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Do Incumbents Improve Service Quality in Response to Entry? Evidence from Airlines' On-Time Performance

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We examine if and how incumbent firms respond to entry and entry threats using nonprice modes of competition. Our analysis focuses on airline service quality. We find that incumbent on-time performance (OTP) actually *worsens* in response to entry, and even entry threats, by Southwest Airlines. Since Southwest is both a top-performing airline in OTP and a low-cost carrier (LCC), we conjecture that this response by incumbents may be due to a cost-cutting strategy that allows for intense postentry price competition along with preentry deterrence, or it may be due to a postentry differentiation strategy along with preentry accommodation. Further analysis of entry and entry threats by other airlines is inconclusive, providing evidence that is partially consistent with both hypotheses. Nonetheless, the phenomenon of worsening OTP can only be observed when the (potential) entrant is a LCC (Southwest, Jet Blue, and AirTran).

Data, as supplemental material, are available at http://dx.doi.org/10.1287/mnsc.2014.1918.

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1. Introduction

As evidenced by the recent explosion of research on differentiated products competition, understanding how firms and products compete along dimensions other than price (e.g., quality) is both very important from a management and policy viewpoint and highly relevant to many industries. One question of particular interest to academics and practitioners is how firm entry into a market impacts quality provision. From theoretical and empirical analyses, much is known about the relationship between entry and price, and even the threat of entry and price. However, very little is known about the effect of entry (or the threat of entry) on firms' provision of quality.

As prior work has shown (e.g., Bain 1951, Goolsbee and Syverson 2008), prices generally fall in the face of increased competition. This result is highly intuitive: when consumers have more choices, firms have an incentive to take steps to become more appealing in order to make sales; perhaps the most obvious step is to reduce price. It may seem intuitive then to extrapolate from this finding and conclude that firms tend toward "improvement" (from the perspective of the consumer) on all dimensions under their control when competition increases. In particular, we may expect that firms will want to improve the quality of their product or service when facing greater competition.

In this paper, we examine whether and how incumbents adjust their quality provision in response to entry and entry threats. Specifically, we assess how incumbent airlines adjust their on-time performance (OTP) in response to entry and entry threats by a particularly active (potential) entrant, Southwest Airlines. The airline industry provides an ideal setting to conduct this analysis since data on airline on-time performance provide a good measure of product quality and are readily available, and entry and entry threats by Southwest are easily observable. Additionally, OTP is a prominent dimension of quality for airline flights, and perhaps the most important to consumers. In the past few years, some online travel sites (e.g., Orbitz, Travelocity) have begun to list OTP information with price for each flight alternative. Moreover, the Federal Aviation Administration requires all airlines with at least 1% of domestic market share to report OTP data. Furthermore, Forbes (2008) provides strong evidence that prices fall substantially with flight delays.

Our analysis reveals what may seem to be a counterintuitive result: incumbents' on-time performance actually *worsens* in response to entry and entry threats by Southwest. To our knowledge, this is the first paper to empirically examine incumbents' quality response to entry and entry threats. The fact that this finding differs from what may seem to be straightforward extrapolation from empirical findings concerning price and quality competition, in general, serves to emphasize the importance of directly analyzing incumbent quality response.

Prior theoretical analyses of nonprice responses to competition have generated ambiguous results concerning the relationship between quality and competition. Schmalensee (1974) finds the relationship to be positive, whereas Gal-Or (1983) shows it to be negative and Swan (1970) shows it to be insignificant. Still others suggest that it depends on modeling assumptions (Schmalensee 1979, Banker et al. 1998). In contrast, prior empirical work analyzing the relationship between quality and competition tells a more consistent story. For example, Domberger and Sherr (1989), Mazzeo (2003), Rupp et al. (2006), and Prince and Simon (2009) find the relationship to be positive, i.e., quality improves when competition increases. The last three of these papers all study OTP for airlines.[1]

Although our findings seemingly contradict these prior empirical analyses, there are several important differences in our approach. First, nearly all of these prior empirical studies use cross-sectional data, making causal inference difficult. Moreover, most of this research analyzes the relationship between market structure and average quality provision, including any entrants. Very little of this work focuses directly on the incumbents' responses to entry, and none allows these responses to depend on characteristics of the entrant (as discussed below, Southwest has important characteristics, at least some of which are likely driving our result). Also, none looks at quality response to entry threats.[2] By using panel data, and excluding the entrants from our data, we are able to isolate the incumbents' quality response to entry and entry threats, and we attempt to assess the impact of (potential) entrant characteristics on incumbent quality response.

After establishing the empirical regularity of our findings for Southwest, we extend our analysis by considering explanations for why incumbents would choose to worsen their on-time performance. There are many plausible theories as to how airlines may compete on quality (discussed above). However, we limit our consideration to two such theories that can generate predictions consistent with our Southwest findings (i.e., worsening OTP in response to entry and entry threats) and are grounded in two key characteristics of Southwest: (a) it is a low-cost carrier (LCC), and (b) it is consistently a top performer in OTP during the time of our data.

Our first explanation—the cost/price cutting and deterrence response—centers on Southwest's status as a LCC. In this explanation, incumbents cut costs by reducing OTP to aggressively cut prices, with the intent both to deter entry by Southwest and to fight Southwest postentry. Our second explanation—the differentiation and accommodation response—centers on Southwest's superior OTP record. In this explanation, incumbents respond to Southwest entry by moving away from Southwest on the OTP performance dimension (hence reducing OTP) and accommodate entry by making this move before entry actually occurs. For both explanations, strategic changes in OTP may coincide with changes along other quality dimensions as well (e.g., in-flight amenities, baggage management, etc.), as costs are cut in multiple ways, or the airline engages in a general quality repositioning that may involve improvements on non-OTP dimensions (Sweeting 2010, Wang and Shaver 2014). Consequently, our assessment of underlying explanations is a partial one, focusing on one important quality dimension.

It is important to note that we view both explanations as part of an overall strategic response to Southwest entry and entry threats, comprising both quality and price changes. In the differentiation response, as incumbents differentiate away from Southwest by worsening on-time performance, they are forced to cut prices to prevent a drop in demand. In the cost/price cutting response, incumbents cut costs to maintain a minimum level of profits while cutting prices to increase demand. In this vein, both explanations are consistent with incumbents lowering price in response to Southwest entry and entry threats, as found by Goolsbee and Syverson (2008). Moreover, it is striking that our results show that incumbents begin worsening on-time performance about three quarters before Southwest threatens the route; this timing matches exactly with the timing of the price-cutting response to Southwest entry threats found by Goolsbee and Syverson (2008).

We attempt to empirically distinguish between the above two explanations by exploiting the fact that each has differing empirical predictions for different types of (potential) entrants. In particular, if incumbents are cutting costs/prices to deter entry, then they should be more likely to worsen OTP in response to low-cost (potential) entrants, and less likely to do so in response to high-cost (potential) entrants. In contrast, if incumbents are following a differentiation strategy with regard to OTP, then they should be more likely to worsen OTP in response to (potential) entrants with better OTP, and more likely to improve OTP in response

[1] Several other papers analyze OTP in the airline industry, none of which find any indication of a worsening of OTP in response to increased competition. These include Mayer and Sinai (2003), Forbes (2008), and Forbes and Lederman (2010).

[2] Several recent papers measure strategic response to entry threats for other variables: Dafny (2005) and Ellison and Ellison (2011) test for strategic investment, and Goolsbee and Syverson (2008) test for strategic price cutting.

to (potential) entrants with poor OTP. We test these predictions by analyzing incumbents' responses to (potential) entrants other than Southwest, and assessing how these responses relate to the (potential) entrants' cost and OTP records.

Our analysis of responses to other (potential) entrants shows a similar worsening of OTP (compared to Southwest) in response to AirTran and Jet Blue, and an improvement in OTP in response to Frontier and America West. The incumbent responses to the remaining airlines show no consistent (statistically significant) OTP movement in either direction. We then construct a relative, normalized measure of each (potential) entrant's OTP and cost (i.e., operating cost per available seat mile). Next, we calculate correlations between each of these (potential) entrant measures and several point estimates measuring incumbents' long-run OTP response to entry and entry threats by each (potential) entrant.[3] Based on these correlations, we find only partial support for each hypothesis.

The cost/price cutting hypothesis is supported by our finding that incumbents appear to worsen OTP in response to (potential) entry by three of the four lowest-cost airlines in our sample, and by a (weakly) negative correlation between incumbent OTP response and (potential) entrant costs. However, this support is mitigated by our finding that incumbents improve OTP in response to two other LCCs, and by the inconsistent sign of this correlation across all of our measures of long-run OTP response.

The differentiation hypothesis is supported by a notably stronger correlation between incumbent OTP response and potential entrant OTP. However, this support is mitigated by our finding that incumbents worsen OTP in response to a very low-performing (potential) entrant in AirTran but not in response to any other high-performing (potential) entrant besides Southwest and Jet Blue.

Although this additional analysis cannot conclusively point to one hypothesis over the other, perhaps the most notable takeaway is that the counterintuitive finding of worsening OTP we find for Southwest is only replicated for other LCCs (Jet Blue and AirTran), despite AirTran not being a high performer on OTP.

The implications of these findings are several. To begin, they improve our understanding of how airlines compete. We demonstrate that Southwest entry and entry threats cause incumbents to worsen their on-time performance. In addition, our analysis provides new insights into the ways firms respond to entry threats and entry along nonprice dimensions. Prior theoretical and empirical work relating market structure to average quality provision often suggests that average quality and competition are positively correlated. Our results show that, even in an industry where this relationship appears to hold (e.g., Mazzeo 2003), it does not imply that each firm will improve its quality in response to new competition, or to the threat of it. Consequently, customers should not necessarily expect improved quality from incumbents when a new rival enters or threatens to enter a market. In particular, air travelers have reason to be wary of incumbents' quality response to entry threats and entry by a low-cost or high-OTP (potential) entrant. Taking a broader view, our results show that the welfare implications of (potential) entry likely depends on the entrant, as incumbent response, at least with regard to quality, can vary notably. Further, although improvements may occur in other quality dimensions, (potential) entry may involve the average consumer actually experiencing lower quality at least on one important dimension.

[3] As we note in §5.3, we use OTP data for Frontier from 2005 to round out this measure (thus assuming at least short-run persistence in performance for prior years)—the first year such data were available.

