Can Consumer Rights Improve Service Quality? Evidence from European Air Passenger Rights

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Abstract

Under EU Air Passenger Rights legislation ("EC261"), carriers must provide assistance and cash compensation to passengers in case of long delay. We study whether the regulation reduces flight delay. EC261 applies uniformly to flights departing from the EU, but covers only EU carriers on EU–bound flights. Exploiting this variation, we find that regulated flights are 5% more likely to arrive on time, and mean arrival delay is reduced by almost four minutes. The effect is strongest on routes with little competition, and for legacy carriers. Thus, consumer rights can improve quality when incentives from competition are weak.

Keywords: consumer protection, flight delays, service quality, regulation, EC261/2004
JEL: D18, K20, D22, L93

Protecting consumers is a central, and perhaps the ultimate, objective of regulatory policy. In recent years, consumer rights policy has emerged as an important regulatory instrument. Such consumer rights – ranging from rights to information and product safety, through a right to withdrawal and, in its most advanced form, a right to quality – are created by the government through law, but allow consumers to seek legal redress di-

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rectly from firms. This contrasts to all other forms of regulation, in which a government agency imposes rules directly on a regulated firm.

Our paper provides important empirical evidence on the effectiveness of consumer rights. We study the aviation market, where consumer rights regulation is arguably more advanced than in any other market. Specifically, we focus on the pioneering EU Air Passenger rights regulation ("EC261"), under which – following a decision by the European Court of Justice, as we discuss below – passengers are entitled to cash compensation if their flights are badly delayed.

Although flight delays are slowly decreasing (Forbes et al., 2019), they are still a persistent quality problem in the airline industry, which has not been resolved by competition (Ater and Orlov, 2015). Soft-touch regulations, such as the US delay disclosure program, appear to have encouraged gaming (Forbes et al., 2015) rather than service improvement.[1] At the same time, while three-quarters of delay minutes are caused by airline operations or late arriving aircraft, passengers are often left to bear the burden when a delay occurs – be it in terms of inconvenience, lost time or incremental expenses. Flight delays cause also substantial externalities due to lost business productivity (Ball et al., 2010).

This paper provides robust evidence that EC261 is effective in reducing average flight delay. Our main estimate reveals an average treatment effect of the regulation of nearly 5 minutes of departure delay reduction. This impact is clearly economically important in magnitude compared to a population average delay of around 12 minutes,[2] and is independent of airlines' decisions on scheduled flight duration. Statistically, the hypothesis

[1]The authors observed delay reduction only for a very small subset of flights, those with departure delay around the disclosure threshold.

[2]See Eurocontrol (2007) and Bureau of Transportation Statistics' on-time performance database.

of no impact can be very firmly rejected. The results hold for other measures of flight punctuality (arrival delay and share of "on-time flights"), and 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 within–route variation in regulatory coverage based on the country of origin of the carrier. This arises from the partial extra–territorial application of the European passenger rights regulation on extra-EU routes (i.e. routes connecting an airport in the EU with an airport outside of the EU). All flights departing from an airport inside the EU are covered. On routes originating outside, only flights operated by EU carriers fall under the regulation; here, we observe flights that are covered and not covered operating on the same route and scheduled around the same time.[3]

This makes it possible to identify the impact of the regulation while allowing for carrier fixed effects *and* controlling for route-time effects (e.g. caused by airspace congestion).

These findings have four important implications for the literature. First, EC261 is an example of a policy successful in reducing airline delay; prior research on US regulations indicates their potential inefficiency in addressing delay. Forbes et al. (2015) study how airlines respond to incentives to "game" the US Department of Transportation (DOT) on-time market transparency 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

[3]For concreteness, consider flights between the JFK airport in New York and London Heathrow operated by two US carriers Delta and American Airlines and two UK-based airlines: British Airways and Virgin Atlantic. On the flight from London to New York, all passengers have a right to compensation, disregard of the airline chosen. In contrast, on the return route from New York to London, only British Airways and Virgin are subject to EC261 regulation while passengers on Delta and American flights do not have the compensation right.

reported delay when a flight is expected to have a delay just above this threshold.[4] In a follow-up paper, Forbes et al. (2018) observe impact of the transparency program on *average* delay reduction, which however is a result of increased scheduled duration, not an improvement from flight operations. 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 canceled, and the introduction of the rule may have caused longer gate departure delay.

Secondly, our results provide some empirical evidence on possible positive effects of consumer protection law. As highlighted in the literature on behavioral industrial organization (e.g. Inderst and Ottaviani (2013); Grubb (2014)), consumers may not fully take into account contingencies that are unlikely ex ante when making a purchase decision; for example, they may fail to realize the costs they could face in case of a long flight delay. In this case, making insurance mandatory can protect consumers. As our results show, such a regulation can have broader benefits by encouraging firms to increase average quality. At the same time, the trade-off for these benefits is a reduced freedom of contracts.

Third, our results provide further evidence of low marginal costs of airline delay reduction. The provisions of EC261 apply to flight delays exceeding three hours, which occur on around 0.5% of flights; hence, expected costs of the regulation for any given

[4]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 operate employee bonus programs that reward performance according to the DOT ranking; these have similar threshold effects even with automatic reporting. This suggests that flights at risk of missing the 15 minute mark may be marginally accelerated. Although the study lacks the pre-regulation period, these findings suggest that the DOT program may be subject to gaming at threshold.

flight must be low. At the same time, we find large average effects of delay reduction. These results are consistent with Nicolae et al. (2016), who consider the delay reduction impact of introducing checked baggage fees. 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 carriers introducing baggage fees saw a median reduction in departure delay of 3.3 minutes relative to competing carriers that did not.

Fourth, passenger rights lead to stronger delay reductions on routes where competition is low. Theory shows that the relationship between competition and quality is ambiguous, and the empirical evidence is consistent with this. Mazzeo (2003) shows that delays fall when a route moves from a monopoly carrier to duopoly, while Ater and Orlov (2015) show increased competition due to Internet penetration worsens on-time performance. Similarly, Prince and Simon (2014) find that (actual or threatened) entry by Southwest, a low-cost airline, worsens incumbent on-time performance.[5] In our model, these route-level delay effects are captured by the route-time fixed effect, allowing us to focus on the interaction between the effect of the regulation and route competition. Our results show that EC261 leads to stronger delay reduction when market concentration, as measured by the Herfindahl-Hirschman index, is high.

