# Can Regulation Improve Service Quality? Evidence from European Airline Passenger Rights

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**Abstract**

European Air Passenger rights regulation makes carriers liable to care and compensation in case of poor service, such as long delays. This regulation has uniform coverage for flights originating in the EU, but covers only EU carriers on flights departing outside EU but bound for EU. Exploiting this variation in coverage, we find that the regulation causes a reduction in average airline delay of over 4 minutes. Delay reduction is strongest on routes with weak competition and originating in North America as compared to Asia. These findings suggest that consumer rights regulation can be effective not just for redress, but also improve service quality.

*Keywords:* flight delays, service quality, regulation, EC261/2004, consumer protection
*JEL:* L51, L93, K23, D22, L15

## 1. Introduction

When the market appears to fail consumers through poor service, policy-makers look for regulatory instruments to address the issue. Flight delay is a case in point. It is a serious quality issue in the airline industry, with the average flight arriving around twelve minutes late and one-quarter of flights have a delay exceeding 15 minutes.[1] Three-quarters of delay minutes are caused by airline operations or late arriving aircraft. But when a delay occurs, passengers are often left to bear the burden – be it in terms of inconvenince, lost time or incremental expenses.[2] This apparent inequity has triggered various policy

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[1]This is true in both the US and Europe. See Eurocontrol (2007), DOT

[2]See Ball et al. (2010)

responses to mitigate airline delay. In the US, the Department of Transport has operated a market transparency program since 1987, under which monthly "on-time" reports are published for the major airlines.[3] The European Union instead addresses airline service through a comprehensive "passenger rights" legislation (Bobek and Prassl, 2016), which grants passengers rights to assistance – such as meals and hotel accomodation – as well as cash compensation in case of poor service quality, such as long delay. So far, little is known about the *effectiveness* of these policies in improving service quality, although there is evidence that airlines seek to "game" regulations at the margin.

This paper provides robust evidence that the European passenger rights regulation is effective in reducing average flight delay. Our main estimate an average treatment effect of the regulation of 4.92 minutes of delay reduction. This impact is clearly economically important in magnitude. Statistically, the hypothesis of no impact can very firmly rejected, and the result is robust to alternative specifications. Moreover, we find that the regulation is most effective at delay reduction on routes where competition is low.

Our identification strategy exploits variation in regulatory coverage based on the country of origin of the carrier, and the direction of the flight. This interesting source of variation arises from the partial extra–territorial application of the European passenger rights regulation. On routes originating in a non-EU country with a destination in an EU country, flights operated by carrier registered in the EU are covered under the regulation, while those operated by a non-EU carrier are not. However, all flights originating from an EU airport are covered the regulation, irrespective of country of origin of the carrier. Hence, non–EU carriers are covered by the regulation only when departing from a EU airport. This makes it possible to identify the impact of the regulation while allowing for carrier fixed effects *and* controlling for route-time effects (arising e.g. due to airspace congestion).

Existing evidence on airline service regulation is focused on possible gaming at the margin rather than overall effectiveness. Forbes et al. (2015) study how airlines respond to incentives to "game" the US Department of Transport on-time market transparency

[3]Additional policies to impprove on-time performance were implemented (Winston, 2013, p. 798). The Federal Aviation Authority (FAA) also introduced quotas for take-offs and landings at the most congested airports ("slot control") in a bid to reduce delays. Moreover there are fines for carriers with excessive tarmac delays, as discussed below.

program. Under the program, a flight is classified as on-time if delay is less than 15 minutes; this creates particularly strong incentives to reduce reported delay when a flight is expected to have delay just above this threshold. Forbes et al. (2015) find that airlines which self-report their delay time misreport arrival times for flights arriving just after the 15 minute threshold. Second, some airlines which operate employee bonus programs that reward performance according to the DOT ranking show similar threshold effects even with automatic reporting; thus suggests that flights at risk of missing the 15 minute mark may be marginally accelerated. These findings show that the DOT program is subject to gaming at threshold, but the authors do not seek to address whether the transparency program makes any meaningful difference to overall airline delays. Relatedly, Fukui and Nagata (2014) study the DOT's tarmac delay rule, which penalizes airlines holding passengers on the tarmac for more than three hours with considerable fines (up to $27,500 per passenger). They likewise find evidence consistent with gaming: flights at risk of long tarmac delay may be cancelled, and the introduction of the rule may have caused longer gate departure delay.