2. Why Might Quality Worsen in Response to Entry and Entry Threats?

In this section, we discuss pertinent theoretical reasons why incumbent airlines may choose to worsen their on-time performance in response to entry and entry threats by Southwest. In general, we posit that incumbent airlines will develop an overall strategic response to Southwest entry and entry threats, comprising both quality and price changes. Therefore, we would expect incumbents to make strategic decisions that alter on-time performance at the same time that they cut prices. As a result, we would expect to see on-time performance begin to change at the same time that we see prices begin to fall, shortly before Southwest's entry threat (and prior to Southwest actually entering the route).

We frame this discussion around two central characteristics of Southwest Airlines during the time of our data set: (1) Southwest is a low-cost carrier and (2) Southwest is the clear top performer with respect to on-time performance. Below, we argue that each of these characteristics could cause incumbents to worsen on-time performance in response to entry and entry threats by Southwest (behavior we observe in our data), but through differing channels: the first (Southwest's LCC status) may lead to an aggressive *cost/price cutting* response, and the second (Southwest's superior OTP record) may drive an accommodating *product differentiation* response. We then consider how we might try and distinguish which channel is at work in our data.

Before proceeding to these arguments, we first provide evidence for the fundamental premise underlying both of these responses, that airlines do influence on-time performance at the route level.[4] As Mazzeo (2003) notes, airlines can make different kinds of route-level investments that affect on-time performance. As an example, airlines can hire additional employees to speed up processes such as loading and unloading baggage, check-in, etc. To avoid delays resulting from mechanical failures, airlines can maintain an additional airplane(s) at an airport, or have a ready supply of mechanics available. They also can reduce time spent in the air by using larger airplanes that can fly faster. In addition, they can acquire more slots at airports. Finally, airlines can influence on-time performance by altering their flight schedules (e.g., scheduling flights for less busy times of the day), as well as decisions about holding flights to wait for connecting passengers.[5]

Although many of the investments described above are more airport specific than route specific, they are highly fungible, and may be quickly reallocated across routes within an airport. Drawing on an example provided by Mazzeo (2003), if the preflight inspection indicates a mechanical problem with the American Airlines plane scheduled to fly from Dallas to Nashville, then American might instead use the plane that was scheduled to fly to Indianapolis, on the Nashville route. Similarly, airlines might shift flight crews or baggage handlers across routes in response to route-specific conditions. Improvements in technology have greatly facilitated this sort of resource reallocation by airlines in recent years (Mazzeo 2003).

Mazzeo (2003), Rupp et al. (2006), Prince and Simon (2009), and Mayer and Sinai (2003) provide empirical support for the idea that airlines adjust their investments in service quality on a route-by-route basis. As noted above, Mazzeo (2003), Rupp et al. (2006), and Prince and Simon (2009) find that airlines provide worse on-time performance on less competitive routes. Similarly, Mayer and Sinai (2003) find that airlines provide worse on-time performance on flights leaving their hubs, because they schedule many flights to arrive at the hub at the same time, in order to facilitate convenient connections, and because they hold flights to wait for connecting passengers. Finally, Borenstein and Netz (1999) show that route-level competition influences airlines' flight schedules.

2.1. Cost/Price Cutting

During the time of our data, Southwest is the predominant low-cost carrier in the United States. A LCC generally has lower ticket prices and offers fewer "comforts" for their flights (e.g., no first class tickets, no reserved seating, no in-flight meals, etc.). The first two columns of Table 1 show that Southwest is the lowest-cost airline in our data (measured by cost per available seat mile).[6] Since Southwest often offers particularly low prices, incumbents may feel pressured to lower their prices on routes entered or threatened by Southwest. Indeed, Goolsbee and Syverson (2008) find that incumbents cut prices substantially in response to entry and entry threats by Southwest. Given that incumbent airlines choose to compete on price with Southwest when Southwest threatens to enter a route, they may be willing to make sacrifices along other dimensions, including on-time performance, in order to cut costs on these routes. Doing so enables them to more aggressively cut prices while still preserving some minimum level of profit margin. The feasibility of this cost/price cutting strategy depends on two factors: the extent to which OTP impacts costs, and the extent to which customers respond more to price than to OTP.

Regarding the first factor, as the discussion above suggests, on-time performance can be linked to an airline's costs in many ways. The inputs associated with improving on-time performance, including additional ticketing agents, baggage handlers, mechanics, landing slots, and airplanes, all affect an airline's costs; clearly, a reduction in these inputs would lower an airline's costs, enabling greater price cuts while maintaining a given profit margin. Moreover, as noted above, although many of these costs are more airport-specific, at least some of these costs are incurred at the route level.

Regarding the second factor, in general, it seems clear that customers are more responsive to price changes than to changes in on-time performance; many websites allow travelers to compare ticket prices across airlines, whereas finding on-time performance data is more difficult (this was especially true during the time period of this study; online travel sites were not yet posting on-time performance data). Moreover, new entry intensifies price competition, making demand more elastic. This is especially true when Southwest enters, because of Southwest's low-cost/low-price strategy. As a result, incumbent airlines have a clear incentive to cut costs in response to entry by Southwest, in order to enable greater price cuts while maintaining a minimum level of profitability. This cost-cutting behavior, along with the resulting price cutting, would result in both lower prices and the worsening OTP we observe in our empirics.

Airlines may also find it optimal to engage in this cost/price cutting, OTP-worsening behavior in response to the threat of entry by Southwest, in the hopes of deterring Southwest from entering. Indeed, Goolsbee

[4] This discussion follows that of Prince and Simon (2009).

[5] We would not consider any of these decisions to be large or irreversible; airlines do not commit themselves to a particular level of service quality through these decisions. The one possible exception would be the airline's schedule. However, airlines do adjust schedules in response to demand changes. Therefore, even schedules are somewhat reversible.

[6] We discuss this table in greater detail in §3.3.

Table 1 Airline On-Time Performance (1987–2004) and Cost Data (1990–2004)

Carrier	Fraction of flights arriving at least 15 minutes late (%)	Normalized annual fraction of flights arriving at least 15 minutes late (ranking)	Operating expenses per available seat mile ($)	Normalized annual operating expenses per available seat mile
Air Tran[a]	21.2	0.590 (12)	0.084	−0.788
Alaska Air	23.7	0.476 (11)	0.099	0.212
America West	21.4	−0.088 (5)	0.077	−1.099
American	20.8	−0.146 (4)	0.100	0.100
Continental	21.1	0.023 (6)	0.103	0.147
Delta	22.3	0.410 (9)	0.102	0.207
Frontier[b]			0.091	−0.360
Jet Blue[c]	16.9	−0.678 (2)	0.092	−0.681
Northwest	20.1	−0.311 (3)	0.100	0.128
Southwest	17.5	−1.152 (1)	0.076	−1.143
TWA[d]	22.0	0.220 (8)	0.096	0.074
United	23.7	0.471 (10)	0.104	0.312
USAir	21.4	0.034 (7)	0.135	1.988

[a]Air Tran began reporting OTP data in 2003 and cost data in 1994.
[b]Frontier began reporting OTP data in 2005 and cost data in 1994.
[c]Jet Blue began reporting OTP data in 2003 and cost data in 2000.
[d]TWA Ceased operations in December 2001.

and Syverson (2008) find evidence that incumbents begin price cutting shortly (about three quarters) before Southwest threatens the route. Several seminal theoretical papers (e.g., Dixit 1979, Spence 1981, Klemperer 1987) provide rationales for firms engaging in competitive actions before new rivals enter. In our setting, perhaps the most pertinent of these rationales is an attempt to increase switching costs (Klemperer 1987).[7] Specifically, incumbents may choose to reduce price while worsening OTP, as a way to increase demand in the short run (while maintaining minimal profits).[8, 9] This could help deter entry by locking customers in, via such mechanisms as frequent flyer miles. Cutting on-time performance is particularly effective in this context, because it only affects demand with a lag. As a result, airlines are able to reduce costs, enabling additional price cutting, without trading off any of the short-term increase in demand. Such behavior would generate a worsening of OTP following an entry threat, as we observe in our data.

In sum, incumbent airlines may choose to reduce investments in OTP as part of a cost/price cutting response to entry and entry threats by Southwest. Postentry, the cost cutting supports an aggressive pricing strategy in response to Southwest's low prices; preentry, the cost cutting supports price cutting in an effort to increase demand in the hopes of deterring entry.

2.2. Product Differentiation

Besides being the predominant LCC in the United States during the time of our data, Southwest also performed the best on the on-time performance dimension. As we show in the third and fourth columns of Table 1, Southwest's overall OTP record over this time period was substantially better than all carriers except Jet Blue. Consequently, incumbents on routes where Southwest enters can reasonably expect a strong relative on-time performance by Southwest.

If we view on-time performance as a dimension of vertical differentiation, we can call on basic theoretical models of product differentiation to form expectations as to how incumbents will respond to entry by Southwest. Consider a simple model where two firms compete along a single dimension of vertical differentiation (and then compete on price). For such a model, a general prediction emerges from equilibrium analysis—firms will differentiate (often maximally) along the quality dimension (see Tirole 2000).

This prediction is quite useful in our setting for two reasons. First, the majority (approximately 70%) of the routes we analyze that Southwest enters move from monopoly to duopoly; hence, the simple duopoly model is directly applicable, at least with respect to market structure. Second, because of Southwest's advantage in the provision of OTP, differentiating incumbents likely will have to move down in quality to move away from Southwest. Consequently, if incumbents are

[7] Other mechanisms include capacity commitment (Dixit 1979) and long-term contracting (Aghion and Bolton 1987). However, Goolsbee and Syverson (2008) find evidence against capacity changes, and long-term contracting with passengers generally is not an option.

[8] Goolsbee and Syverson (2008) note that they do find evidence of more price cutting on routes with a higher presence of business travelers (who likely have a greater participation rate for frequent flyer programs). This certainly is not conclusive, and as they note, ignores the possibility of passengers correctly forecasting future lock-in and thus requiring greater price declines.

[9] In addition, lowering on-time performance might enable the incumbent to improve its performance on other dimensions of service quality (e.g., by offering expanded flight schedules with smaller planes).

attempting to engage in product differentiation along the OTP dimension in response to entry by Southwest, we should expect this to result in worsening OTP.

