CRUISE ACTIVITY AND POLLUTION: THE CASE OF BARCELONA[1]

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Abstract

Worldwide, one of the main causes of mortality is air pollution. To tackle this problem, local, regional and national governments have implemented policies to reduce emissions from industrial and on-road sources. However, when designing this type of policies, shipping emissions are often missed. Nowadays, the demand for cruises is increasing drastically and its economic relevance is also increasing in port-cities. In this sense, Barcelona is the main cruise port in the Mediterranean and the port is located near the centre of the city. In this regard, this paper analyses the impact of cruise ships in the air quality of the entire city of Barcelona using a dataset with information about pollutants and the number of cruises arriving to the port. We show that there is a direct impact between cruises arriving, in movement or berthing at night at the port and the pollution in all over the city, for all the pollutants analysed. In addition, the size of the cruise also affects the air quality. The larger the cruise is, the higher the emission generated is. Moreover our simulations show that all the city is affected by these emissions.

Keywords: Air pollution, Cruise ships emissions, Port-city, Port externalities, Port of Barcelona, Urban air quality, NO_x, CO, Particulate matter

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[1] Authors thank ….. All errors are ours.

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INTRODUCTION

Air pollution is one of the main causes of mortality worldwide. Every year 7 million premature deaths are linked to air pollution, 3 of them due to ambient air pollution. Moreover, air pollution is also a risk factor of pollution-related diseases, such as, respiratory infections, chronic obstructive pulmonary disease, lung cancer, stroke and heart disease (WHO, 2014). Industry, agriculture, on-road traffic and heating are the main sources of air pollution in urban areas, being on-road traffic the main contributor to urban air pollution (Raaschou-Nielsen et al. 2010, Holman 1999). Recognition of the importance of air pollution has led authorities to make significant efforts to improve the air quality, reducing emissions from industrial and on-road traffic sources. To reduce pollution, the first initiative implemented in Europe was the Air Quality Framework Directive 96/62/EC, which established standards for a variety of pollutants[4]. In 2005 the European Commission proposed to consolidate the Framework Directive and other related directives into a single Ambient Air Quality Directive, adopted as 2008/50/EC[5]. The Ambient Air Quality Directive along with the Directive 2004/107/EC, provides the reference framework for the control of air pollution in the EU. In Spain the Real Decreto 102/2011 sets and establishes air quality objectives regarding the concentrations of a range of pollutants[6]. In the case of Barcelona, the city council is implementing different policies to reduce the use of private cars and easing the use of public transport and alternative methods of transport like bicycles. These polices are aimed to reduce emissions and these emission reductions could be translated into an increase in the relative weight of other pollution sources such as shipping.

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[4] Including ozone, particulate matter (PM_{10}) and nitrogen dioxide (NO_2).

[5] Including a set of objectives for fine particulate matter ($PM_{2.5}$)

[6] Sulfur dioxide, nitrogen dioxide and nitrogen oxides, particles, lead, benzene, carbon monoxide, ozone, arsenic, cadmium, nickel and benzo(a)pyrene

Shipping is an important economic source for maritime cities, studies show that shipping activities generated 117 billion euros in the European Union in 2013. This activity not only generates wealth but also direct and indirect jobs. It is estimated that 615,000 people are directly employed in the shipping sector and more than a million people in indirect jobs. In addition, the cruise industry is a significant economic factor for tourism areas. In 2016, the direct cruise sector contribution in Europe went up to 20.69 billion euros, while indirect and induced economic contribution was up to 29.46 billion euros. In terms of employment, studies show that 185,842 jobs are directly related to the cruise sector in Europe while 195,584 jobs are related in an indirect or induced way by this sector (CLIA 2017).

Worldwide, during the period 2011-2016, the demand for cruises has increased an 18.32%.[7] This increase is matched with an increase in the capacity deployed by the cruise sector[8], in the same period the cruise sector increased its capacity from 121.8 million of bed days up to 1,635 million. It is important to note that the two areas with major deployment are the Caribbean, and the Mediterranean, with 55.07 and 30.53 million beds respectively. (CLIA 2017). In terms of passengers, it is estimated that 6.78 million passengers were carried by cruises ships in Europe during 2016, being Barcelona the main cruise port in Europe with 2.68 million passengers in 2016.

Along with the increase of the shipping and cruise sector activities worldwide, researchers have started to analyse the impact of these activities in the pollution of ports. Studies show that shipping activities are an important factor of pollution in the

[7] In Europe (excluding Russia and Central and Eastern countries) the demand has increased an 8.45% in the same period.

[8] In millions of bed days.

port area. Moreover, all types of vessels have impact on these generated pollution, including cruise ships.

In this regard, shipping activities and, concretely, the cruise sector, generate wealth to their home cities but also generate a negative externality in terms of increased pollution that can provoke health problems among the population of these cities. This is due to the proximity of ports to urban areas. Operations carried at ports can influence human health, inducing serious health problems such as premature mortality, asthma, bronchitis and heart failure symptoms (IAPH, 2007). In this regard, Tzannatos (2010) estimated that ship emissions in the passenger port of Piraeus reach 2,600 tons annually and their estimated externalities over this period are around 51 million euros. Also, in Piraeus, Chatzinikolaou et al. (2015) estimated that the total external cost in health caused by coastal passenger and cruise ships is about 26.3 million euros yearly. Moreover, McArthur and Osland (2013) estimated that the costs of ships emission in the port of Bergen are between 10 and 21.5 million euros per year.

Taking this into account, in our paper we analyse the impact of cruise ships in the pollution generated in the city of Barcelona. As said before, Barcelona is the main port in Europe in terms of cruise ships passengers. In the last years the number of cruise ships passengers has increased from 225,937 in 1995 up to 2,712,247 in 2017, an increase of 1,100% in 23 years.[9] Also the number of cruise ships operating in the port has increased drastically, from 447 in 1998 up to 778 in 2017[10]. See Figure 1.

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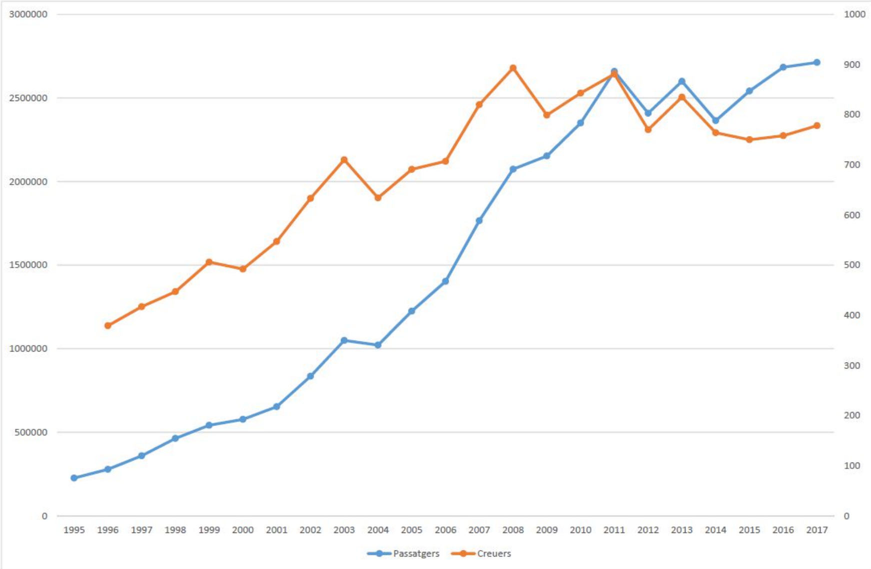
[9] In our period analysed, 2012-2016, the number of passengers increased from 2,408,634 up to 2,683,499, an increase of 11.41%.