Small changes in airline policy can have significant impacts on delay reduction. Nicolae et al. (2016) consider checked baggage fees in the US. Charging for baggage may reduce the number of baggage items passengers carry, reducing utilization of ground services and making plane loading faster (they refer to this as the "below-the cabin effect"). Nicolae et al. (2016) find that carrers introducing baggage fees saw a median in reduction in departure delay of 3.3 minutes relative to competing carriers that did not.

On-time performance of airlines is related to competition, although results have found different results. The classic study of Mazzeo (2003) found delays to be especially high on routes where only a single carrier is active. However, Ater and Orlov (2015) study the effect of internet penetration, and find the associated increase in competition to lead to lower prices but also longer scheduled durations and more delay. Prince and Simon (2014) find that entry (threats) by Southwest worsens on-time performance. But in Europe, LCC entry may improve on-time performance (Bubalo and Gaggero, 2015).

## 2. Airline Passenger Rights Regulation

Airline passenger rights in the European Union are laid down in Regulation 261/2004 (henceforth EC261). With the aim of "ensuring a high level of protection for passengers",

the regulation grants passengers certain rights against the carrier operating the flight,[4] should certain *liability events* arise. The regulation is mandatory, so passengers and airlines cannot agree through conditions of carriage to limit or waive rights created by the regulation. This is one aspect that makes the European regulation rather unique: in the US, regulators impose obligations on carriers directly, but do not directly mandate terms in the conditions of carriage regarding delay.

Of central interest in this paper are passenger rights in case of flight delay. The regulation is concerned with "long delays" in arrival *at the final destination* exceeding three hours. Thus, missed connecting flights qualify as a reason for long delay. In case of a long delay, passengers have a right to care and assistance. This includes free phone calls, meal vouchers and – in case of overnight stays – hotel accomodation, which must be fully covered by the operating carrier. Such care must always be granted, irrespective of who is at fault for the delay. Additionally, passengers receive a substantial cash compensation for lost time due unless the airline can prove the delay to have been caused by "exceptional circumstances". This compensation ranges from EUR 250 for a three-hour delay on a short flight of less than 1500km or EUR 600 for a delay of at least four hours on a long-haul flight with distance exceeding 3500km. Reflecting the motive of compensation, these cash payments are not bounded by the ticket price; thus, the airline may well need to refund more than 100% of the ticket price in case of long delay. Part (a) of panel 1 summarizes these remedies under the EC261 regulation.

Coverage of the regulation is almost, but not fully, universal. All flights departing from an airport located in the European Union[5] fall under the scope of EC261, although – depending on the flight category – there is some variation in the amount of cash compensation passengers are entitled to. The situation is more interesting for routes headed to an EU-airport but originating outside the EU. On such routes, flights operated by carrier from an EU member state must grant EC261 passenger rights. But flights operated by non-EU carriers are under no such obligation. And in practice, non-EU carriers also do not voluntarily grant equivalent passenger rights on these routes. This pattern of coverage reflects a trade-off between ensuring consumer protection for passengers and

[4]The *operating carrier* is always liable under the regulation, irrespective if the ticket was sold through another carrier.

[5]Additionally, some non-EU countries also apply the regulation. Examples include Switzerland and Norway. When we talk of "EU countries", we mean to include also non-EU countries which apply EC261.

PANEL 1
EU261 Passenger Rights: The Case of Long Delay

- **Right to care**
  phone calls, meals, hotel accomodation "according to the principle of proportionality"
- **Re-routing** to reduce delay or reimbursement of ticket
- **Cash compensation** for lost time, according to flight category and length of delay:

| Flight Category | Distance (km) | Delay | Compensation |
|---|---|---|---|
| 1 | $\leq 1500$ | 3h | EUR 250 |
| 2 | $1500 - 3500$ | 3h | EUR 400 |
| 3 | $> 3500$ | 3h-4h | EUR 300 |
| | | $\geq$ 4h | EUR 600 |

(a) Remedies for Delay

| | | Flight Direction | |
|---|---|---|---|
| | | Inbound to EU | Outbound from EU |
| Carrier | EU Carrier | Yes | Yes |
| Origin | Non-EU Carrier | No | Yes |

(b) Coverage of EU261 on Flights Involving a Non-EU Airport

*Source: Compiled by authors based on Bobek and Prassl (2016) and European Union (2016)*

limiting extra-territorial application of what is domestic EU law.