If it is the case that incumbent firms find it optimal to differentiate away from Southwest in OTP in response to entry, they may find it optimal to do so in response to entry threats as well. For example, if incumbents view an entry threat as a signal that entry is imminent (as is generally the case with Southwest) and there are adjustment costs for OTP inputs, they may choose to begin adjusting these inputs before entry occurs to, e.g., smooth out these costs over time as they move to the postentry equilibrium. Such adjustment costs may include union contracts, landing slot licenses, etc. This would result in a decline in OTP after the entry threat emerges, as we observe in our data.

Although the rather clear prediction from the duopoly model may make it seem particularly likely that it is the mechanism behind the worsening OTP we observe, it misses some important complexities of the airline industry. For example, airlines compete along many nonprice dimensions, not just one. These include on-time performance, destinations served, flight times and frequencies, aircraft size, and customer service. The theoretical literature analyzing quality competition along multiple dimensions generally shows that firms will differentiate along some dimensions and imitate along others (e.g., Ben-Akiva et al. 1989, Neven and Thisse 1990).[10] Further, if one dimension is sufficiently dominant, firms will maximally differentiate along that dimension and minimally differentiate along all others (Irmen and Thisse 1998). However, it is unclear whether OTP would be one of the dimensions along which differentiation would occur.

The airline industry differs from the simple duopoly model also because airlines compete in many different markets, and against many different combinations of competitors with differing characteristics. The extant theoretical work relating quality provision to market structure has varying predictions from no relationship (Swan 1970), to positive or negative, depending on assumptions (e.g., Schmalensee 1979, Banker et al. 1998).[11] Hence, it is again unclear whether the predictions for the single-dimension duopoly model regarding OTP should apply to the more complex airline market, thus making it unclear whether product differentiation is the underlying mechanism behind the worsening OTP we observe.

In sum, a worsening of OTP because of a product differentiation response to entry and entry threats by Southwest represents an "accommodating" response by incumbents. It involves movement to a new (lower) equilibrium OTP after entry occurs, and initiating such a movement when an entry threat emerges—thus accommodating entry from the onset of the process.[12]

2.3. How to Distinguish Differentiation from Intense Price Competition

Sections 2.1 and 2.2 illustrate how a fighting cost/price-cutting response and an accommodating product differentiation response can each generate the worsening of on-time performance in response to Southwest entry and entry threats that we observe in our data. Below, we describe how we assess these two explanations empirically. Of course, a hybrid of these explanations is possible, wherein airlines either engage in intense price competition preentry and product differentiation postentry, or vice versa. However, such hybrid strategies seem less likely, since they require strategic decision makers to follow very different competitive strategies pre- and postentry. Nonetheless, our empirical analysis will also allow us to assess any hybrid strategy, should it be a possibility.

As we discuss above, our two competing explanations for incumbents' worsening OTP in response to Southwest entry and entry threats hinge on Southwest's status as a LCC and a top performer in OTP. If, for example, an entrant was instead average, or inferior in its provision of OTP, the product differentiation model predicts that incumbents would be more likely to differentiate by increasing OTP in this case. Similarly, the cost/price-cutting model predicts that incumbents would not worsen OTP in response to entry and entry threats from non-LCC's (or, more generally, higher-cost airlines).

As we detail below, we are able to observe entry, entry threats, and incumbent OTP response for (potential) entrants of widely varying OTP and cost levels (measured in cost per available seat mile). Consequently, we can evaluate how incumbents' OTP responses

[10] Although the extant theoretical work on multidimensional differentiation suggests that differentiation should occur on some dimensions, it is not obvious ex ante which dimensions these will be. The small amount of empirical work looking at incumbent nonprice response to entry emphasizes this ambiguity. For example, Goolsbee and Petrin (2004) find that cable television quality (in the form of, e.g., number of pay-per-view channels and channel capacity) increases with the entry of direct broadcast satellite. This result suggests minimal differentiation, as cable tries to "keep pace" with satellite. In contrast, Netz and Taylor (2002) find that spatial differentiation of retail gas stations is greater when the number of competitors increases.

[11] Empirical research has often found a positive relationship between quality and competition. For example, Domberger and Sherr (1989) find that customer satisfaction in legal services increases with competition. Similarly, Mazzeo (2003) and Rupp et al. (2006) find that on-time performance improves with competition, and Economides et al. (2008) show that new entry increases the number of types of local phone plans offered. Domberger et al. (1995) find a weak, but positive, relationship between competition and cleaning service quality.

[12] In contrast, if incumbents wished to engage in entry deterrence when strategically choosing OTP, they would likely choose to improve OTP to preempt Southwest's entry at the high end of the OTP scale.

to entry (threats) correlate with these two measures, and assess whether either (or both) explanation(s) is supported.

3. Data

We examine incumbent quality responses to entry and entry threats from Southwest using the U.S. Department of Transportation (DOT) Bureau of Transportation Statistics (BTS) On-Time Performance data set. Specifically, we use data on on-time performance by the other carriers providing nonstop service on routes threatened by Southwest during the period 1993–2004. In total, our data set comprises more than 67 million domestic flights.[13] For our primary analysis, we restrict our sample to flights between the 58 airports that Southwest ever serves during our sample.[14] We expand this sample to include the 100 busiest U.S. airports (by number of passengers) when considering response to other entrants and when assessing the robustness of our findings.

Whereas Goolsbee and Syverson (2008) define a route as a pair of airports, we define a route as an origin-destination pair. In other words, in our analysis, O'Hare-Dulles and Dulles-O'Hare are two separate routes. To be concrete, we distinguish between routes and route pairs. We make this distinction because on-time performance is a flight-level phenomenon, rather than an itinerary-level phenomenon like fares. Similarly, because on-time performance is measured only for individual flights, we restrict our analysis to nonstop service.

To make estimation more manageable, we aggregate our data into carrier-route-quarter cells. We then estimate weighted least-squares models, weighting each observation by the number of flights in each cell. Doing so yields identical estimates to those we would obtain running OLS on the disaggregated flight-level data.

Our general approach to measuring entry and entry threats follows that of Goolsbee and Syverson (2008). They note that when Southwest begins operating in airports on both sides of a route but not the route itself, the likelihood that Southwest will start offering service on that route in the near future rises dramatically. Exploiting this fact, we define a route to be threatened by entry from Southwest when Southwest serves both endpoint airports on a route, but does not offer nonstop service on the route itself. For example, Southwest began flying out of Jacksonville in 1997. Then, in the second quarter of 2004, it entered Philadelphia and began offering service from Philadelphia to Tampa. Although it had not entered the Philadelphia to Jacksonville (or Jacksonville to Philadelphia) route, it now threatened that route because it offered service from both endpoint airports. We define the entry to occur during the quarter in which Southwest begins offering nonstop service on the threatened route. In the above example, entry occurred during the fourth quarter of 2004, when Southwest began offering nonstop service from Jacksonville to Philadelphia, and vice versa.

As the above example illustrates, entry and entry threats occur simultaneously for routes that comprise a route pair, like Jacksonville to Philadelphia and Philadelphia to Jacksonville; when Southwest threatens or enters the route-pair in one direction, it also does so in the opposite direction. Therefore, in our estimation, we cluster our standard errors at the route-pair level. In this way, we allow for correlation in the error terms among all observations by carriers flying Jacksonville-Philadelphia or Philadelphia–Jacksonville (for example).

For each route in our sample, we examine data for the 12 quarters preceding the quarter in which Southwest enters the second endpoint airport and first threatens the route, the quarter in which Southwest establishes a presence in the second endpoint airport, and the 12 quarters following the quarter in which Southwest establishes a presence at the second endpoint airport.

We exclude routes where Southwest entered a second endpoint airport simultaneously with offering service on the route. In such cases we cannot cleanly identify the threat of entry separately from the actual entry. In total, we observe 275 routes (145 route-pairs) that Southwest threatened to enter, of which Southwest actually entered 237 (125 route pairs) with nonstop service prior to the end of 2004.[15] This yields 4,822 carrier-route-quarter observations for incumbent carriers on threatened routes.[16]

3.1. Measurement of Entry and the Threat of Entry

To identify entry threats and entry, we use the DOT BTS Data Bank 1B (DB1B) of the Origin and Destination (O&D) Survey, which is a quarterly 10% sample of tickets for domestic flights.[17] Using these data, we create three sets of entry dummy variables to capture the full effect of both the threat of entry, and actual entry, by Southwest. First, because airlines may become aware of Southwest's expansion plans before they actually

[13] These data are available to other researchers upon request from the authors.

[14] We exclude San Francisco because Southwest exits this airport in 2001.

[15] Note that our sample includes fewer route pairs than Goolsbee and Syverson's, because the on-time performance data set has incomplete coverage of routes with few passengers.

[16] We do not have 25 observations for many carrier routes because of truncation at the start of the sample, and because, in some cases, the airline did not fly the route during the entire 25-quarter period.

[17] We use this data set because it provides more complete coverage of routes served by each carrier.

occur, we construct dummies to indicate the quarters preceding the quarter in which Southwest enters the second endpoint airport of a route and threatens that route. In the above example, these dummy variables would indicate the quarters preceding the second quarter of 2004. Second, we include a set of dummies to measure the period following the quarter in which Southwest establishes a presence in the second endpoint airport without offering service on the route. Third, we include a set of dummy variables to indicate the quarter of entry onto the route, i.e., the quarter in which Southwest begins offering nonstop service on the route, as well as subsequent quarters.

3.2. Dependent Variables: On-Time Performance

For our dependent variables, we initially consider the three most frequently cited measures of on-time performance. In published reports, the DOT BTS generally defines a flight to be late if it arrives at the gate at least 15 minutes late. Hence, our first measure of on-time performance measures the proportion of carrier i's flights on route j in quarter t that arrives at least 15 minutes late. Our second measure places stricter requirements for characterizing a flight as late. Specifically, it measures the proportion of flights on route j in quarter t that arrives at least 30 minutes late. Our third measure of on-time performance is the average number of minutes late (or early) that carrier i's flights on route j in quarter t arrive at the gate, relative to its scheduled arrival time.

