The Dual Effects of Mergers on Peripheral Markets: Evidence from the U.S. Airline Industry*

Myongjin Kim† Joe Mazur‡

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Abstract: Can mergers have significant effects on markets where *neither* of the merging firms currently competes? Economic theory suggests as much, and references to such effects are common on both sides of the antitrust courtroom. Yet empirical support for a merger's effects on these "peripheral" markets is all but missing. Using data on four large mergers in the U.S. airline industry, we provide the first empirical evidence of peripheral market effects, documenting considerable heterogeneity across markets. While these effects amount to a pro-competitive reduction in overall prices of 2% to 3% in our context, we establish theoretical and empirical support for both pro- and anti-competitive outcomes, as mediated by two distinct, often opposing, effects on the threat of entry: 1) an increase in the merged firm's likelihood of entry, and 2) the merger's elimination of a potential entrant. By providing a baseline estimate for both effects and offering insight into which markets are liable to be affected, our results are likely to be important for antitrust policy in general, and merger remedies in particular.

Keywords: Mergers; Potential Entrants; Market Structure; Antitrust; Threat of Entry
JEL Codes: L41; L11; D43; L93

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†Department of Economics, University of Oklahoma, Norman, OK 73019, Email: *mjkim@ou.edu*.

‡Corresponding author. Department of Economics, Mitchell E. Daniels, Jr. School of Business, Purdue University, West Lafayette, IN 47907, Email: *mazur3@purdue.edu*.

1 Introduction

The effects of mergers on market performance are of perennial interest to economists and policy makers alike, but which markets' performance do we examine? Virtually all studies of horizontal merger effects focus on "overlap markets," where the merging parties compete directly with one another, but economic theory teaches us that, in addition, a merger which changes the parties' likelihood of entry into new markets could have significant and lasting effects on those markets as well.[1] Nevertheless, empirical study of such markets is practically nonexistent. At the same time, the prospect of entry by merging firms into new markets is commonly put forth to argue in favor of mergers (e.g. Sprint/T-Mobile or Spirit/Frontier), yet formal analysis of this prospect is equally lacking. It seems only natural, then, to ask how, and to what extent, mergers may affect markets in which *neither* merging firm currently competes. We term these "peripheral markets."

To be clear, the *loss* of potential competition due to a horizontal merger can, to quote the U.S. Department of Justice and Federal Trade Commission,[2] "raise significant competitive concerns," and competition authorities around the world give those concerns due weight. Yet while policy makers and economists agree that a merger's elimination of potential competition is an important antitrust issue,[3] the opposing effect, whereby a merger creates or strengthens the pro-competitive threat of entry, remains woefully understudied.[4] Furthermore, even those studies which explore the elimination of a potential entrant do so in the

[1]For example, the threat of potential entry matters for the price level in cases of limit pricing, as in Milgrom and Roberts (1982) and Sweeting et al. (2020); in cases of tacit or overt collusion, as in Ivaldi et al. (2007) and Shin (2021); and in cases of competitive constraint, as summarized in Kwoka (2008). An extreme example would be the notion of perfect contestability, put forth by Baumol et al. (1982), which suggested that under certain conditions the threat of entry could perfectly counteract market power. See Shepherd (1984) for one of many early critical appraisals of the theory.

[2]Moreover, they note that the degree of concern should depend at least in part on the competitive threat posed by the potential entrant. See section 5.3 of the 2010 Horizontal Merger Guidelines, available for download here: `https://www.justice.gov/atr/file/810276/download` Guideline 4 of the 2023 Draft Merger Guidelines addresses the same concerns and is available for download here: `https://www.justice.gov/d9/2023-07/2023-draft-merger-guidelines_0.pdf`

[3]See, for example, Kwoka (2008) for a helpful discussion.

[4]The only study we are aware of which makes this point is Gil and Kim (2021), which examines quality effects of new, merger-induced entry threats using U.S. airline data.

context of "intermediate markets" (i.e those in which only one of the merging carriers is an incumbent).[5] Peripheral markets thus remain absent from both study and discussion[6] despite their scope for both pro- and anti-competitive merger effects. Instead, peripheral markets are simply assumed to be unaffected by horizontal mergers.[7] The question we aim to answer in this paper is, Are they?

Using data on four recent mergers in the U.S. airline industry, we tie market-specific changes in the threat of potential entry to changes in market price, demonstrating that horizontal mergers can indeed affect the performance of peripheral markets. Yet these effects are highly heterogeneous across markets, owing to the presence of two distinct, often opposing, forces influencing the overall threat of entry. The first is the *quality* effect, which reflects the fact that the merged firm may pose a stronger competitive threat than either merging party on its own. The second is the *composition* effect, which reflects the fact that the merger necessarily eliminates a potential competitor, even if that potential competitor may be very unlikely to enter.

To quantify changes in the threat of entry, we first estimate a probit model of entry using, among other variables, airline presence at each endpoint airport as predictors. Using the probit estimates, we then calculate the change in *pro forma* entry probability due to the merger-induced change in endpoint presence.[8] Across all markets and mergers we analyze, we find that about 19% of markets experience a change in entry probability of 10 percentage points or more, and an additional 16% of markets experience a change of 5 to 10 percentage points. Yet that change can be positive or negative depending on whether the quality or composition effect dominates. To compare the relative strength of these two effects -

[5] See, for example, Kwoka and Shumilkina (2010), Le (2016), and Le (2019).

[6] The nearest example we have found is He and Rupp (2022), which examines merger effects in a variety of market structures, including connecting markets where potential entry by the merging carriers into direct service is a consideration. However, the analysis in that work is not constructed in a way that can isolate the merger's effect upon such markets.

[7] Indeed, for this reason, such markets often make up the control group for traditional merger retrospective studies. See, for example, Carlton et al. (2019) and Ashenfelter and Hosken (2010).

[8] For example, if the merging carriers' relative positions at each endpoint of a given market are asymmetric, such that each carrier is strong at only one endpoint, one might expect the merger to enhance the combined firm's ability to profitably enter that market.

and to compare our results to prior work on the elimination of potential competition[9] - we decompose the overall change in entry probability into its two components, finding significant heterogeneity across markets.

Next, we link market performance with merger-induced changes in the threat of entry. Guiding our analysis is a theoretical framework for coordination under the threat of entry, which suggests the possibility of non-monotonic price effects. We therefore regress logged mean prices in peripheral markets upon the change in entry probability and its interaction with the pre-merger probability of entry, allowing us to capture potential non-monotonicity in the effect of entry probability on prices. Overall we find significant effects of entry probability on mean fares, and - rather more compellingly - our findings are qualitatively consistent across mergers. In particular, increases in entry probability are associated with 2-3% lower fares when the initial entry probability is low, while the same changes are associated with higher fares when the initial entry probability is substantially higher. Our results support the U-shaped pattern identified in Sweeting et al. (2020) and, as suggested by our theoretical framework, point to the possibility of coordinated strategic entry deterrence.

Our paper makes three primary contributions. First, we contribute to the academic literature on merger effects in general by documenting two distinct, consistent, and statistically significant effects of mergers on peripheral markets. Further, we quantify each of these effects for one set of mergers in a particular industry, allowing us to evaluate their strength relative to one another, their heterogeneity across markets, and their magnitude relative to the merger effects found elsewhere in the literature.

Second, our paper supports policy makers by demonstrating that mergers may affect potential entry by the merging firms into peripheral markets, either positively or negatively, and by giving a sense for how large these effects might be, especially relative to one another. This dimension of change in the competitive landscape due to horizontal combinations is given very little attention in the antitrust literature, despite the common claim among merging

[9] For example, this work allows us to compare the composition effect found in, among others, Kwoka and Shumilkina (2010) to both the quality and composition effects established herein.

companies that their union would enable them to compete more effectively.[10] Moreover, our paper has the potential to better inform merger remedies such as forcible divestitures. While the timeliness, likelihood, and sufficiency of potential entry into overlap markets figure prominently into merger analyses as well as remedy prescriptions, the effects of remedies on entry into peripheral markets appear unconsidered. Yet our results suggest that a forcible divestiture which relieves market power in one market could have the unintended consequence of higher prices in peripheral markets due to a weakening of the threat of entry there. In such cases, consumers in peripheral markets could end up subsidizing consumers in overlap markets, a violation of the U.S. antitrust authorities' mandate to prevent a lessening of competition "in any market," per Section 7 of the Clayton Act.

Third, we add to the study of mergers and potential entry specifically in the airline industry. Relative to a long line of airline merger retrospectives studying overlap markets, we focus on peripheral markets, shedding new light on the overall level of competitiveness engendered by these mergers.[11] Relative to the literature on potential entry, which covers positive (as in Gil and Kim (2021)) and negative (as in Kwoka (2008)) changes to the threat of entry in separate veins, this paper shows that both positive and negative effects can occur simultaneously as the result of a merger. Moreover, our continuous approach to measuring changes in the threat of entry distinguishes us from the literature. Whereas Gil and Kim (2021), Goolsbee and Syverson 2008; Prince and Simon 2015, and He and Rupp (2022)

[10]For example, Sprint and T-Mobile executives claimed that their merger would enable them to enter rural markets that neither currently served, and the companies argued that only together could they effectively deploy 5G throughout the U.S. (The T-Mobile press release dated April 29, 2018 is available here: `https://www.t-mobile.com/news/press/5gforall`) Both claims eventually became conditions for the Federal Communications Commission's (FCC) approval of the merger. (The FCC news release dated November 5, 2019 is available here: `https://www.fcc.gov/document/fcc-approves-merger-t-mobile-and-sprint`) In the context of airlines, the proposed merger between Frontier and Spirit provided another explicit example of company leaders pointing to new market entry as one of the benefits of their combination. (The New York Times article summarizing these claims, dated February 7, 2022, can be found here: `https://www.nytimes.com/2022/02/07/business/frontier-spirit-airlines-merger.html`)

[11]Other work outside of overlap markets includes the aforementioned works by He and Rupp (2022), Kwoka and Shumilkina (2010), and others, as well as Dix and Orzach (2021), which aims to demonstrate that price effects on non-stop routes - such as the direct effect of a merger, for example - will have similar, but muted, effects on connecting routes which use those non-stop routes as legs. In the context of a merger, however, the connecting markets identified by Dix and Orzach (2021) are not peripheral markets, since one or more of the merging carriers actively competes on them.

all employ binary or discrete indicators for whether an airline represents an entry threat, we adapt the approach of Sweeting et al. (2020), which estimates a probit model of entry, and uses the estimates to construct measures of entry probability.[12] Using this approach to define potential entry yields three distinct improvements, namely, it allows us to use more markets in our analysis relative to the preexisting binary definition; it differentiates between markets that are likely vs. unlikely to be entered, thereby varying exposure to the entry threat "treatment;" and it enables us to identify non-monotonic effects of the threat of entry on prices.

2 Literature Review

In this section, we review the two strands of literature most relevant for our paper, namely, works examining empirically the price effects of completed mergers on non-overlapping markets,[13] and those concerning the threat of entry. We take each in turn.

2.1 Merger Effects in Non-Overlapping Markets

While the merger retrospective literature is dense, its focus has been - quite sensibly - upon overlap markets. Studies of the effects of mergers on other markets are therefore very few.[14] Most are concerned with the prospect of potential entry, which we cover in more depth in the next subsection. The first and best example along these lines is the work of Kwoka and Shumilkina (2010), which empirically demonstrates that the elimination of

[12] This approach is similar to that of Ellison and Ellison (2011) in the pharmaceutical industry and Dafny (2005) in the market for inpatient medical procedures to identify entry-deterring behavior. Subsequent work by Shin (2021) has also utilized this approach.

[13] While our paper is also directly connected to the literature on traditional merger retrospectives, which focus on overlap markets, we refer the interested reader to the literature review in Kim and Mazur (2022) for that discussion.

[14] One interesting new exception is Dix and Orzach (2021), which suggests that an airline merger which raises prices on a particular route may also raise prices on routes which use that route as a connection, or leg. Notably, the routes in question are all served by one of the merging carriers, so none of these would qualify as peripheral markets in our sense, although some may qualify as intermediate markets, depending on the network structure of the merging carriers.

potential competition tends to increase prices. Kwoka and Shumilkina (2010) document a 5 to 6 percentage point increase in prices due to the merger of USAir (now US Airways) and Piedmont Airlines in markets where one of the two carriers was a potential entrant, and the other was an active market participant. Other studies, such as Le (2016) and Le (2019), establish similar patterns. On the other hand, more recent work by Gil and Kim (2021) recognizes that a merger can also establish a new threat of entry in markets where neither merging firm currently competes. While that study finds no significant price effect, it documents an increase in quality and convenience in markets where the merger plausibly establishes a threat of new entry by the merged firm. Perhaps the closest to our own work is He and Rupp (2022), which documents price movements before, during, and after three significant airline mergers, separating the analyses according to whether the merged firms were incumbents, potential entrants, or a mix of the two. Thus, He and Rupp (2022) document price trends in peripheral markets alongside trends in other markets, providing useful insight into how these markets compare with one another before and after a merger. Nevertheless, the analysis stops short of parsing these trends in order to formally identify a particular merger's effect upon any one market structure. Importantly, the authors do recognize that a merger could potentially have either positive or negative effects on peripheral markets, which is why their approach includes them. Our paper provides a natural way of synthesizing and quantifying the effects found in the aforementioned literature, while also linking the varied entry threat effects of a merger to its effect on prices.