[10] In our period analysed, 2012-2016, the increase of cruise ships have been from 770 to 778. It is important to note that the number of cruise ships is limited by the capacity of the port.

Figure 1. Number of passengers and cruise ships (1995-2017)



Source: Own elaboration

Recent studies have analysed the impact of shipping activity to pollution in port areas. Particulate matter (PM) emissions from shipping causes approximately 60,000 premature deaths each year (Corbett et al. 2007). In terms of CO_2, a significant share of its emissions are derived from the time that ships stay in the port (Habibi and Rehmatulla, 2009). For the case of cruise ships, Eckhardt et al (2013) show that mean concentrations of SO_2 are 45% higher periods where cruise ships are present at harbours in Svalbard. In Bergen, McArthur and Osland (2013) showed that cruise ships were the second type of vessel emitting higher pollution of NOx, SO_2, PM_{10}, $PM_{2.5}$ and CO_2. Following this literature, Tichavska and Tovar (2015a) calculated the emissions generated by cruise ships and ferries in Las Palmas. Authors show that passengers' ships were the main source of emission of pollutants except for CO.

Moreover, for the case of the Mediterranean, CO_2 emissions from cruise and passenger ships are estimated to be about 10% of all ship emissions (Faber et al., 2009). Focusing on Barcelona, Pey et al. (2013) showed that 19% of the PM_{10} concentration near the harbour was exclusively related to emissions taking place at harbour. Additionally, in a study carried by the Autonomous Government of Catalonia showed that, although the main source of atmospheric pollution in Barcelona is due to road transport (52% for PM_{10} and 40% for NO_x), emissions from the harbour area are also important (8% for PM_{10} and 9% for NO_x).

It is important to remark the geographical distribution of the port of Barcelona. The port of Barcelona has two main areas for boarding cruise ships, one called Moll de Barcelona and the other called Moll Adossat. In the first one there are two International Maritime Terminals, the Internacional Nord and the International Sud. These two terminals are located near the city, at 854 meters from the city. In the second one we can find 5 terminals, Internacional A, Internacional B, Internacional C, Internacional D and Internacional E[11.] These terminals are the main ones receiving cruise ships each day[12] and they are allocated at a distance from the city of Barcelona in a range between 2 up to 2.5 km. As it can be seen, the terminals are allocated pretty near the city, so it is very likely that the pollution originated by the cruise activity can influence the urban area of Barcelona and its inhabitants.

For this reason our main objective is to analyse the impact of the cruise ships activity not only on the pollution generated in the port area but also in all the urban area from Barcelona. We use a database of pollutants in different air quality stations of the city of Barcelona and the number of cruise ships arriving and leaving daily the port of Barcelona during the period 2012-2016 to analyse the impact of these ships in the air quality of Barcelona. Based on this data, we show that the pollution generated by cruise

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[11] The terminal Internacional E has been opened in May 2018

[12] In the week from May 9th to May 15th, 81% of ships arrived to a Terminal allocated in the Moll Adossat.

activity affects all the city of Barcelona, not only the port. This pollution generated affects up to 11 km away from the port. In addition, our results enable us to simulate the impact of each pollutant generated by cruise activity in the port all over the city of Barcelona.

As far as authors know, this is the first time that it is analysed the impact of the activity of cruise ships on the air quality of the city, instead of the impact of the activity in the port area. In this regard it is important to remark the works of Saxe and Larsen (2004), and Poplawski et al. (2011). Saxe and Larsen (2004) modeled the dispersal of NO_x, SO_2 and PM_{10} due to ships in three Danish harbours. They found that emissions of NO_x and PM_{10} from ships in harbours could impose a health problem to people in Copenhagen and Elsinore[13]. Poplawski et al. (2011) modelled also the impact of cruise ships in Victoria but then they compared their predicted results with measured concentrations in the nearest air quality network. They show that NO_2 and SO_2 levels were higher on days with cruise ships in port.

In our paper we analyse econometrically the impact of cruise ships in the air quality of Barcelona instead of trying to model that impact as previous authors did. We find that the cruise activity on the port not only affects the air quality in the port area but also in all Barcelona city for the pollutants analysed. Our simulations show that the activity of only one cruise affects the air quality up to 11 km far away from the port. Our results can guide the regulatory framework of port cities in regard of improving air quality. Note that regulatory framework, if correctly implemented, can play an important role in the reduction of pollutants in the ambient air. Tovar et al (2017) analysed the emissions generated in 4 ports with different regulatory frameworks. Although 3 ports had 3

[13] Note that authors believe that health problems related to NO_x should be lower in Danish ports rather than South European harbours due to the higher concentration of O_3 in South Europe.

different regulatory frameworks, authors show that differences in emissions cannot be explained only by regulatory differences.

The rest of the paper is organized as follows. Section 2 presents the data set. Section 3 presents the methodology applied in the empirical analysis. Section 4 show the results of this analysis. Section 5 shows simulations about the effects of cruises in the pollution generated in Barcelona. Finally, Section 6 concludes.

DATABASE

Our empirical analysis draws on information collected from the Air Quality Monitoring web of the Government of Catalonia[14]. We gather the daily mean data from 5 types of pollutants, CO, NO, NO_2, PM_{10} and $PM_{2.5}$ for 11 air quality stations[15] in the metropolitan area of Barcelona located at a maximum distance of 9 km from the port.[16] The information about cruises is gathered from the Port of Barcelona webpage, in its cruise section, data about the cruise ships arriving and leaving the port of Barcelona since 1 January 2012 is available. We gather data about the total number of cruises arriving and leaving the port daily and also the number of cruises berthing at the port during night-time. Finally, data about weather conditions is gathered from the meteorological service of the Government of Catalonia, the Meteocat. In this case, we collect the daily average data about temperature, rain, relative humidity, atmospheric pressure and wind's force and direction. Table 1 shows some descriptive statistics of the variables. Note that, taking into account the maximum levels of pollutants allowed by the European Directive, the air quality stations from Eixample and Sant Gervasi

[14] Its information is drawn from the Xarxa de Vigilància i Previsió de la Qualitat de l'Aire.

[15] All 11 are automatized stations.

[16] In order to calculate distances we used as a reference the Terminal Internacional D, the remotest terminal to the city.

exceeded the maximum annual level of NO_2 for all the period (also, Sant Adrià exceeded it in 4 of the 5 years).