All three of these measures of on-time performance compare the elapsed time from scheduled departure to actual arrival time with the scheduled time for the flight (scheduled departure time to scheduled arrival time). This means that airlines can manipulate a flight's on-time performance by lengthening the scheduled time for the flight. Consequently, we include two more measures of on-time performance: scheduled time and travel time. Scheduled time is the amount of time from the scheduled departure time to the scheduled arrival time. Using scheduled time allows us to assess whether airlines systematically change flight windows in response to Southwest entry threats and entry. Travel time, as first described by Mayer and Sinai (2003), measures only the time from when the flight is scheduled to depart until the time that it actually arrives. In this way, it measures actual elapsed time plus the delay in departing the airport. It is unaffected by changes in the scheduled time for the flight. For this reason, and reasons discussed below, the bulk of our analysis will focus on travel time.

3.3. Southwest's Cost and On-Time Performance Record

A key point in our analysis is Southwest's superiority in cost and on-time performance. In Table 1 we report

Table 2 **Descriptive Statistics**

Variable	Mean	Std. dev.
Fraction of flights arriving at least 15 minutes late	0.180	0.119
Fraction of flights arriving at least 30 minutes late	0.083	0.078
Arrival delay (minutes)	4.113	6.689
Scheduled flight time	138.783	68.606
Travel time	144.384	68.941
Load factor	0.613	0.164
Carrier's flights on the route	243.947	170.285
Flights arriving at destination airport	18,313.61	12,021.35
Flights departing from origination airport	18,258.12	12,006.78

airline operating expenses[18] and OTP data; columns 1 and 3 report the raw averages, and columns 2 and 4 report normalized annual averages. Among national U.S. carriers, Southwest was the lowest-cost airline from 1990–2004, with the other LCCs (Air Tran, America West, Frontier, and Jet Blue) all close behind; the legacy carriers had substantially higher costs. Moreover, Southwest had, by a substantial margin, the highest normalized on-time arrival rate between 1987 (when data were first collected) and 2004, and the highest raw mean on-time arrival rate among those airlines with at least three years of OTP data (Jet Blue and Air Tran only enter the OTP database in 2003).[19] During this time period, 82.5% of Southwest's flights arrived on time, and 79.9% of Northwest's (the second-best performer's) flights arrived on time (U.S. Department of Transportation 1994–2005). To put this discrepancy into context, it is about 72% as great as the gap between Northwest and the worst-performing carrier, United (76.3%). These data provide clear evidence that Southwest had a record of superior OTP provision relative to the other major U.S. airlines during the period of our sample.

3.4. Summary Statistics

Table 2 reports descriptive statistics for our sample. On average, 18% of flights in our sample arrive at least 15 minutes late, and 8.3% arrive at least 30 minutes late. Overall, the average flight arrived 4.1 minutes late. The average scheduled flight time was 138.8 minutes, and the average travel time was 144.4 minutes. The average flight was 61.3% full, and carriers offered about 244 flights on a route each quarter. Overall, there were about 18,300 flights arriving and departing from the average airport each quarter.

[18] The operating expenses data are from DOT BTS Air Carrier Financial Reports, Schedule P-1.2. The available seat miles are from the DOT BTS Air Carrier Summary Data T1 data set.

[19] TWA ceased operating in December 2001; Frontier does not enter the OTP database until 2005.

4. Estimation Strategy

To examine whether airlines vary their on-time performance in response to the threat of, or actual, entry by Southwest, we estimate a set of fixed-effects models for the various measures of on-time performance described above. The variables of interest are the dummy variables indicating entry and entry threats by Southwest. In all models, we also include carrier-route-pair fixed effects to control for unobserved differences across carriers and route-pairs, and carrier-quarter fixed effects to control for any changes over time in the carrier's overall on-time performance.

Because we include carrier-route-pair fixed effects in all models, and because we omit dummy variables for the 9th–12th quarters preceding the quarter in which Southwest establishes a presence at the second endpoint airport, our estimated coefficients indicate the carrier's on-time performance in the dummy period relative to its performance in the two- to three-year period (9–12 quarters) prior to the quarter in which Southwest establishes a presence at the second endpoint airport, creating the threat of entry for the given route. As discussed above, in all models we cluster the standard errors at the carrier-route-pair level, to account for correlations in the standard errors.

Our primary regression is the following:[20]

$$\begin{aligned} y_{ijt} = {} & \mu_{ij} + \delta_{it} + T_{ijt}^{-8} + T_{ijt}^{-7} + T_{ijt}^{-6} + T_{ijt}^{-5} + T_{ijt}^{-4} + T_{ijt}^{-3} \\ & + T_{ijt}^{-2} + T_{ijt}^{-1} + T_{ijt}^{0} + T_{ijt}^{1} + T_{ijt}^{2} + T_{ijt}^{3+} + E_{ijt}^{0} + E_{ijt}^{1} \\ & + E_{ijt}^{2} + E_{ijt}^{3+} + Load_{ijt} + \ln CarrierFlights_{ijt} \\ & + \ln DestFlights_{ijt} + \ln OrigFlights_{ijt} + \varepsilon_{ijt}. \end{aligned}$$

Here, y_{ijt} is one of the on-time performance measures described above for carrier i on route-pair j in quarter t. The first two right-hand-side variables represent carrier-route-pair and carrier-quarter fixed effects, respectively. The T variables are dummies that capture the proximity of that observation to the Southwest threat. For example, T^{-8} equals one if the observation occurred eight quarters before Southwest threatened to enter, T^{-7} equals one if the observation occurred seven quarters before Southwest threatened to enter, etc. The variable T^0 indicates the quarter in which Southwest actually enters the second endpoint airport, threatening the route. The variables T^1 and T^2 indicate the first two quarters after Southwest has threatened the route, but before Southwest has actually started offering service on the route, and T^{3+} indicates the 3rd–12th quarters after Southwest has threatened the route but not yet begun to fly on the route. Similarly, the E variables indicate the number of quarters since Southwest begins offering service; E^0 indicates the quarter in which Southwest actually begins offering service on the route, E^1 and E^2 indicate the first two quarters after Southwest begins offering service, and E^{3+} indicates the 3rd–12th quarters after entry. Finally, we include four additional control variables. *Load* controls for the average load factor,[21] $\ln CarrierFlights$ is the logged number of flights that the carrier offers on the route, and $\ln OrigFlights$ and $\ln DestFlights$ are the logged number of flights at the origin and destination airports, respectively.[22]

By controlling for load factor, we preclude the possibility that our results are being driven by more crowded flights (yielding more delays), resulting from incumbents cutting prices in response to the threat of entry and actual entry by Southwest. Since concurrent changes in this variable pose a clear concern, we estimated these models including quadratic and cubic load factor terms as well, with no material effect on our results. Similarly, by controlling for the carrier's number of flights on the route, we rule out the possibility that our results simply reflect changes in incumbents' flight schedules. Finally, by controlling for the number of flights at the endpoint airports, we can eliminate the possibility that greater congestion at the endpoint airports, resulting from Southwest entry, is driving the increase in delays that we observe.

5. Results

5.1. Main Results

In Table 3, we examine how incumbents' on-time performance responds to entry and entry threats by Southwest. All three conventional measures of arrival delay indicate that airlines begin responding to the threat of entry before Southwest even threatens the route; incumbents' on-time performance begins to worsen before Southwest actually enters the second endpoint airport, and it continues to do so following Southwest threatening the route, and following entry, as well. We note that one should not be surprised that incumbents begin responding prior to Southwest threatening the route, since it is likely that airlines are aware of Southwest's intentions to enter an airport before entry occurs.[23]

[20] We constrain μ_{ij} to be equal to μ_{ik} when j and k have the same endpoints, i.e., carrier routes with the same endpoint airports have a common carrier-route-pair fixed effect.

[21] Load factor is the percentage of seats on each flight occupied by paying passengers. To construct this variable, we use data on passenger levels and number of seats on the plane from the T-100 Domestic Segment data set.

[22] We construct these variables by aggregating the total number of flights arriving and departing from each airport during the quarter, using data from the on-time performance data set.

[23] "The relevant time period should be when the incumbents first realize that Southwest's chances of entering a route have risen. Southwest announces entry months before the entry actually occurs in order to advertise, sell tickets, hire workers, and such. Southwest's entry into Washington Dulles, for example, was publicly announced six months before the first day of operations" (Goolsbee and Syverson 2008, p. 1620).

Table 3 Incumbents' On-Time Performance Response to Entry and Entry Threats by Southwest