2.2 Entry Threat Studies

Economists have long recognized that the threat of entry by a new competitor can influence incumbent behavior, and in ways that potentially differ from the effects of actual entry.[15] Strategic behaviors such as limit pricing to deter entry, for example, only have effect before entry has actually occurred. Despite the importance of entry threats in theoretical models

[15] For a helpful and concise discussion, see Kwoka (2008).

of imperfect competition, empirical study of the effects of potential entry remains relatively scarce. Nevertheless, it appears to tell a fairly uniform story, namely, that the threat of entry tends to reduce prices, at least within the airline industry. Morrison (2001) and Goolsbee and Syverson (2008) study incumbent pricing behavior in response to threatened entry by Southwest Airlines, finding significant price reductions when Southwest establishes itself as a potential entrant into a given market. Sweeting et al. (2020) re-consider this "Southwest effect" through the lens of a dynamic limit pricing model, finding suggestive evidence that limit pricing by monopoly incumbents may indeed be at the heart of incumbent price reductions. Extending the sample to non-monopoly markets but still focusing on threatened entry by Southwest, the dissertation by Shin (2021) reminds us of the fact that price reductions in response to the threat of entry need not be motivated by monopoly limit pricing, but may very well be the equilibrium response of tacitly colluding incumbents. Prince and Simon (2015) study non-price behavior of incumbents in response to threatened, and actual, entry by Southwest, finding that on-time performance worsens in response to both actual and potential competition. Shin (2021)'s methodology for accounting for the likelihood of entry roughly follows Sweeting et al. (2020), and his sample is more far-reaching. For these reasons, Shin (2021) is nearest to our own paper in those dimensions. Our focus, however, is on the merger-induced threat of entry and its various effects on peripheral markets, whereas Shin (2021) and its precedents aim to identify (and/or disentangle the mechanism for) price reductions due to newly threatened entry by Southwest, as traditionally defined in the literature.

3 Methodology

Our basic analytical approach proceeds in two stages for each merger. In the first stage, we estimate a flexible probit model of entry using pre-merger data for both merging carriers. Using those estimates, we predict the probability of entry for the merged carrier, which we then use to calculate the overall change in the probability of entry, as well as its component effects. In the second stage, we regress logged mean prices on these changes in entry probability, allowing them to have effects that vary with the pre-merger probability of entry. Doing so allows us to directly connect the change in entry threat to the change in prices. Our main approach in the second stage is similar to a two-way fixed effects model (difference-in-differences) with a continuous treatment (change in entry probability).[16] In the rest of this section, we first define the probability (or threat) of entry and highlight how our approach differs from others in the literature. Next, we provide details for our first stage estimation and associated entry threat calculations. Finally, we detail our second stage estimation of the effects of mergers on log prices.

3.1 Defining Entry Threat

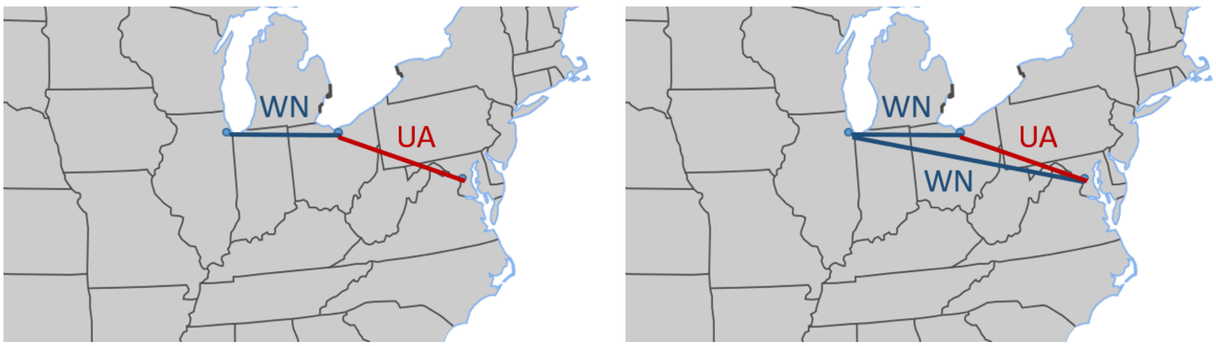
Similar to prior related studies such as Goolsbee and Syverson (2008), Prince and Simon (2015), Gil and Kim (2021), Sweeting et al. (2020), and Shin (2021), our empirical strategy leverages changes in competitors' presence in the endpoint airports of a given route as signals for entry threat. To understand how our work advances this frontier, it is helpful to delineate the various prior approaches. The studies just mentioned identify the threat of entry based on a rival airline establishing presence in both endpoints of a route.[17] For example, suppose we want to examine the Cleveland (CLE) to Washington Dulles (IAD) market, which is currently served only by United (UA), as depicted in panel (a) of Figure 1. Southwest (WN) has presence at one endpoint, CLE, because it serves the Chicago Midway (MDW) to Cleveland (CLE) market, but Southwest has no presence at IAD. Once Southwest begins to serve the IAD-MDW market, as in panel (b) of Figure 1, it becomes a potential entrant on

[16] In future drafts, we hope to address the potential bias discussed in Goodman-Bacon (2021) by employing Callaway et al. (2021) and/or Callaway and Sant'Anna (2021) in robustness checks.

[17] While this seems to have become the standard definition, Morrison and Winston (1987) first established endpoint presence at a single airport as its standard. That study found no qualitative change in the results when using dual-endpoint-presence to define potential entrants and also acknowledged that one could define potential entry much more liberally. For instance, Morrison (2001) allows for various (discrete) degrees of potential entry status based on the number of airports served.

the CLE-IAD market by virtue of having presence at both endpoint airports. An important feature of this definition is that it is binary by nature. Either a carrier is a potential entrant or it is not.[18]

Figure 1: Entry Threat Based on Rival's Entry into Second Endpoint



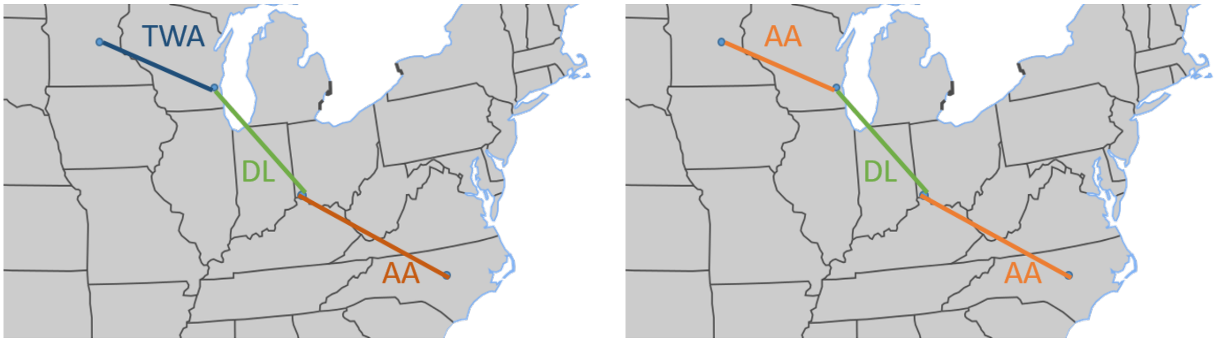
(a) Before WN's Entry in IAD (b) After WN's Entry in IAD

Gil and Kim (2021) exploit changes in airline presence that arise due to mergers as another novel source of exogenous variation in the threat of potential entry. They posit that a merger between two airlines that were not operating on a given route, but did operate independently at different endpoints of that route, would increase the likelihood of entry of the newly merged airline on that route. As an illustrative example, consider the market between Milwaukee (MKE) and Cincinnati (CVG), and suppose it is served only by Delta (DL), as depicted in Figure 2. Suppose as well that TWA is present at MKE because it serves the Minneapolis (MSP) to MKE route, and that American (AA) is present at CVG because it serves the Raleigh/Durham (RDU) to CVG route. In this scenario, neither TWA nor AA is currently a potential entrant on the market in question, but if AA and TWA were to merge, then the merged carrier would become a potential entrant. Again the definition of a potential entrant is binary, but the reason for its change is a merger, as opposed to new service commenced by a rival.

Our paper employs the same source of variation in potential entry, that is, a merger be-

[18]Note that this remains true even when we increase the threshold for defining "presence" at an airport. That is, even if we strengthen what it means to be a potential entrant, the definition itself remains binary. Moreover, the data limitations this binary definition creates for recent mergers, as discussed below, do not go away with a stronger definition of potential entry.

Figure 2: Entry Threat Based on Rivals' Merger



(a) Before AA-TWA Merger (b) After AA-TWA Merger

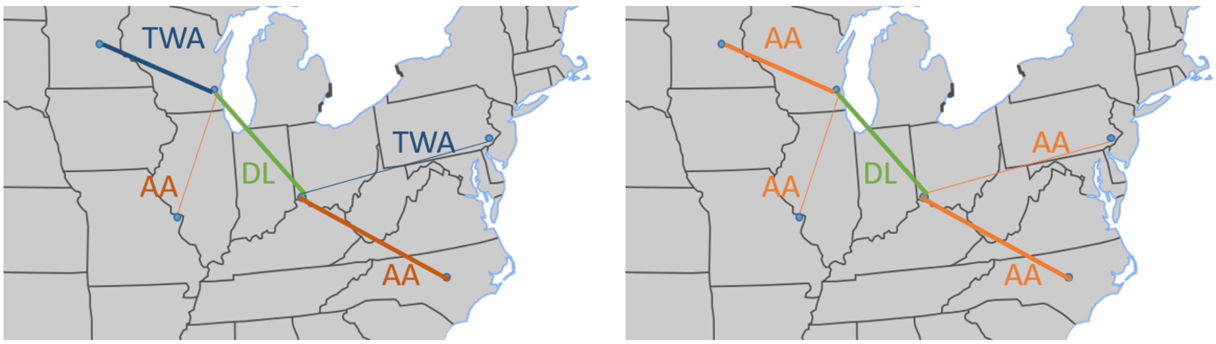
tween carriers that do not serve the market in question. However, our definition of a potential entrant, and of the entry threat itself, differs from the prior literature in an important and useful way. Rather than a binary definition of potential entrant status, we allow a carrier's status as a potential entrant to be a continuous variable, defined as its likelihood of entry, on the interval [0,1]. Defining potential entrants this way affords us two key benefits. First, it allows us to consider a much larger set of data. To illustrate, consider again the MKE to CVG route, but suppose now that both TWA and AA had presence at both endpoints prior to the merger, as in panel (a) of Figure 3. According to the binary definitions of potential entrant status employed by prior work, a merger between AA and TWA would not change the set of potential entrants. Nevertheless, it may be the case that a merger does in fact change the merged firm's entry probability. For example, as denoted by the thickness of the route lines in Figure 3, suppose that the relative strength of AA and TWA at each endpoint is highly asymmetric. That is, TWA is strong at MKE, while AA is strong at RDU. It is not hard to imagine that, given such asymmetry, the merger between TWA and AA might result in a stronger threat of entry by the merged carrier.[19] Indeed, Berry (1992) and Aguirregabiria and Ho (2012) both find that a greater degree of presence correlates with higher likelihood of entry.

Moreover, given the significant increases in carrier networks over the last two decades,

[19]This kind of asymmetry is precisely what we see in the data surrounding the mergers we are examining.

more recent mergers very rarely change the potential entrant status of their merging parties under the prior, binary definition. In other words, the binary definition of a potential entrant based on service at both endpoints is unhelpful in analyzing the effect of changes in the threat of entry due to recent airline mergers, such as the ones we investigate in this paper.[20]

Figure 3: Entry Threat Based on Rivals' Merger and Accounting for Presence



(a) Before AA-TWA Merger (b) After AA-TWA Merger

To account for changes in entry probability in cases where both merging carriers had presence at both endpoint airports on a route, we adapt the approach of Sweeting et al. (2020), who examine incumbent behavior in response to the threat of entry by Southwest. As in Goolsbee and Syverson (2008), Sweeting et al. (2020) consider Southwest to be a potential entrant at the moment it begins serving both endpoint airports of a market. Thus, their definition of potential entrant status remains binary. In order to investigate the reason for Southwest's effect on prices prior to its entry, however, they further estimate Southwest's probability of entry, conditional on being a potential entrant, and use the predicted entry probabilities as a continuous explanatory variable in a regression of logged prices.[21] We follow a similar approach by estimating a probit model of entry for the merging carriers,

[20]For example, under the binary definition of potential entrant status, for the AA/US merger, only 5 markets would face an increased threat of potential entry as a result of the merger. The UA/CO merger yields 3 markets, and the DL/NW merger yields 0.

[21]They find that on markets where Southwest is either very likely or very unlikely to enter, there is very little pre-entry price effect, while on markets where Southwest's entry is hard to predict, the price effect is statistically significant and strongly negative. The authors find that these results, when taken together and considered alongside a dynamic theoretical model, are suggestive of limit pricing as the likely reason for Southwest's pre-entry effect on average prices. A similar approach to defining the likelihood of entry was employed in other contexts by Dafny (2005) and Ellison and Ellison (2011).

with the exception that we do not condition on either carrier's status as a potential entrant. Rather, we treat *all* carriers as potential entrants, and simply allow their likelihood of entry to vary continuously, from nearly zero to near certainty. We then use the fitted model to predict entry probabilities for the merged carrier. Returning to the example of TWA and AA above, if entry probability is, say, strongly predicted by the geometric average of airport presence at the two endpoints,[22] then while neither TWA nor AA would have a high value of average presence, the merged carrier would, and its predicted entry probability would reflect that.

The second advantage of defining potential entrants this way is that it allows us to decompose the merger-induced change in entry probability and separately analyze its two components. To illustrate, consider a hypothetical merger. Before the merger, each of the merging parties has its own probability of entering a given market. Call these probabilities A and B, and without loss of generality, suppose that B is weakly larger than A. After the merger, the merged firm has a potentially different probability of entering, which we might expect under normal circumstances to be weakly larger than A or B. Call this probability C. Because the merger simultaneously changes C while also eliminating one of A or B, it changes both *composition* (i.e. number) and *quality* (i.e. likelihood of entry) of potential entrants. Thus, the overall effect of the merger on peripheral markets could be *either an increase or a decrease* in entry probability, and the effect may differ from market to market. Indeed, that is exactly what we find.

Our paper is the first to shed some empirical light on this important distinction, and we do that by decomposing the change in entry probability into the *quality* effect, which relates only to C being different (we expect, weakly higher) than A or B, and the *composition* effect, which relates only to the loss of a potential entrant. We measure the quality effect as the difference between C and B, reflecting only the change in entry probability of the merged firm itself.