Potential effects of the regulation fall into two categories. First, there is an *insurance* dimension as a direct consequence of care and compensation in case of poor service. But second there is a *service quality* dimension: airlines may react to passenger rights as an implicit tax on low quality, and hence increase their service quality. From a welfare perspective, this service quality effect is likely to be crucial, as any actions that airlines take to reduce expected delay or delay variability benefit all passengers. Evaluating the strength of the service quality channel is our key objective in what follows.

The partial application of EC261 to non-EU carriers provides variation that makes identification of the service quality impact of the regulation possible. On routes headed

for Europe, the difference in delay between EU and non-EU carriers contains some information about the effectiveness of EC261 in reducing airline delay. By comparing flights operating on the same route and around the same time, it is possible to control for systemic causes of delay such as airport congestion or weather conditions. However, this simple difference could potentially be confounded by other factors. For example, we cannot rule out a priori that European airlines are more punctual than their North American competitors. To control for such differences, the reverse direction – flights originating in the EU and headed for a non-EU destination – is useful: due to the universal application of EC261 in this direction, cross-carrier variation in delay can be used to control for airline-fixed effects. In the analysis that follows, we use various panel designs exploiting this legal quirk.

EC261 was significantly shaped over time by case law and implemented gradually against the continued opposition of airlines. This is particularly true for delay compensation. The original text of the regulation explicitly rules out cash compensation for delay, reserving it for the case of flight cancellation. However, in the controversial landmark *Sturgeon case* (Garben, 2013), the European Court of Justice determined that a long delay has equivalent effect to a cancellation, and accordingly compensation should be paid. This ruling thus drastically broadened the scope of EC261 compared to earlier practice. However, public awareness of passenger rights was initially low, leading few passengers to make the claims they were entitled to (European Commission, 2014). It also met fierce resistance from airlines, who initially refused to apply the ruling to those few passengers that did seek compensation. Over time, so–called "claims agencies" proliferated. These agencies charge a contingency fee to distressed passengers, and credibly threaten to sue airlines in case of non-compliance with the *Sturgeon* ruling. Over time, these developments made the initial opposition of airlines untenable, and rising public awareness may have caused an increase in claims. Due to this gradual implementation, before/after analyses are not feasible to assess the impact of EC261.

European Passenger rights in case of delay are exceptionally strong compared other major aviation markets. The international situation is surveyed in ICAO (2013). In the US, the Department of Transport relies on the market, aided by its delay transparency program, to deal with airline delay.[6] Its *Consumer Guide to Air Travel* informs passen-

[6]However, in 2011 Civil Aviation Authority created a right to compensation in case of denied boarding,

gers that "there are no federal requirements" for assistance or care in case of delays; passengers are advised to take note of each airline's "own policies" and engage in "defensive planning". Similarly, the Canadian Transportation Agency follows a "circumstance-focused approach" to passenger rights in lieu of comprehensive passenger rights legislation. Notably, Israel and Saudi Arabia introduced passenger rights legislation including assistance and compensation in case of long delays; however, their specific regulations are beyond the scope of the present paper. From a global perspective, the potential of airline passenger rights is still largely untapped.

Airlines sometimes implement voluntary approaches to ease the burden on passengers affected by extreme delays. In the US, some airlines offer discounted hotel accomodation in case of delay ("distressed passenger rate"). Others encourage consumers to purchase third-party travel insurance, which may provide assistance in case of delay. Finally, some airlines offer delay insurance as an ancillary purchase, perhaps to signal their reliability. For example, one European low-cost carrier offers an "On-time Guarantee" at a charge of EUR 10; in case of a delay exceeding one hour, the "guarantee" pays EUR 100 in flight vouchers to the consumer. Clearly, the protection offered here is more limited than under EC261; whether this reflects a market failure or simply low consumer demand for insurance is a separate issue we do not seek to tackle here.

## 3. Identifying the EC261 Effect

Our cross-sectional unit is a flight number, indexed $f$, and time unit $t$ is a calendar day. For each flight number, we observe the $\text{route}_f$ on which it is operated, whether this route starts in a non-EU airport and terminates in an EU airport (denoted by $\text{eu.bound}_f$). We also have the $\text{airline}_f$ which is operating the flight as well as whether this airline is "Community Carrier" under EC261 (denoted by $\text{eu.carrier}_f$), and whether the flight departs from an airline hub, denoted $\text{from.hub}_f$.