Table 1. Descriptive statistics

Pollutant	Mean	Std. Dev.	Minimum	Maximum
NO	17.551(μg/m^3)	20.961	1 (μg/m^3)	277 (μg/m3)
NO_2	39.462(μg/m^3)	17.131	1 (μg/m^3)	144 (μg/m^3)
CO	0.427 (μg/m^3)	0.231	0.2 (mg/m^3)	3.4 (mg/m^3)
PM_{10}	25.076(μg/m^3)	11.115	3 (μg/m^3)	218 (μg/m^3)
$PM_{2.5}$	16.036(μg/m^3)	6.829	2 (μg/m^3)	67 (μg/m^3)

Source: Own elaboration

Also, there are important differences between air quality levels among different areas of Barcelona. In this regard, Table 2 shows the air quality station's location with the minimum and maximum means for each pollutant.

Table 2. Air quality stations with minimum and maximum pollution

Pollutant	Minimum mean	Maximum mean
NO	7.058 (μg/m^3)	37.187 (μg/m^3)
	Vall d'Hebron	Eixample
NO_2	29.510 (μg/m^3)	55.474 (μg/m^3)
	Vall d'Hebron	Eixample
CO	0.274 (mg/m^3)	0.636 (mg/m^3)
	Vall d'Hebron	Eixample
PM_{10}	23.263 (μg/m^3)	27.406 (μg/m^3)
	Vall d'Hebron	Eixample
$PM_{2.5}$	12.913 (μg/m^3)	17.113 (μg/m^3)
	Vall d'Hebron	Eixample

Source: Own elaboration

Focusing on cruises, it is important to remark the annual distribution of cruise ships arriving at the port of Barcelona. Table 3 shows the monthly number of cruises arriving at the port of Barcelona. The main month receiving cruises is October, with 548 cruise ships entering the port during the 5 years analysed. October was also the main month receiving cruise ships for years 2012, 2014, 2015 and 2016. On the contrary, February is the month when the port of Barcelona receives the lowest number of cruises with a total number of 83 during the period, and it is also the lowest month for years 2012 to 2015.

Table 3. Number of cruise ships per month

	Total	Std. Dev.
January	108	11.115
February	83	8.891
March	140	11.330
April	414	20.300
May	490	20.682
June	360	18.004
July	369	19.260
August	408	19.403
September	470	21.363
October	548	22.220
November	334	17.674
December	154	12.328

Source: Own elaboration

Table 4 shows the daily mean number of cruises entering, leaving or berthing at night at the port of Barcelona during the period.

Table 4. Average daily cruises entering, leaving or berthing at night (all sample)

	Mean	St. Dev.	Min.	Max.
Entry	2.122	1.730	0	9
Leaving	2.121	1.715	0	9
Berthing at night	0.273	0.552	0	3

Source: Own elaboration

Table 5 shows the same information but taking into account only days with entries, leavings and berthing of cruises:

Table 5. Average daily cruises entering, leaving or berthing at night (only days with activity)

	Mean	St. Dev.	Min.	Max.

Entry	2.671	1.517	1	9
Leaving	2.650	1.507	1	9
Berthing at night	1.211	0.464	1	3

Source: Own elaboration

EMPIRICAL STRATEGY

To approximate the effects of cruise activity on the different pollutants, we use the following reduced model:

$$
\begin{aligned}
Y_{it} &= \beta_0 + \beta_1 CruiseAct_{it} + \beta_2 CruiseAct * Km_{it} + \beta_3 CruiseAct * Km_{it}^2 + \\
&+ \beta_4 CruiseParked_{it} + \beta_5 CruiseParked * Km_{it} + \beta_6 CruiseParked * Km_{it}^2 + \\
&+ \beta_7 CruisePassengers_{it} + \beta_8 CruisePassengers * Km_{it} + \beta_9 CruisePassengers * Km_{it}^2 + \\
&+ \beta_j X_{it} + \varepsilon_{it}
\end{aligned}
$$

Where the dependent variable is the level of each of the pollutants (NO, NO_2, NO_X, CO, PM_{10} and $PM_{2.5}$), which are explained by:

- The cruise activity carried out in the port of Barcelona, which we approximate through three different variables: 1) a variable with the number of cruise ships moving during the day, which measures the number of cruise ships entering and leaving the port during the same day, 2) the number of cruise ships that enter the port during that day, 3) the number of cruise ships that have left the port of Barcelona during that day. We expect a positive and significant coefficient to be present, approaching the average impact of cruise activity in the city of Barcelona. Each of these three variables are included equally interacting with the distance between the point of measurement of air quality and the cruise port of Barcelona, as well as this same variable squared. With these two variables we approximate the effect of the cruises depending on the distance to the port, and whether that relationship is linear or not. We hope that as we move away from the port of Barcelona the effect of cruise activity will be less.

- To take into account not only the cruise ships that enter or leave the port, but also those that remain berthed during the night, the number of cruise ships that are stationed in the port, those that enter the port one day and leave other. It should be noted that cruise ships docked at the port continue to operate and carry out activities, so we expect the coefficient that accompanies this variable to be positive and significant. As in the previous case, the variable interacted with the distance to each of the air quality stations is also introduced, and the variable squared.

- A third element to consider is the size of the cruise, so the variable of the number of average passengers per cruise is introduced. This variable results from dividing the number of total passengers entering the port during the month by the total number of cruise ships arriving during that month. Unfortunately we do not have more detailed information on the number of passengers that allows us to identify the different size of the cruise ships entering the port of Barcelona per day.

- In addition to the variables that reflect the activity of the cruise ships in the port of Barcelona, we control for a whole set of variables that could affect the level of pollution: 1) the day of the week, for which variable dummies are included for each one of the days of the week, except Sunday, which acts as a point of reference; 2) the month of the year, include dummy variables for each of the months, except December, which acts as a reference variable; 3) the different years, including dummy variables for each year of the sample, except for 2012, which acts as reference year; 4) Atmospheric conditions, so we include the daily average of temperature, atmospheric pressure, accumulated rainfall and relative humidity; 5) Wind speed; 6) the wind direction, for which we include 15 dummy variables that take value 1 when the wind has blown in that direction during that day. The wind direction can be: North-Northeast (N-NE), North-East (NE), East-Northeast (E-NE), East (E), East-Southeast (E-SE), South-East (SE), South (S), South-Southwest (S-SW), South-West (SW), West-Southwest (W-SW), West (W), West-Northwest (W-NW), North-West (NW), North-Northwest (W-NW), and North (N). Enter all the addresses except the North (N) that is taken as a reference. It also includes a time variable that grows throughout the period, and that same variable squared, to capture any type of trend in the evolution of pollution.

Before carrying out the econometric estimations, it was found that the database, with a data panel structure, presented problems of heterokedasticity and autocorrelation of order one. This fact makes us use an estimator that produces robust Newey-West standard errors to the problems of heterokedasticity and autocorrelation[17]. This estimator only compute pooled OLS estimates, not fixed or random effects. In the following section we can see the econometric results.