The paper continues by introducing the EU Air Passenger Rights regulation the following section. Section 2 then discusses our identification strategy, addressing both specification and the sources of variation we exploit; this is followed by the data description. Section 4 presents the key results on delay impact, followed by a discussion of the underlying mechanisms in section 5. Lastly, section 6 concludes.

[5]In Europe, LCC entry may improve on-time performance (Bubalo and Gaggero, 2015).

1. EU Air Passenger Rights Regulation

Air 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,[6] should certain *liability events*[7] arise. The regulation is mandatory, so passengers and airlines cannot agree through conditions of carriage to limit or waive rights created by the regulation.

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 accommodation, 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 the right to claim substantial cash compensation for lost time, which is due unless the airline can prove the delay was caused by "exceptional circumstances".[8] This compensation ranges from EUR 250 for a three-hour delay on a short flight of less than 1500km to EUR 600 for a delay of at least four hours on a long-haul flight with distance exceeding 3500km (see appendix table A1 for details). Reflecting the motive of compensation, these cash payments are

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

[7]Denied boarding, flight cancellation or long delay

[8]Perhaps the most well known case which brought the EC261 regulation into the spotlight was the volcano ash clouds following the Eyjafjallajökull eruptions in spring 2010. 107,000 flights were canceled during an 8-day period following the eruption, accounting for 48% of total air traffic in EU and roughly 10 million passengers. The ash-cloud is treated as an extraordinary circumstance, so airlines were exempt from disbursing cash compensation. The airlines, however, were obliged to provide care, including accommodation and food, for the affected passengers.

FIGURE 1
EC261 Passenger Rights: The Case of Long Delay

	Intra-EU	Outbound from EU	Inbound to EU
EU Carrier	✓	✓	✓
non-EU Carrier	✓	✓	✗

EU Passenger Rights Apply	No Coverage
Right to care (including meals and accommodation) **Re-routing** (to reduce delay) **Cash compensation** (from €250 to €600 for delays over three hours at final destination)	

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

not limited by the ticket price; thus, the airline may well need to refund more than 100% of the ticket price in case of long delay. Figure 1 summarizes these remedies under the EC261 regulation.

Coverage of the regulation is broad but not universal. All flights departing from an airport located in the European Union[9] fall under the scope of EC261. The situation is more interesting for routes headed to an EU-airport but originating outside the EU. On such routes, flights operated by a 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 quirk in coverage, summarised in Figure 1, will be fundamental for

[9] 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.

identification, as described in section 2.

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*[10] (Garben, 2013), the European Court of Justice in 2009 determined that a long delay has an effect equivalent 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.[11] 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 to other major aviation markets (see ICAO (2013) for a survey) or other modes of transport. In the US, the Department of Transportation relies on the market, aided by its delay transparency program, to deal with flight delay.[12] Its *Consumer Guide to Air Travel*

[10]Christopher Sturgeon, Gabriel Sturgeon and Alana Sturgeon v Condor Flugdienst GmbH (C-402/07)

[11]Airlines do not publish information on claim rates. The European Commission estimates that only approximately 10% of eligible passengers request compensation.

[12]However, the US Civil Aviation Authority created a right to compensation in case of denied boarding in 2011, which follows the EC261 model for this specific liability event.

informs passengers 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". Notably, Israel and Saudi Arabia, Indonesia, New Zealand and, more recently, India and Canada 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 accommodation 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.

2. Identifying the EC261 Effect

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

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

$$y_{f,c,t} = \beta \text{EU Carrier}_c \times \text{EU-Bound}_f + \text{Route}_{f,t} + \text{Airline}_c + \gamma \text{From Hub}_{f,c} + \epsilon_{f,c,t} \quad (1)$$

where $y_{f,c,t}$ is our dependent variable of interest, primarily gate departure delay. Our main goal is to estimate β, 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 them, 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; these fixed effects also absorb the effect of EC261 on routes departing from EU, where there is no variation in coverage.

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 especially crucial in the European setting and the European slot control system.[13] 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

[13]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 while waiting for a landing slot (see Eurocontrol (2016)) 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.

EU $\text{Carrier}_c \times \text{EU-Bound}_f$ 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.[14] Furthermore, Rupp (2009) conducts a study with similar controls but using 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 of over two minutes; hub status at destination has no impact on departure delay.[15]

Our baseline control strategy is to include an airline-hub indicator. This takes the value one if a carrier is operating connecting flights from a given airport. In other words, connections operated by code-share are not considered hubbing. This specification is consistent with Mayer and Sinai (2003), who find the hub effect to be statistically indistinguishable between medium and large airline hubs.[16]

The necessary condition for our identification to work is the lack of delay compensation schemes in other regions. This condition is met for the carriers and destinations in our sample described in section 3.[17]

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

[15]See table 6 in Rupp (2009)

[16]Due to the focus of our sample on most traffic-intensive routes, we do not have small hubs in the dataset.

[17]It has to be noted that our sample includes routes to Canada and India as well as a carrier from New Zealand where some forms of delay compensation schemes are implemented. However, in New Zealand, the scheme is limited to domestic flights only, while delay compensations in Canada and India were implemented in 2019, i.e. after the end of our sample period. Thus, those compensation schemes do not pose a threat to our identification.

2.1. Sources of Variation

We have considerable variation in EC261 coverage, with around half of inbound EU flights not covered, but there is some collinearity of the treatment with airline hub status. This arises from the legacy airline model, where "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, EU $\text{Carrier}_c \times \text{EU-Bound}_f$, is colinear with a combination of airline and route fixed effects as well as the hub indicator *among legacy carriers.* This can cause a loss of precision, as it becomes harder for the model to disentangle EC261 and the hub effect.

It is possible to rely on the limited within-variation in hubbing structure created by carriers operating purely point-to-point (P2P) models to disentangle these two effects. 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 are accounted for by legacy carriers – and the particular airlines may not be typical.[18] Hence it is not satisfactory to rely on this variation alone.

Secondly, we include additional routes *not* subject to EC261 to get more data which can tie down the hub effect. On US domestic routes, where flight data are easily available from the Department of Transportation, the EC261 treatment is always zero but we have strong variation in hub status. Thus, we extend our sample with domestic flights of US carriers among the US airports. The selection criterion is that both the carrier and each airport should already be included in the sample. This creates separate variation which

[18]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.

ties down the hub effect. For robustness, we also allow the airline-hub effect to vary by airline.[19]

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.