	1	2	3	4	5
	Fraction of flights arriving at least 15 minutes late	Fraction of flights arriving at least 30 minutes late	Arrival delay (minutes)	Scheduled flight time	Travel time
8 quarters prethreat (T^{-8})	0.015	0.007	1.083	−0.820	0.666
	(0.006)*	(0.004)†	(0.366)**	(0.275)**	(0.439)
7 quarters prethreat (T^{-7})	0.013	0.004	0.970	−0.971	0.511
	(0.006)*	(0.003)	(0.371)**	(0.321)**	(0.429)
6 quarters prethreat (T^{-6})	0.006	0.000	0.775	−0.808	0.394
	(0.007)	(0.004)	(0.376)*	(0.350)*	(0.337)
5 quarters prethreat (T^{-5})	0.002	−0.000	0.370	−0.795	0.194
	(0.006)	(0.004)	(0.364)	(0.371)*	(0.465)
4 quarters prethreat (T^{-4})	0.012	0.001	0.604	−0.537	0.755
	(0.007)†	(0.003)	(0.416)	(0.372)	(0.496)
3 quarters prethreat (T^{-3})	0.016	0.007	1.002	−0.398	1.384
	(0.008)*	(0.004)†	(0.494)*	(0.403)	(0.582)*
2 quarters prethreat (T^{-2})	0.024	0.012	1.174	−0.319	1.564
	(0.008)**	(0.004)**	(0.527)*	(0.491)	(0.632)*
1 quarter prethreat (T^{-1})	0.024	0.012	1.201	−0.758	1.159
	(0.008)**	(0.004)**	(0.549)*	(0.484)	(0.641)†
Southwest threatens route (T^{0})	0.022	0.009	1.299	−0.471	1.737
	(0.009)*	(0.005)†	(0.609)*	(0.499)	(0.716)*
1 quarter postthreat (no flights) (T^{1})	0.010	0.006	0.356	−0.193	0.985
	(0.011)	(0.005)	(0.624)	(0.514)	(0.744)
2 quarters postthreat (no flights) (T^{2})	0.013	0.006	0.352	0.101	1.209
	(0.011)	(0.005)	(0.640)	(0.540)	(0.793)
3–12 quarters postthreat (no flights) (T^{3+})	0.023	0.010	1.148	−0.027	1.951
	(0.010)*	(0.005)†	(0.703)	(0.602)	(0.839)*
Southwest begins flying route (E^{0})	0.023	0.011	1.113	−0.498	1.539
	(0.011)*	(0.006)*	(0.701)	(0.552)	(0.799)†
1 quarter postentry (E^{1})	0.031	0.016	1.756	−0.610	2.231
	(0.011)**	(0.005)**	(0.730)*	(0.626)	(0.870)*
2 quarters postentry (E^{2})	0.026	0.012	1.369	−0.490	1.810
	(0.012)*	(0.006)*	(0.798)†	(0.636)	(0.931)†
3–12 quarters postentry (E^{3+})	0.032	0.018	1.646	−0.502	2.284
	(0.013)*	(0.006)**	(0.831)*	(0.719)	(1.004)*
Load factor	0.126	0.043	7.150	−5.048	2.404
	(0.024)**	(0.014)**	(1.290)**	(2.746)†	(3.116)
Carrier's flights on the route	−0.004	−0.002	−0.224	−0.649	−1.017
	(0.006)	(0.003)	(0.310)	(0.605)	(0.705)
Ln(flights arriving at destination airport)	−0.000	−0.007	0.196	−0.565	−0.106
	(0.013)	(0.007)	(0.703)	(1.007)	(1.024)
Ln(flights departing from origination airport)	0.030	0.012	2.017	−3.466	−1.206
	(0.013)*	(0.007)†	(0.675)	(0.825)**	(0.932)
Wald test: (T^{-3} to E^{3+})–(T^{-8} to T^{-4})					1.119*
Wald test: (T^{-5} to T^{-4})–(T^{-8} to T^{-6})					−0.050
Wald test: (T^{-3} to T^{-2})–(T^{-8} to T^{-6})					0.950*
N	4,822	4,822	4,822	4,822	4,822

Notes. All models are weighted by the number of flights. All models include carrier-route-pair and carrier-quarter fixed effects. Standard errors clustered by carrier-route-pair are reported in parentheses. Excluded category is quarters 9–12 prethreat. Models 1 and 2 are marginal effects from fractional logit models.
$^{\dagger}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$.

To quantify the effects of entry threats and entry on on-time performance, we initially treat the final coefficient estimates for each (i.e., the coefficient estimates for T^{3+} and E^{3+}) as the long-run effect of an entry threat (on routes where entry does not occur for at least three quarters after the threat) and entry, respectively. Doing so, we see that the fraction of the incumbent's flights that arrive at least 15 (30) minutes late were about 3.2 (1.8) percentage points higher than the baseline when three or more quarters have passed since entry, and 2.3 (1.0) percentage points higher when three or more quarters have passed since an entry threat emerged (but no entry occurred). These are large effects given that, on average, 18 (8.3) % of flights arrive at least 15 (30) minutes late. Similarly, in the third model, the average arrival delay is about 1.6 minutes more than the baseline when three or more quarters have passed since entry, and about 1.1 minutes more than the baseline when three or more quarters have passed since an entry threat by Southwest. Again, this represents an economically significant effect relative to the average delay of 4.1 minutes. To further put these results into context, Mazzeo (2003) finds that arrival delays on monopoly routes are about 1.4–1.5 minutes longer than on routes with competition. In other words, the effect of Southwest threatening or entering a route is about the same as the effect of a competitive route becoming monopolized.[24]

Although these results provide evidence that incumbent airline delays increase in response to entry and entry threats by Southwest, all three measures can be manipulated by airlines simply altering scheduled flight times. If this is the case, then the change in delays we observe would not represent a strategic shift involving reallocation (or reduction) in resources to alter on-time performance, but rather a simple change on paper as to how long each flight should take. We explore this possibility in column 4 of Table 3. The results in column 4 show that airlines do have shorter scheduled flight times in all but one period, relative to the base period (9–12 quarters prior to threat). However, the effects are relatively small (generally less than one minute) and are usually statistically insignificant. Moreover, the largest and statistically significant reductions in scheduled time occur more than a year before Southwest even threatens to enter the route, making it unlikely that the changes we observe are a strategic response to an entry threat or entry. Hence, this does not appear to be a viable explanation for the increases in arrival delays that we observe.

Since airlines do not appear to respond to Southwest entry and entry threats by altering scheduled flight times, the only other way to respond that affects on-time performance is to change the actual time it takes to complete a flight. Such a change is more economically and strategically interesting, as it would require actual changes in resource allocation, rather than a simple schedule change on paper. We are able to measure this operational component of on-time performance by using travel time as our dependent variable. As mentioned above, travel time does not depend on schedule time—it is the time elapsed from the scheduled departure to actual arrival. We present our results concerning travel time in column 5 of Table 3. Here, we see a very clear pattern of longer travel time prior to the entry threat and continuing following the entry threat and entry. The estimated long-run effect of an entry threat on travel time is an increase of two minutes over the baseline period (9–12 quarters prethreat), and the estimated long-run effect of entry on travel time is an increase of 2.3 minutes relative to the baseline period. Both are statistically significant. In Figure 1, we illustrate our results for travel time to help visualize the overall pattern we find. Figure 1 clearly reveals that around four quarters before the threat of entry (T-4), there is a marked increase in incumbents' travel time, with incumbents' travel time generally worsening through the postthreat and postentry periods.

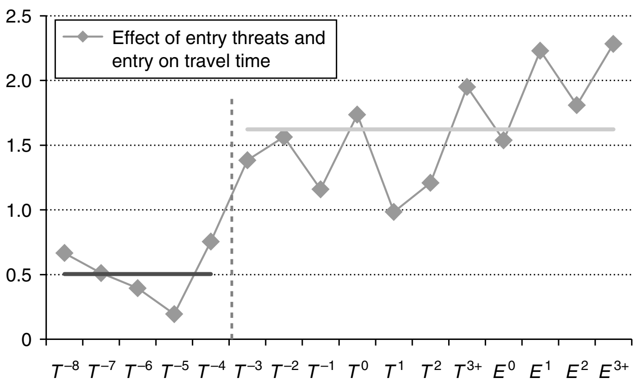
It is difficult to say precisely when airlines begin responding to the threat of entry by Southwest. The results in Table 3 indicate that incumbents' arrival delays worsen as early as eight quarters prior to Southwest threatening the route. However, the results show that delays in quarters 4–6 prior to Southwest threatening the route are usually smaller than those in the preceding quarters, and are usually not significantly different from the omitted comparison period. Moreover, the results for scheduled time, in column 4, indicate that the airlines shortened scheduled flight times 5–8 quarters before Southwest threatens the route, providing an explanation for the increase in arrival delays in these early periods. In column 5, we see that it is not until three quarters before being threatened by Southwest that airlines begin to increase travel time. The delays then generally remain elevated through the threat and entry by Southwest. This is consistent with the three arrival delay models, which all show a large increase in arrival delays, with no reduction in scheduled flight time, beginning three quarters before Southwest threatens the route. These results provide some suggestive evidence that, consistent with Goolsbee and Syverson (2008), the airlines generally begin to respond to the threat of entry about three quarters before Southwest enters the second endpoint airport of a route. As we note above, this concurrence of behavior is suggestive of a shift in overall strategy occurring at that time.

For all subsequent analyses, we report results only for travel time. This is because the results in Table 3 show that arrival delays may be influenced by changes in the scheduled flight time. And, given that there is no evidence that airlines adjust schedule time in response to entry or the threat of entry by Southwest, we focus our analysis on the other component of on-time performance that airlines do appear to adjust in response to entry and entry threats by Southwest, actual travel time.[25]

[24] As Mazzeo (2003) notes, it is difficult to assess the social welfare implications of our results, because we do not observe the demand response to the worsening in OTP.

[25] Our results using arrival delays are generally consistent with those obtained using travel time, with the discrepancies generally explained by changes in scheduled flight times occurring in the

Figure 1 Effect of Entry Threats and Entry on Incumbent Travel Time



To better assess our claim that airlines begin reducing their on-time performance about three quarters before Southwest threatens the route, we conduct a Wald test that compares the average travel time from T^{-3} (three quarters before a threat) forward through E^{3+} (3–12 quarters postentry), to the average travel time between T^{-8} and T^{-4} (eight to four quarters before a threat). The test statistic, which is statistically significant at 5%, indicates that, on average, travel time is about 1.1 minutes greater between T^{-3} and E^{3+} than it is between T^{-8} and T^{-4}.[26] To further assess whether incumbents begin responding three quarters before Southwest threatens the route, we conduct two additional Wald tests. The first compares travel time between T^{-8} and T^{-6} (8 and 6 quarters prethreat) with travel time between T^{-5} and T^{-4} (five and four quarters prethreat). The second compares travel time between T^{-8} and T^{-6} with travel time between T^{-3} and T^{-2} (three and two quarters prethreat). The first test shows no difference in travel time, and the second test shows that travel time increases by a statistically significant amount (nearly one minute) in the later period. These two tests bolster the belief that airlines begin cutting back on their on-time performance about three quarters before Southwest threatens the route. Taken together, the results in Table 3 provide strong evidence that airlines begin reducing or reallocating their on-time performance resources about three quarters before Southwest threatens their route.

5.2. Robustness of the Findings

In this subsection, we assess the robustness of our main findings. We first consider a falsification test to assess the validity of our results. To do so, we follow the approach used by Goolsbee and Syverson (2008). Here, we look at incumbents' OTP response at the primary airport(s) in a metropolitan area when Southwest threatens to enter or enters a secondary airport. For example, when Southwest began flying out of Orlando in 1994, it threatened the Orlando–Chicago Midway route because Southwest was already flying out of Chicago Midway. In this analysis, we examine incumbents' OTP response for those carriers flying the Orlando–Chicago O'Hare route (although Southwest does not serve O'Hare), rather than the Orlando–Chicago Midway route. To do so, we use the date of the entry threat into the airport that Southwest actually entered (in this example, we would use the date when Southwest began flying out of Orlando).