[22] We define airport presence below as the total number of ticketed enplanements and deplanements for a given carrier out of a particular airport during a particular quarter.

$$\textit{quality effect} = C - B$$

We measure the composition effect as the difference between $(1-A)*(1-B)$ and $(1-B)$, reflecting only the change in entry probability due to the loss of a potential competitor.[23]

$$\begin{aligned}
\textit{composition effect} &= B - [1 - (1 - A) * (1 - B)] \\
&= B - 1 + (1 - A) * (1 - B) \\
&= (1 - A) * (1 - B) - (1 - B)
\end{aligned}$$

In both cases, we are being conservative in the sense that we are choosing the carrier that minimizes the change in probabilities.[24] Having thus decomposed the merger's effect, we can quantify just how important each merger is for facilitating vs. eliminating potential entry.

3.2 First Stage: Probit Model of Entry

In the first stage of our analysis, we estimate a probit model of entry on a pre-defined set of markets. Defining a market to be any non-directional pair of airports, we include in our sample every market between the largest 125 airports in the contiguous U.S., regardless of whether or not that market is actually served.[25] Next we define entry as a binary variable equal to one if, in any of the next four quarters, a given carrier flies more than 20 ticketed

[23]For simplicity, we are assuming that if one of the pre-merger firms were to enter, the other would not, such that we only have to think about the odds that a single firm joins the market.

[24]Our conservative approach implicitly assumes that C is weakly higher than B, which we expect, but need not necessarily be true. Our estimated probit results indicate that C is indeed larger than A or B in the vast majority of cases. Instances of a negative quality effect account for fewer than 10% of observations, and likely reflect non-linearities in the effect of airport presence on entry probability. Note that the composition effect is defined to be weakly negative.

[25]We tabulate traffic using data for quarter 2 of the year 2000, keeping all airports that account for at least 0.05% of total domestic U.S. traffic. After dropping airports outside the contiguous U.S., our set of markets continues to account for about 90% of all domestic passenger flight traffic in the U.S.

DB1B passengers (roughly equivalent to 200 actual passengers) between those two endpoints, regardless of initial origin or final destination.

Our set of explanatory variables includes the following: airport presence at both endpoints and geometric average presence across those endpoints; non-stop flight distance between the two endpoints; an indicator for long distance routes (round-trip distance greater than 2000 miles); geometric average population across endpoints; an indicator for the presence of slot constraints on the market[26]; indicators for year and quarter; and various polynomials and interactions of the aforementioned variables. For details on how each of these elements is computed and the data cleaned, please refer to the next main section of the paper.

With variables so defined, we next estimate a separate probit for each merger, using only the entry decisions of the merging firms in the pre-merger period, and treating all coefficients as common to both firms. This decision enables us to re-compute entry probabilities for the merged firm using *pro forma* presence values at each endpoint airport that are equal to the sum of presence for each merging carrier in the pre-merger period.[27] Just as important, this decision allows us to refrain from speculating on how the merger might change the merged carrier's overall network structure.

Lastly, we compute the relevant probability figures to be used in the next stage. Each merging carrier's entry probability is computed as the probit estimation's predicted value. Per the previous subsection, the baseline (i.e. pre-merger) entry probability is defined to be the maximum of these values among the two merging carriers. The overall change in entry probability, the composition effect, and the quality effect, are computed as described in the previous subsection, using the probit estimation's predicted values, but replacing the endpoint presence values with *pro forma* endpoint presence values equal to the sum of the merging firms' values. To reduce noise in these figures due to seasonal variation in

[26]Slot-controlled airports include John F. Kennedy International Airport (JFK), Newark Liberty International Airport (EWR), LaGuardia Airport (LGA) and Washington Reagan National Airport (DCA). Slot restrictions at Chicago O'Hare (ORD) expired in 2000 and are accounted for in our sample.

[27]Note that our set of explanatory variables must therefore deliberately exclude things like market-carrier dummies or hub indicators. We believe much of the impact of such market-carrier variables is accounted for by presence alone.

overall entry activity, we average these effects over the four quarters prior to the merger's announcement.

3.3 Second Stage: Difference-in-Differences

In the second stage, we regress logged average prices upon the measures computed from the first-stage estimation to examine how incumbent airlines in peripheral markets respond to changes in the threat of entry. Our setup is similar to the difference-in-differences approach with a continuous treatment effect used by Sweeting et al. (2020). We deviate from their approach in two ways. First, all observations are subject to treatment, albeit to varying degrees. Many markets, for example, will experience a change in entry probability that is virtually zero, and the effect on the remaining markets will be identified off of them. Second, whereas Sweeting et al. (2020) test for monotonicity by allowing the treatment effect to be quadratic in entry probability, we instead interact the change in entry probability with the baseline probability of entry of the unmerged firms. One can think of our approach intuitively as estimating the slopes of tangent lines at various points along the entry probability curve. This approach is necessary, since, unlike Sweeting et al. (2020), the changes we observe do not start from zero, as is implied by the Sweeting et al. (2020) approach.

We estimate the following baseline model at the market-carrier level:

$$Y_{irt} = \alpha + \beta_1 Delta_{irt} + \beta_2 Delta_{irt} * BaseProb_{ir} + \gamma X_{irt} + \omega_{ir} + \theta_t + \epsilon_{irt}, \tag{1}$$

where Y_{irt} represents the natural logarithm of market-carrier-level passenger-weighted average ticket prices of incumbents for carrier i on directional route r at time t. $\mathbf{X}_{irt}$ is a vector of carrier-route and carrier-time varying covariates that could affect ticket prices. They are HHI, which captures market concentration, and total market-level passengers, capturing market size. $BaseProb_{ir}$ is a continuous variable indicating the baseline entry probability estimated in the first stage, while $Delta_{irt}$ measures the calculated change in entry probability due to the merger. While $BaseProb_{ir}$ is absorbed by carrier-route fixed effects, the interaction term $Delta_{irt} * BaseProb_{ir}$ captures potential non-monotonicity in incumbents' pricing responses to a marginal change in entry probability. ω_{ir} and θ_t capture the market-carrier and the time fixed effects, respectively. Because ours is a two-step procedure, we report bootstrapped standard errors using 100 bootstrap iterations.

4 Theoretical framework

Guiding our second-stage regression specification is a simple model of tacit collusion under the threat of entry, extended to encompass the prospect of coordinated entry deterrence via limit pricing. We first show that, in the absence of strategic entry deterrence, average prices across markets where tacit collusion is possible should decline monotonically as the probability of potential entry rises.[28] Next, we allow for incumbent firms to instead coordinate on an entry-limiting price, demonstrating that the non-monotonic result of Sweeting et al. (2020), whereby a marginal increase in the threat of entry will tend to decrease average prices in markets where entry probabilities are relatively low, while increasing them where the threat of entry is sufficiently high, can obtain outside of a monopoly context. We conclude that where tacit collusion is more likely, this U-shaped pattern is more likely to emerge.

4.1 Tacit Collusion vs. Entry Threat

Suppose a particular market is supplied by two firms, with a third firm posing a threat of potential entry. The doupolists compete in an infinitely repeated game, where in any given period prior to entry, the third firm may enter with probability γ. Per-period collusive profit for each firm in the duopoly is $\pi_m = \frac{\Pi_M}{2}$, where Π_M represents the profit a monopolist would earn in the market. Let $\pi_n < \pi_m$ be each duopolist's profit in the Nash equilibrium of the stage game, and let $\pi_d > \pi_m$ be the single-period profit for a duopolist choosing to

[28]Note that Shin (2021) arrives at a similar conclusion regarding tacit collusion in the face of potential entry using a different approach.

deviate from a collusive agreement. If the third firm enters, per-period profit for each firm will become $\pi_e < \pi_m$. Assume as well that no further entry would be possible if the third firm enters, and that the third firm would not choose to enter if the incumbents were at the non-cooperative equilibrium.[29] Supposing that all firms discount future profits according to a factor α, it is straightforward to show that trigger strategies can support tacit collusion as an equilibrium only when the present value of collusion weakly exceeds the present value of defection. When $\gamma = 0$, this amounts to

$$\left(\frac{1}{1-\alpha}\right)\pi_m \;\; \geq \;\; \pi_d + \left(\frac{\alpha}{1-\alpha}\right)\pi_n$$

from which we can derive an expression for $\underline{\alpha}$, the lowest value of α that can sustain tacit collusion as an equilibrium:

$$\underline{\alpha} = \frac{\pi_d - \pi_m}{\pi_d - \pi_n}$$

However, when $\gamma > 0$, firms must factor in the threat of entry. Since entry can only happen one time, the expected present value (EPV) of future profits under tacit collusion is given by[30]

$$\begin{aligned}
\mathbb{E}\left[PV_{collusion}\right] &= \pi_m + \gamma\left(\alpha\pi_e + \alpha^2\pi_e + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ (1-\gamma)\,\gamma\left(\alpha\pi_m + \alpha^2\pi_e + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ (1-\gamma)^2\,\gamma\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ (1-\gamma)^3\,\gamma\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_m + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ (1-\gamma)^4\,\gamma\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_m + \alpha^4\pi_m + \alpha^5\pi_e + ...\right) \\
&+ \; ...
\end{aligned}$$

[29]Note that, by extension, we are assuming that in the event of defection, entry would not be threatened thereafter, and π_n would remain unchanged.

[30]See the appendix for a detailed explanation of this formulation and its simplification.

which simplifies to

$$
\begin{aligned}
\mathbb{E}\left[PV_{collusion}\right] &= \pi_m + \gamma \sum_{k=0}^{\infty}\left[\alpha^k (1-\gamma)^k \left(\sum_{j=1}^{\infty} \alpha^j \pi_e + (1-\gamma)^j \alpha \pi_m\right)\right] \\
&= \pi_m + \left(\frac{\gamma\alpha}{1-\alpha(1-\gamma)}\right)\left[\left(\frac{1}{1-\alpha}\right)\pi_e + \left(\frac{1-\gamma}{\gamma}\right)\pi_m\right] \\
&= \pi_m\left(1 + \frac{\gamma\alpha}{1-\alpha(1-\gamma)}\left(\frac{1-\gamma}{\gamma}\right)\right) + \pi_e\left(\frac{\gamma\alpha}{1-\alpha(1-\gamma)}\right)\left(\frac{1}{1-\alpha}\right) \\
&= \pi_m\left(1 + \frac{\alpha(1-\gamma)}{1-\alpha(1-\gamma)}\right) + \pi_e\left(\frac{\gamma\frac{\alpha}{1-\alpha}}{1-\alpha(1-\gamma)}\right) \\
&= \pi_m\left(\frac{1}{1-\alpha(1-\gamma)}\right) + \pi_e\left(\frac{\gamma\frac{\alpha}{1-\alpha}}{1-\alpha(1-\gamma)}\right) \\
&= \frac{\pi_m + \gamma\pi_e\frac{\alpha}{(1-\alpha)}}{1-\alpha(1-\gamma)}
\end{aligned}
$$

and which we will refer to as $EPV(\gamma)$. So what happens to $EPV(\gamma)$ as γ changes? Because entry only serves to reduce the future payoffs to tacit collusion, its value declines in γ. We can easily see this by differentiating $EPV(\gamma)$ with respect to γ.

$$
\frac{\partial EPV(\gamma)}{\partial\gamma} = \frac{\alpha(\pi_e - \pi_m)}{(1+\alpha(\gamma-1))^2}
$$

Note that $\pi_e < \pi_m$, so the numerator is negative, while the denominator, a squared term, is positive. Since $EPV(\gamma)$ declines monotonically in γ, the threshold value for α such that trigger strategies can sustain tacit collusion rises monotonically in γ as well, thereby reducing the likelihood that tacit collusion will be played in equilibrium.

$$
\begin{aligned}
\frac{\partial\underline{\alpha}}{\partial\gamma} &= \frac{-\frac{\partial\pi_m}{\partial\gamma}}{\pi_d - \pi_n} \\
&= \frac{-\alpha(\pi_e - \pi_m)}{(1+\alpha(\gamma-1))^2}\left(\frac{1}{\pi_d - \pi_n}\right) \\
&> 0
\end{aligned}
$$

Thus, given a heterogeneous cross-section of markets, and assuming firms either play trigger strategies or stage-game Nash equilibria, this result is enough to establish the claim that, in expectation, equilibrium prices will fall monotonically as entry probability rises, since an increased threat of entry weakly increases the likelihood that tacit collusion will break down.[31]

4.2 Coordinated Limit Pricing vs. Entry Threat

What if the same duopolists recognize instead that their fortunes are maximized by coordinating to deter entry? That is, instead of choosing the collusive price, the firms choose a sub-collusive limit price, such that the potential entrant would no longer find it profitable to enter. The first and most reasonable concern over such a hypothesis is that it simply sounds far-fetched. Yet if we are willing to believe that firms can agree (whether explicitly or implicitly) on a price to collude, why would we not be willing to believe they might choose that price to deter entry as well? Such behavior under the threat of entry is similar to that of the Brazilian cement oligolopy studied by Salvo (2010). The second and more biting concern is whether the duopolists' chosen price would truly represent a credible commitment not to raise prices if they failed to deter entry.[32] Therefore, we must assume a degree of asymmetric information. In particular, if the potential entrant is unsure whether its entry would induce an accommodative price increase, then limit pricing by the incumbents may successfully deter entry. Given that a potential entrant is unlikely to know whether the price she observes is the result of collusion, competition, or something in between, this assumption seems eminently reasonable for our simple context. For simplicity, then, suppose that limit pricing serves as an effective deterrent against entry as long as serving the market at the limit price would not be profitable for the potential entrant.[33]

[31] Moreover, that breakdown needn't be the mechanism by which equilibrium prices fall. Under reasonable conditions, firms can sustain cooperation at lower discount factors by choosing a sub-collusive price for cooperation. For a given discount factor, then, we could map the change in γ to the change in the highest sustainable cooperative price, showing that it, too, declines monotonically in γ.