Then our primary estimating equation follows a fixed effects strategy and is given by

$$y_{ft} = \beta \text{eu.carrier}_f \times \text{eu.bound}_f + \theta_{\text{route}_f,t} + \text{airline}_f + \mathbf{X}_{ft} + \epsilon_{ft} \quad (1)$$

following the EC261 model for this specific liability event.

where $y_{ft}$ is our dependent variable of interest, primarily gate departure delay. Our main goal is to estimate $\beta$, the impact of being covered by the EC261 which is estimated using within-route variations in coverage on EU-bound flights, as discussed above. We allow for airline fixed effects to capture innate differences between, which is standard. Moreover, we allow for a *route-time* fixed effect, which controls for transient, route-specific factors such as airspace congestion or local conditions at either arrival or departure airport. Inclusion of route-time fixed effects is a particular luxury of our setting because our variation is *within* the route-time dimension, while other airline delay studies typically explore market or policy changes collinear with route-time.

Controlling for route-time fixed effects is potentially crucial in the European setting, and particularly for Heathrow airport. To reduce environmental pollution and increase safety, European air traffic control (ATC) works according to a slot control system. Under this system, ATC assigns a Calculated Time of Take Off (CTOT) taking into account expected conditions at the arrival airport based upon the predicted time of arrival. The objective of this system is to reduce the time planes spend flying in a "holding pattern" over the arrival airport in wait of a landing slot.[7] An important consequence is that a departure in, say, Miami, may be delayed due to expected congestion in Heathrow 9 hours later. Since Heathrow is one of the most congested airports in Europe, the ability to include route-time fixed effects is particularly valuable for our present study.

It remains to decide on a control strategy, i.e. determining $\mathbf{X}_f t$. Due to route-time fixed effects, standard controls such as weather, airport concentration, congestion indices or demographic variables, are not required. Instead, we have to control for possible confounding factors that are correlated with $\text{eu.carrier}_f \times \text{eu.bound}_f$ after removing airline and route-day group means.

Based on the literature, the need to control for airline-hub status is clear. Mayer and Sinai (2003) conduct a study of determinants of excess travel time for US domestic flights; after controlling for airport-level covariates (airport hub size and airport concentration), which in our design would be absorbed by route-time FEs, they find that airline hubbing is a significant determinant of excess travel time.[8] Relatedly, Rupp (2009) con-

[7]See Eurocontrol (2016) for a concise discussion of slot control.

[8]Determinants of delay are similar in Europe but coefficients differ, according to Santos and Robin (2010), who use a similar study design.

ducts a study with similar controls but departure delay as a dependent variable, which is most closely related to our dependent variable. His results indicate a statistically significant increase in departure delay from airline hubs, ranging from 1.07 to 2.38 minutes depending on hub size at origin; hub status has destination has no impact on departure delay.[9].

Our baseline control strategy is to include an airline-hub indicator. This takes the value one if a carrier is operating connecting flights between the same carrier. In other words, connections operated by code-share are not considered hubbing; if we were to broaden the definition in this direction, the airline-hub dummy would be nearly always one. This specification is consistent with Mayer and Sinai (2003), who find the hub effect to statistically indistinguishable between medium and large airline hubs; due to the focus of our sample on most traffic-intensive routes, we do not have small hubs in the dataset.

Due to the structure of international airline route networks, multicollinearity is a problem when controlling for airline hubbing. In the legacy airline model, "flag carriers" operate hubs in their home countries, and start international flights from these hubs. Hence, on a route originating outside the EU, legacy EU carriers never depart from a hub, while legacy foreign carriers always do. Hence our variation in coverage, $\text{eu.carrier}_f \times \text{eu.bound}_f$, is almost perfectly colinear with a combination of airline and route fixed effects as well as the hub indicator *among legacy carriers*. Hence, it is difficult to separately identify hub and EC261 effects.

To address this challenge, we pursue two approaches. First, it is possible to rely on the limited within-variation in hubbing structure created by carriers operating purely point-to-point models in our sample. These carriers do not operate connecting flights, and hence fail to satisfy the classical definition of a hub. This breaks the multicollinearity and makes it possible to estimate the model. However, this source of variation is limited – the bulk of flights on long-haul routes is accounted for by legacy carriers – and the particular airlines may not be typical.[10] Thus, this form identification is invariably problematic.