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[17] The Stata command that permit robust standard errors is newey2.

RESULTS

In the next tables we can find the results of the econometric regressions. In the table 6 we present the effect of cruise movements in the pollution levels. In the annex 1 we can find the results for cruise departures and entrance.

Table 6. Effects of cruise movements in the pollution levels

	NO	NO_2	NO_X	CO	PM_{10}	$PM_{2.5}$
Constant	-139.828***	-14.239	-102.905***	-2.298***	-134.192***	-43.282***
	(11.499)	(9.998)	(19.402)	(0.188)	(16.030)	(6.265)
Movement	**10.985*** **	**8.744*** **	**15.249*** **	**0.322*** **	**1.391* **	**1.858*** **
	(0.813)	**(0.698)**	**(1.372)**	**(0.018)**	**(0.855)**	**(0.406)**
Movement*	**-3.828*** **	**-2.948*** **	**-4.953*** **	**-0.105*** **	**-0.667** **	**-0.726*** **
Km	**(0.264)**	**(0.230)**	**(0.448)**	**(0.006)**	**(0.281)**	**(0.133)**
Movement*	**0.317*** **	**0.233*** **	**0.387*** **	**0.008*** **	**0.061*** **	**0.063*** **
Km^2	**(0.020)**	**(0.018)**	**(0.035)**	**(0.0005)**	**(0.021)**	**(0.010)**
Parked	**8.926*** **	**6.071** **	**12.271** **	**0.372*** **	**0.775**	**0.108**
	(3.185)	**(2.661)**	**(5.359)**	**(0.068)**	**(3.063)**	**(1.534)**
Parked*Km	**-2.893*** **	**-1.987** **	**-3.848** **	**-0.121*** **	**-0.487**	**-0.123**
	(1.023)	**(0.880)**	**(1.746)**	**(0.022)**	**(1.000)**	**(0.511)**
Parked*Km^2	**0.224*** **	**0.155** **	**0.288** **	**0.009*** **	**0.046**	**0.016**
	(0.078)	**(0.069)**	**(0.135)**	**(0.002)**	**(0.076)**	**(0.040)**
Monday	9.163***	10.230***	19.371***	0.090***	2.939***	0.853***
	(0.332)	(0.269)	(0.545)	(0.006)	(0.398)	(0.195)
Tuesday	11.654***	12.178***	23.635***	0.097***	4.195***	1.084***
	(0.417)	(0.327)	(0.681)	(0.007)	(0.477)	(0.224)
Wednesday	13.523***	13.503***	27.347***	0.112***	4.815***	1.661***
	(0.462)	(0.339)	(0.737)	(0.007)	(0.430)	(0.112)
Thursday	12.899***	13.758***	26.727***	0.110***	4.241***	1.783***
	(0.423)	(0.332)	(0.689)	(0.007)	(0.433)	(0.230)
Friday	11.730***	13.872***	25.651***	0.098***	5.122***	2.103***
	(0.383)	(0.321)	(0.654)	(0.007)	(0.384)	(0.229)
Saturday	4.545***	5.870***	10.376***	0.030***	1.631***	1.280***
	(0.283)	(0.248)	(0.484)	(0.005)	(0.343)	(0.198)
January	0.515	-8.047*	-13.072	-0.028	25.903***	-4.159
	(5.217)	(4.317)	(8.940)	(0.091)	(5.148)	(2.738)
February	-7.162	-7.336*	-20.679**	-0.040	25.715***	-4.367*
	(4.816)	(3.970)	(8.256)	(0.084)	(4.898)	(2.520)
March	-13.356***	-10.067***	-28.872***	-0.066	19.053***	-4.872**
	(4.356)	(3.596)	(7.465)	(0.076)	(4.223)	(2.257)
April	-21.814***	-19.200***	-45.806***	-0.128*	11.394***	-8.717***
	(3.930)	(3.202)	(6.697)	(0.068)	(3.733)	(2.028)
May	-26.080***	-24.419***	-53.966***	-0.175***	6.183*	-9.861***
	(3.518)	(2.831)	(5.963)	(0.061)	(3.237)	(1.784)
June	-30.439***	-28.250***	-62.337***	-0.246***	1.286	-10.097***
	(3.152)	(2.496)	(5.297)	(0.054)	(2.972)	(1.606)
July	-33.358***	-31.682***	-67.734***	-0.253***	-6.409***	-11.518***

	(2.790)	(2.158)	(4.637)	(0.048)	(2.304)	(1.378)
August	-36.469***	-36.467***	-75.631***	-0.303***	-12.530***	-13.302***
	(2.402)	(1.814)	(3.952)	(0.041)	(1.904)	(1.168)
September	-32.662***	-26.841***	-61.893***	-0.220***	-11.305***	-11.058***
	(1.981)	(1.447)	(3.218)	(0.033)	(1.490)	(0.939)
October	-22.074***	-14.852***	-38.858***	-0.105***	-5.459***	-7.626***
	(1.664)	(1.094)	(2.587)	(0.027)	(1.224)	(0.746)
November	-10.370***	-7.366***	-19.04***	-0.033	-0.297	-4.032***
	(1.306)	(0.735)	(1.920)	(0.020)	(0.919)	(0.506)
2013	-2.241	7.185	12.455	0.016	-31.947***	3.644
	(5.670)	(4.720)	(9.760)	(0.100)	(5.730)	(2.944)
2014	-7.770	14.386	21.371	0.027	-60.080***	6.893
	(11.247)	(9.378)	(19.364)	(0.197)	(11.219)	(5.815)
2015	-17.109	20.604	25.578	0.093	-86.892***	11.055
	(16.889)	(14.057)	(29.053)	(0.295)	(16.933)	(8.727)
2016	-33.896	20.807	14.570	0.048	-121.096***	8.646
	(22.488)	(18.725)	(38.687)	(0.393)	(22.382)	(11.558)
Temperature	0.516***	0.839***	1.489***	0.007***	1.508***	0.461***
	(0.064)	(0.054)	(0.110)	(0.001)	(0.068)	(0.033)
Atmospheric	0.168***	0.083***	0.205***	0.003***	0.108***	0.062***
pressure	(0.010)	(0.009)	(0.017)	(0.0002)	(0.015)	(0.005)
Cumulative	0.006	0.155***	0.164***	0.0004	-0.084***	-0.058***
rainfall	(0.020)	(0.018)	(0.037)	(0.0004)	(0.031)	(0.011)
Relative	0.059***	-0.143***	-0.116***	-0.0006***	0.136***	0.033***
Humidity	(0.015)	(0.011)	(0.024)	(0.0002)	(0.013)	(0.007)
Wind speed	-4.815***	-6.175***	-10.962***	-0.037***	-0.582***	-0.908***
	(0.168)	(0.137)	(0.283)	(0.002)	(0.172)	(0.081)
N-NE	-1.208	-1.394	-3.898**	0.026	-0.308	-0.030
	(1.230)	(0.850)	(1.972)	(0.019)	(1.046)	(0.673)
N-E	-1.973*	-1.262*	-3.342**	0.047***	0.900	0.302
	(1.029)	(0.748)	(1.651)	(0.018)	(0.970)	(0.503)
E-NE	-2.579***	-3.189***	-4.503***	0.050***	0.723	0.132
	(0.934)	(0.669)	(1.495)	(0.016)	(0.803)	(0.463)
E	-1.000	-4.072***	-3.831**	0.066***	1.181	0.418
	(0.979)	(0.689)	(1.556)	(0.017)	(0.820)	(0.478)
E-SE	0.023	-4.211***	-2.244	0.066***	2.204**	0.371
	(1.070)	(0.749)	(1.699)	(0.019)	(0.999)	(0.492)
S-E	0.954	-2.926***	0.541	0.061***	0.685	0.789
	(1.243)	(0.858)	(1.940)	(0.019)	(0.889)	(0.544)
S-SE	1.058	-0.533	2.311	0.072***	1.276	1.138**
	(1.161)	(0.837)	(1.845)	(0.021)	(0.886)	(0.538)
S	2.108**	-0.022	4.207**	0.064***	2.189***	1.017**
	(1.063)	(0.771)	(1.714)	(0.018)	(0.850)	(0.513)
S-SW	2.366**	0.040	4.661***	0.054***	2.928***	1.353***
	(1.041)	(0.736)	(1.631)	(0.017)	(0.845)	(0.493)
S-W	2.184**	0.798	5.705***	0.052***	2.419***	1.612***
	(0.940)	(0.662)	(1.483)	(0.015)	(0.793)	(0.461)
W-SW	1.204	-0.198	3.471**	0.030***	1.034	1.199***
	(0.911)	(0.630)	(1.427)	(0.014)	(0.762)	(0.445)
W	0.639	-1.180*	0.427	0.014	-0.489	0.238
	(0.927)	(0.619)	(1.433)	(0.015)	(0.761)	(0.453)