[32] That is, if the potential entrant would find it profitable to enter at the collusive price, and if the potential entrant knows that conditional upon its entry the incumbents would find the collusive price more appealing than their sub-collusive limit price, then limit pricing would be ineffective at deterring entry, as explained in Milgrom and Roberts (1982).

[33] Note that we could easily allow for the potential entrant to have some prior over the likelihood of each possible pricing outcome upon her entry, and we could re-frame the limit price as that which makes

To begin, consider the two extreme cases in the analysis of limit pricing, namely, when it is ineffective and when it is unnecessary. If the potential entrant's costs (either of entry or of serving the market) are sufficiently low as to make entry profitable even at the non-cooperative price, then limit pricing will be pointless and entry will be assured. We can think of this case as one where $\gamma = 1$. In such a case, the duopolists may as well set the collusive price until entry occurs next period. On the other hand, if the potential entrant's costs are prohibitively high, such that entry would not be profitable even at the collusive price, then limit pricing is unnecessary, and the duopolists will find it optimal to set the collusive price. We can think of this case as one where $\gamma = 0$. Where limit pricing has some bite is between these two extremes, i.e. when $0 < \gamma < 1$.

Define $p_l(\gamma)$ to be the effective limit price, such that for $0 < \gamma < 1$, entry is successfully deterred, and let $\pi_l(\gamma)$ be each duopolist's profit at that price. Recall that π_n is the Nash equilibrium of the stage game, so for the cases we are considering, $\pi_m > \pi_l(\gamma) > \pi_n$. The trade-off these incumbents face is similar to that which a monopolist would face. They can successfully deter entry in order to maintain their sub-collusive price in perpetuity, but only by sacrificing collusive profit each period. The optimality of such a scheme will depend on how big that sacrifice must be in order to effectively deter entry. For low values of γ, the incumbents will be more likely to find limit pricing optimal because the potential entrant is fairly weak, such that π_l will be very close to π_m. Conversely, if the potential entrant is rather strong, such that γ is high, then effective deterrence will be very costly (i.e. π_l will be very close to π_n), and less likely to be the optimal choice.

Where the analysis deviates from that of monopoly limit pricing is in the stability of tacit collusion under accommodation. That is, if the incumbents choose not to deter entry, they get the EPV of collusion constructed above, which declines in γ. Thus, when γ is low, they earn something very close to π_m, but as γ rises, the payoff to coordination falls, eventually lowering the price at which collusion can be sustained. This decline in the payoff

her unprofitable in expectation. Since the intuition and conclusions are the same, we opt for the simpler approach. But see Milgrom and Roberts (1982) and Sweeting et al. (2020) for helpful exposition.

to accommodating will tend to make limit pricing *more* appealing, but the same rise in γ will also serve to *lower* the effective limit price. In other words, as γ rises, both the sub-collusive cooperative price and the effective limit price are falling. Optimal firm behavior in equilibrium, then, depends critically on the shape of $\pi_l(\gamma)$. To see this, suppose that the incumbents consider only the limit price and the monopoly price. For limit pricing to be optimal in this simpler case, we must have

$$
\begin{aligned}
\left(\frac{1}{1-\alpha}\right)\pi_l(\gamma) &\geq EPV(\gamma) \\
\left(\frac{1}{1-\alpha}\right)\pi_l(\gamma) &\geq \frac{\pi_m + \gamma\pi_e\frac{\alpha}{(1-\alpha)}}{1-\alpha\left(1-\gamma\right)}
\end{aligned}
$$

When $\gamma = 0$, both sides are equivalent, but as γ increases, both sides decline. Thus, some assumptions about $\pi_l(\gamma)$ are necessary to determine the optimal price at which to coordinate.

Nevertheless, we can still draw some important conclusions about observed prices without specifying a functional form for $\pi_l(\gamma)$ if we consider the role played by α. Consider $\alpha = 0$, such that firms are myopic. In this case, neither limit pricing nor tacit coordination of any kind can be sustained, and equilibrium prices will be those of the stage game regardless of γ. Changes to the threat of entry, then, will have no effect whatsoever upon equilibrium prices. By contrast, consider the case of $\alpha \to 1$. For any value of $\gamma < 1$, there must exist an α such that tacit collusion can be sustained. Moreover, all values of γ less than that chosen value would also sustain tacit collusion. Thus, for α sufficiently high, the comparative statics of price w/r/t γ must mirror those of the monopoly case. In other words, when α is near 1, we will be more likely to see the non-monotonicity of prices in γ described in Sweeting et al. (2020), and when α is near 0, we will be more likely to see no effect whatsoever.

Along similar lines, things that would tend to disrupt tacit collusion, such as financial distress or a greater number of players, would tend to lessen or nullify that non-monotonicity, while things that tend to stabilize tacit collusion, like multi-market contact, would tend to amplify it. Noting that a cross-section of markets will vary along these and other relevant dimensions, it stands to reason that any non-monotonicty found in the data represents the muted average across markets with varying degrees of exposure to merger-induced entry threat effects.

5 Data Description

5.1 Data Sources and Sample Construction

We study the following mergers announced between 2008 and 2013: Delta-Northwest ("DLNW") was announced 4/2008; United-Continental ("UACO") was announced 5/2010; Southwest-Air Tran Airways was announced 9/2010; and American Airlines-US Airways was announced 2/2013.[34] For the purposes of our study, we treat the merger announcement date as the point at which the entry probabilities of the merging carriers changed.

Fare data come from the U.S. Department of Transportation's (DOT) Origin and Destination Survey, Data Bank 1B, hereafter referred to as DB1B, which represents a 10% sample of domestic U.S. airline tickets, aggregated quarterly from 1993 to the present.[35] This data set has been frequently employed in previous studies on the U.S. airline industry.

In constructing the data set, we focus exclusively on direct, round-trip fares, representing about 40% of overall domestic passengers carried in a typical year.[36] We next drop itineraries with different ticketing carriers in each direction, and we also eliminate duplicates and fares not deemed "credible" by the DOT. We combine subsidiaries with their parent companies as well as any commonly owned carriers, such as result from the close of a merger.[37] For our primary specification, we ignore variation in fare class and operating carrier. Thus, all

[34] Our analysis can easily accommodate more mergers. In future drafts, we expect to include American Airlines-TWA; America West-US Airways; and Alaska-Virgin America.

[35] Available here: https://www.transtats.bts.gov/DataIndex.asp

[36] For example, in quarter 2 of 2019, out of 9.9 million passengers in the raw DB1B data, 3.9 million of them (or about 39%) flew on 2-coupon, round-trip flights.

[37] Data cleaning code is available from the authors upon request.

direct, round-trip fares on a given directional market, ticketed by a given carrier, during a given year and quarter, are treated as the same product.

While we allow prices to depend on the direction of travel, for the purposes of quantifying entry, we define markets to be non-directional airport pairs, such that a flight from Chicago Midway (MDW) to Orlando International (MCI) is treated identically to a flight in the other direction, but would be distinct from a flight between Chicago O'Hare (ORD) and MCI. Our decision to analyze airport pairs instead of city pairs reflects our view of entry probability on a given market, which we estimate using airline presence at each endpoint airport as a key explanatory variable. Endpoint presence implies access to gates and other resources associated with providing service at a given airport, but has little bearing on an airline's cost of providing service at other geographically proximate airports.[38]. To construct our measure of airport presence, we sum all passengers enplaned and deplaned at each airport for each ticketing carrier in each year and quarter, using the raw DB1B data at the segment level. Defining presence in this way, we can easily compute the *pro forma* presence values for a merged firm by summing the values for each firm prior to the merger.

5.2 Descriptive Statistics

Table 1 presents the summary statistics of our sample based on the Delta-Northwest merger. Table 2 presents the summary statistics of our sample based on the United-Continental merger. Table 3 presents the summary statistics of our sample based on the American-US Airways merger. Table 4 presents the summary statistics of our sample based on the Southwest-AirTran merger.

[38]We recognize, of course, that heavy presence at one airport in a city reduces an airline's likelihood of entry into alternative airports in that city. That is, Southwest is unlikely to start flying out of ORD partly because it has an enormous presence at MDW. For now, we are excluding this information from our probit estimation.

Table 1: Summary Statistics: DL-NW

	(1)				
	Mean	Std. Dev.	Median	Min.	Max.
Market-level passengers (thousands)	15.35	17.93	8.27	0.20	117.95
HHI	0.25	0.19	0.20	0.00	1.00
N	1.57	0.77	1.00	1.00	4.00
Change in Entry Prob	0.04	0.06	0.03	-0.15	0.31
Composition Effect	-0.04	0.03	-0.03	-0.19	-0.00
Quality Effect	0.08	0.07	0.06	-0.04	0.41
Gini Coefficient of Fare	0.20	0.05	0.19	0.02	0.46
Std. dev. of Fare	170.01	82.59	154.98	16.10	619.39
Mean Fare	429.42	140.58	418.68	78.89	1408.39
Min. Fare	167.22	85.46	156.69	25.17	693.65
Max. Fare	1044.72	457.05	989.37	115.38	1999.96
25th Pctl. of Fare	310.02	103.69	297.96	45.86	1119.85
50th Pctl. of Fare	386.30	132.30	369.47	49.68	1740.18
75th Pctl. of Fare	513.02	187.51	484.90	49.68	1863.75
Origin pop. (millions)	4.43	4.60	2.41	0.12	18.82
Destination pop. (millions)	4.01	3.96	2.70	0.12	18.82
Geometric avg. pop. (millions)	3.19	2.26	2.53	0.30	15.61
Distance (thousands of miles)	1.61	1.05	1.35	0.17	5.38
Distance over 2000 miles	0.28	0.45	0.00	0.00	1.00
Slot-controlled airport	0.19	0.39	0.00	0.00	1.00
Observations	34487				

Table 2: Summary Statistics: UA-CO

	(1)				
	Mean	Std. Dev.	Median	Min.	Max.
Market-level passengers (thousands)	14.51	17.54	7.97	0.20	141.91
HHI	0.26	0.21	0.21	0.00	1.00
N	1.50	0.72	1.00	1.00	5.00
Change in Entry Prob	0.05	0.07	0.03	-0.33	0.40
Composition Effect	-0.03	0.03	-0.02	-0.16	-0.00
Quality Effect	0.07	0.08	0.05	-0.30	0.43
Gini Coefficient of Fare	0.20	0.05	0.19	-0.00	0.45
Std. dev. of Fare	170.48	79.48	154.40	0.00	663.85
Mean Fare	433.37	145.04	411.28	50.22	1461.36
Min. Fare	153.98	94.12	145.20	25.06	1112.30
Max. Fare	1062.02	433.83	1027.19	50.22	1999.83
25th Pctl. of Fare	316.90	107.12	302.76	25.80	1388.13
50th Pctl. of Fare	390.46	137.61	365.60	37.59	1747.47
75th Pctl. of Fare	513.20	190.66	474.81	37.59	1876.01
Origin pop. (millions)	4.78	4.91	3.18	0.12	18.82
Destination pop. (millions)	3.70	4.42	2.07	0.12	18.82
Geometric avg. pop. (millions)	3.16	2.31	2.36	0.31	15.61
Distance (thousands of miles)	1.74	1.06	1.52	0.19	5.44
Distance over 2000 miles	0.32	0.47	0.00	0.00	1.00
Slot-controlled airport	0.16	0.36	0.00	0.00	1.00
Observations	38797				

Table 3: Summary Statistics: AA-US

	(1)				
	Mean	Std. Dev.	Median	Min.	Max.
Market-level passengers (thousands)	10.88	13.89	5.49	0.20	94.12
HHI	0.27	0.21	0.22	0.00	1.00
N	1.32	0.57	1.00	1.00	4.00
Change in Entry Prob	0.05	0.09	0.05	-0.57	0.50
Composition Effect	-0.05	0.05	-0.04	-0.22	-0.00
Quality Effect	0.10	0.10	0.09	-0.36	0.56
Gini Coefficient of Fare	0.20	0.05	0.20	0.01	0.48
Std. dev. of Fare	189.52	83.12	171.58	3.29	643.72
Mean Fare	481.75	169.07	457.11	56.63	1327.45
Min. Fare	166.60	104.15	151.75	25.01	807.14
Max. Fare	1070.88	392.53	1054.90	104.01	1999.85
25th Pctl. of Fare	348.16	128.35	334.12	25.80	973.69
50th Pctl. of Fare	435.90	164.24	408.90	37.59	1498.85
75th Pctl. of Fare	583.46	228.71	533.19	37.59	1889.74
Origin pop. (millions)	4.58	4.71	2.94	0.21	18.82
Destination pop. (millions)	3.48	4.20	1.98	0.12	18.82
Geometric avg. pop. (millions)	2.95	2.19	2.23	0.31	15.61
Distance (thousands of miles)	1.52	0.93	1.29	0.19	5.19
Distance over 2000 miles	0.25	0.43	0.00	0.00	1.00
Slot-controlled airport	0.11	0.31	0.00	0.00	1.00
Observations	28662				

Table 4: Summary Statistics: WN-FL

	(1)				
	Mean	Std. Dev.	Median	Min.	Max.
Market-level passengers (thousands)	14.83	22.98	5.82	0.20	201.30
HHI	0.24	0.18	0.20	0.00	1.00
N	1.69	0.95	1.00	1.00	7.00
Change in Entry Prob	0.03	0.08	-0.00	-0.06	0.64
Composition Effect	-0.01	0.01	-0.01	-0.13	-0.00
Quality Effect	0.04	0.08	0.00	-0.02	0.65
Gini Coefficient of Fare	0.22	0.05	0.21	0.01	0.46
Std. dev. of Fare	224.01	93.82	215.29	11.39	702.70
Mean Fare	516.34	163.94	509.64	58.16	1408.39
Min. Fare	160.51	104.81	145.34	25.06	807.14
Max. Fare	1307.01	413.93	1311.97	102.79	1999.93
25th Pctl. of Fare	363.72	122.46	350.71	26.54	1277.00
50th Pctl. of Fare	458.89	163.72	436.47	38.60	1740.18
75th Pctl. of Fare	622.00	235.08	586.47	62.65	1889.74
Origin pop. (millions)	5.75	5.71	4.47	0.21	18.82
Destination pop. (millions)	4.90	5.14	3.18	0.12	18.82
Geometric avg. pop. (millions)	3.85	2.81	2.97	0.31	15.61
Distance (thousands of miles)	1.65	1.12	1.31	0.13	5.44
Distance over 2000 miles	0.29	0.45	0.00	0.00	1.00
Slot-controlled airport	0.40	0.49	0.00	0.00	1.00
Observations	36399				

6 Results

6.1 First Stage: Computing Changes in Entry Probabilities

Table 5 presents the results of our first-stage probit estimation of entry. Pseudo-R-squared values range from 0.24 to 0.37, slightly below but still roughly in line with the 0.37 value reported in Appendix D of Sweeting et al. (2020). As expected, presence at the origin and destination both have a positive impact on the likelihood of entry, while long distances reduce entry probability, all else equal. We expect our specification can be further improved to increase predictive accuracy. It is worth noting, however, that the present specifications all outperformed those that used binary indicators of potential entrant status in place of continuous presence measures. In other words, by at least one measure of predictive accuracy, our definition of potential entry status outperforms the traditional binary presence metric, in most cases by a considerable margin.