For this falsification test, there are five metropolitan markets where Southwest entered a secondary airport without also serving the primary airport(s). We use data from routes out of the following airports in these five metropolitan areas:

- LaGuardia, JFK, and Newark airports (Southwest threatens entry into routes from Islip, Long Island);
- Miami (Southwest threatens entry into routes from Ft. Lauderdale);
- Reagan National and Washington Dulles (Southwest threatens entry into routes from BWI);
- Boston (Southwest threatens entry into routes from Providence and Manchester);
- Chicago O'Hare (Southwest threatens entry into routes from Midway).

We report the results of this analysis in the first column of Table 4. The results are noticeably different from our baseline results (column 5 of Table 3). Although some coefficients are positive, we do not see the same consistent pattern of positive and statistically significant effects on travel time response; only one of the threat or entry coefficients is statistically significant. These results bolster the validity of our main results, providing additional evidence that the worsening in on-time performance that we observe is caused by Southwest's entry threat and entry and not by changes in local conditions.

Although the results of our falsification test cast doubt on the concern that changes in local conditions may be influencing both changes in on-time performance and influencing Southwest's entry decisions, it may still be the case that changes in conditions at the airports themselves may be biasing our results. This would be true if Southwest chooses to enter airports where on-time performance is worsening. We address this possibility in two different ways. First, we control for incumbents' on-time performance on routes between a threatened airport and airports that Southwest does not serve (using the 100 busiest U.S. airports). The idea is to use the incumbents' on-time performance on routes to and from airports not served by Southwest to control for other changes, unrelated to

time period well before strategic response to entry threats would be plausible (mainly 7–8 quarters prethreat).

[26] This amount understates the increase in travel time in the latter period because it does not give greater weight to the T^{3+} and E^{3+} periods, each of which comprise more than one quarter (but vary in length by route pair).

Table 4 Robustness Tests: Airport Selection and Falsification Test

	1	2
	Falsification test using nearby airports	Controlling for travel time on non-SW routes at endpoint airports
Travel time for non-SW routes from origin airport		−0.003
		(0.039)
Travel time for non-SW routes from destination airport		0.156
		(0.033)**
8 quarters prethreat (T^{-8})	−0.567	0.828
	(0.657)	(0.667)
7 quarters prethreat (T^{-7})	−0.768	1.263
	(0.794)	(0.792)
6 quarters prethreat (T^{-6})	−0.348	1.185
	(0.736)	(0.671)†
5 quarters prethreat (T^{-5})	−0.030	1.346
	(0.721)	(0.814)†
4 quarters prethreat (T^{-4})	1.178	1.998
	(0.918)	(0.913)*
3 quarters prethreat (T^{-3})	2.583	2.756
	(1.110)*	(0.952)**
2 quarters prethreat (T^{-2})	0.467	3.444
	(0.921)	(0.920)**
1 quarter prethreat (T^{-1})	0.387	2.440
	(1.087)	(0.926)**
Southwest threatens route (T^{0})	0.294	2.953
	(1.305)	(0.988)**
1 quarter postthreat (no flights) (T^{1})	0.536	2.486
	(1.231)	(1.175)*
2 quarters postthreat (no flights) (T^{2})	0.401	1.942
	(1.296)	(1.055)†
3–12 quarters postthreat (no flights) (T^{3+})	1.721	2.457
	(1.415)	(1.113)*
Southwest begins flying route (E^{0})	1.423	2.674
	(1.247)	(1.125)*
1 quarter postentry (E^{1})	1.384	3.193
	(1.631)	(1.237)*
2 quarters postentry (E^{2})	1.938	2.815
	(1.841)	(1.201)*
3–12 quarters postentry (E^{3+})	0.997	3.362
	(2.182)	(1.366)*
N	5,690	3,062

Notes. All models are weighted by the number of flights. All models include carrier-route-pair and carrier-quarter fixed effects and other controls shown in Table 1. Standard errors clustered by carrier-route-pair are reported in parentheses. Excluded category is quarters 9–12 prethreat.
†$p < 0.10$; *$p < 0.05$; **$p < 0.01$.

Southwest's imminent entry, at the threatened airports. For example, in the case of Southwest threatening to enter the Philadelphia–Jacksonville route, we would use the incumbent's on-time performance on flights between Philadelphia and Jacksonville and any airports that Southwest does not serve, such as Laguardia, Boston, Reagan National, etc.

We report the results of this analysis in the second column of Table 4. The pattern of results is very similar to those reported in our baseline model, though the effects in this model are actually larger. These results work against the possibility that our findings are driven by unobserved changes in the airports that Southwest threatens. We find no evidence that Southwest selects airports to enter where on-time performance is worsening.

The above results suggest that our results are not being biased by airport selection by Southwest. Nonetheless, we further explore this possibility by directly examining Southwest airport entry decisions. Using a standard hazard model, we assess whether worsening on-time performance (as measured by travel time) at an airport increased the hazard of entry by Southwest (for this analysis, we use the 100 busiest U.S. airports). In our model, we control for the average load factor at the airport in each quarter, the average number of flights on each route from the airport in each quarter, the number of flights departing from the airport each quarter, as well as year-quarter fixed effects. In addition, we control for annual total employment and population at the airport's metropolitan statistical area. We report the results of this analysis in column 1 of Table 5. The results show that the average travel time prior to Southwest's entry at the airport has no impact on Southwest's hazard of entry. Consistent with the results in Table 4, these results provide no evidence that Southwest chooses to enter airports where travel time is already worsening.

A potential concern with our hazard analysis using travel time as a regressor is that the effect of travel time may be primarily identified off of cross-sectional variation. If so, it does not adequately address the concern that Southwest may be entering a given airport at a time when that airport is performing unusually poorly (relative to its average). To address this concern,

Table 5 Southwest Airport Entry

	1	2
	Airport entry hazard	Airport entry hazard
Airport average travel time	−0.004	
	(0.005)	
Residual travel time on routes not served by Southwest		0.006
		(0.028)
Airport load factor	8.221	3.704
	(3.342)*	(2.432)
Airport average carrier flights on the route	−0.885	−0.085
	(0.462)	(0.315)
Flights departing from airport	−0.234	−0.390
	(0.206)	(0.197)
Ln(population)	−1.631	−0.910
	(1.858)	(1.756)
Ln(employment)	1.795	0.998
	(1.895)	(1.789)
N	3,828	3,656

Notes. These are discrete-time hazard models. All models include year-quarter fixed effects.
*$p < 0.05$.

we draw on the same approach that we used to control for the airport selection effects in column 2 of Table 4. We first rerun our baseline travel time regression, using only routes never served by Southwest. (We report these results in the appendix.) Because all of the threat and entry dummy variables are always zero for the routes that Southwest never serves, the regression only includes the control variables: load factor, the carrier's number of flights on the route, the number of flights at the endpoint airports, and the carrier-quarter and carrier-route fixed effects. Because these routes are not threatened by Southwest, the residuals from this regression capture that unobserved component of travel time at each airport that is not impacted by Southwest's entry decision (i.e., these residuals capture the same component of travel time that we attempt to control for in column 2 of Table 4). We then rerun our hazard model, including these travel time residuals, along with airport average load factor, airport average number of carrier flights per route, number of flights departing from the airport, and year-quarter fixed effects. This allows us to assess whether unobserved shocks to airport conditions, unrelated to Southwest's imminent entry, influenced Southwest's entry decision.

The results of this hazard analysis, which we report in column 2 of Table 5, show that unobserved shocks to travel time have no impact on Southwest's hazard of entry. Consistent with the results of the regression analysis in column 2 of Table 4, and consistent with the preceding hazard model results (in column 1 of this table), the results of this hazard model, using the travel time residuals, provide no evidence that Southwest chooses to enter airports where on-time performance is worsening.

To further test the robustness of our findings, we run our baseline travel time model using data only through the second quarter of 2001. Given the major structural change in the industry after September 2001, this analysis allows us to determine whether or not our results are driven by this shock. The results are in the first column of Table 6 and are very similar to our baseline results, indicating that our results are not being driven by the post-9/11 period.[27]

As an additional robustness check, we consider whether our results are driven by flights between airports that are not hubs for the carrier. Carriers might be more likely to worsen OTP on these routes because delays on these routes do not spill over to affect other routes on the carrier's network. To assess this possibility, we rerun our baseline model using a sample of flights that either originate or terminate at a carrier's hub. The results are in the second column of Table 6, and again are quite similar to our baseline results, suggesting that the non-hub flights are not driving our results.

Finally, we consider whether our results are being driven by heterogeneity among incumbents. More specifically, we assess whether our results for incumbent responses to Southwest entry and entry threats are driven by smaller incumbents who may be more likely

Table 6 Additional Robustness Tests: Pre-9/11 Only, Flights to/from Carrier's Hub Only, Seven Major Carriers Only

	1	2	3
	Pre-9/11	Flights to/from carrier's hub	Seven major carriers
8 quarters prethreat (T^{-8})	0.676	0.549	0.384
	(0.437)	(0.486)	(0.436)
7 quarters prethreat (T^{-7})	0.521	0.343	0.456
	(0.432)	(0.531)	(0.467)
6 quarters prethreat (T^{-6})	0.414	0.552	0.236
	(0.344)	(0.417)	(0.422)
5 quarters prethreat (T^{-5})	0.238	0.670	−0.117
	(0.472)	(0.554)	(0.539)
4 quarters prethreat (T^{-4})	0.807	1.035	0.502
	(0.507)	$(0.590)^{\dagger}$	(0.603)
3 quarters prethreat (T^{-3})	1.414	1.437	1.202
	$(0.590)^{*}$	$(0.636)^{*}$	$(0.666)^{\dagger}$
2 quarters prethreat (T^{-2})	1.615	1.511	1.270
	$(0.648)^{*}$	$(0.688)^{*}$	$(0.730)^{\dagger}$
1 quarter prethreat (T^{-1})	1.223	1.283	0.812
	$(0.660)^{\dagger}$	$(0.679)^{\dagger}$	(0.714)
Southwest threatens route (T^{0})	1.795	1.901	1.310
	$(0.743)^{*}$	$(0.755)^{*}$	$(0.783)^{\dagger}$
1 quarter postthreat (no flights) (T^{1})	0.996	1.058	0.686
	(0.787)	(0.825)	(0.864)
2 quarters postthreat (no flights) (T^{2})	1.214	1.544	0.890
	(0.840)	$(0.887)^{\dagger}$	(0.936)
3–12 quarters postthreat (no flights) (T^{3+})	1.856	2.707	1.835
	$(0.888)^{*}$	$(0.834)^{**}$	$(0.936)^{\dagger}$
Southwest begins flying route (E^{0})	1.535	1.658	1.539
	$(0.836)^{\dagger}$	$(0.891)^{\dagger}$	$(0.894)^{\dagger}$
1 quarter postentry (E^{1})	2.215	1.955	2.278
	$(0.910)^{*}$	$(0.992)^{*}$	$(1.007)^{*}$
2 quarters postentry (E^{2})	1.772	1.497	1.598
	$(0.976)^{\dagger}$	(1.051)	(1.047)
3–12 quarters postentry (E^{3+})	2.248	2.349	2.360
	$(1.056)^{*}$	$(1.160)^{*}$	$(1.153)^{*}$
N	4,535	2,773	3,728

Notes. All models are weighted by the number of flights. All models include carrier-route-pair and carrier-quarter fixed effects. All models include other controls shown in Table 1. Standard errors clustered by carrier-route-pair are reported in parentheses. Excluded category is quarters 9–12 prethreat.
$^{\dagger}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$.