W-NW	-0.586	-3.962***	-2.928**	-0.012	-0.585	-0.118
	(0.930)	(0.628)	(1.449)	(0.015)	(0.789)	(0.464)
N-W	-1.242	-4.870***	-4.576***	-0.021	0.340	-0.503
	(0.951)	(0.635)	(1.457)	(0.015)	(0.910)	(0.478)
N-NW	-1.381	-2.960***	-3.181*	-0.002	0.276	0.986*
	(1.074)	(0.721)	(1.648)	(0.016)	(0.978)	(0.563)
Time	-0.012	-0.038***	-0.071***	-0.0002	0.072***	-0.021**
	(0.016)	(0.013)	(0.027)	(0.0003)	(0.016)	(0.008)
$Time^2$	0.00002***	0.00001***	0.00003***	6.28e-08**	4.50e-06***	6.76e-06***
	(1.76e-06)	(1.10e-06)	(2.74e-06)	(2.53e-08)	(1.22e-06)	(7.33e-07)
No Obs.	19795	19761	19259	8663	7382	9495
F-Test	112.36***	227.70***	156.23***	66.62***	50.87***	48.31***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Robust Standard errors to heterokedasticity and autocorrelation in brackets. (***) 1%, (**) 5%, (*) 10%.

Table 7. Effects of cruise movements in the pollution levels (passengers included)

	NO	NO_2	NO_X	CO	PM_{10}	$PM_{2.5}$
Constant	-139.618***	-9.819	-94.452***	-1.641***	-138.558***	-56.584***
	(11.681)	(10.014)	(19.756)	(0.187)	(15.669)	(6.201)
Movement	**0.917**	**3.300*** **	**5.880*** **	**0.015**	**1.461**	**2.001*** **
	(1.200)	**(0.918)**	**(1.937)**	**(0.023)**	**(1.084)**	**(0.558)**
Movement* Km	**-0.176**	**-0.928*** **	**-1.735*** **	**-0.008**	**-0.502**	**-0.621*** **
	(0.391)	**(0.304)**	**(0.638)**	**(0.008)**	**(0.361)**	**(0.185)**
Movement* Km^2	**0.014**	**0.061*** **	**0.133*** **	**0.0007**	**0.036**	**0.044*** **
	(0.030)	**(0.024)**	**(0.049)**	**(0.0006)**	**(0.027)**	**(0.015)**
Parked	**1.995**	**2.312**	**5.860**	**0.163** **	**0.388**	**0.285**
	(3.248)	**(2.671)**	**(5.443)**	**(0.065)**	**(3.127)**	**(1.571)**
Parked*Km	**-0.375**	**-0.595**	**-1.648**	**-0.055** **	**-0.235**	**-0.072**
	(1.045)	**(0.885)**	**(1.774)**	**(0.021)**	**(1.023)**	**(0.523)**
Parked* Km^2	**0.016**	**0.037**	**0.114**	**0.004*** **	**0.019**	**0.005**
	(0.080)	**(0.069)**	**(0.137)**	**(0.002)**	**(0.078)**	**(0.041)**
PassengersXcruise	**10.303*** **	**3.330*** **	**7.933*** **	**0.390*** **	**2.834** **	**1.806*** **
	(1.276)	**(0.857)**	**(1.993)**	**(0.021)**	**(1.136)**	**(0.596)**
PassengersXcruise *Km	**-3.911*** **	**-2.160*** **	**-3.457*** **	**-0.104*** **	**-0.146**	**-0.091**
	(0.340)	**(0.244)**	**(0.544)**	**(0.006)**	**(0.311)**	**(0.168)**
PassengersXcruise * Km^2	**0.326*** **	**0.185*** **	**0.273*** **	**0.007*** **	**0.026**	**0.021**
	(0.026)	**(0.019)**	**(0.043)**	**(0.0005)**	**(0.024)**	**(0.013)**
Monday	9.183***	10.243***	19.367***	0.089***	2.947***	0.869***
	(0.331)	(0.268)	(0.544)	(0.006)	(0.397)	(0.194)
Tuesday	11.636***	12.144***	23.602***	0.098***	4.200***	1.104***
	(0.414)	(0.325)	(0.679)	(0.007)	(0.474)	(0.221)
Wednesday	13.514***	13.479***	27.322***	0.112***	4.834***	1.694***
	(0.459)	(0.336)	(0.736)	(0.007)	(0.427)	(0.220)
Thursday	12.864***	13.691***	26.674***	0.111***	4.238***	1.812***
	(0.421)	(0.329)	(0.688)	(0.007)	(0.430)	(0.227)