3. Data

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

3.1. Flight Data: Extra-EU Routes

We have collected scheduled and actual flight times of all scheduled commercial flights on the top 15 most traffic intensive extra-EU markets over an 8-month sample period. The choice is driven by a trade-off between statistical power and cost, as flight data must be purchased commercially.

Based on *Eurostat* data, we obtain number of passengers carried by transportation market in 2016.[20] The leading international routes are entirely "category 3" flights (i.e. extra-EU over 3500km), with one exception.[21] To make sure that the EC261 is uniform

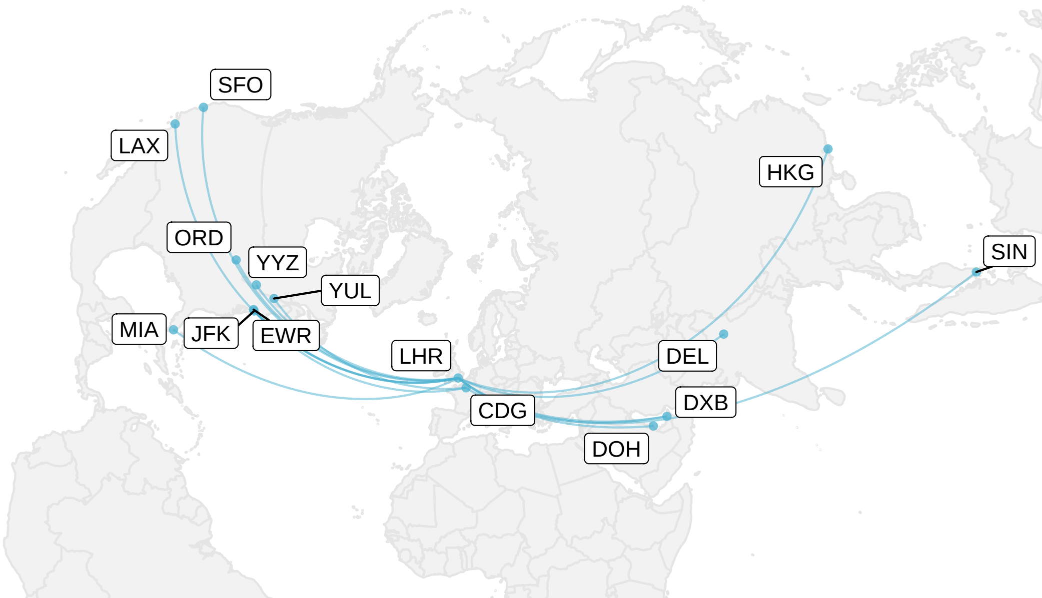
[19]We thank Ricard Gil for suggesting this.

[20]Database: avia_par

[21]The exception is Düsseldorf-Antalya, which is top 15 in terms of passenger volume but has a great circle distance below 3500km. This route has been replaced in our data set with the 16th most busy extra-EU market; London Heathrow – Newark.

throughout the sample, we limit our attention to category 3 markets only. The full map of extra-EU routes considered in the sample is shown in figure 2.

FIGURE 2
Map of Extra-EU Routes



Notes: For airport codes, see table A2
Source: Authors.

We obtain scheduled and actual flight data from *FlightAware*, (FA) a commercial vendor. The sample period, which is determined by the time of data collection only, runs from 4th November 2016 to 6th July 2017. Flight schedule information is based on airline data available to the vendor. Actual flight data are collected by the vendor from two sources. Actual gate departure and gate arrival times are based on airline-reported times. Take-off and landing times are based on satellite position data the vendor obtained from the ADS-B system, a radio transponder installed on all commercial aircrafts.[22] In total, data on 55 483 flights is obtained.

We supplement the flight data with a list of hub airports for each carrier in the sample, according to the hub definition outlined in the previous section (see appendix table A2 for details). Flight volume and the number of carriers active are highly variable depending on the transportation market. Figure 2 and appendix tables A2 and A3 show the details. Some markets, typically with high passenger volume, experienced entry, including by the EU based point-to-point carrier Virgin Atlantic. The former is crucial for identifying the hub effect. As shown in appendix table A4, those flights cover for 20% of the EU-outbound flights operated by an EU-carrier. An additional source of variation comes from so-called "fifth freedom" flights, i.e. flights between foreign countries as a part of services connecting the airline's own country. Air New Zealand, for example, operates a connection from Los Angeles to Auckland with a stopover in London Heathrow.[23] The "fifth freedom" flights make up 2% of the EU-bound flights operated by a non-EU carrier that do not depart from a hub.

[22]Collection of individual flight data is crowd-sourced to thousands of radio enthusiasts around the world. Data collectors equipped with simple, often home-made radio receivers can track signal from all aircrafts up to 150 miles away. The signal is then sent to a flight data provider, processed, and published on-line.

[23]Importantly, these stopovers do not serve only refueling, as airlines operating the "fifth freedom" flights are allowed to sell tickets for each leg separately.

Furthermore, the descriptive tables show considerable variation in competition. US markets, for example, have at least three carriers – two US, one European – 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.

To create more within-airline hub variation to improve our control strategy for the hub effect discussed above, we obtain flight-level data for US domestic flights from the US Department of Transportation (DoT) for the entire sample period. Specifically, we include data on all flights operated by all (three) US-based carriers between all (six) US airports in our main sample; 91594 flights in total. This dataset contains the same variables as our FlightAware data set for extra-EU flights. The US legacy carriers typically operate from multiple hubs; nevertheless, 14% of the US domestic flights in our sample were not operated from carrier's hub.

We then apply a data cleaning procedure following Forbes et al. (2015) on this combined data set: first, we remove all flights with incomplete flight data (5672 FA observations and 1011 DoT) [24] and those which did not reach their destination (due to diversion or cancellation). Second, we limit the sample to carriers for which data on flights on more than one route are available (239 from FA). Finally, as in Forbes we remove Forbes et al. (2015) extreme observations, in the bottom and top 0.0025% of the distribution of the following variables: departure delay, arrival delay, taxi-in, taxi-out.[25] This leaves us a total of 137157 observations, 88731 from DoT and 48426 from FA.