Figure 4 illustrates in-sample fit for each probit estimation, using data for years 5 through 2 prior to each merger's announcement.[39] Overall fit is quite good for all four mergers. Figure 5 illustrates out-of-sample fit for each probit estimation, using years 2 through 5 after the merger's announcement. While actual entry is far below predicted entry in all but the WNFL merger, we do not expect to see the same level of fit as for the pre-merger data. Divestitures, changes in organization of the merged firm, de-hubbing, and the like are all factors that could explain the lower levels of actual entry seen in the legacy mergers. Nevertheless, what matters for incumbent behavior, at least in the near term, is predicted entry. To the extent that our estimates accurately reflect the expectations of incumbents - even if those expectations turn out to be wrong - we will have captured what we require for linking the threat of entry to prices.

[39]Year 1 prior to merger announcement is excluded to avoid any merger effects, since the binary dependent variable *entry* for any given period in the probit is defined to equal 1 if the carrier serves the market any time in the subsequent 4 quarters.

Figure 4: In-Sample Fit

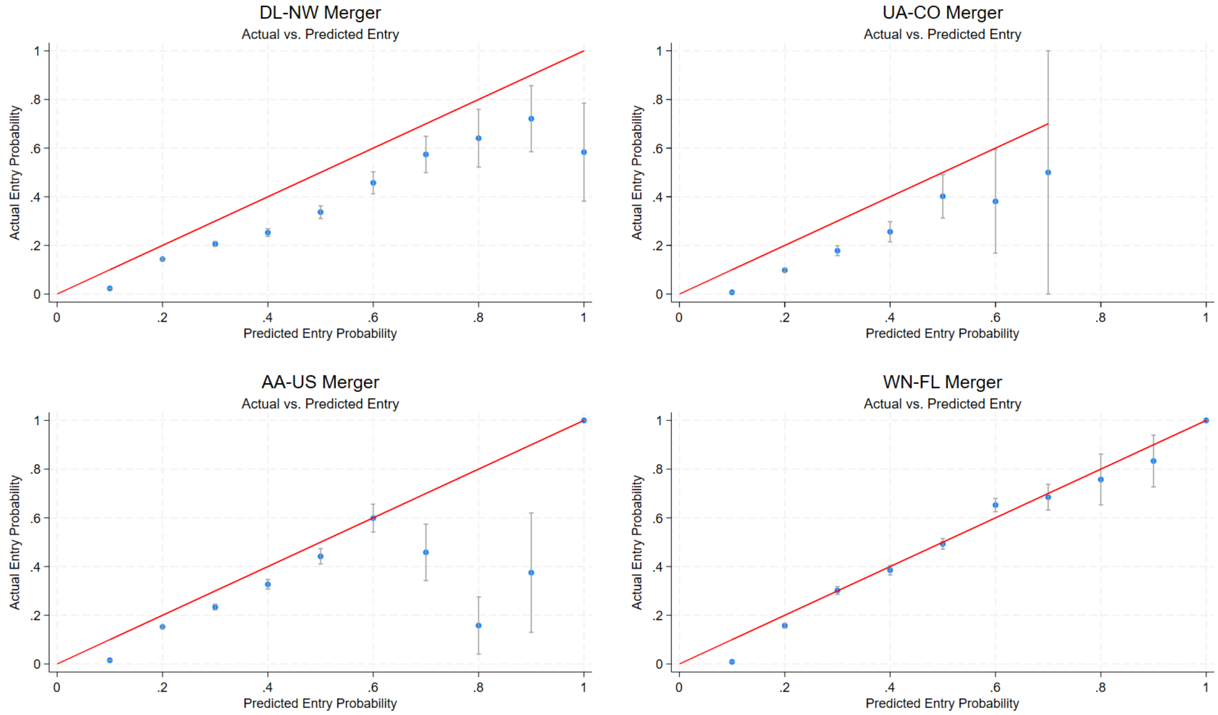
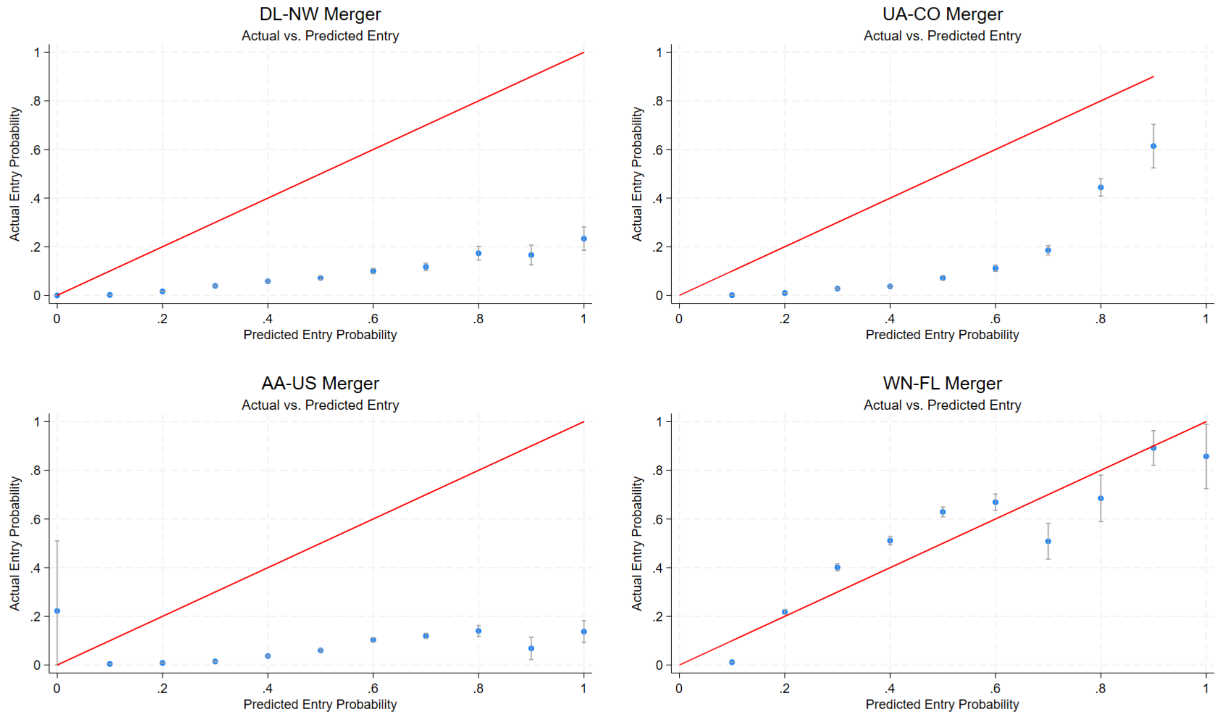


Table 5: Probit Estimation

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Entry				
Distance	0.475***	-0.287***	1.339***	0.245***
	(0.030)	(0.027)	(0.039)	(0.030)
Distance^2	-0.274***	-0.033***	-0.568***	-0.159***
	(0.011)	(0.012)	(0.017)	(0.011)
Distance^3	0.037***	0.012***	0.064***	0.023***
	(0.001)	(0.002)	(0.002)	(0.001)
Long distance	-0.016	-0.002	-0.041**	-0.008
	(0.012)	(0.014)	(0.018)	(0.011)
Slot control	0.168***	-0.003	-0.325***	0.175***
	(0.009)	(0.011)	(0.018)	(0.010)
Population (geometric average)	0.350***	0.389***	0.444***	0.298***
	(0.008)	(0.008)	(0.010)	(0.008)
Population^2	-0.036***	-0.041***	-0.050***	-0.014***
	(0.001)	(0.001)	(0.002)	(0.001)
Population^3	0.001***	0.001***	0.002***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Presence (geometric average)	0.074***	0.066***	0.072***	0.107***
	(0.003)	(0.002)	(0.002)	(0.002)
Presence^2	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Distance*Presence	0.035***	0.046***	0.007***	0.043***
	(0.002)	(0.002)	(0.002)	(0.002)
Distance*Presence^2	-0.000***	-0.000***	-0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Presence*Distance^2	-0.006***	-0.006***	-0.001***	-0.007***
	(0.000)	(0.000)	(0.000)	(0.000)
Presence^2*Distance^2	0.000***	0.000***	0.000**	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Quarter FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Observations	818727	948222	972193	1093032
Pseudo R^2	0.240	0.282	0.370	0.291

Population x presence interactions and separate origin and destination presence effects suppressed.

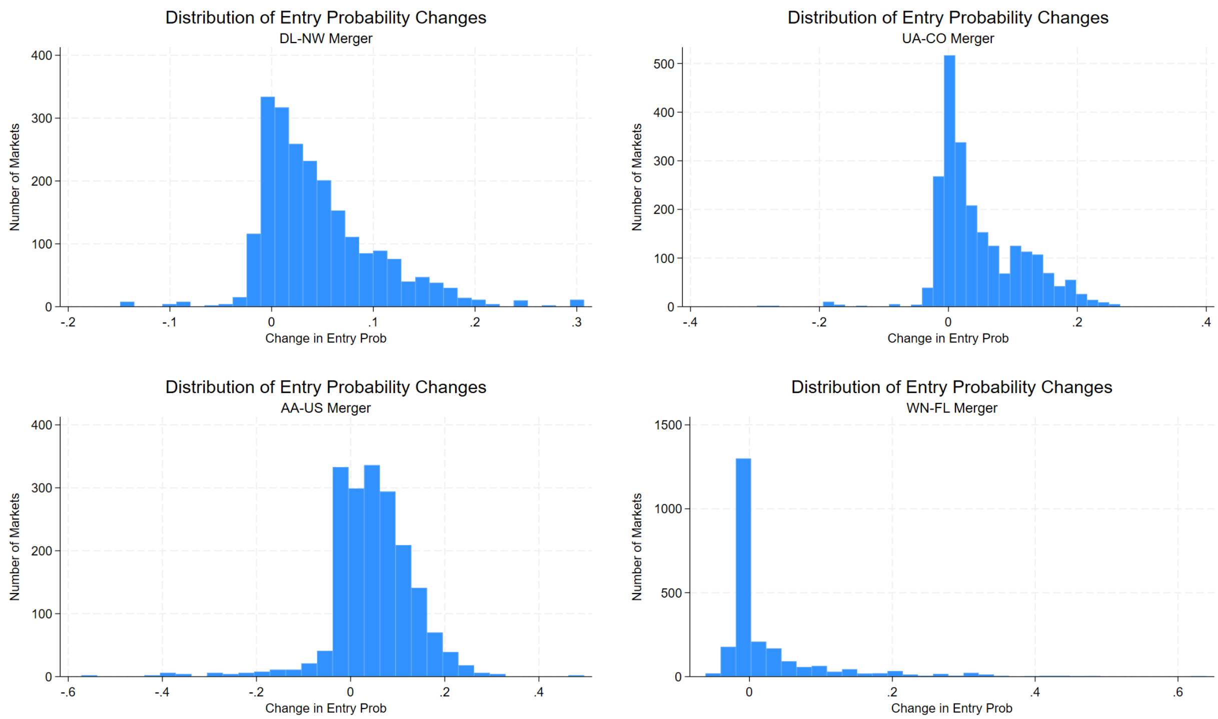
Figure 5: Out-of-Sample Fit



Using these estimates, we change endpoint presence values to account for the combination of the merging firms' activities at each endpoint, and compute the associated entry probability for the merged carrier. We then compute the overall change in entry probability due to the merger, which we decompose into the composition and quality effects. Figure 6 presents the overall changes in market-level entry probabilities in peripheral markets for each merger. The main takeaway from this figure is that entry probability change is centered around zero, as one would expect, but has a great deal of variation, and includes non-trivial changes in likelihood of entry. To put these figures in context, consider that the inflection point in Sweeting et al. (2020)'s estimates of the fare effect of Southwest's likelihood of potential entry into monopoly markets occurs around 30% likelihood. Thus, modest changes on the order of 5% or 10% are likely to have a noticeable effect.