Friday	11.723***	13.851***	25.622***	0.097***	5.132***	2.440***
	(0.381)	(0.319)	(0.653)	(0.007)	(0.380)	(0.226)
Saturday	4.564***	5.870***	10.363***	0.030***	1.658***	1.307***
	(0.282)	(0.247)	(0.484)	(0.005)	(0.343)	(0.195)
January	0.888	-6.468	-12.007	-0.083	24.066***	-4.993*
	(5.165)	(4.298)	(8.916)	(0.087)	(5.056)	(2.708)
February	-6.730	-5.155	-18.979**	-0.106	23.098***	-5.841**
	(4.769)	(3.961)	(8.238)	(0.080)	(4.788)	(2.508)
March	-13.105***	-9.381***	-28.410***	-0.088	17.769***	-5.144**
	(4.320)	(3.575)	(7.447)	(0.072)	(4.169)	(2.241)
April	-21.822***	-20.073***	-46.599***	-0.107	12.670***	-7.703***
	(3.931)	(3.191)	(6.724)	(0.065)	(3.766)	(2.008)
May	-25.946***	-24.488***	-53.926***	-0.159***	6.448**	-9.675***
	(3.491)	(2..813)	(5.952)	(0.058)	(3.235)	(1.766)
June	-30.049***	-26.232***	-60.211***	-0.255***	-1.831	-12.052***
	(3.151)	(2.506)	(5.329)	(0.053)	(2.920)	(1.626)
July	-32.788***	-28.861***	-64.211***	-0.270***	-10.620***	-14.216***
	(2.860)	(2.209)	(4.769)	(0.048)	(2.308)	(1.437)
August	-35.980***	-33.800***	-72.857***	-0.318***	-16.414***	-15.952***
	(2.492)	(1.877)	(4.111)	(0.041)	(1.938)	(1.238)
September	-32.500***	-25.842***	-60.656***	-0.211***	-13.119***	-12.224***
	(1.976)	(1.449)	(3.233)	(0.032)	(1.485)	(0.948)
October	-22.057***	-14.607***	-38.400***	-0.095***	-6.089***	-7.998***
	(1.645)	(1.086)	(2.579)	(0.026)	(1.208)	(0.739)
November	-10.492***	-8.227***	-19.737***	-0.013	0.930	-3.268***
	(1.332)	(0.760)	(1.986)	(0.019)	(0.941)	(0.500)
2013	-2.458	6.769	12.450	0.049	-30.857***	3.497
	(5.629)	(4.692)	(9.737)	(0.095)	(5.644)	(2.914)
2014	-8.160	13.645	21.429	0.083	-58.410***	6.567
	(11.165)	(9.321)	(19.317)	(0.187)	(11.073)	(5.756)
2015	-17.479	20.705	26.682	0.149	-86.714***	9.520
	(16.794)	(13.973)	(29.011)	(0.281)	(16.798)	(8.640)
2016	-34.215	21.761	16.600	0.099	-122.564***	6.050
	(22.387)	(18.612)	(38.655)	(0.375)	(22.287)	(11.448)
Temperature	0.514***	0.842***	1.466***	0.004***	1.547***	0.488***
	(0.064)	(0.054)	(0.110)	(0.001)	(0.068)	(0.033)
Atmospheric	0.170***	0.087***	0.203***	0.002***	0.106***	0.070***
pressure	(0.010)	(0.009)	(0.017)	(0.0002)	(0.014)	(0.005)
Cumulative	0.018	0.166***	0.162***	-0.0005	-0.071**	-0.046***
rainfall	(0.020)	(0.018)	(0.037)	(0.0004)	(0.031)	(0.011)
Relative	0.046***	-0.155***	-0.114***	0.0002	0.119***	0.025***
Humidity	(0.015)	(0.011)	(0.024)	(0.0002)	(0.014)	(0.007)
Wind speed	-5.157***	-6.437***	-11.045***	-+0.032***	-0.849***	-1.049***
	(0.171)	(0.143)	(0.290)	(0.002)	(0.180)	(0.083)
N-NE	-1.051	-1.368*	-3.851*	0.032*	-0.129	0.014
	(1.219)	(0.848)	(1.974)	(0.018)	(1.030)	(0.665)
N-E	-1.831*	-1.220*	-3.392**	0.049***	1.137	0.429
	(1.014)	(0.751)	(1.649)	(0.017)	(0.963)	(0.499)
E-NE	-2.389***	-3.068***	-4.554***	0.045***	0.967	0.217
	(0.919)	(0.670)	(1.494)	(0.015)	(0.790)	(0.460)
E	-0.641	-3.794***	-3.816**	0.052***	1.505*	0.590

	(0.965)	(0.689)	(1.554)	(0.016)	(0.807)	(0.473)
E-SE	0.262	-4.005***	-2.297	0.049***	2.449**	0.475
	(1.055)	(0.746)	(1.694)	(0.017)	(0.982)	(0.488)
S-E	1.068	-2.841***	0.432	0.045**	0.925	0.880
	(1.228)	(0.856)	(1.932)	(0.018)	(0.875)	(0.538)
S-SE	1.167	-0.422	2.223	0.054***	1.399	1.211**
	(1.145)	(0.835)	(1.839)	(0.020)	(0.875)	(0.535)
S	2.144**	-0.013	4.053**	0.052***	2.338***	1.077**
	(1.048)	(0.768)	(1.710)	(0.017)	(0.840)	(0.509)
S-SW	2.422**	0.046	4.534***	0.044***	3.078***	1.449***
	(1.024)	(0.734)	(1.627)	(0.016)	(0.831)	(0.488)
S-W	2.367**	0.900	5.687***	0.047***	2.611***	1.670***
	(0.925)	(0.660)	(1.482)	(0.014)	(0.776)	(0.456)
W-SW	1.465	-0.062	3.554**	0.033**	1.233*	1.260***
	(0.900)	(0.627)	(1.426)	(0.014)	(0.744)	(0.439)
W	0.742	-1.166*	0.423	0.022	-0.496	0.246
	(0.912)	(0.617)	(1.434)	(0.015)	(0.741)	(0.446)
W-NW	-0.258	-3.812***	-2.701*	0.006	-0.574	-0.134
	(0.913)	(0.623)	(1.447)	(0.014)	(0.771)	(0.457)
N-W	-0.871	-4.668***	-4.259***	-0.007	0.447	-0.464
	(0.934)	(0.632)	(1.457)	(0.014)	(0.887)	(0.471)
N-NW	-1.219	-2.882***	-3.003*	0.007	0.357	0.938*
	(1.059)	(0.719)	(1.646)	(0.015)	(0.952)	(0.554)
Time	-0.011	-0.036***	-0.071***	-0.0003	0.067***	-0.020***
	(0.015)	(0.013)	(0.027)	(0.0003)	(0.016)	(0.008)
Time^2	0.00002***	0.00001***	0.00003***	8.70e-08***	6.90e06***	7.19e-06***
	(1.79e-06)	(1.10e-06)	(2.77e-06)	(2.53e-08)	(1.25e-06)	(7.35e-07)
No Obs.	19795	19761	19259	8663	7382	9495
F-Test	110.94***	219.72***	148.33***	77.50***	49.87***	47.95***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Robust Standard errors to heterokedasticity and autocorrelation in brackets. (***) 1%, (**) 5%, (*) 10%.

