}{\bar{P}_{pre}} - \frac{\hat{P}_{post} - \hat{P}_{pre}}{\hat{P}_{pre}} \tag{12}$$

The latter, the average industry-wide percentage price change, is subtracted from the observed percentage price change in order to account for variation in the price change between the pre- and post-merger periods, that is not solely driven by the merger, but by other causes, such as overall inflation, changes in aggregate demand as well as fluctuations in the prices of fuel and other inputs.

[25] In order to be consistent with the simulation sample from the post-merger prediction, the post-merger data for the observed price changes also consists of the forth quarter of the year after the operations of the merged firms were fully integrated.

7.3 Comparison of Observed and Predicted Price Changes

Table 11 shows the average observed and predicted relative price changes in the overlap markets for each of the three mergers. Several findings can be drawn from the results.

Table 11: Average Observed vs. Predicted Relative Price Changes (%)

	Number of Overlap Markets	*Observed Price Change*	*Predicted Price Change*	
			Nested Logit	2-Level NL
DL-NW	753	-1.1 (0.8)	17.3 (0.4)	61.4 (2.0)
F9-YX	14	-33.8 (3.0)	20.5 (4.1)	68.9 (16.2)
UA-CO	73	46.1 (6.3)	29.9 (1.7)	123.0 (8.4)

Notes: Predicted price changes are based on 7,298 airline-itinerary observations for mergers and rivals in an overlap market from the forth quarter of the year 2008 (pre-merger period), which includes 882 unique markets. Due to the large number of overlap markets the computational results presented for the Delta-Northwest merger have been achieved using the Vienna Scientific Cluster (VSC). Figures reported are unweighted means. Standard errors for the mean are reported in parentheses.

First, the observed price changes are statistically as well as economically significant. However, in the literature there are widely varying estimates of price effects - for example, Lee (2014) studied the Delta-Northwest merger and found different price effects. Though, his analysis focused on product groups - small, medium and large share goods - as well as on changes in product characteristics. Chen and Gayle (2019), who studied the Delta-Northwest and the United-Continental mergers, investigated solely the merger's effect on product quality and thus, did not provide any price effects. Nevertheless, previous studies pointed out that the estimates of price effects depend strongly on assumptions and exclusions (see, e.g. Peters (2006, p.641)). Hence, they are fairly sensitive to which specifications and calculations have been made (e.g. the cleaning of the data, the choice of the model or the selection of markets and periods).

Second, worth noting is also the large observed price reduction (∼34 percent) following the Frontier-Midwest merger and the large observed price increase (∼46 percent) following the United-Continental merger. Both price developments could have already been seen in the summary statistics in Section 4. The large observed price reduction following the Frontier-Midwest merger is consistent with the hypothesis that carriers with a relatively small number of overlap markets, who in addition have not integrated their operations - as it has been a merger of brands only (see distinct characteristics of the airline mergers in Section 4) - are not able to increase their market power by much after the merger. Thus, the firm's previous price constraining effect - of keeping prices low in order to avoid losing sales to rivals - will still remain (see argumentation on price changes arising from mergers in Section 7.1). Whereas, the large observed price increase following the United-Continental merger comes from the fact that both airlines have been reporting huge losses in the recession prior to the merger. As a result, the merging carriers had been financially distressed and hence had a tendency to charge unsustainable low prices prior to the merger, while after the merger large relative price increases could have been noticed.

Third, the predicted price increases of the 2-level nested logit model are significantly greater compared to those of the nested logit model. This is a result from the lower demand parameter β_P (in absolute value) as well as the lower estimated cross-price elasticities obtained from the 2-level nested logit model (see Tables 6 and 8). As the predictions from the 2-level nested logit model are too far away from the actual observed price changes (and as the necessary restrictions of the ρ parameters, according to 5.2, only indicate a minor, neglectable importance of allowing for closer substitution between itineraries within the same airline), the further analysis will be carried on with the nested logit model from now onward.

Finally, the comparison of relative price changes shows major differences between the average observed and the average predicted price changes. Even though, the nested logit model correctly predicted the largest price change for the United-Continental merger, the simulation substantially understates the observed price effects for this merger - which is again consistent with the fact that the merging airlines had been financially distressed prior to the merger. However, the simulation substantially overstates the observed price effects for the Frontier-Midwest merger, which is consistent with the high cross-price elasticity compared to the other mergers, that have already pointed to the direction that the post-merger prices will be over-predicted for this merger (see Section 5.3).

In line with Peters (2006, p.647), these results suggest that standard "merger simulations can be useful in understanding the effect of a merger on unilateral pricing incentives", however, they do not yield accurate forecasts of a merger's overall effect, at least in the context of the airline industry. As the predicted price changes are different from the observed ones, in the next section the observed price changes will be decomposed into individual components by incorporating post-merger data into the model, in order to address the question of what accounts for the differences.