Our preferred strategy to control for hubbing effects involves including additional routes from hub airports, but not covered by EC261. Driven by data availability, we

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[9]See table 6 in Rupp (2009)

[10]In our baseline sample, point-to-point models appear in conjunction with new carriers (i.e. who were not previously legacy carriers) and fifth-freedom flights, as discussed below.

include domestic flights in the US between the US airport pairs in our sample. This allows creates separate variation which ties down the hub effect. For robustness, we also allow the airline-hub effect to vary by airline[11]. In principle, it is possible that airlines with worse on-time performance, reflected their fixed effect, could also have a higher marginal delay due to hubbing. This could bias our estimates if airline fixed effects are systematically different between EU and non-EU carriers.

## 4. Data & Methods

### *4.1. Transportation Markets*

We define each airport pair as a transportation *market*, which consists of two directional *routes*.

EC261 creates small variations in coverage across domestic EU markets, and large variation in coverage within markets that involve a non–EU airport. For EU–domestic flights, rights to care always apply although the size of the compensation for lost flights increases discontinuously when the distance exceeds 1500km. Exploiting this variation is difficult, as it would be collinear with route-fixed effects. For this reason, we focus on within-route variation on international routes with one leg outside the EU.

Based on *Eurostat* data, we obtain passengers carried by transportation market in 2016[12]. We focus on the largest markets in terms of passengers carried, satisfying the condition that one leg is outside the EU. We then obtain the "great circle distance" for each market through *GreatCircleMapper.net*. The leading international routes are entirely "category 3" flights (i.e. involving a distance of at least 3500km), with one exception[13]. To make sure that the EC261 is uniform throughout the sample, we limit attention to category 3 markets only.

Next, we face a trade-off between statistical power and cost, as flight data need to be purchased commercially. Based on an initial power calculation, we decide on to obtain data for the top 15 most traffic intensive markets and an 8-month sample period.

The final sample contains 12 markets originating in London-Heathrow airport and three starting from Paris CDG airport. London, by far the largest city in the EU, is very

[11] We thank Ricard Gil for suggesting this

[12] Database: avia_par

[13] The exception is Düsseldorf-Antalya, which makes the top 15 at a great circle distance below 2500km.

prominent; its network includes the main North American global cities (New York with JFK and Newark, Los Angeles, etc.) but also reflects colonial heritage with connections to Singapore, Hong Kong etc. From Paris, JFK and Montreal are included. For both London and Paris we include the Dubai market, which is potentially special as demand is largely driven by connecting flights offered by Emirates.

### *4.2. Flight Data: Non-EU/EU Routes*

We obtain scheduled and actual flight times from *FlightAware*, a commercial vendor. First we obtain, for each market, the list of all scheduled flights during the sample period. The sample period, which is determined by the time of data collection only, runs from 4th November 2016 to 6th July 2017. This schedule information is based on airline data available to the vendor.

We then collect actual flight times. For each flight, we observe the actual gate departure and gate arrival times. This information is based on airline-reported times. Second, we observe actual runway departure and runway arrival times, which are based on satellite position data the vendor obtained from the ADS-B system. We then apply a data cleaning procedure following Forbes et al. (2015) on this data set: first, we remove all flights which did not reach their destination (due to diversion or cancellation). Second, we drop all flights where the actual gate departure precedes the scheduled gate departure by more than 15 minute or arrive more than 60 minutes ahead of schedules; these observations likely represented corrupted data (e.g. due to rescheduling). This leaves us a total of 48426 flights.

Flight volume and the number of carriers active is highly variable depending on the transportation market. Table A1 shows the details. One interesting observation relates to so–called "fifth freedom flights". For example, Air New Zealand (NZ) operates a connection from Los Angeles to Auckland, with a stopover in London Heathrow. Similarly, Air India offers a service from Newark Liberty to Delhi, with stopover in Heathrow. We do a robustness test on fifth freedom flights below, as airlines operating such layover flights may have different incentives to provide on-time performance compared to those that provide nonstop flights.

Generally, the results show interesting variation in competition. Some markets, typically with high passenger volume, experienced entry, including by low cost carrier Virgin Atlantic. Moreover, the US markets have at least three carriers – two US, one Eu-

ropean – while many Asian and Canadian markets still have only two carriers. This variation in competition will be useful later on to assess how regulation interacts with the intensity of market competition.