One of the primary contributions of our paper is to decompose this merger effect into two important components, the composition effect, whereby the probability of entry by any firm is reduced by virtue of the merger eliminating a firm from the set of potential entrants,

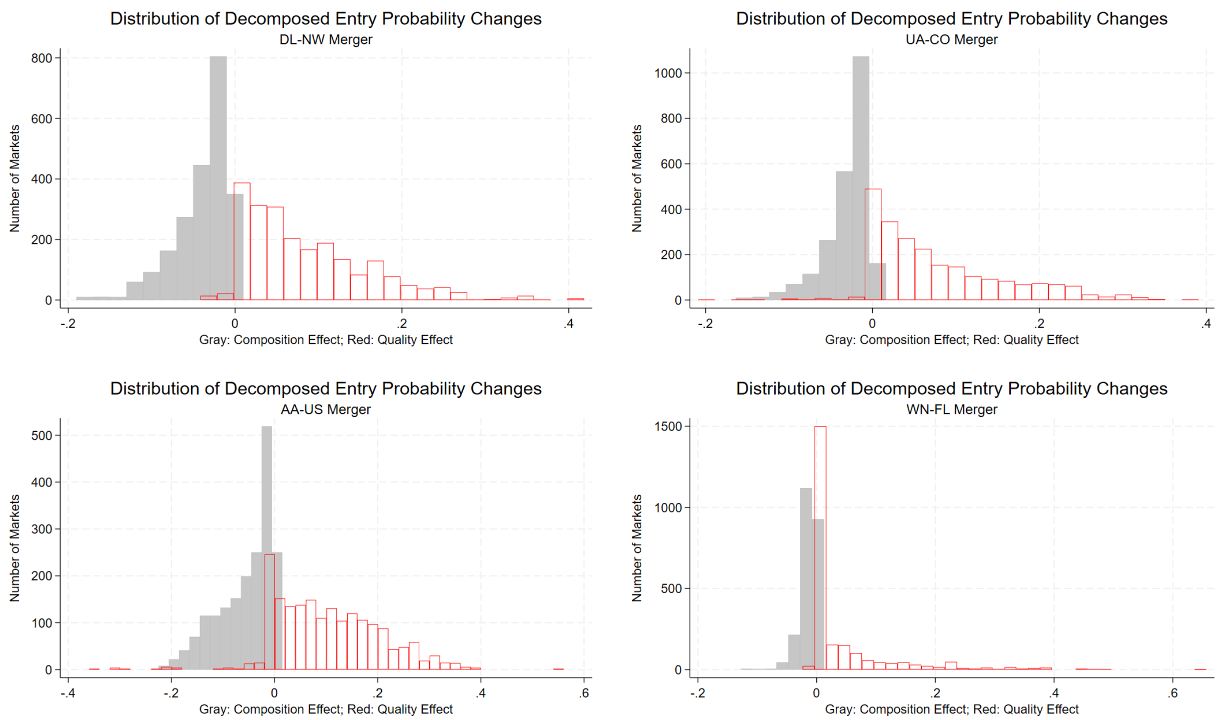
Figure 6: Distribution of Changes in Entry Probability



and the quality effect, whereby the probability of entry of the merged firm itself changes, for example, because the merger improves the merged firm's presence at both endpoints. Figure 7 presents the decomposition in market-level entry probabilities in peripheral markets for each merger. The first observation here is that both effects are at play at the same time, and both may represent appreciable changes in the threat of entry. While other authors such as He and Rupp (2022) have speculated that mergers could have either a positive or a negative effect prices in peripheral markets, we demonstrate empirically that in fact a merger is likely to have both effects.

Not only does the merger have both positive and negative effects, but the overall impact of the merger will differ across peripheral markets in an intuitive way that depends on which of these components dominates. For example, in markets where the merger eliminates a fairly strong potential entrant but does little to increase the merged firm's entry position, the overall effect will be to reduce the threat of entry. Conversely, in markets where the merger eliminates a weak potential entrant but substantially improves the merged firm's entry position, the overall entry threat will tend to increase.

Figure 7: Decomposition of Changes in Entry Probability



6.2 Second Stage: Price Effects of Merger-Induced Entry Threat

All of this estimation and decomposition is useful for illustrating the varied effects a merger can have on the threat of entry, but does any of it actually matter for market performance? To answer that question, we now examine the price effects of these changes in entry probability on peripheral markets. In short, they matter, and that result is perhaps of even greater importance for our view of antitrust policy.

Table 6 reports the estimates for all mergers using market-carrier-level variation and looking at the overall change in entry probability.[40] Fixed effects for time and market-carrier are included. In line with the nonlinear relationship identified in Sweeting et al. (2020), we interact the effect with the baseline entry probability as well and find a similar pattern. Standard errors, reported in parentheses, are computed using 100 iterations of a

[40] All three second-stage results tables are reproduced using only market-level variation in the appendix.

bootstrapping routine which samples with replacement from the start of the first estimation stage. Resampling is clustered at the origin-destination level. Figure 8 plots the overall effect of the change in entry probability as a function of the baseline entry probability for each merger. The clear takeaway is a robust, U-shaped pattern, whereby the threat of entry is associated with lower prices when entry probability is low, and as entry probability rises, marginal increases in the threat of entry are associated with higher prices. While the location of the minimum point for this U varies by merger, the overall shape of the response in prices to merger-induced changes in the threat of entry appears to be consistent across mergers.

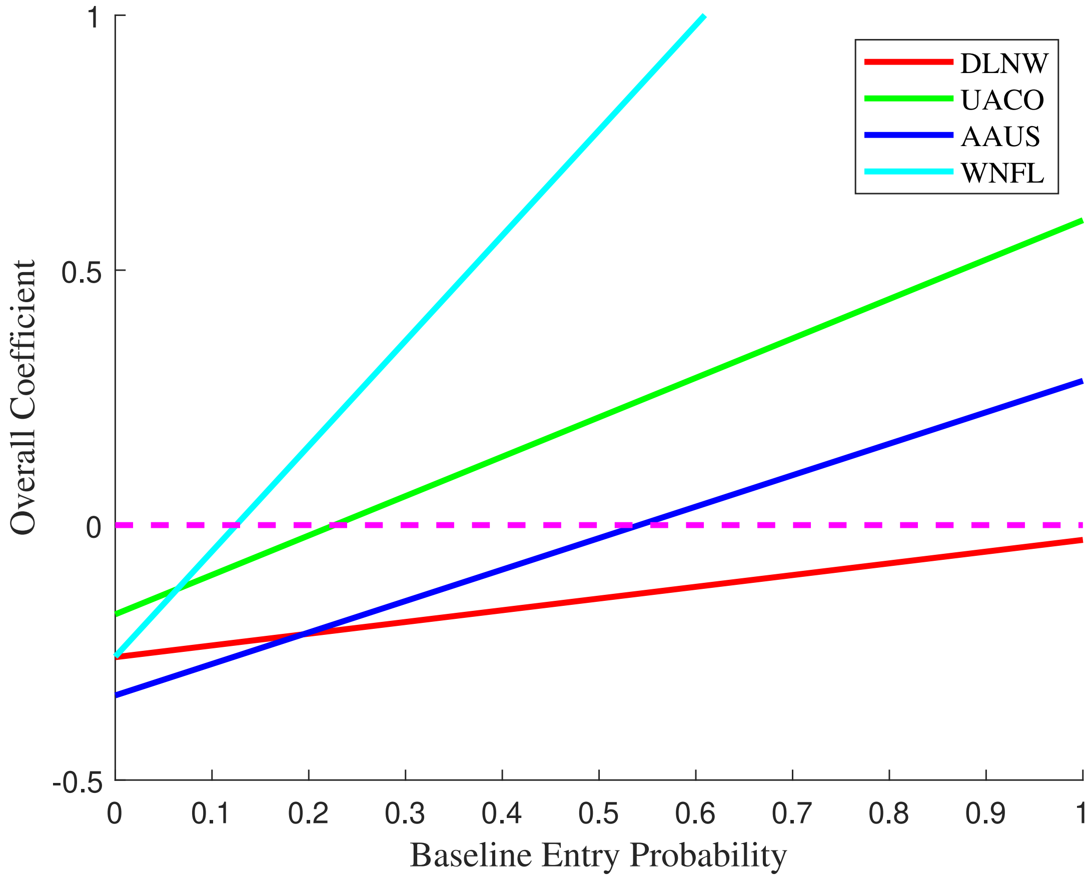
Table 6: Market-Carrier-Level Regressions
Overall Change in Entry Probability

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.072***	-0.080***	-0.134***	-0.014
	(0.006)	(0.007)	(0.008)	(0.009)
HHI	-0.011	-0.005	-0.015***	-0.015**
	(0.007)	(0.006)	(0.006)	(0.007)
N	-0.058***	-0.026***	-0.004	-0.070***
	(0.008)	(0.008)	(0.007)	(0.010)
Change in Entry Prob	-0.259*	-0.175*	-0.258***	-0.334***
	(0.137)	(0.093)	(0.073)	(0.107)
Baseline Entry Prob x Change in Entry Prob	0.230	0.773**	2.065**	0.617**
	(0.449)	(0.300)	(0.873)	(0.258)
Constant	6.535***	6.455***	6.802***	6.752***
	(0.011)	(0.010)	(0.009)	(0.015)
Market-Carrier FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	34749	39139	36649	28927
Adjusted R^2	0.878	0.880	0.863	0.895

Bootstrapped standard errors in parentheses.

Table 7 reports the estimates for all mergers using market-carrier-level variation and looking at the decomposition of the change in entry probability. Both the quality effect and the composition effect are also interacted with the baseline entry probability. As in the

Figure 8: Overall Coefficient on Change in Entry Probability
vs. Baseline Entry Probability



previous set of results, market-carrier fixed effects and time fixed effects are included, and bootstrapped standard errors are given in parentheses.

One more important question remains to be answered by the analysis, namely: Does any of this matter in the end? Given the wide range of baseline entry probabilities, the heterogeneity of merger-induced changes to them, and the non-monotonicity of the effect of those changes upon prices, it is far from clear whether there is any overall effect of a given merger on the performance of peripheral markets. Table 8 aims to provide some clarity by comparing price changes in those markets most effected by a merger to those markets least effected. Following the approach in Kim and Mazur (2022), we use markets with a probability change of less than 5% in absolute value as the control group and estimate the

Table 7: Market-Carrier-Level Regressions

Decomposed Change in Entry Probability

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.071***	-0.081***	-0.134***	-0.015
	(0.006)	(0.007)	(0.008)	(0.009)
HHI	-0.011	-0.004	-0.014**	-0.014**
	(0.007)	(0.006)	(0.006)	(0.007)
N	-0.057***	-0.026***	-0.005	-0.074***
	(0.008)	(0.008)	(0.007)	(0.010)
Quality Effect	-0.485	-0.235	-0.238	-0.369
	(0.554)	(0.387)	(0.688)	(0.282)
Baseline Entry Prob x Quality Effect	1.336	0.892	0.966	0.644
	(1.814)	(1.028)	(4.341)	(0.445)
Composition Effect	-0.761	-0.853**	-2.232***	-0.946***
	(0.520)	(0.379)	(0.637)	(0.314)
Baseline Entry Prob x Composition Effect	2.984*	2.260**	5.926*	0.980*
	(1.718)	(1.039)	(3.233)	(0.523)
Constant	6.532***	6.456***	6.802***	6.765***
	(0.011)	(0.010)	(0.009)	(0.016)
Market-Carrier FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	34749	39139	36649	28927
Adjusted R^2	0.878	0.880	0.864	0.896

Bootstrapped standard errors in parentheses.

effect of each merger on the remaining peripheral markets. All four mergers yield a negative coefficient on log price, usually in the range of 2-3%, although we are quick to point out that significance levels vary by specification.[41] Nevertheless, relative to the "pure" control group, the affected peripheral markets seem to experience a non-trivial decline in prices, indicating a pro-competitive effect of mergers on peripheral markets in general. Our analysis of the welfare implications of this effect, as well as its comparison with the effects upon overlapping markets, are ongoing.

Table 8: Market-Carrier-Level Regressions
Merger Effect on Log(Price) in Peripheral Markets

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.126***	-0.098***	-0.168***	-0.025*
	(0.014)	(0.013)	(0.020)	(0.014)
HHI	-0.005	0.010	0.027**	0.002
	(0.012)	(0.007)	(0.011)	(0.008)
N	-0.047***	-0.027***	-0.008	-0.053***
	(0.009)	(0.007)	(0.011)	(0.010)
Affected market	-0.014	-0.018*	-0.034*	-0.012
	(0.016)	(0.009)	(0.019)	(0.012)
Constant	6.524***	6.431***	6.764***	6.725***
	(0.011)	(0.013)	(0.019)	(0.015)
Market-Carrier FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	33545	37834	36042	27850
Adjusted R^2	0.895	0.885	0.855	0.908

Bootstrapped standard errors in parentheses.

6.3 Robustness Checks

Because factors like airport presence, which increase a carrier's likelihood of entry into direct service, may also increase entry into connecting service, one might worry that our main

[41] Our market-level specification in the appendix yields three affected mergers out of four, whereas the market-carrier-level specification presented here yields only two.

results for price effects - which consider only direct flights - may be driven by *actual* entry into connecting service, as opposed to the threat of entry into direct service, as claimed. To investigate this possibility, we re-run all specifications with a more limited data set that drops any markets in which the merging carriers provided connecting service before or after the merger. Results are provided in Tables 9 through 11.

What we find is both intuitive and interesting. First, we find a much larger coefficient on the change in entry probability for three of the four mergers, whereas the third (AAUS) appears to produce a non-result. Moreover, the interaction with baseline entry probability appears to produce a non-result as well. We believe these patterns can be explained by differences in baseline entry probabilities for the two samples. In all four mergers, the baseline probability of entry in markets where at least one of the merged firms provides connecting service is two to three times higher than the baseline for markets in the restricted sample. The average baseline for these markets is in the 3% to 7% range, and even the 75th percentiles range from 4% to 10%. Given that the inflection point for the effect of entry probability on prices occurs at or above this level for all four mergers, it makes sense that we would see a negative, monotonic effect.

A related concern is that prices or availability of connections may have changed, as opposed to changes in actual entry into connecting service. When we examine the price of connecting service and the number of available connecting flight products on markets where either merging firm provided connecting service, we find no significant changes. If anything, prices for connecting service rose slightly, and the number of connecting products offered fell slightly, but both of these changes were small, and would have precisely the opposite effect to what motivated the concern.