[24]A complete flight record contains information on the following key flight phases: scheduled gate departure, actual gate departure, take-off, landing, actual gate arrival and scheduled gate arrival time.

[25]Thus we remove observations which: depart more than 15 minutes ahead of the schedule or with more than 345 minutes delay; arrive more than 60 minutes ahead of the schedule or with more than 349 minutes delay; Taxi out less than 8 minutes and more than 87 minutes, taxi out more less less than 1 minute and more than 66 minutes.

On average, flight quality measures are very similar in both samples. 74.4% of the extra-EU long-haul flights arrive within 15 minutes of the scheduled arrival. The score for the US domestic flights is only 1.3% lower. The US domestic flights, however, have longer average departure (14.9 min vs 9.3 min) and arrival delays (7.4 min vs 3.7 min).

4. Results: Delay Impact of EC261

We find an economically important and statistically significant effect of EC261 regulation on both departure and arrival delay, as well as on-time performance. Estimation results are presented in table 1, where column (1) reports results for departure delay. Our model attributes a delay reduction of 4.92 minutes on average to the EC261 regulation, after controlling for airline-hub status, route-time fixed effects and airline fixed effects. This estimate is certainly large compared to an average departure delay of 10 minutes on international routes, and economically important. Statistically, we can very robustly reject the hypothesis of no effect (at the 1% level). However, the standard error is relatively large at 1.11 minutes, so there is some uncertainty associated with the precise magnitude of the effect. The same holds for arrival delay, where the estimated EC261 impact is 3.90 minutes of delay reduction. As column (3) shows, EC261 is associated with a 5% improvement in "on-time performance" (i.e. whether arrival delay is below 15 minutes). Finally, for delays exceeding three hours, the coefficient estimate is low with high standard error; this imprecision is not surprising, because only 0.5% of extra-EU flights in our sample arrive that late.

These results suggest that EC261 has an important impact on flight quality through improving mean performance, rather than reducing the likelihood of extremely poor performance. At first pass this appears surprising because the liability events under the regulation focus on long delays. However, it is important to note that delay *at final*

TABLE 1
Delay Impact of EC261

Dependent Variable	Departure Delay (minutes)	Arrival Delay (minutes)	Arrival On time	Arrival Delay >180 min
	(1)	(2)	(3)	(4)
EU-bound$_f$ ×EU Carrier$_c$	−4.92	−3.90	0.054	−0.004
	(1.11)	(1.20)	(0.014)	(0.003)
From Hub$_{f,c}$	3.60	3.31	−0.046	−0.002
	(0.53)	(0.58)	(0.006)	(0.002)
Num. obs.	137157	137157	137157	137157
R^2 (full model)	0.25	0.31	0.28	0.31

Notes: All regressions include airline and route-day fixed effects. Standard errors are clustered at the route-day level. Arrival on time and Arrival delay >180 are binary variables that takes value one if a flight arrives within 15 minutes of the scheduled arrival time and over 180 minutes after the scheduled arrival time respectively, and zero otherwise.
Source: Authors.

destination is what matters for the regulation; carriers operating connecting flights have a strong incentive to make sure their passengers don't miss connections. This suggests one source of heterogeneity in the EC261 effect, since carriers offering point-to-point service only do not face this incentive.

The baseline results are robust to changes in the estimation sample. Our baseline results are based on the full sample, which complements extra-EU flights with US domestic flights. In appendix table A5, we estimate the same departure delay specification, but splitting the sample according to the sources of variation identified in the previous section. The point estimates in a subsample restricted to the extra-EU flights only show a smaller EC261 effect, and a larger hub effect. However, precision suffers due to the multicollinearity issues discussed above. Restricting the sample even further to the

EU-US routes only does not significantly affect the point estimates. Excluding point-to-point carriers from the main sample leads to a much larger EC261 effect on delay, consistent with connecting passengers being an important part of the EC261 incentives. Throughout all specifications, the hypothesis of differences of coefficients between the subsamples can be statistically rejected at standard significance levels.

One may fear that there are systematic differences between the airlines schedules between the EU and non EU carriers. Such differences could lead to differences in airport congestion or weather conditions experienced by the airlines and would not be picked up by the route-day fixed effects included in the main specification, which would introduce bias. To assure this is not the case, as a robustness test, we replace the route-day fixed effect with a route-time fixed effects in columns (1-6) of the table A6. In the first four columns we split each day into six-hour (columns 1-2) and two-hours blocks (columns 3-4), thus adding four and twelve time-specific route effects per day for each route. This modifies the sample that we effectively use in the regression, but does not affect the results.[26] As a further robustness check, in columns (5-6), we split flights into time windows with a duration not exceeding 120 minutes according to an optimal matching algorithm; each time window must contain at least one EU carrier and one non-EU carrier. This procedure maximizes the number of flights effectively used in estimation and covers 76% of all extra-EU flights in our sample. See appendix table A7 for a detailed breakdown of matched flights. The route-time fixed effects can capture even very short term systemic delay causes. Adopting this specification considerably increases R^2, which is not surprising, and does not significantly affect the estimated EC261 coef-

[26]With six-hour-route fixed effects we have 9 707 six-hour-route time blocks with just one observation, with two-hour-route fixed effects this number increases to 37 819, compared to 451 blocks with a single with day-route fixed effects.

ficients. However, due to the invariably smaller sample size, precision suffers. Hence, in the following regressions, we return to the baseline specification with a hub dummy variable and a route-day fixed effect.

These results are also robust to changes in specification. One possible generalization is to allow the hub effect to vary by airline, e.g. because connecting flights are operated differently. Columns (7-8) of appendix table A6 contain results for this specification. Given the nature of our dataset, we have within airline-hub variation for EU-US transportation markets; thus, the other routes do not contribute to the estimate of EC261 impact under this specification. Hence, the results of this specification should be compared to column 5 of table 2; the differences in coefficients are small in magnitude and not statistically significant.