Long haul flights have less delay than domestic flights. As table A2 shows, average gate departure delay for our sample is 9.28 minutes, which compares to around 12 minutes for EU-domestic and US-domestic flights. Likewise, gate arrival delay is also lower at 3.65 minutes. However, considerable variation remains. For departure delay, the interquartile range is 15 minutes, while for arrival delay it increases to 30 minutes. This partly reflects the fact that developments en route, such as flight path changes or weather incidents, add variation to arrival delay on top of departure delay. For this reason, our main analysis focuses on gate departure delay – the variable most directly controlled by airlines – although we turn to arrival delay as a robustness test.

### *4.3. Additional Data*

**Airline Level Data.** Legacy carriers often operate a business model heavily reliant on providing connecting flights through hubs. As shown by Mayer and Sinai (2003), delays on connections departing from a hub need not be "evil" – the carrier may wait for connecting passengers to arrive. Moreover, routine technical checks may be scheduled to take place in hub airports, increasing the likelihood that a delay due to technical fault may occur in a hub airport relative to a non-hub airport. Thus, there may be a "hub effect" on airline delay. Controlling for hub effects is clearly important for our estimation, because North American airlines headed for Europe generally depart from a hub airport, while European airlines do not. Thus, some of the difference in delay on a given US-Europe route may reflect the hub effect, rather than a genuine EC261 effect: departing from a hub is correlated with our treatment. We develop a comprehensive fixed effects strategy to deal with this issue below. For the purpose of this analysis, we collect for each airline their list of hub airports. Secondly, we collect for each airline whether it is a "legacy carrier" (in the sense of being a former state-owned flag carrier) or a "low cost carrier" (startup airline). Finally, we record if an airline is a "Community Carrier" in the sense regulation EC261. Only Community Carriers are covered under EC261 when flying non-EU to EU. The complete airline data set is to be shown in an appendix.

**US Domestic Flights.** We obtain flight-level for US domestic operated by the carrier

in our main sample from the US Department of Transport for the entire sample period. This dataset contains the same observations as our FlightAware data set for EU/non-EU flights. We use the augmented data set to create more within-airline hub variation to improve our control strategy for the hub effect discussed above.

## 5. Results

Baseline estimation results are presented in table 1. Consider first column (1), which presents coefficient estimates for the simple limited to European markets. After controlling for fixed effects, the model attributes reduction in departure delay of 3.19 minutes to variations in coverage of EC261. Compared to an average of departure delay of just under 10 minutes on international routes, such a delay reduction appears to be economically important in magnitude. Statistically, the hypothesis of no impact can be rejected at the 5% level (standard errors are clustered at the route-day level). However, the coefficient is relatively imprecisely estimated, and the hypothesis that the true impact is small cannot be rejected (95% confidence interval ranges from $[-6.19, -0.19]$). In the same model, departure from a hub airport is associated with an increase in delay 4.57 minutes. This estimate seems somewhat high in the light of earlier literature.[14] Overall, these results provide some evidence that EC261 is associated with a meaningful delay reduction but considerable statistical uncertainty remains.

Enlarging the sample to include US domestic flights considerably strengthens precision. As estimates in column (2) show, standard errors are reduced for *both* the EC261 and the hub estimate. The individual coefficients are quite importantly affected: EC261 is now estimated to cause a delay reduction of 4.92 minutes, or approximately 50% more than in the first specification. At the same time, the hub effect has shrunk to 3.60 minutes. Note that the sum of the coefficients on eu.bound$_f \times$eu.carrier$_f$ and from.hub$_f$ is relatively stable between models (1) and (2). This is quite expected given the earlier discussion which suggested multicollinearity is likely a problem with the sample in model (1). Overall, the results of model (2) considerably strengthen the evidence that EC261 improves service quality. On the one hand, the larger point estimate combined with smaller error now makes it possible to reject the hypothesis of no impact (or an eco-

[14]However, the confidence interval has a range $[2.95, 6.20]$; this means that equality with earlier estimates also cannot be firmly rejected.