As we can see in the previous tables, the number of cruises in movement generates a positive impact on the level of pollution, for all types of pollutants. It can also be seen how the impact of cruises decreases with the distance to the port. Logically, as the point of measurement of air quality is farthest from the port, the impact of the pollution generated by the cruises is lower. It should be noted, however, that this reduction in the impact of cruises on pollution is decreasing.

The number of berthed cruises follows the same pattern as the number of cruise ships in movement (those entering and leaving the port on the same day), but the impact is significantly lower.

Table 7 incorporates the variable of the average number of passengers per cruise, to take into account the size of the cruises. By incorporating this variable it can be observed that the larger the cruise, the greater the impact on pollution levels.

In the following section, a simulation of the effects of cruises on pollution levels is performed, depending on the distance to the cruise ship dock at the port of Barcelona.

Regarding the control variables, all have the expected signs:

The dummy variables of the different days of the week show how Sunday is the day of least contamination of the week, showing significantly higher levels during the working days, those where there is a greater economic activity.

Regarding the evolution of the contamination throughout the year, it can be observed that the summer months are the ones with the lowest level of contamination, while the winter months (December, January and February) have the highest levels. This pattern is repeated in all pollutants, with greater or lesser intensity.

Regarding the variables that reflect the temporary effect, we can see that in general there is no significant change in pollution levels in the last 5 years, once we take into account the daily evolution of the pollution collected in the variable “time”. As you can see, the reduction of NO_X and $PM_{2.5}$ is constant and decreasing (the variable “time2” is negative and significant).

The speed and direction of the wind is another element that can affect pollution levels. We can see how at a higher wind speed the level of contamination decreases significantly. The direction is important too. When the wind blows in Northeast direction pollution levels decrease, while when the wind blows southwest, pollution levels rise. As can be seen in the following graph, when the wind blows from the northeast, pollution goes out to the sea, whereas when the wind direction is southwest, pollution enters inside the city.