Delay reductions of EC261 cannot be explained by "gaming", such as airlines strategically increasing scheduled flight times or affecting other flight phases (see Appendix figure A1 for details) to reduce measured delay. On the one hand, the fact that EC261 has a strong effect on departure delay already rules out schedule padding as an alternative explanation. Indeed, as shown in the Appendix table A8, the airlines affected by the EC261 regulation actually operate on tighter schedules than their unregulated competitors. EU legacy carriers schedule their flights back to Europe to be 4.5 minutes shorter than their foreign legacy competitors. As the remaining columns of the table show, EU carriers also have actually shorter in-air times and shorter taxi-in times. This is likely due to a combination of two factors: on the one hand, fleet effects – some planes fly faster than others – may explain the shorter in-air time. [27] Secondly, more favourable posi-

[27]Conditional on aircraft type, the freedom to choose cruise speed at will is limited. On the one hand, slot control system at congested airports requires airlines to assess the flight time before departure. On the other hand, fuel economy and technological considerations play a role. For a typical airliner, the range between the cruising and maximum speed is rather narrow, making it difficult for airlines to reduce flight

tioning of terminals (relative to runways) reduces taxi-in times; the pattern we observe could be explained by airlines having more favourable locations in their home airports as compared to foreign airlines operating from the same airport.

These results provide strong evidence that EC261 leads to a meaningful improvement in airline service quality. This improvement was driven by a reduction in mean delay both at the gate departure and gate arrival level, rather than a reduction in the probability of severe delay only. Accordingly, there is evidence for improved on-time performance, defined as 15 minutes arrival delay or less and limited evidence of a reduction in extreme delays (defined as delays exceeding three hours). Moreover, there is some evidence that the effect is heterogeneous across carriers: excluding point-to-point carriers from the sample leads to an even stronger EC261 effect. In the analysis that follows, we explore more closely how the EC261 impact interacts with airline and transportation market characteristics.

There is some evidence that small differences between scheduled and actual departure are coded as zero values, but this does not affect our results. Gate departure times are based on airline reporting, and there are differences reporting methodologies between airlines (e.g. automatic vs. manual, see Forbes et al. (2015)). In our dataset, we see that airlines are disproportionately more likely to report zero delay, with EU airlines especially likely to report zero delay (16% of flights) as compared to non-EU airlines (6% of flights). This discontinuity is clearly visible in the empirical distribution function, see appendix figure A2. Thus, it certainly seems possible that there is some censoring.

delay after take-off. Airbus A340-642 flying between London and New York (5555km) a speed increase from the aircraft's cruising speed (0.82M or 871 km/h) to the maximum speed allowed by the aircraft producer (0.86M or 914 km/h) decreases the flight time only by 17min (or 4%). This reduction comes, however, at quite a substantial cost. Fuel consumption increases by more than 20% or 10 tonnes of jet fuel, which would cost more than $20,000 extra (simulation performed using freeware Aircraft Emissions and Performance software Piano-X (available at http://www.piano.aero/)).

In column 1 of table A9, we see that flights with exactly zero recorded delay are likely to have longer measured taxi-out times; this would be consistent with censoring, since the taxi-out time is calculated using automatic measurement from ADS-B recorders. To investigate the robustness of our results to this censoring, we introduce a coarse delay variable. This variable codes *all* delays between -5 and 5 minutes to zero. When re-estimating our model with this dependent variable, we find that our earlier results are nearly unchanged. Thus, the results are robust to possible censoring of delay around zero.

5. Discussion: What drives EC261 Impact?

To better understand the driver of EC261 impact, this section investigates heterogeneity according to airline and transportation market characteristics. Our discussion is organized around the results shown in table 2.

Due to the regulatory focus on delay "at final destination", EC261 affects legacy airlines more strongly than point-to-point carriers. As column (1) of table 2 shows, this is reflected in a weaker EC261 delay reduction impact on point-to-point carriers as compared to legacy ones. By the point estimates, the delay reduction is around 25% smaller for point-to-point carriers. Although the estimate is not statistically significant, this is not entirely surprising given the relatively small market share of point-to-point in the transportation markets we consider.

Routes with weaker competition have a stronger EC261 impact. Prior research has found mixed results on competition and airline service quality; e.g. 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,

TABLE 2
EC261: Heterogeneity of Delay Impact

Dependent Variable	Departure Delay				
	(1)	(2)	(3)	(4)	(5)
$\text{EU-bound}_f \times \text{EU Carrier}_c$	−5.56	−0.34	0.35	−4.58	−1.00
	(1.27)	(1.98)	(1.89)	(1.89)	(1.72)
$\times$ Point-to-Point Carrier_c	1.46				
	(0.99)				
$\times$ Route HHI_f		−11.51			
		(4.22)			
$\times$ (Route-day HHI_f			−12.94		
			(3.91)		
$\times$ (UK $\text{Market})_f$				−0.37	
				(1.71)	
$\times$ (North Am. $\text{Market})_f$					−4.13
					(1.49)
From $\text{Hub}_{f,c}$	3.40	3.54	3.52	3.61	3.62
	(0.57)	(0.51)	(0.51)	(0.51)	(0.50)
Num. obs.	137157	137157	137157	137157	137157
R^2 (full model)	0.23	0.23	0.23	0.23	0.23

Notes: All regressions include airline and route-day fixed effects. Standard errors are clustered at the route-day level.
Source: Authors.

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. We test this hypothesis by interacting the EC261 effect with the Herfindahl-Hirschman index, bearing in mind the limitations of our sample which contains only 15 markets affected by EC261. We first add a linear interaction between the route Herfindahl-Hirschman index and the EC261 effect. In column (2), we calculate the HHI index values (on a zero to one scale) based on number of flights per airline for each route throughout the sample period. In column (3), we account for differences in the level of competition between the airlines on different dates and for changes throughout the sample period and calculate the HHI for each route for each day. based on number of flights per airline for each route throughout the sample period. Given the distribution of HHI in the sample and the results in column (2), the effect ranges from 2.53 minutes of delay reduction on the most competitive routes to 7.78 minutes on the least competitive routes.[28] Thus, there is evidence of a negative interaction between market competitiveness and the impact of EC261.

Enforcement of EC261 is national, although the letter of the regulation applies uniformly across the EU. In the legal literature, the role of national differences in implementation of regulations is frequently debated (e.g. Bobek and Prassl (2016)). 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 (4) shows no evidence of heterogeneity in enforcement, at least between the UK and France.

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 successfully pursued a strategy of product differentiation offering higher service quality than European and US 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.

[28]The HHI values per route on EU-routes vary between 0.22 and 0.68 with the mean of 0.44.