8 Decomposition into Component Price Effects

In analogy to Peters (2006, pp.643-644) idea of accounting for the differences between observed and predicted price changes, the observed post-merger price change can be decomposed into its component effects (see Table 12) by incorporating post-merger data into the model. This means one solves for the equilibrium prices under various counterfactual assumptions about what changes after the merger.

Table 12: Component Price Effects

Component Effects	Changes	Pre- and Post-Merger Data
Loss of Competition	predicted price change from merger simulation	post-merger ownership structure S_j pre-merger variables (except P, q)
Observed Changes	changes in the set of products changes caused by entry/exit	post-merger observed variables pre-merger unobserved variables (ξ, c)
Unobserved Demand-Side Changes	changes in the demand-side residual ξ	post-merger (un)observed variables pre-merger c
Unobserved Supply-Side Changes	changes in the supply-side residual c	remaining unexplained portion post-merger c

The first component of the observed post-merger price change is the loss of competition, where the merged airline sets prices to maximize the combined pool of profits. This is equal to the predicted price change from the merger simulation, as described in the previous Section 7.1. In a merger simulation the post-merger ownership structure S_j is used, while all variables (except price P and quantity), including ξ (unobserved characteristics) and c (marginal costs), are held fixed at pre-merger levels.

The second component consists of changes, which can be observed in the post-merger data, namely changes in the set of products, changes caused by entry or exit, and any changes in the non-price observed variables. This means one solves for the equilibrium prices under the post-merger ownership structure S_j, with post-merger values of the observed variables, while holding the unobservables (ξ and c) fixed at pre-merger levels.

The third component consists of unobserved demand-side changes. These are changes in the demand-side residual ξ, such as changes in unobserved product characteristics (e.g. service quality). This means one solves for the equilibrium prices under the post-merger ownership structure S_j, with post-merger values of both observed and unobserved demand variables and with pre-merger values of c.

Finally, the forth component consists of unobserved supply-side changes. These are changes in the supply-side residual c, such as changes in marginal costs and firm conduct. This is then by construction the remaining unexplained portion of the observed price change with post-merger values of c.

Table 13: Estimated Average Component Price Effects

	Component Price Effects (pp.)				
	Loss of Competition	Observed Changes	Unobserved Demand-Side Changes (ξ)	Unobserved Supply-Side Changes (c)	*Observed Price Change (%)*
DL-NW	17.3	-5.5	1.7	-14.6	-1.1
F9-YX	20.5	-20.6	0.7	-34.4	-33.8
UA-CO	29.9	-19.6	-20.3	56.1	46.1

Notes: The estimated effect of the loss of competition is the predicted price change from the merger simulation with the nested logit model, as reported in Table 11. The estimated component price effects are reported in percentage points (pp.) and add up to the observed price change, reported in Table 11. Due to the large number of overlap markets the computational results presented for the Delta-Northwest merger have been achieved using the Vienna Scientific Cluster (VSC).

Table 13 reports the estimated average component price effects, where the estimated effect of the loss of competition in the first column is the predicted price change from the merger simulation with the nested logit model using pre-merger data, as reported in Table 11, and the observed price change in the last column was observed in the post-merger data and reported in Table 11. The results indicate that for each of the three mergers, the unobserved supply-side changes account for most of the difference between the observed and predicted price effects.

For the Delta-Northwest merger, the over-prediction in price is mainly driven by a large reduction in the supply-side residual c. This would either imply substantial post-merger efficiencies (i.e. large marginal cost decreases) or a more plausible interpretation would be that - as Delta and Northwest had been two of the world's largest carriers prior to the merger with a large number of overlap markets, where both carriers provided service prior to the merger - some degree of tacit collusion might have already existed between them prior to the merger. As a consequence, as suggested by Peters (2006, p.645), "merger simulation over-predicts the price effect because the Bertrand oligopoly model overstates the extent of pre-merger competition".

The substantial over-prediction in price for the Frontier-Midwest merger is mainly driven by a large reduction in the supply-side residual c, followed by a large reduction in the observed demand-side changes. On one side changes in the set of products, such as changes caused by entry, seem to have played a significant role in over-predicting the price effect. This is exactly what can be observed in the post-merger data - the number of unique products for mergers and rivals increased by 75 percent for the overlap markets of the Frontier-Midwest merger in the post-merger period compared to the pre-merger period.[26] On the other side changes in marginal costs and firm conduct seem to have played an even more significant role in over-predicting the price effect. The reduction in the supply-side residual c seems somewhat counterintuitive, as one would predict an under-prediction in price due to the small number of overlap markets for the Frontier-Midwest merger, which would be consistent with plausible post-merger inefficiencies (i.e. marginal cost increases) or alternatively, with a coordinated effect, which allowed for a collusive conduct among the rivals (see Peters (2006, p.646)). However, the Frontier-Midwest merger had the highest cross-price elasticities compared to the other mergers (see Section 5.3), which suggests that their products were often particularly close substitutes for each other. As a consequence, the Bertrand oligopoly model again overstates the extent of pre-merger competition and thus, merger simulation over-predicts the price effect.