[27] We also note here that our findings are robust to alternative definitions of the baseline period (e.g., 5–12 quarters prethreat and 5–8 quarters prethreat, as opposed to 9–12 quarters prethreat). The results start to lose statistical significance as the baseline period moves forward up to 3–6 quarters prethreat; however, this is to be expected if response to threats largely began approximately three quarters prethreat, as our main results suggest. Our results are also robust to extensions of the baseline period (e.g., 13–16, 9–16, and 5–16 quarters prethreat). Lastly, our control for load factor could be problematic if demand responds to on-time performance, so we have replicated our analysis excluding this variable; the results change minimally.

to fight aggressively in response to Southwest entry threats. To assess this possibility, we rerun our baseline model only including the seven major carriers: American, Continental, Delta, Northwest, TWA, United, and USAir. The results are in the third column of Table 6, and once again, the results are very similar to our baseline results using the full sample, suggesting that responses by smaller incumbents are not driving our results.

5.3. Results for Other Entrants

A key aspect of our logic, developed in §2, is that incumbent airlines would choose to worsen OTP in response to entry threats and entry by Southwest for one of two reasons: As part of a cost- and price-cutting strategy designed to deter and fight entry by Southwest, or to differentiate away from Southwest's superior OTP. The cost/price-cutting hypothesis suggests that airlines should not worsen OTP (as a means to cut costs) as much (or should improve OTP) in response to (potential) entrants who have higher costs than Southwest does (e.g., non-LCCs), and that incumbents should similarly worsen OTP for (potential) entrants with comparably (to Southwest) low costs (e.g., other LCCs). In contrast, the differentiation hypothesis suggests that incumbents will worsen OTP in response to (potential) entrants with high OTP (e.g., Jet Blue or Northwest) and improve OTP in response to (potential) entrants with low OTP (e.g., United, Delta, or Alaskan Airlines).

To test these hypotheses, we examine incumbents' response to entry and entry threats by other airlines. To do so, for each national carrier in the on-time performance data set, we identify the sample of routes threatened by that airline between 1993–2004, following the same approach that we used for our sample of routes threatened by Southwest (here we expand the sample to include all of the 100 busiest U.S. airports, not just those served by Southwest).[28] We then examine incumbents' responses to entry and entry threats by each of these airlines and try to determine whether the pattern of responses corresponds more closely to the cost/price cutting hypothesis or the differentiation hypothesis.

The results of this analysis are in Table 7. Although it is difficult to summarize so many results across 12 regressions, we note several important findings. In seven cases,[29] the Wald test is actually negative, indicating that incumbent travel time actually improved in the period from T^{-3} to E^{3+}. Only in the cases of entry threats/entry by Air Tran, Alaskan Airlines, Jet Blue, and Northwest, do we see positive Wald tests, with Jet Blue providing the sole significant test statistic. Similarly, in only two of the regressions, those for Air Tran and Jet Blue, do we see incumbents' travel time begin to increase about three quarters prior to the entry threat and remain elevated through the threat and entry period. Both the E^{3+} and T^{3+} coefficients were positive and statistically significant for these two (potential) entrants; neither the E^{3+} nor T^{3+} coefficient was positive and statistically significant in any other case. In contrast, we observe a statistically significant improvement in performance in response to entry and entry threats by Frontier and America West.

Taken together these results seem to provide some tentative support for the cost/price cutting hypothesis over the differentiation hypothesis. Specifically, the three airlines for which we observe a pattern of worsening incumbent OTP performance beginning approximately three quarters before a threat (Southwest, Air Tran, and Jet Blue) are among the four lowest cost airlines (America West being the exception). In contrast, although Jet Blue (a leader in OTP) induces a worsening of OTP by incumbents, none of the four potential entrants with the next best OTP records (Northwest, American, Continental, and USAir), provide any evidence of causing incumbents to worsen OTP in response to entry or entry threats. Moreover, Air Tran, the other (potential) entrant that induces incumbents to worsen OTP in response to entry threats and entry has the lowest on-time arrival record of any airline in the sample.

Although the above evidence is suggestive, it is difficult to draw a strong conclusion in favor of the cost/price cutting hypothesis, since (potential) entry by two LCCs (America West and Frontier) caused OTP improvements by incumbents. However, it is noteworthy that (potential) entry by two non-LCCs (TWA and Delta) caused largely similar OTP responses (in direction and magnitude) by incumbents, although no non-LCCs generated patterns anywhere close to those of Southwest, Jet Blue, and AirTran. Further, unlike the differentiation hypothesis, the cost/price cutting hypothesis does not have a clear prediction concerning incumbent OTP response to entrants with high operating costs.

We also attempt to more systematically assess these two hypotheses by examining the relationship between each (potential) entrant's historical cost and OTP provision with incumbent responses observed in Tables 3 and 7. We use overall on-time arrival rates of the (potential) entrants between October 1987 and December 1998 (reported in Table 1) to provide a measure of their OTP record (we use data from 1987 through the end of 1998, the midpoint of our sample, because it is the airline's previous/established record of OTP that

[28] We exclude smaller regional affiliate carriers such as American Eagle.

[29] We are unable to calculate a Wald test statistic for American, because there were insufficient observations to identify the E^{3+} coefficient. However, when we do a Wald test comparing T^{-3} to E^{+2} versus T^{-8} to T^{-4}, the resulting Wald test statistic is negative (−1.070).

Table 7 Incumbents' Travel-Time Response to Entry and Entry Threats by Other Airlines

Routes threatened by:	1 Air Tran	2 Alaska Airlines	3 America West	4 American	5 Continental	6 Delta	7 Frontier	8 Jet Blue	9 Northwest	10 TWA	11 United	12 USAir
8 quarters prethreat (T^{-8})	0.760	−0.259	0.564	−2.043	0.764	−1.769	0.048	−0.020	−0.307	−0.860	1.149	0.066
	(0.278)**	(0.162)	(0.192)**	(0.886)*	(0.270)	(0.537)**	(0.164)	(0.255)	(0.279)	(0.439)†	(1.374)	(0.457)
7 quarters prethreat (T^{-7})	0.600	−0.212	0.037	2.073	1.794	1.250	−0.423	0.505	0.020	−0.054	0.092	−0.128
	(0.310)†	(0.198)	(0.191)	(1.278)	(0.325)	(0.900)	(0.226)†	(0.341)	(0.375)	(0.433)	(0.956)	(0.665)
6 quarters prethreat (T^{-6})	0.510	0.148	0.151	1.897	0.409	0.657	−0.503	0.967	−0.6018	0.413	3.743	1.707
	(0.339)	(0.215)	(0.202)	(1.426)	(0.362)	(0.606)	(0.276)†	(0.432)*	(0.503)	(0.520)	(1.097)**	(0.851)*
5 quarters prethreat (T^{-5})	0.349	0.177	−0.445	1.452	0.315	2.497	−0.200	0.564	−0.596	−0.498	4.523	1.725
	(0.363)	(0.245)	(0.226)*	(1.194)	(0.400)	(0.933)**	(0.315)	(0.430)	(0.504)	(0.573)	(1.093)**	(0.981)†
4 quarters prethreat (T^{-4})	0.786	0.064	0.085	0.128	0.498	−0.086	−0.306	1.258	0.729	−0.376	2.313	1.776
	(0.406)†	(0.290)	(0.223)	(0.764)	(0.459)	(0.591)	(0.341)	(0.488)*	(0.539)	(0.572)	(1.279)†	(1.120)†
3 quarters prethreat (T^{-3})	0.933	0.090	−0.632	0.663	0.636	−0.086	−0.354	0.948	−0.186	−0.989	−1.502	1.034
	(0.432)*	(0.285)	(0.239)**	(0.718)	(0.485)	(0.626)	(0.360)	(0.539)†	(0.580)	(0.698)	(0.988)	(1.212)
2 quarters prethreat (T^{-2})	0.774	0.401	−0.249	0.601	0.719	−1.243	−0.793	1.238	0.055	−0.078	−1.828	1.682
	(0.463)†	(0.305)	(0.271)	(0.781)	(0.565)	(0.829)	(0.380)*	(0.580)*	(0.629)	(0.668)	(1.315)	(1.330)
1 quarter prethreat (T^{-1})	0.467	0.392	−0.163	1.494	1.062	−0.668	−0.515	1.474	−0.003	−0.505	−3.773	0.765
	(0.482)	(0.338)	(0.286)	(1.214)	(0.569)†	(0.824)	(0.416)	(0.658)*	(0.697)	(0.769)	(1.307)**	(1.455)
Entrant threatens route (T^{0})	1.012	0.161	0.087	−0.738	0.390	−0.543	−0.149	1.830	0.690	−0.616	−11.282	0.046
	(0.551)†	(0.387)	(0.315)	(0.993)	(0.591)	(0.691)	(0.477)	(0.691)**	(0.717)	(0.833)	(7.411)	(1.506)
1 quarter postthreat (no flights) (T^{+1})	0.723	−0.112	−0.596	−0.337	1.358	−2.173	−0.810	1.387	0.245	−1.541	3.176	0.482
	(0.585)	(0.452)	(0.343)†	(2.857)	(0.707)†	(1.055)*	(0.522)	(0.775)†	(0.726)	(0.903)†	(8.560)	(1.697)
2 quarters postthreat (no flights) (T^{+2})	1.233	−0.120	−0.402	−1.971	1.580	−0.305	−1.535	2.139	0.086	−0.781	3.732	0.983
	(0.610)*	(0.473)	(0.370)	(3.471)	(0.714)*	(1.013)	(0.550)**	(0.863)*	(0.727)	(0.888)	(8.937)	(2.045)
3–12 quarters postthreat (no flights) (T^{3+})	1.263	−0.251	−0.418	0.044	0.812	−1.017	−0.932	3.353	0.587	−1.226	2.456	1.179
	(0.666)†	(0.515)	(0.429)	(1.783)	(0.754)	(0.996)	(0.631)	(0.996)**	(0.847)	(1.041)	(8.458)	(2.241)
Entrant begins flying route (E^{0})	1.277	0.483	−0.523	−0.458	0.452	−2.063	−1.344	2.425	−0.055	0.034	−3.139	−1.259
	(0.703)†	(0.650)	(0.553)	(1.783)	(0.748)	(0.971)*	(0.711)†	(1.135)*	(0.903)	(1.174)	(9.436)	(2.249)
1 quarter postentry (E^{+1})	1.629	0.150	−0.737	−0.091	0.629	−0.203	−1.272	0.665	0.442	−0.467	−5.675	−0.041
	(0.789)*	(0.718)	(0.611)	(2.665)	(0.790)	(0.817)	(0.777)	(1.092)	(0.963)	(1.380)	(9.477)	(2.428)
2 quarters postentry (E^{+2})	1.427	0.116	−0.781	−2.892	−0.026	−0.608	−1.854	1.242	0.207	−1.782	−1.756	1.567
	(0.788)†	(0.724)	(0.590)	(2.724)	(0.870)	(1.162)	(0.928)*	(1.171)	(1.044)	(1.233)	(9.440)	(2.741)
3–12 quarters postentry (E^{3+})	2.444	−0.832	−0.326		0.646	0.798	−2.272	2.159	1.102	−1.683	−2.939	4.605
	(0.993)*	(0.714)	(0.600)		(0.881)	(1.002)	(0.830)**	(1.295)†	(1.030)	(1.293)	(9.299)	(3.309)
Wald test: (T^{-3} to E^{3+})–(T^{-8} to T^{-4})	0.598	0.060	−0.509†		−0.005	−1.426	−0.799*	1.059†	0.440	−0.601	−4.451	−0.015
LCC	Y		Y				Y	Y				
OTP ranking (1987–2004)	12	11	5	4	6	9	NA	2	3	8	10	7
N	20,433	48,587	32,370	2,598	16,057	1,296	35,276	6,388	8,723	9,415	1,217	9,611