To test this hypothesis, column (5) interacts the EC261 with a dummy indicating if the non-EU region is in US. This seems to be a very powerful discriminator: the impact of EC261 on non-US routes becomes small and statistically insignificant, while the impact on US markets becomes even larger and statistically more powerful.

6. Conclusion

Consumer rights legislation has rapidly proliferated in the European Union, and covers many sectors of the economy. Besides passenger rights, examples include a statutory minimum warranty period for consumer durables, a consumer's right to repay a credit early or a "cooling off period" to change one's mind about an online purchase. These regulations increasingly constrain the freedom of contracts between firms and consumers. But little is known about the impact of these laws, whether directly on consumers with a grievance or indirectly through changes in industry service quality. This paper begins to fill the void by studying the impact of a specific form of consumer rights regulation, air passenger rights, on service quality within the affected industry.

We exploit the partial application of regulation EC261 on routes bound for EU but originating outside the bloc. On these routes, carriers from the EU are covered by the regulation, while foreign carriers are not; in contrast, on routes originating in the EU, all carriers are covered. This variation in coverage makes a difference-in-differences strategy feasible.

We find robust evidence that the regulation is effective in improving airline punctuality. Our baseline regression focuses on gate departure delay, because this measure – unlike arrival delay – is not affected by scheduled flight time, which is chosen by the airline. This model shows a delay reduction of nearly five minutes due to the regulation; for arrival delay, we obtain qualitatively the same result, but the point estimate is smaller

(3.9 minutes). The regulation also leads to a 5% improvement in "on-time" performance. In further analysis, we find the regulation to have a weaker effect on point-to-point carriers, and a stronger effect on routes with weak competition. These results show that consumer rights regulation, if designed in a way that makes "gaming" difficult, can improve service quality.

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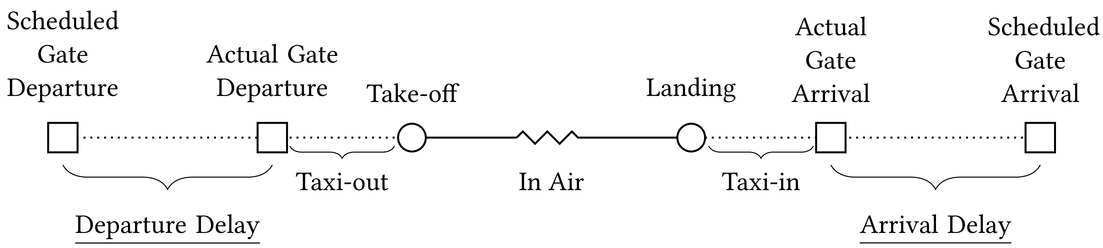
Appendix

TABLE A1
Monetary Compensation for Lost Time under EC261

			Route	
Flight Category	Distance (km)	Delay	intra EU	extra EU
1	$\leqslant 1500$	3h	EUR 250	EUR 250
2	$1500 - 3500$	3h	EUR 400	EUR 400
3	> 3500	3h-4h	EUR 400	EUR 300
		$\geqslant$ 4h	EUR 400	EUR 600

Source: Compiled by authors based on European Union (2016)

FIGURE A1
Anatomy of a Flight Delay: Measurement, Proximate Causes and Mitigation



System Delay Causes
- Aviation System
- Extreme Weather
- Security

Airline Delay Causes
- Aircraft Arriving Late
- Carrier Delay
- Cancellation

Delay Mitigation
- Turnaround Buffer
- Operations Quality

System Delay Causes
- Aviation System
- Extreme Weather
- Diversion

Delay Mitigation
- Schedule Buffer
- Higher Flight Speed

Source: Compiled by authors

TABLE A2
Carriers

Airline	Airline (IATA codes)	EU Carrier	Unique routes	Observation count	Airline Hubs (IATA codes)
Extra-EU flights:					
British Airways	BA	YES	24	13668	LHR
American Airlines	AA	NO	10	5562	JFK, LAX, MIA, ORD
United Airlines	UA	NO	8	5003	EWR, LAX, ORD, SFO
Virgin Atlantic	VS	YES	16	4388	
Emirates	EK	NO	4	4087	DXB
Air France	AF	YES	6	3027	CDG
Air Canada	AC	NO	4	2291	YUL, YYZ
Qatar Airways	QR	NO	2	2226	DOH
Delta Air Lines	DL	NO	4	2096	JFK, LAX
Cathay Pacific	CX	NO	2	2048	HKG
Singapore Airlines	SQ	NO	2	1826	SIN
Air India	AI	NO	4	1073	DEL
Jet Airways	9W	NO	2	469	DEL
Air New Zealand	NZ	NO	2	429	
Qantas	QF	NO	2	233	
US domestic flights:					
American Airlines	AA	NO	18	41586	JFK, LAX, MIA, ORD
United Airlines	UA	NO	24	34467	EWR, LAX, ORD, SFO
Delta Air Lines	DL	NO	10	12678	JFK, LAX

Airport IATA codes extensions are as follows CDG - Paris Charles de Gaulle Airport, LHR - London Heathrow airport, DXB - Dubai International Airport, JFK - New York John F. Kennedy International Airport, YUL - Montréal–Pierre Elliott Trudeau International Airport, DEL - New Delhi Indira Gandhi International Airport , DOH - Doha Hamad International Airport, EWR - Newark Liberty International Airport, HKG - Hong Kong International Airport, LAX - Los Angeles International Airport, MIA - Miami International Airport, ORD - Chicago O'Hare International Airport, SFO - San Francisco International Airport, SIN - Singapore Changi Airport, YYZ - Toronto Pearson International Airport.