The substantial under-prediction in price for the United-Continental merger is mainly driven by a large increase in the supply-side residual c. This would either imply substantial post-merger inefficiencies (i.e. large marginal cost increases) or a change in firm conduct. The latter seems more plausible, as one possible explanation might be that since both airlines had been financially distressed prior to the merger, they had been charging extremely low fares and they may have been pricing below the short-run profit-maximizing level, while after the merger the mode of competition might have changed (called the coordinated effect of a merger). For example, tacit collusion might have become easier.

[26] In comparison, the number of unique products for mergers and rivals increases post-merger by only 2.5 percent for the overlap markets of the Delta-Northwest merger and by 33.9 percent for the overlap markets of the United-Continental merger.

9 Discussion

The goal of this paper has been to evaluate how accurate the simulated prices - offered as forecasts of post-merger outcomes - are. Even though, the study finds that standard simulation methods do not generally provide an accurate forecast, the study provides, however, several explanations for this finding. First, as already mentioned by Peters (2006, p.628), the "simulation relies on strong assumptions about the post-merger behavior of demand, costs and conduct" and thus, "if these assumptions are violated, it might be more appropriate to interpret the simulated price changes as a measure of one component of the merger's effect on prices rather than as a forecast of the overall effect". Therefore, a decomposition of the observed post-merger price change into its component effects is suggested, which finds that deviations from the assumed model of firm conduct play an important role in accounting for the differences between the predicted and observed price changes. Hence, this paper suggests a need for richer models of firm conduct, as merger simulations may only be useful in understanding the effect of a merger on unilateral pricing incentives (i.e. price changes with the same mode of competition). However, it is typically hard to evaluate the coordinated effect of merger - resulting from tacit collusion or a change in the mode of competition - as one typically does not know the "right" ownership structure, where conduct parameters may take positive values for products owned by the rival firms, if some form of collusion exists. Second, these differences in prices are influenced by distinct characteristics between the airline mergers, such as financial distress and the number of overlap markets, i.e. market dominance.

One potential shortcoming of examining the airline industry is that the static non-cooperative oligopoly model typically used in merger simulations might be ill-suited for the airline industry. A previous study by Werden, Froeb, and Scheffman (2003, p.94) has, for example, already pointed-out that "pricing in airline markets is not well explained by any oligopoly model that can be used in merger simulation." As a consequence, these kind of models might be better suitable for other industries, as the consumer product market, and thus, one should be particularly cautious about extrapolating from the results of this study to other industries (worry about external validity).

Another potential shortcoming of this study is that estimates of price effects depend strongly on assumptions and exclusions, as they are fairly sensitive to which specifications, assumptions and calculations have been made (e.g. the cleaning of the data or the selection of markets and periods). Thus, there is a wide variation of estimates of price effects in the literature. Shortcomings, therefore, might include that the post-merger effects considered in this paper are those that occurred within the first year after the merger was completed, and thus, other effects, such as entry responses, which took longer to occur, are not captured in the results (a similar point is made by Peters (2006, p.645)). Another difficulty represents the exclusion of markets - as different economists might find, for example, a different number of passengers or flights per quarter appropriate to include in the study.

10 Conclusion

One of the aims of this research has been to contribute to Peters (2006) study by examining more recent developments in the U.S. airline industry. This paper finds that the results are similar to his findings, even when using different airline mergers at a different time period. In analogy to his study, this paper documents that merger simulations yield large over- as well as large under-predictions of price effects, which are determined by distinct characteristics between the airline mergers and the resulting price elasticities. This paper also highlights that an important focus in determining the impact of the mergers on prices should lie on the role of marginal costs and firm conduct, as supply-side effects play an important role in accounting for the differences between the predicted and observed price changes. However, in contrast to his study, the results of this paper do not show a wrong rank order, as the simulations, for example, correctly predicted the largest price change for the merger with the actual largest observed price change, namely for the United-Continental merger.

Another difference to Peters (2006) research is that two of the three examined mergers show price reductions after the merger. This is usually untypical, as the main economic concern from mergers is that consumers will be confronted with an increase in price as a profit-maximizing multi-product firm will take into account the fact that some of the lost sales will go to other products which represent substitutes for this product - now produced by the merging airlines. But in the case of the Frontier-Midwest merger, the large observed price reduction is consistent with the hypothesis that carriers with a relatively small number of overlap markets, who in addition have not integrated their operations - as it has been a merger of brands only - are not able to increase their market power by much after the merger. Thus, the firm's previous price constraining effect - of keeping prices low in order to avoid losing sales to rivals - will still remain. As a result, the starting position of this study compared to Peters (2006) is different, as the models of choice might not be able to capture those insights.