Notes. All models are weighted by the number of flights. All models include carrier-route-pair and carrier-quarter fixed effects. Standard errors clustered by carrier-route-pair are reported in parentheses. Excluded category is quarters 9–12 prethreat.
$^{\dagger}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$.

affects incumbent responses).[30] Similarly, we use cost measures for the (potential) entrants between 1990 and 1998 (since these data begin in 1990 and we again stop at the midpoint of our sample).

In Table 8, we list each (potential) entrant's normalized on-time arrival rate and costs along with the corresponding Wald test statistic, and incumbents' long-run response to entry threats and entry by that airline (the coefficients for T^{3+} and E^{3+}). At the bottom of the table, we report the correlations of the on-time arrival rates with the Wald test statistics, and the long-run response to entry threats and entry. Consistent with the differentiation hypothesis, the negative correlations indicate that incumbents worsen OTP more in response to entry threats by carriers with better records of OTP provision. The smaller negative correlations, along with the positive correlation with E^{3+}, provide little support for the cost/price cutting hypothesis, as they provide little evidence that incumbents worsen OTP more in response to lower-cost (potential) entrants.[31] However,

[30] For Air Tran and Jet Blue, we use on-time arrival rates for 2003 and 2004, the first two years that these airlines enter the on-time performance data set. Similarly, for Frontier, we use on-time arrival rates from 2005, its first year in the data set.

[31] One possible concern with our results for these (potential) entrants, which are generally hub-and-spoke airlines, is that the (potential) entrant's presence at two airports may not be perceived as a "threat" by incumbents when both airports are spokes in the (potential) entrant's network. For example, when United began operating out of El Paso airport in 2002, it threatened the Atlanta-El Paso

Table 8 (Potential) Entrants' On-Time Performance Ranking (September 1987–December 1998) and Incumbent Responses to Entry Threats and Entry

(Potential) entrant	Normalized annual fraction of flights arriving at least 15 minutes late (1987–1998)	Normalized annual cost per available seat mile (1990–1998)	Wald test: (T^{-3} to E^{3+})–(T^{-8} to T^{-4})	Incumbent long-run response to entry threat (T^{3+})	Incumbent long-run response to entry (E^{3+})
Air Tran[a]	0.59	−0.788	0.598	1.263	2.444
Alaska Air	0.201	0.437	0.06	−0.251	−0.832
America West	−0.403	−1.25	−0.509	−0.418	−0.326
American	−0.25	−0.027		0.044	
Continental	0.236	−0.168	−0.005	0.812	0.646
Delta	0.587	0.132	−1.247	−1.017	0.798
Frontier[b]	−0.818	−0.36	−0.799	−0.932	−2.272
Jet Blue[c]	−0.678	−0.681	1.059	3.353	2.159
Northwest	−0.306	0.008	0.437	0.587	1.095
TWA	0.477	0.136	−0.601	−1.226	−1.683
United	0.623	0.216	−4.451	2.457	−3.017
USAir	−0.012	1.997	−0.059	1.179	4.512
Southwest	−1.392	−1.15	1.119	1.951	2.284
		Correlation with OTP	−0.576	−0.378	−0.416
		Correlation with cost	−0.242	−0.101	0.176

[a]OTP data are for 2003 and 2004; cost data are for 1994–1998.
[b]OTP data are for 2005 and cost data are for 1994–1998.
[c]OTP data are for 2003 and 2004; cost data are for 2000–2004.

this evidence should only be considered tentative, because in Table 8 we are treating all of the estimates of incumbent response (coefficients on T^{3+} and E^{3+}, and Wald test statistics) equally, regardless of their level of precision (i.e., there is notable variation in standard errors). For example, many confidence intervals for these measures include both positive and negative numbers, implying the signs of these correlations are not highly definitive.

In sum, we are unable to clearly discriminate between these two hypotheses. We find some tentative evidence in support of each, and some evidence that is inconsistent with each. However, at the very least, these additional results clearly indicate that the phenomenon of incumbents worsening OTP in response to (potential) entry that we pinned down for Southwest is only replicated by other LCCs, not all of which are top performers in OTP. Hence, this particular (perhaps surprising) strategic response seems best characterized as one that is caused by entry threats and entry by LCCs only.

6. Discussion and Conclusions

We examine whether entry and entry threats by Southwest Airlines cause incumbent airlines to improve their on-time performance as a way to protect their market share. Perhaps surprisingly, our results show that airlines do not improve on-time performance in response to Southwest entry and entry threats; rather, incumbent on-time performance worsened. We show this finding is robust to a wide range of specifications and controls.

In light of this finding, we consider two explanations for this finding: incumbents worsen OTP in an effort to cut costs in order to compete against Southwest's low costs/prices; or incumbents worsen OTP to differentiate away from Southwest, the top-performing airline on this dimension of quality. We attempt to test these two explanations by comparing incumbent responses to entry threats and entry by carriers with varying degrees of OTP provision and operating costs. We find evidence partially supportive of both hypotheses. Although neither hypothesis is fully supported, it is noteworthy that the phenomenon of worsening on-time performance can only be observed when the (potential) entrant is a low-cost carrier (Southwest, Jet Blue, and AirTran).

Future work may be able to draw even stronger conclusions about the underlying mechanism(s). As mentioned in the Introduction and §2, strategic changes in OTP may coincide with movements along other quality dimensions as well (e.g., in-flight amenities, baggage management, etc.). Measuring how these other dimensions change along with OTP may provide insights about if and how airlines are engaging in a general quality repositioning. In addition, if other dimensions are not changing, then one can more thoroughly test the differentiation hypothesis by assessing whether incumbents who improve OTP in response to entry (threats) also increase prices in response to entry

route (it already operated out of Atlanta). However, Delta, which offered nonstop service on the Atlanta-El Paso route was likely not concerned that United would enter this route, recognizing that United would only provide service connecting Atlanta and El Paso through its Dallas-Fort Worth hub. To control for this issue, we rerun our analyses for each (potential) entrant, limiting the sample in each case to flights to or from the (potential) entrant's hub(s). In this way, we isolate those cases where the likelihood of entry is relatively high. When we do so, we find that our results are virtually unchanged; incumbents still do not respond to entry threats or entry by this group.

(threats). The challenge for researchers is to find other markets where we can measure quality as we can with airline OTP. Finding such data for other markets would also enable researchers to assess whether the worsening in quality we find extends beyond airlines; as just one example, we might ask whether entry (threats) for local broadband Internet stymie or accelerate incumbents' growth rates for data speeds.

Our findings generate several key takeaways. First, they show that entry and entry threats by at least some airlines can cause incumbents to reduce their on-time performance. Further, although prior theoretical and empirical work often suggests that average quality and competition are positively correlated, our results show that, even for an industry where this relationship appears to hold, it does not imply that each firm will improve its quality in response to new competition, or the threat of it. More broadly, our findings suggest that the welfare implications of (potential) entry likely depend on the entrant, and may involve the average consumer actually experiencing lower quality.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/mnsc.2014.1918.

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Appendix. Travel-Time Regression for Routes Never Threatened by Southwest

	Travel time
Load factor	7.491
	(1.206)**
Carrier flights on the route	−0.445
	(0.332)
Flights arriving at destination airport	2.450
	(0.421)**
Flights departing from origination airport	3.747
	(0.393)**
N	78,074

Notes. All models are weighted by the number of flights. All models include carrier-route-pair and carrier-quarter fixed effects. Standard errors clustered by carrier-route-pair are reported in parentheses.
$^{**}p < 0.01$.

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