TABLE 1
Delay Impact of EC261

| Dependent Variable | Departure Delay | | Arrival Delay | |
|---|---|---|---|---|
| Model | (1) | (2) | (3) | (4) |
| **Coefficient Estimates** | | | | |
| $\text{eu.bound}_f \times \text{eu.carrier}_f$ | $-3.19$ | $-4.92$ | $-3.97$ | $-3.90$ |
| | (1.53) | (1.11) | (1.72) | (1.20) |
| $\text{from.hub}_f$ | 4.57 | 3.60 | 3.27 | 3.31 |
| | (0.83) | (0.53) | (0.93) | (0.58) |
| **Fixed Effects** | | | | |
| Route-Day | ✓ | ✓ | ✓ | ✓ |
| Airline | ✓ | ✓ | ✓ | ✓ |
| **Sample Coverage** | | | | |
| EU/Non-EU Flights | ✓ | ✓ | ✓ | ✓ |
| US Domestic Flights | | ✓ | | ✓ |
| Observations | 48426 | 137157 | 48426 | 137157 |
| $R^2$ | 0.25 | 0.23 | 0.38 | 0.31 |

*Source:* Authors. Standard errors are clustered at the Route-Day level.

nomically negligible impact) at very conservative $p$-values. Second, the magnitude of the hub effect is now firmly in line with the results of Mayer and Sinai (2003) and Rupp (2009).

Results for arrival delay are qualitatively the same as for departure day. For arrival delay, the estimated coefficients of the EC261 are almost unchanged between models (3) and (4) at just below four minutes of delay reduction. The point estimates fall between those of models (1) and (2). Again, standard errors fall as the sample is increased to include US domestic flights. These findings strengthen our assessment that regulation EC261 leads to airline delay reduction.

We now explore potential heterogeneity in EC261 impact depending on the conditions of a specific transportation market. Our baseline EC261 estimate is an average of

TABLE 2
Heterogeneity of Delay Impact of EC261

| Dependent Variable | Departure Delay | | | | |
|---|---|---|---|---|---|
| Model | (1) | (2) | (3) | (4) | (5) |
| **Coefficients** | | | | | |
| $\text{eu.bound}_f \times \text{eu.carrier}_f$ | −0.34 | −3.79 | −4.58 | −4.58 | −2.20 |
| | (2.09) | (1.24) | (2.00) | (2.00) | (1.29) |
| $\times$ Route $\text{HHI}_f$ | −11.51 | | | | |
| | (4.45) | | | | |
| $\times$ $(\text{Route HHI>Median HHI})_f$ | | −2.31 | | | |
| | | (1.08) | | | |
| $\times$ $(\text{UK Market})_f$ | | | −0.37 | −0.37 | |
| | | | (1.81) | (1.81) | |
| $\times$ $(\text{North Am. Market})_f$ | | | | | −4.12 |
| | | | | | (1.15) |
| $\text{from.hub}_f$ | 3.54 | 3.57 | 3.61 | 3.61 | 3.65 |
| | (0.53) | (0.53) | (0.53) | (0.53) | (0.53) |
| **Fixed Effects** | | | | | |
| Route-Day | ✓ | ✓ | ✓ | ✓ | ✓ |
| Airline | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Sample Coverage** | | | | | |
| EU/Non-EU Flights | ✓ | ✓ | ✓ | ✓ | ✓ |
| US Domestic Flights | ✓ | ✓ | ✓ | ✓ | ✓ |
| Num. obs. | 137157 | 137157 | 137157 | 137157 | 137157 |
| $R^2$ (full model) | 0.23 | 0.23 | 0.23 | 0.23 | 0.23 |

*Source:* Authors. Standard errors clustered at the route-day level.

potentially heterogeneous impacts across markets.

One potential driver is competition, where theory is ambiguous on how it relates to service quality. Empirically, Mazzeo (2003) found that competition increases service quality, while Ater and Orlov (2015) found that competition actually increases delays. How regulation interacts with market competition is similarly an open question. One possible mechanism is that under low competition, airlines exert little effort to reduce delays. In this case, the marginal cost of delay reduction is likely to be low, and the regulation can have a significant effect. To test this hypothesis, bearing in mind the limitations of our sample which contains only 15 markets, we first add a linear interaction between the route Herfindahl-Hirschmann index and the EC261 effect. The results are presented in column (1) of table 2. The estimate favours a linear relationship between the route Herfindahl-Hirschmann index and EC261 effect. Given the distribution of HHI in the sample, the effect ranges from 2.53 minutes of delay reduction on the most competitive routes to 7.78 on the least competitive routes. As a robustness test, we interact the EC261 with an indicator if the route HHI exceeds the median HHI. This yields essentially the same results. Thus, there is evidence of a negative correlation between market comptitiveness and the impact of EC261.