In line with Peters (2006, p.647), the main take-away of this study is that merger simulations can be useful in understanding the effect of a merger on unilateral pricing incentives, however, they do not yield accurate forecasts of a merger's overall effect, at least in the context of the airline industry. Since deviations from the assumed model of firm conduct play an important role in accounting for the differences between the predicted and observed price changes, there is a need for richer models of firm conduct. In conclusion, the literature on merger simulation in the airline industry would benefit from future work, which incorporates richer models of firm conduct into the methodology - but it is typically hard to evaluate the coordinated effect of merger (i.e. tacit collusion or a change in the mode of competition).

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A Appendix

The utility equation for the logit model is given by the expression below. It follows the first model derivations from McFadden (1980, p.16) as well as the idea from Berry (1994, p.250) of obtaining the mean utility from the differences in log market shares:

$$\begin{aligned}
ln(s_j) - ln(s_0) &= ln\left(\frac{exp(\delta_j)}{1+\sum exp(\delta_j)}\right) - ln\left(\frac{1}{1+\sum exp(\delta_j)}\right) \\
&= ln\left(exp(\delta_j)\right) - ln\left(1+\sum exp(\delta_j)\right) - ln\left(1\right) + ln\left(1+\sum exp(\delta_j)\right) \\
&= ln\left(exp(\delta_j)\right) \\
&= \delta_j
\end{aligned} \tag{13}$$

Similarly, following Berry (1994, pp.252-253), one can obtain the utility equation for the nested logit model by the following expression:

$$
\begin{aligned}
ln(s_j) - ln(s_0) &= ln\left(\frac{exp(\delta_j/\rho)}{\sum_{l\in g} exp(\delta_l/\rho)} \cdot \frac{\sum_{l\in g} exp(\delta_l/\rho)^\rho}{\sum_g(\sum_{l\in g} exp(\delta_l/\rho))^\rho}\right) - ln\left(\frac{1}{\sum_g(\sum_{l\in g} exp(\delta_l/\rho))^\rho}\right) \\
&= ln\left(\frac{exp(\delta_j/\rho)(\sum_{l\in g} exp(\delta_l/\rho))^{\rho-1}}{\sum_g(\sum_{l\in g} exp(\delta_l/\rho))^\rho}\right) - ln\left(\frac{1}{\sum_g(\sum_{l\in g} exp(\delta_l/\rho))^\rho}\right) \\
&= ln\left(exp(\delta_j/\rho)\right) + (\rho-1)\cdot ln\left(\sum_{l\in g} exp(\delta_l/\rho)\right) - \rho\cdot ln\left(\sum_g\left(\sum_{l\in g} exp(\delta_l/\rho)\right)\right) - ln\left(1\right) + \rho\cdot ln\left(\sum_g\left(\sum_{l\in g} exp(\delta_l/\rho)\right)\right) \\
&= ln\left(exp(\delta_j/\rho)\right) + (\rho-1)\cdot ln\left(\sum_{l\in g} exp(\delta_l/\rho)\right) \\
&= ln\left(exp(\delta_j/\rho)\right) + \rho\cdot ln\left(\sum_{l\in g} exp(\delta_l/\rho)\right) - ln\left(\sum_{l\in g} exp(\delta_l/\rho)\right) \\
&= ln\left(\frac{exp(\delta_j/\rho)}{\sum_{l\in g} exp(\delta_l/\rho)}\right) + \rho\cdot ln\left(\sum_{l\in g} exp(\delta_l/\rho)\right) \\
&= ln(s_{j|g}) + \rho\cdot ln\left(\sum_{l\in g} exp(\delta_l/\rho)\right) \\
&= ln(s_{j|g}) + \rho\cdot ln\left(\sum_{l\in g} exp(\delta_l/\rho)\right) + \delta_j - \rho\cdot\delta_j/\rho \\
&= ln(s_{j|g}) + \rho\cdot ln\left(\sum_{l\in g} exp(\delta_l/\rho)\right) + \delta_j - \rho\cdot ln(exp(\delta_j/\rho)) \\
&= ln(s_{j|g}) - \rho\cdot ln\left(\frac{exp(\delta_j/\rho)}{\sum_{l\in g} exp(\delta_l/\rho)}\right) + \delta_j \\
&= ln(s_{j|g}) - \rho\cdot ln(s_{j|g}) + \delta_j \\
&= \delta_j + (1-\rho)\cdot ln(s_{j|g})
\end{aligned}
\tag{14}
$$

In analogy, the utility equation for the 2-level nested logit model can be derived, however, it is more complex.