TABLE A3
Routes

Extra-EU			US domestic		
Market	Airlines	Num. obs.	Market	Airlines	Num. obs.
CDG DXB	AF, EK	1757	EWR LAX	UA	6133
CDG JFK	AA, AF, DL	2732	EWR MIA	AA, UA	4567
CDG YUL	AC, AF	1394	EWR ORD	UA, AA	6140
LHR DEL	AI, BA, 9W, VS	2785	EWR SFO	UA	7502
LHR DOH	BA, QR	2905	JFK LAX	AA, DL	10509
LHR DXB	BA, QF*, EK, VS	4757	JFK MIA	AA, DL	5366
LHR EWR	AI*, BA, UA, VS	3646	JFK ORD	AA	526
LHR HKG	BA, CX, VS	3188	JFK SFO	AA, DL	6136
LHR JFK	AA, BA, DL, VS	8199	LAX MIA	AA, DL	4621
LHR LAX	AA, NZ*, BA, UA, VS	3386	LAX ORD	UA, AA	9786
LHR MIA	AA, BA, VS	2005	LAX SFO	UA, AA, DL	9316
LHR ORD	AA, BA, UA	3728	MIA ORD	UA, AA	6540
LHR SFO	BA, UA, VS	2475	MIA SFO	AA, UA	2402
LHR SIN	BA, SQ	2735	ORD SFO	UA, AA	9187
LHR YYZ	AC, BA	2734			

IATA airline code and airport extensions listed in this table are shown in table A2.
Airlines annotated with * serve a given market under 5th freedom of the air provisions.

TABLE A4
Summary Statistics for Main Regression Samples

Variable	EU Bound	EU Carrier	Mean	SD	Min	Max
Departure Delay (min)	No	No	5.97	25.31	-15	342
	No	Yes	11.45	24.29	-15	320
	Yes	No	12.77	31.26	-15	339
	Yes	Yes	6.65	25.40	-15	328
	US Domestic		14.88	39.31	-15	345
Arrival Delay (min)	No	No	-0.99	32.78	-60	332
	No	Yes	2.40	29.95	-60	315
	Yes	No	8.65	35.76	-60	337
	Yes	Yes	4.10	29.67	-58	331
	US Domestic		7.94	43.26	-60	348
On time arrival (dummy indicating arrival delay < 15 min)	No	No	0.78	0.41	0	1
	No	Yes	0.74	0.44	0	1
	Yes	No	0.69	0.46	0	1
	Yes	Yes	0.77	0.42	0	1
	US Domestic		0.73	0.44	0	1
From hub (dummy indicating airline hub at departure airport)	No	No	0.00	0.00	0	0
	No	Yes	0.80	0.40	0	1
	Yes	No	0.98	0.15	0	1
	Yes	Yes	0.00	0.00	0	0
	US Domestic		0.86	0.34	0	1

Source: DoT and Flight Aware. Data in rows marked as US Domestic represents US Domestic flights and is sourced from the US Depertment of Transport data base. The remaining rows represent extra-EU flights sourced from Flight Aware (flightaware.com)

TABLE A5
Delay Impact of EC261: Impact of Sample Coverage

Dependent Variable	Departure Delay			Arrival Delay		
	(1)	(2)	(3)	(4)	(5)	(6)
Coefficient Estimates						
EU-bound$_f$ ×EU Carrier$_c$	-3.19	-6.74	-3.63	-3.97	-6.45	-7.63
	(1.53)	(1.57)	(1.83)	(1.72)	(1.68)	(2.02)
From Hub$_{f,c}$	4.57	3.37	5.10	3.27	3.31	2.95
	(0.83)	(0.62)	(1.02)	(0.93)	(0.66)	(1.12)
Sample Coverage						
Routes						
EU-US	✓	✓	✓	✓	✓	✓
Other Extra-EU	✓			✓		
US Domestic		✓			✓	
Carriers						
Legacy Carriers	✓	✓	✓	✓	✓	✓
Point-to-Point	✓		✓	✓		✓
Num. obs.	48426	111040	26171	48426	111040	26171
R^2 (full model)	0.25	0.22	0.23	0.38	0.30	0.36

Source: Authors. All regressions include airline and route-day fixed effects. Standard errors are clustered at the route-day level.

TABLE A6
Further Robustness Tests

	Route-6hrs-time-blocks		Route-2hrs-time-blocks	
	Dep. Delay	Arr. Delay	Dep. Delay	Arr. Delay
	(1)	(2)	(3)	(4)
EU-bound$_f$ × EU Carrier$_c$	−6.91	−5.25	−6.91	−5.82
	(1.34)	(1.43)	(1.91)	(2.03)
From Hub$_{f,c}$	2.88	2.91	3.59	3.30
	(0.65)	(0.70)	(0.93)	(0.99)
Num. obs.	137157	137157	26754	26754
R^2 (full model)	0.45	0.52	0.70	0.74

	Route-Time Matching		Airline-Hub FEs	
	Dep. Delay	Arr. Delay	Dep. Delay	Arr. Delay
	(5)	(6)	(7)	(8)
EU-bound$_f$ × EU Carrier$_c$	−6.38	−6.71	−5.50	−5.99
	(2.28)	(2.51)	(1.11)	(1.21)
From Hub$_{f,c}$	3.46	2.08		
	(1.25)	(1.38)		
Num. obs.	36923	36923	137157	137157
R^2 (full model)	0.49	0.59	0.23	0.31

Source: In models (1) and (2), we allow the hub effect to vary by airline, essentially creating an airline-hub fixed effect. In models (3) and (4), we replace the route-day fixed effect with a route-time four hour window. All regressions include airline fixed effects and standard errors clustered by route-time.

TABLE A7
Matched flights per route

Market	non Eu-bound		EU-bound		Share non Eu-bound	Share EU-bound
	Matched	Unmtached	Matched	Unmtached	Matched	Matched
CDG DXB	453	418	674	212	0.48	0.24
CDG JFK	883	494	319	1036	0.36	0.76
CDG YUL	253	454	111	576	0.64	0.84
LHR DEL	314	1077	259	1135	0.77	0.81
LHR DOH	788	307	1285	525	0.28	0.29
LHR DXB	487	1951	366	1953	0.80	0.84
LHR EWR	230	1545	257	1614	0.87	0.86
LHR HKG	103	1380	598	1107	0.93	0.65
LHR JFK	118	3970	325	3786	0.97	0.92
LHR LAX	224	1463	195	1504	0.87	0.89
LHR MIA	300	748	35	922	0.71	0.96
LHR ORD	528	1333	253	1614	0.72	0.86
LHR SFO	58	1155	391	871	0.95	0.69
LHR SIN	498	881	524	832	0.64	0.61
LHR YYZ	380	1007	294	1053	0.73	0.78
Total	5617	18183	5886	18740	0.76	0.76