Table 9: Market-Carrier-Level Regressions
Overall Change in Entry Probability

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.070***	-0.094***	-0.149***	-0.050***
	(0.018)	(0.012)	(0.009)	(0.018)
HHI	-0.034**	0.004	-0.021**	-0.016
	(0.015)	(0.011)	(0.008)	(0.014)
N	-0.082***	-0.031**	-0.000	-0.083**
	(0.025)	(0.015)	(0.008)	(0.033)
Change in Entry Prob	-2.638**	-1.219**	-0.407***	-0.016
	(1.227)	(0.482)	(0.152)	(0.459)
Baseline Entry Prob x Change in Entry Prob	14.177	4.266	2.149	2.374
	(13.037)	(4.028)	(1.682)	(3.352)
Constant	6.331***	5.181***	6.795***	6.289***
	(0.036)	(0.024)	(0.010)	(0.046)
Market-Carrier FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	8946	12087	27332	7727
Adjusted R^2	0.889	0.885	0.869	0.908

Bootstrapped standard errors in parentheses.

Table 10: Market-Carrier-Level Regressions
Decomposed Change in Entry Probability

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.072***	-0.094***	-0.148***	-0.051***
	(0.018)	(0.012)	(0.009)	(0.018)
HHI	-0.036**	0.004	-0.021**	-0.015
	(0.015)	(0.011)	(0.008)	(0.014)
N	-0.081***	-0.031**	-0.003	-0.085***
	(0.024)	(0.016)	(0.008)	(0.032)
Quality Effect	-2.007	-1.192	-0.587	-0.018
	(2.434)	(1.327)	(1.608)	(1.336)
Baseline Entry Prob x Quality Effect	9.116	3.988	5.928	2.235
	(16.068)	(9.744)	(13.639)	(6.525)
Composition Effect	1.345	-0.703	-7.107***	-2.138*
	(2.246)	(0.902)	(1.301)	(1.262)
Baseline Entry Prob x Composition Effect	-0.558	3.125	59.936***	12.503**
	(10.098)	(3.231)	(10.639)	(5.358)
Constant	6.309***	5.178***	6.798***	6.290***
	(0.035)	(0.024)	(0.010)	(0.045)
Market-Carrier FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	8946	12087	27332	7727
Adjusted R^2	0.890	0.885	0.870	0.909

Bootstrapped standard errors in parentheses.

Table 11: Market-Carrier-Level Regressions

Merger Effect on Log(Price) in Peripheral Markets

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.176***	-0.118***	-0.193***	-0.086***
	(0.036)	(0.019)	(0.027)	(0.019)
HHI	-0.053*	0.009	0.028**	0.008
	(0.029)	(0.012)	(0.014)	(0.017)
N	-0.038*	-0.014	-0.003	-0.033
	(0.020)	(0.016)	(0.011)	(0.023)
Affected market	-0.018	-0.032	-0.059***	-0.012
	(0.038)	(0.020)	(0.020)	(0.033)
Constant	6.455***	5.553***	6.751***	6.172***
	(0.080)	(0.018)	(0.023)	(0.047)
Market-Carrier FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	8607	11685	26891	7435
Adjusted R^2	0.877	0.866	0.855	0.919

Bootstrapped standard errors in parentheses.

7 Conclusions

To summarize, our paper examines the effects of four recent airline mergers on prices and the threat of entry in peripheral markets, where neither merging firm currently competes, finding a consistent and statistically significant pattern. Increases in the threat of entry are associated with lower prices when initial entry probability is low, and with higher prices when entry probability is relatively higher. These findings represent the second step of a two-stage procedure, which first estimates a probit model of entry for each pair of merging firms. Using those estimates, we compute how each merger changes the threat of entry and document significant heterogeneity across markets in the overall effect. Further, we decompose the overall change in entry probability into two components, namely, the quality effect, which measures the change in entry probability of the merged firm itself, and the composition effect, which captures the reduction in entry probability due to the elimination of a potential entrant. We show that these two effects most often run counter to one another, such that the degree to which a given merger impacts a given market depends on the relative strength of each one. Finally, we aggregate these entry threat effects across markets, finding that merger-induced changes in the threat of new entry may lead to lower prices overall – on the order of 2% to 3% – for what have heretofore been considered unaffected markets.

Our paper complements the existing empirical literature on the effects of potential entry by identifying non-monotonic price responses to incremental, merger-induced changes in the likelihood of entry, which, on the whole, may result in lower prices on average. Our paper is the first to quantify and compare both positive and negative merger-induced changes in entry probability. In addition, we add to the merger retrospectives literature by documenting how a merger of two large firms can affect prices in markets where neither firm currently competes. Our study reveals important spillover effects of mergers that run counter to the traditional concerns of antitrust policy with respect to mergers in overlap markets, where firms are in direct competition. Given how numerous and sizeable such peripheral markets can be, our research suggests a potential new consideration for antitrust practitioners. Finally, by modeling and estimating the potential entry threat as a continuous variable - as opposed to a binary or discrete variable as in many prior studies - we are able to quantitatively compare the dual effects of mergers on the threat of entry in peripheral markets. While much more remains to be done, even within this study, we believe our paper makes a valuable and policy-relevant contribution to our understanding of the overall effects of mergers on firm behavior.

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Appendix

A Market-Level Regression Results

The following tables produce results at the market-level instead of the market-carrier level.

Table A1: Market-Level Regressions
Overall Change in Entry Probability

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.074***	-0.093***	-0.140***	-0.019*
	(0.007)	(0.007)	(0.007)	(0.010)
HHI	-0.012*	-0.001	-0.015**	-0.010
	(0.006)	(0.006)	(0.007)	(0.007)
N	-0.065***	-0.053***	-0.026***	-0.118***
	(0.008)	(0.009)	(0.009)	(0.017)
Change in Entry Prob	-0.352**	-0.173*	-0.211***	-0.224
	(0.160)	(0.102)	(0.078)	(0.146)
Baseline Entry Prob x Change in Entry Prob	0.322	0.853***	2.173**	0.360
	(0.513)	(0.322)	(0.952)	(0.321)
Constant	6.538***	6.487***	6.823***	6.802***
	(0.012)	(0.012)	(0.010)	(0.019)
Market FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	26921	31212	27517	24941
Adjusted R^2	0.865	0.859	0.849	0.867

Bootstrapped standard errors in parentheses.

Table A2: Market-Level Regressions

Decomposed Change in Entry Probability

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.074***	-0.094***	-0.140***	-0.020*
	(0.007)	(0.007)	(0.007)	(0.010)
HHI	-0.012*	-0.000	-0.014*	-0.010
	(0.006)	(0.006)	(0.007)	(0.007)
N	-0.064***	-0.053***	-0.026***	-0.121***
	(0.008)	(0.009)	(0.009)	(0.018)
Quality Effect	-0.598	-0.209	-0.201	-0.247
	(0.693)	(0.365)	(0.716)	(0.385)
Baseline Entry Prob x Quality Effect	1.536	0.784	1.020	0.463
	(2.187)	(1.029)	(3.327)	(0.611)
Composition Effect	-1.219*	-0.724*	-3.328***	-0.243
	(0.624)	(0.428)	(0.591)	(0.437)
Baseline Entry Prob x Composition Effect	4.137*	1.576	9.132***	-0.040
	(2.119)	(1.225)	(2.591)	(0.704)
Constant	6.537***	6.488***	6.823***	6.808***
	(0.012)	(0.012)	(0.010)	(0.020)
Market FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	26921	31212	27517	24941
Adjusted R^2	0.866	0.859	0.850	0.867

Bootstrapped standard errors in parentheses.

Table A3: Market-Level Regressions

Merger Effect on Log(Price) in Peripheral Markets

	(1) DLNW	(2) UACO	(3) WNFL	(4) AAUS
Log of market-level passengers	-0.118***	-0.115***	-0.174***	-0.041***
	(0.014)	(0.014)	(0.014)	(0.014)
HHI	-0.000	0.013**	0.025***	0.004
	(0.009)	(0.006)	(0.009)	(0.008)
N	-0.052***	-0.044***	-0.025***	-0.087***
	(0.009)	(0.008)	(0.009)	(0.013)
Affected market	-0.024*	-0.024***	-0.022	-0.026**
	(0.013)	(0.008)	(0.015)	(0.011)
Constant	6.520***	6.436***	6.777***	6.755***
	(0.011)	(0.013)	(0.015)	(0.017)
Market FE	✓	✓	✓	✓
Time FE	✓	✓	✓	✓
Observations	25766	29935	26918	23944
Adjusted R^2	0.902	0.878	0.858	0.869

Bootstrapped standard errors in parentheses.

B EPV of Collusion

The following illustrates how to arrive at the expected present value of collusion given in the main text. Let π_e be the profit each incumbent firm earns upon entry by the third firm; let π_m be each incumbent firm's collusive profit; and define $q = 1 - \gamma$ to be the probability that the third firm does not enter in a given period.

$$\begin{aligned}
\mathbb{E}\left[PV_{collusion}\right] &= \pi_m + \gamma\left(\alpha\pi_e + \alpha^2\pi_e + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ q\gamma\left(\alpha\pi_m + \alpha^2\pi_e + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ q^2\gamma\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ q^3\gamma\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_m + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ q^4\gamma\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_m + \alpha^4\pi_M + \alpha^5\pi_e + ...\right) \\
&+ ...
\end{aligned}$$

Rewrite isolating all but the first term and moving γ to the other side:

$$\begin{aligned}
\frac{\mathbb{E}\left[PV_{collusion}\right] - \pi_m}{\gamma} &= \left(\alpha\pi_e + \alpha^2\pi_e + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ q\left(\alpha\pi_m + \alpha^2\pi_e + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ q^2\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_e + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ q^3\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_m + \alpha^4\pi_e + \alpha^5\pi_e + ...\right) \\
&+ q^4\left(\alpha\pi_m + \alpha^2\pi_m + \alpha^3\pi_m + \alpha^4\pi_M + \alpha^5\pi_e + ...\right) \\
&+ ...
\end{aligned}$$

Now consider the π_e terms, which appear on and above the diagonal. The first row can be written as $\sum_{k=1}^{\infty}\alpha^k\pi_e$, which simplifies to $\left(\frac{\alpha}{1-\alpha}\right)\pi_e$. The π_e terms in each remaining row can be written in terms of the first row, such that - distributing the q terms - all π_e terms can be written collectively as

$$\sum_{k=0}^{\infty}(q\alpha)^k\left(\frac{\alpha}{1-\alpha}\right)\pi_e$$

Now consider the π_m terms, which appear below the diagonal. The first column can be written as $\sum_{k=1}^{\infty}q^k\alpha\pi_m$, which simplifies to $\left(\frac{q}{1-q}\right)\alpha\pi_m$. Each remaining column can be written in terms of the first column, such that all of the π_m terms can be written collectively as

$$\sum_{k=0}^{\infty}(q\alpha)^k\left(\frac{q}{1-q}\right)\alpha\pi_m$$

The coefficient for both terms simplifies to $\frac{1}{1-q\alpha}$, allowing us to simplify the equality to the following:

$$\frac{\mathbb{E}\left[PV_{collusion}\right] - \pi_m}{\gamma} = \left(\frac{1}{1-q\alpha}\right)\left[\left(\frac{\alpha}{1-\alpha}\right)\pi_e + \left(\frac{q}{1-q}\right)\alpha\pi_m\right]$$

Recalling that $q = 1 - \gamma$ and moving terms to the right-hand side, we arrive at the equation from the body of the text.

$$\mathbb{E}\left[PV_{collusion}\right] = \pi_m + \left(\frac{\gamma\alpha}{1-\alpha\left(1-\gamma\right)}\right)\left[\left(\frac{1}{1-\alpha}\right)\pi_e + \left(\frac{1-\gamma}{\gamma}\right)\pi_m\right]$$

C Sub-Collusive Coordination

The following is a simple walk-through of tacit coordination at a price level lower than true collusion, which may arise if, for example, firms' discount factors would not support true tacit collusion in equilibrium.

Consider the standard n-firm Cournot model with constant and identical marginal costs of c, no fixed costs, and inverse market demand of $P = a - bQ$. Cournot profit is

$$\pi_{Cournot} = b\left(\frac{1}{n+1}\frac{a-c}{b}\right)^2$$

and collusive profit is $\frac{1}{n}$ of monopoly profit, or

$$\pi_{collude} = \frac{1}{n}\frac{(a-c)^2}{4b}$$

For reference, note also that the monopoly output is $Q_M = \frac{a-c}{2b}$. To compute profit from defecting, consider a defecting firm's best response. If the remaining players are producing $\frac{n-1}{n}$ of Q_M, then residual inverse demand for firm 1 is

$$\begin{aligned} P &= a - b\left(\frac{n-1}{n}\right)\left(\frac{a-c}{2b}\right) - bq_1 \\ &= a - \frac{n-1}{n}\left(\frac{a-c}{2}\right) - bq_1 \end{aligned}$$

Setting residual marginal revenue equal to marginal cost, we arrive at

$$\begin{aligned} MR_1 &= c \\ a - \frac{n-1}{n}\left(\frac{a-c}{2}\right) - 2bq_1 &= c \\ (a-c)\left(1 - \frac{n-1}{2n}\right) &= 2bq_1 \\ (a-c)\left(\frac{n+1}{2n}\right) &= 2bq_1 \\ q_1^{defect} &= \left(\frac{a-c}{2b}\right)\left(\frac{n+1}{2n}\right) \end{aligned}$$

and the corresponding equilibrium price and profit from defection are

$$\begin{aligned} p &= a - b\left(\frac{n-1}{n}\left(\frac{a-c}{2b}\right) + \frac{n+1}{2n}\left(\frac{a-c}{2b}\right)\right) \\ &= a - \left(\frac{a-c}{2}\right)\left(\frac{2n-2+n+1}{2n}\right) \\ &= a - (a-c)\left(\frac{3n-1}{4n}\right) \\ &= c + \left(\frac{n+1}{4n}\right)(a-c) \end{aligned}$$

and

$$\begin{aligned} \pi_{defect} &= (p-c)\, q_1^{defect} \\ &= \left(c + \left(\frac{n+1}{4n}\right)(a-c) - c\right)\left(\frac{a-c}{2b}\right)\left(\frac{n+1}{2n}\right) \\ &= b\left(\frac{a-c}{2b}\right)^2\left(\frac{n+1}{2n}\right)^2 \end{aligned}$$

respectively.