Enforcement of EC261 is national, although the letter of the regulation applies uniformly across the EU. Our sample only contains two EU member states, so our power to reject equal effects across EU member states is low. We could expect to reject the hypothesis only if the true heterogeneity is very large. This does not appear to be the case: column (3) shows no evidence of heterogeneity in enforcement.

Lastly, we consider heterogeneity by non-EU region. This is potentially important, because the population of non-EU carriers is significantly different across regions. Several Asian carriers have successfuly pursued a strategy of product differentiation offering higher service quality than European and North American legacy carriers. Partly, this is to make the carriers more attractive to connecting passengers, an especially important factor for the Gulf airlines. Therefore, these airlines may be exerting high effort to avoid delays, at a similar level as regulated European airlines, even in the absence of EC261 coverage. To test this hypothesis, column (4) interacts the EC261 with with a dummy indicating if the non-EU region is in North America. This seems to be a very powerful discriminator: impact of EC261 on non-North American routes becomes small and statistically insignificant, while the impact on North American markets becomes even

larger and statistically more powerful.

## 6. Conclusion

Improving quality is an important objective of regulation, but knowing which policy instruments work can be difficult. This paper investigated a particular mechanism – strengthening the rights of airline passengers in case of long delays beyond the level provided "by the market" – and found that airline passenger rights improve on-time performance. Our results imply that consumer protection regulation can potentially improve consumer welfare not just in case of grievances, but also give firms incentives to improve average quality.

We obtain these results by exploiting variations in regulatory coverage in the landmark EU air passenger rights directive. While this legislation applies uniformly to all flights originating in the EU, it only covers European carriers on flights bound for, but departing outside of, the EU. Thus non-EU carriers face the incentives created by the regulation only when flying out of EU, but not inbound. This allows us to estimate the marginal delay reduction caused by the regulation (e.g. due to higher effort) while still controlling for airline and route-time fixed effects. There is evidence of heterogeneity in effects, with stronger service quality effects on routes with low competition or originating in North America.

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## Appendix

TABLE A1
Sample Coverage by Market

| Destination | Market | Air Carriers | # Flights |
|---|---|---|---|
| Delhi | LHR DEL | AI, BA, 9W, VS | 2785 |
| Doha | LHR DOH | BA, QR | 2905 |
| Dubai | LHR DXB | BA, QF, EK, VS | 4757 |
| Newark Liberty | LHR EWR | AI, BA, UA, VS | 3646 |
| Hong Kong | LHR HKG | BA, CX, VS | 3188 |
| New York JFK | LHR JFK | AA, BA, DL, VS | 8199 |
| Los Angeles | LHR LAX | AA, NZ, BA, UA, VS | 3386 |
| Miami | LHR MIA | AA, BA, VS | 2005 |
| Chicago O'Hare | LHR ORD | AA, BA, UA | 3728 |
| San Francisco | LHR SFO | BA, UA, VS | 2475 |
| Singapore Changi | LHR SIN | BA, SQ | 2735 |
| Toronto Pearson | LHR YYZ | AC, BA | 2734 |
| Dubai | CDG DXB | AF, EK | 1757 |
| New York JFK | CDG JFK | AA, AF, DL | 2732 |
| Montreal Trudeau | CDG YUL | AC, AF | 1394 |

*Source: Authors*

TABLE A2
Summary Statistics: Non-EU/EU Routes

| | Gate Dep Delay | Taxi Out | Taxi In | Delay Arr |
|---|---|---|---|---|
| 1 | Min. :-15.000 | Min. :10.00 | Min. : 2.000 | Min. :-60.000 |
| 2 | 1st Qu.: -3.000 | 1st Qu.:16.00 | 1st Qu.: 6.000 | 1st Qu.:-15.000 |
| 3 | Median : 0.000 | Median :21.00 | Median : 8.000 | Median : -1.000 |
| 4 | Mean : 9.276 | Mean :23.03 | Mean : 9.974 | Mean : 3.652 |
| 5 | 3rd Qu.: 12.000 | 3rd Qu.:27.00 | 3rd Qu.:12.000 | 3rd Qu.: 15.000 |
| 6 | Max. :342.000 | Max. :86.00 | Max. :65.000 | Max. :337.000 |

$N = 48426$ observations for each variable

*Source: Authors*