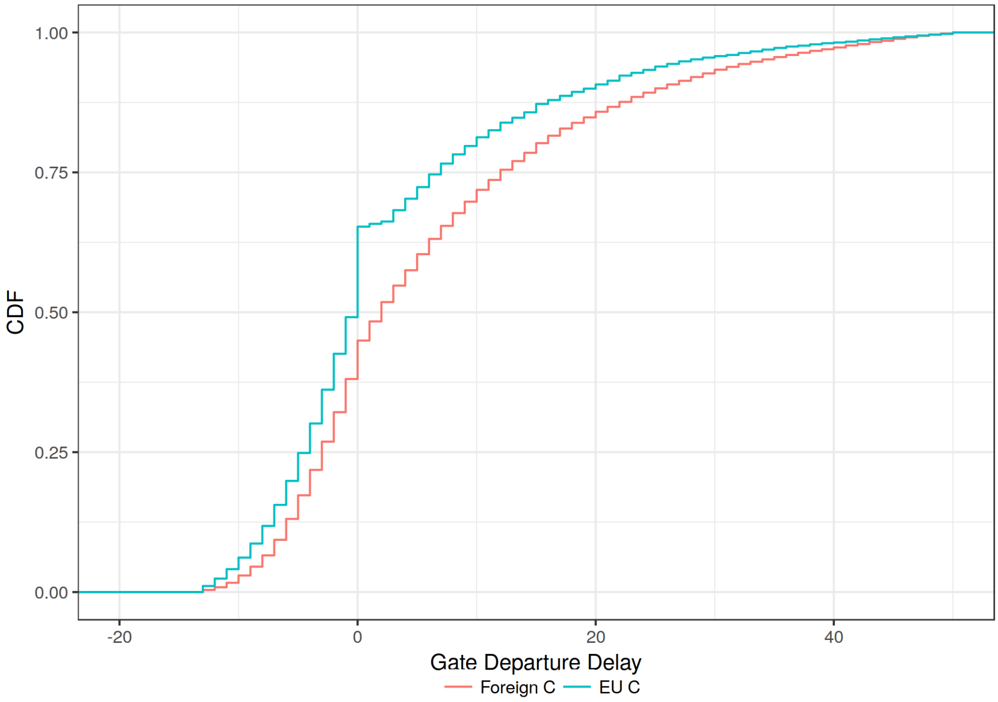
TABLE A8
Impact of EC261 and Flight Phases

Dependent Variable	Scheduled Duration	Taxi-out	In-air	Taxi-in
	(1)	(2)	(3)	(4)
$\text{EU-bound}_f \times \text{EU Carrier}_c$	−5.90	2.44	−3.15	−4.17
	(0.30)	(0.27)	(0.31)	(0.26)
$\text{From Hub}_{f,c}$	−1.38	1.19	−1.40	−1.46
	(0.13)	(0.12)	(0.12)	(0.13)
Num. obs.	137157	137157	137157	137157
R^2 (full model)	0.999	0.322	0.997	0.267

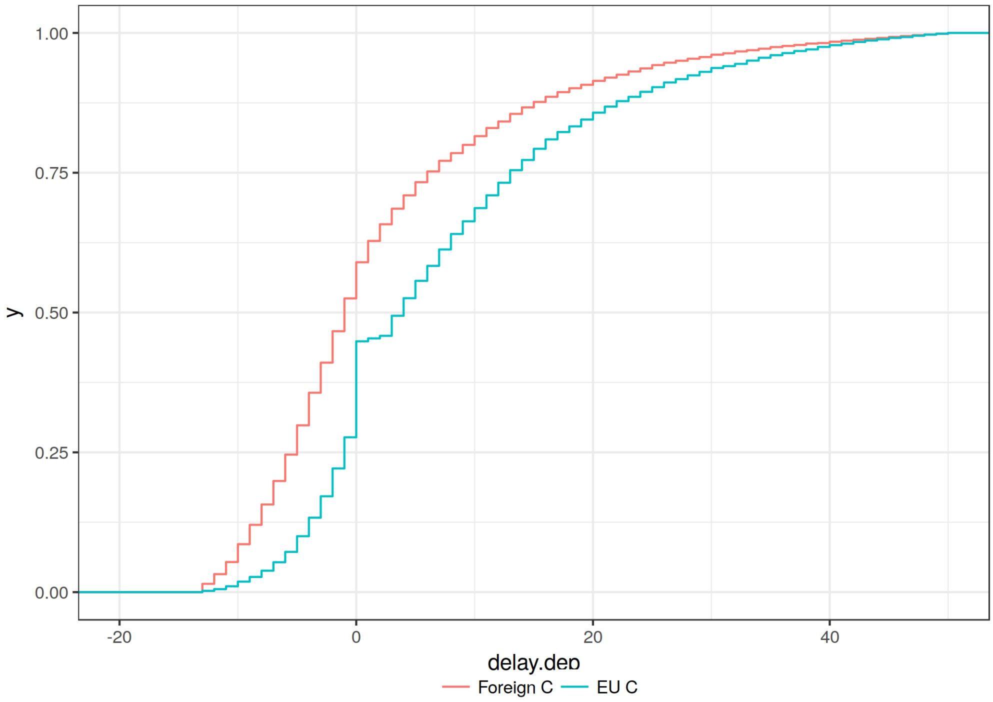
Source: Authors. All regressions include airline and route-day fixed effects. Standard errors are clustered at the route-day level.

FIGURE A2
Distribution of Departure Delay

(a) Flights Bound for EU



(b) Flights Departing from EU



Source: Authors, based on the dataset described in text.

TABLE A9
Robustness: Delay Censoring Around Zero

Dep. Var	Taxi Out	Coarse Departure Delay		
Delay = 0	0.28*			
	(0.12)			
Delay = 0 × EU Carrier$_c$	0.94***			
	(0.21)			
From Hub$_{f,c}$		3.49***	3.89***	4.20***
		(0.44)	(0.73)	(0.48)
EU-Bound$_f$ × EU Carrier$_c$		−4.95***	−5.17***	−4.75***
		(1.02)	(1.48)	(1.12)
Airline FE		Yes		
Further FE	Airport	Route-Day	Airport 120	Airport Day
Num. obs.	137157	137157	76013	137157
R^2 (full model)	0.10	0.23	0.32	0.27
R^2 (proj model)	0.00	0.00	0.01	0.00

Source: Authors' calculations. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$