Next, compute the same values assuming a **higher** output level than Q_M, representing a sub-collusive profit for each firm. Consider each firm's output in the collusive and Cournot cases. Under collusion, each firm produces $\frac{a-c}{2nb}$, whereas under Cournot, each firm produces $\frac{1}{n+1}\frac{a-c}{b}$. To make notation easier, let us refer to the target **total** output level as

$$Q_T = t\left(\frac{a-c}{b}\right)$$

where t is the associated coefficient on the perfectly competitive output amount. Cooperation entails a value for t on the interval $[\frac{1}{2}, \frac{n}{n+1}]$, since it must be greater than monopoly but less than Cournot duopoly. We will examine how π_{defect} and the associated coordination-sustaining threshold value of $\underline{\alpha}$ change when we change Q_T. Note that we already know that $\pi(Q_T)$, which we will refer to as $\pi_{cooperate}$, is decreasing in Q_T and is less than $\pi_{collude}$. Compute the α required to sustain tacit collusion, as a function of t. First, let's write down what $\pi_{cooperate}$ is as a function of t.

$$\begin{aligned}
\pi_{cooperate} &= (p(Q_T) - c)\frac{Q_T}{n} \\
&= (a - bQ_T - c)\frac{Q_T}{n} \\
&= \left(a - bt\frac{a-c}{b} - c\right)\frac{t}{n}\frac{a-c}{b} \\
&= (a - t(a-c) - c)\frac{t}{n}\frac{a-c}{b} \\
&= (a-c)^2\frac{t(1-t)}{nb}
\end{aligned}$$

Compute profit from defecting next. If all other players are producing their shares of the **target** level of output, then residual inverse demand for firm 1 is

$$p = a - b\left(\frac{n-1}{n}Q_T\right) - bq_1$$

Use this to figure out marginal revenue, and set it equal to marginal cost to find firm 1's best response. Notice that it depends on t now.

$$\begin{aligned}
MR_1 &= c \\
a - b\left(\frac{n-1}{n}t\left(\frac{a-c}{b}\right)\right) - 2bq_1 &= c \\
a - c - \left(t\frac{n-1}{n}(a-c)\right) &= 2bq_1 \\
q_1^{defect} &= \frac{(a-c)\left(1 - t\frac{n-1}{n}\right)}{2b}
\end{aligned}$$

Compute equilibrium price as a function of t.

$$\begin{aligned}
p &= a - b\left(t\frac{n-1}{n}\left(\frac{a-c}{b}\right) + \frac{(a-c)\left(1 - t\frac{n-1}{n}\right)}{2b}\right) \\
&= a - (a-c)\left(t\frac{n-1}{n} + \frac{\left(1 - t\frac{n-1}{n}\right)}{2}\right) \\
&= a - \frac{(a-c)}{2}\left(2t\frac{n-1}{n} + 1 - t\frac{n-1}{n}\right) \\
&= a - \frac{(a-c)}{2}\left(1 + t\frac{n-1}{n}\right)
\end{aligned}$$

Compute the resultant profit for the cheating firm.

$$\begin{aligned}
\pi_{defect} &= (p-c)\,q_1^{defect} \\
&= \left(a - \frac{a-c}{2}\left(1 + t\frac{n-1}{n}\right) - c\right)\frac{(a-c)\left(1 - t\frac{n-1}{n}\right)}{2b} \\
&= \frac{a-c}{2}\left(1 - t\frac{n-1}{n}\right)\frac{(a-c)\left(1 - t\frac{n-1}{n}\right)}{2b} \\
&= \frac{(a-c)^2\left(1 - t\frac{n-1}{n}\right)^2}{4b}
\end{aligned}$$

Generalize the expression for $\underline{\alpha}$ by referring to $\pi_{cooperate}$ instead of $\pi_{collude}$, and solve for the minimum value of α that will sustain tacit collusion.

$$\begin{aligned}
\underline{\alpha} &= \frac{\pi_{defect} - \pi_{cooperate}}{\pi_{defect} - \pi_{Cournot}} \\
&= \frac{\frac{(a-c)^2\left(1-t\frac{n-1}{n}\right)^2}{4b} - (a-c)^2\,\frac{t(1-t)}{nb}}{\frac{(a-c)^2\left(1-t\frac{n-1}{n}\right)^2}{4b} - \frac{(a-c)^2}{(n+1)^2 b}} \\
&= \frac{\frac{\left(1-t\frac{n-1}{n}\right)^2}{4b} - \frac{t(1-t)}{nb}}{\frac{\left(1-t\frac{n-1}{n}\right)^2}{4b} - \frac{1}{(n+1)^2 b}} \\
&= \frac{\left(1 - t\frac{n-1}{n}\right)^2 - 4\frac{t(1-t)}{n}}{\left(1 - t\frac{n-1}{n}\right)^2 - \frac{4}{(n+1)^2}} \\
&= \frac{(n - tn + t)^2 - 4nt\,(1-t)}{(n - tn + t)^2 - \frac{4n^2}{(n+1)^2}} \\
&= \frac{(n^2 + t^2n^2 + t^2 - 2tn^2 - 2nt^2 + 2tn) - 4nt + 4nt^2}{(n^2 + t^2n^2 + t^2 - 2tn^2 - 2nt^2 + 2tn) - \frac{4n^2}{(n+1)^2}} \\
&= \frac{n^2 + t^2n^2 + t^2 - 2tn^2 - 2nt + 2nt^2}{n^2 + t^2n^2 + t^2 - 2tn^2 - 2nt^2 + 2tn - \frac{4n^2}{(n+1)^2}} \\
&= \frac{4 + 4t^2 + t^2 - 2t4 - 4t + 4t^2}{4 + t^24 + t^2 - 2t4 - 4t^2 + 4t - \frac{16}{9}}
\end{aligned}$$

Reducing the profitability of cooperation reduces the incentive to cheat, thereby **lowering** the value of $\underline{\alpha}$ required to sustain collusion. To see this, take the first derivative of $\underline{\alpha}$ with respect to t.

$$
\begin{aligned}
\frac{\partial \underline{\alpha}}{\partial t} &= \frac{\partial \frac{1-3t+\frac{9}{4}t^2}{\frac{5}{9}-t+\frac{1}{4}t^2}}{\partial t} \\
&= \frac{\left(\frac{9}{2}t-3\right)\left(\frac{5}{9}-t+\frac{1}{4}t^2\right)-\left(1-3t+\frac{9}{4}t^2\right)\left(\frac{1}{2}t-1\right)}{\left(\frac{5}{9}-t+\frac{1}{4}t^2\right)^2} \\
&= \frac{\frac{5}{2}t-\frac{9}{2}t^2+\frac{9}{8}t^3-\frac{5}{3}+3t-\frac{3}{4}t^2+1-3t+\frac{9}{4}t^2-\frac{1}{2}t+\frac{3}{2}t^2-\frac{9}{8}t^3}{\left(\frac{5}{9}-t+\frac{1}{4}t^2\right)^2} \\
&= \frac{\frac{9}{4}t^2+\frac{3}{2}t^2-\frac{9}{2}t^2-\frac{3}{4}t^2+\frac{4}{2}t-\frac{2}{3}}{\left(\frac{5}{9}-t+\frac{1}{4}t^2\right)^2} \\
&= \frac{\frac{9}{4}t^2+\frac{6}{4}t^2-\frac{18}{4}t^2-\frac{3}{4}t^2+\frac{4}{2}t-\frac{2}{3}}{\left(\frac{5}{9}-t+\frac{1}{4}t^2\right)^2} \\
&= \frac{\frac{4}{2}t-\frac{3}{2}t^2-\frac{2}{3}}{\left(\frac{5}{9}-t+\frac{1}{4}t^2\right)^2} \\
&= \frac{\frac{t}{2}(4-3t)-\frac{2}{3}}{\left(\frac{5}{9}-t+\frac{1}{4}t^2\right)^2}
\end{aligned}
$$

We know that the denominator is positive because it's a quadratic term. Therefore, if the numerator is negative, we have a strictly negative value for this derivative, which would mean that $\underline{\alpha}$ is decreasing in t. So do we have a negative numerator? Well, that's not immediately apparent. If t were 0, the numerator would definitely be negative, but recall that our domain for t is the interval $[\frac{1}{2}, \frac{2}{3}]$. What does the numerator look like on this interval? Let's start with the smallest value of t in the interval, which represents true collusion:

$$
\begin{aligned}
& \frac{\frac{1}{2}}{2}\left(4-3\frac{1}{2}\right)-\frac{2}{3} \\
=\ & \frac{1}{4}\left(\frac{8}{2}-\frac{3}{2}\right)-\frac{2}{3} \\
=\ & \frac{5}{8}-\frac{2}{3} \\
=\ & \frac{15}{24}-\frac{16}{24} \\
<\ & 0
\end{aligned}
$$

So at the start of our interval for t,the numerator is negative, which means that α is decreasing in t. In other words, if we were at the truly collusive output level, we could make collusion "easier" by increasing the cooperative level of output (i.e. t). Now what happens from there? Well, the numerator itself is **weakly increasing** in t over the entire interval. That is, the numerator is going up as t rises. You can see that by plugging in $t = \frac{1}{2}$ below, for example:

$$\frac{\partial}{\partial t}\left(2t - \frac{3t^2}{2} - \frac{2}{3}\right) = 2 - 3t$$

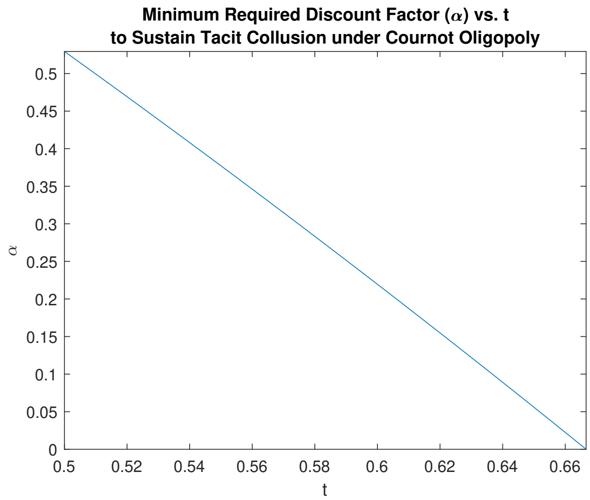
Therefore, the numerator will be at its highest when we get to the very end of the interval, namely, when $t = \frac{2}{3}$. At its largest, then, the numerator takes the following value:

$$\begin{aligned} & \frac{\frac{2}{3}}{2}\left(4 - 3\frac{2}{3}\right) - \frac{2}{3} \\ = & \frac{1}{3}(4-2) - \frac{2}{3} \\ = & \frac{2}{3} - \frac{2}{3} \\ = & 0 \end{aligned}$$

We've shown that the derivative of the numerator starts out negative and rises monotonically until it reaches zero at the end of the interval. Thus, for all $t \in [\frac{1}{2}, \frac{2}{3})$, the derivative of $\underline{\alpha}$ w/r/t t is indeed negative. Just as a quick sanity check, let's throw in another value within the range, $\frac{3}{5}$.

$$\begin{aligned} & \frac{\frac{3}{5}}{2}\left(4 - 3\frac{3}{5}\right) - \frac{2}{3} \\ = & \frac{3}{10}\left(\frac{20}{5} - \frac{9}{5}\right) - \frac{2}{3} \\ = & \frac{33}{50} - \frac{2}{3} \\ = & \frac{99}{150} - \frac{100}{150} \\ < & 0 \end{aligned}$$

A picture would be good, too. Here you go:



Indeed, the $\underline{\alpha}$ required to sustain collusion is declining in t all the way down to $\alpha = 0$, where t corresponds to "cooperation" at the Cournot output level (i.e. there is no actual output restriction). Recall that t was our coefficient on $\frac{a-c}{b}$ that defined the target cooperative output amount, Q_T, so larger values of t correspond to greater output, which you can think of as "less collusive" outcomes. Thus, as the target output level becomes less collusive, the $\underline{\alpha}$ necessary to sustain cheating falls.

It's interesting enough that, even if firms are too impatient to cooperate at the collusive level, they may nevertheless be patient enough to cooperate at some less profitable level (e.g. by jointly producing some higher output level, Q_T, instead of the monopoly output). But **why** is this true? What is the intuition here? Well, notice that reducing the profitability of the cooperative level of production reduces the incentive to cheat by **more** than it reduces the cooperative profit amount. Intuitively speaking, when the cooperative price is very high and output is very low, I will have a large incentive to cheat because I can sell a lot more output at a price that is still quite high, but when the cooperative price is already low, and output already high, there just isn't much money to be made by cheating. It's not worth it anymore. I'll show that in math and then be done.

$$\pi_{cooperate} = \left(\frac{(a-c)^2}{2b}\right) t\,(1-t)$$

$$\pi_{defect} = \left(\frac{(a-c)^2}{2b}\right) \frac{1}{2}\left(1-\frac{t}{2}\right)^2$$

Above, I have written the cooperative and cheating payoffs in easily comparable fashion. Ignoring the first bit in each expression, differentiate the other piece (the one with t) for both, and see what it looks like.

$$\frac{\partial}{\partial t}\left[t\,(1-t)\right] = 1 - 2t$$

$$\frac{\partial}{\partial t}\left[\frac{1}{2}\left(1-\frac{t}{2}\right)^2\right] = -\frac{1}{2}\left(1-\frac{t}{2}\right)$$
$$= \frac{t}{4}-\frac{1}{2}$$

Since values for t are at least $\frac{1}{2}$, we know that both expressions are (weakly) negative. More importantly, we can see already that the second expression is **more** negative on the relevant interval, $t \in [\frac{1}{2}, \frac{2}{3}]$. In other words, increases in t have a small negative effect on cooperative profit, but a stronger negative effect on the profit a cheating firm can earn. That's what we set out to show, and it explains why a sub-collusive level of cooperative profit is more sustainable in this model than true collusion. Here's one more picture for good measure.