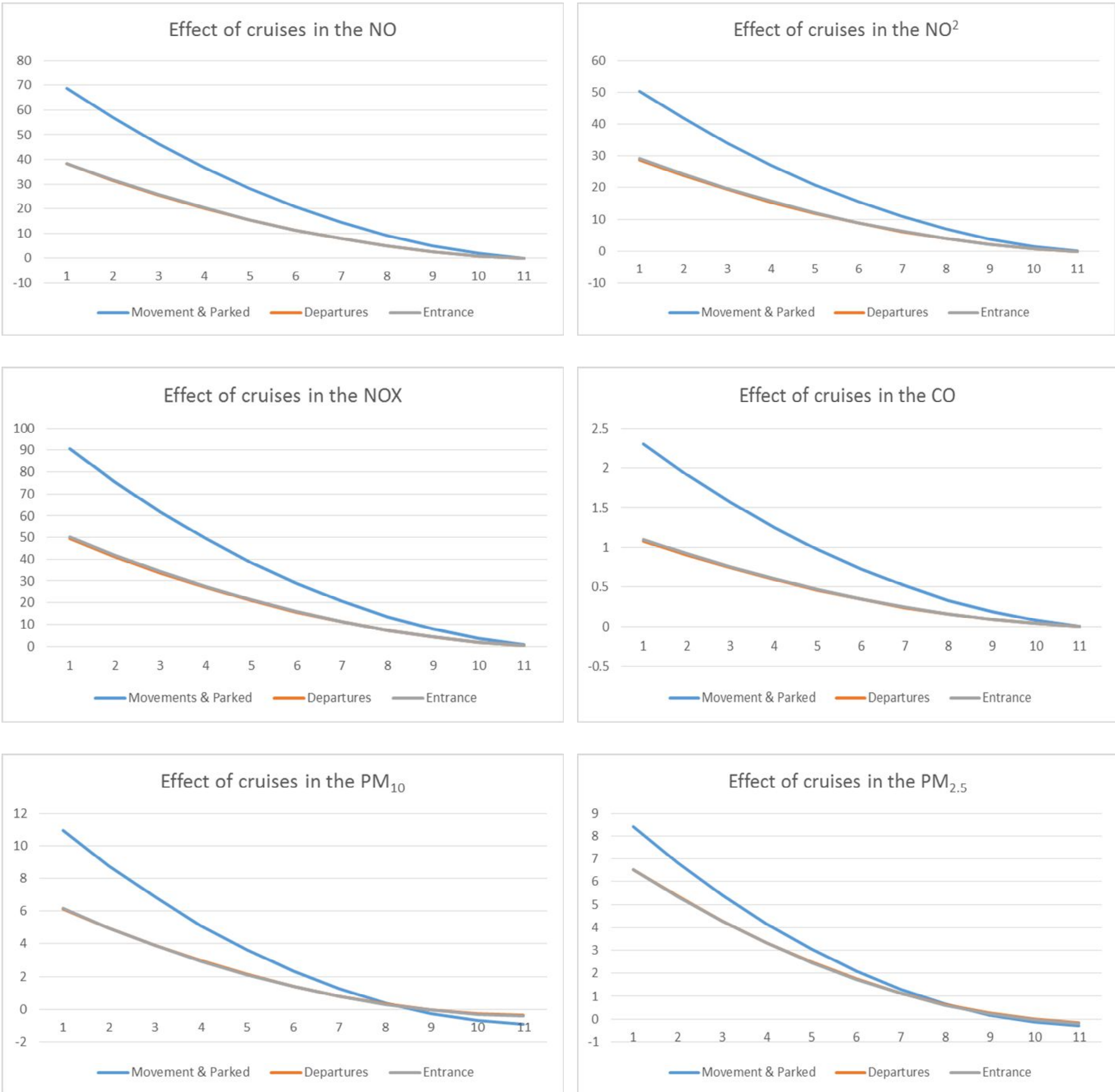
Figure 2. Map of Barcelona

Source: Own elaboration through Google Earth

SIMULATIONS

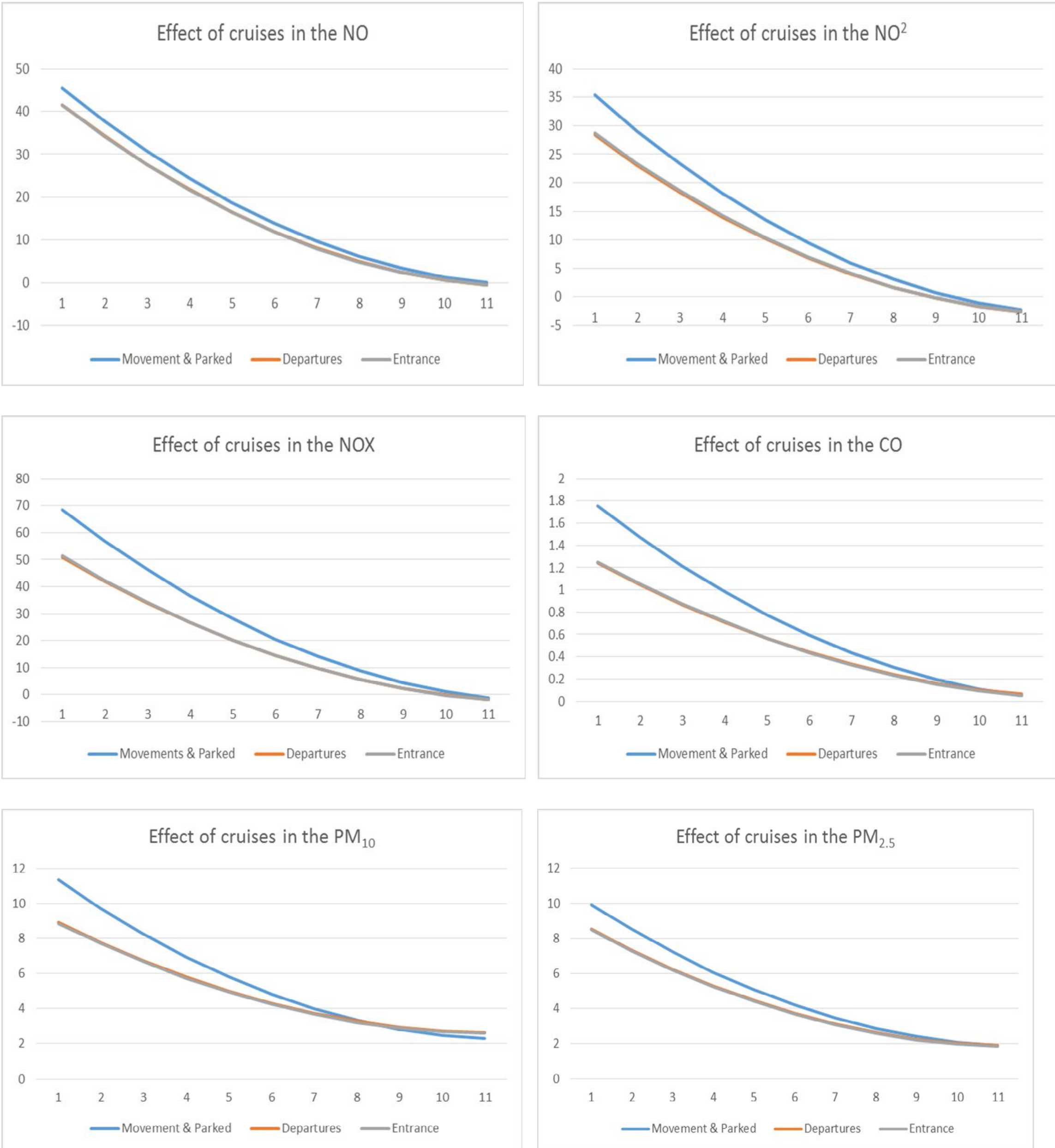
In the following figures we can see a simulation of the effect of cruises on the level of pollution depending on the distance to the cruise port of Barcelona. To calculate this effect we use the average effect of the cruises (for the three estimations) and the average distance of the air quality measurement points, and taking into account the effect of the distance on the pollution levels, we calculate the effect for distance between 1 and 11 kilometres (distance that covers the entire city of Barcelona).

Figure 3: Simulation effects of cruises in pollution



Source: Own elaboration

Figure 4: Simulation effects of cruises in pollution (with passenger variables)



Source: Own elaboration

As can be seen in the previous graphs, the effects of cruises on different pollutants is decreasing, and they disappear (are not significant) between 10 and 11 kilometres. The proximity of the port of Barcelona to the city means that the entire city is affected by the activity of the cruises to a greater or lesser extent, even affecting the bordering municipalities (with a very limited effect).

CONCLUSIONS

In the last years, the demand for cruises ships had a relevant increase, nowadays the Port of Barcelona is the first port in Europe in number of passengers cruise by year. This activity generates wealth for the city but also is an important source of air pollution that can contribute to decrease the air quality not only in the port area but also in all the metropolitan area. In this regard, the cruise activity generates not only wealth but also negative externalities for the citizens of Barcelona. Traditionally, literature has focused its attention in the evaluation of the pollution generated by the shipping activity at the port area, rather in the impact of this pollution in the air quality of the cities.

The goal of this article is to measure the effects of cruise activity at port (cruises arriving, leaving and berthing at night) in the pollution all over the city of Barcelona. By using a dataset collected by the authors we have found that the activity of the cruise ships at port has negative effects on air quality levels all over the city of Barcelona. Our results show that for all the pollutants analysed, NO, NO_2, NO_x, CO, PM_{10}, $PM_{2.5}$ the activity of cruises at the port decreases the air quality level in all city. Moreover, our simulations show that the effect of one cruise arrival to the port affects the air quality up to 11 km. This implies that all the city of Barcelona, and some localities around the city are affected by it, although in a decreasing way. As we move away from the port, the impact decreases disappearing between 10 and 11 kilometres.

The results of this study should provide useful information for drawing policies in port cities, with important influence of the cruise sector, to control the emissions generated by its activity. One direct policy implication should be the inclusion of cruise activity in any local initiative aimed to improve the air quality of port cities. Moreover, as our results show that cruises berthing at night at the port negatively affect air quality, any policy aimed to ease the use of green energies in ports should reduce the emission of pollutants. Finally, although it is not the aim of our paper to calculate the health costs provoked by the cruise activity, this estimation could be used for calculating an optimal tax for passenger's cruises to cope with these health costs.

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Annex 1

Table A1. Effects of cruise departures in the pollution levels

	NO	NO_2	NO_X	CO	PM_{10}	$PM_{2.5}$
Constant	-140.724***	-15.172	-104.035***	-2.305***	-134.402***	-43.421***
	(11.507)	(10.011)	(19.424)	(0.188)	(15.974)	(6.268)
Departures	**10.864*** **	**8.393*** **	**14.920*** **	**0.328*** **	**1.325** **	**1.659*** **
	(0.701)	**(0.599)**	**(1.178)**	**(0.016)**	**(0.678)**	**(0.341)**
Departures* Km	**-3.748*** **	**-2.820*** **	**-4.811*** **	**-0.106*** **	**-0.636*** **	**-0.654*** **
	(0.226)	**(0.196)**	**(0.383)**	**(0.005)**	**(0.222)**	**(0.111)**
Departures* Km^2	**0.309*** **	**0.223*** **	**0.375*** **	**0.008*** **	**0.059*** **	**0.057*** **
	(0.018)	**(0.015)**	**(0.030)**	**(0.001)**	**(0.017)**	**(0.009)**
Monday	9.125***	10.202***	19.315***	0.089***	2.939***	0.851***
	(0.331)	(0.269)	(0.544)	(0.006)	(0.397)	(0.195)
Tuesday	11.651***	12.168***	23.610***	0.096***	4.244***	1.106***
	(0.417)	(0.326)	(0.680)	(0.007)	(0.473)	(0.222)
Wednesday	13.532***	13.498***	27.336***	0.111***	4.835***	1.684***
	(0.462)	(0.337)	(0.737)	(0.008)	(0.426)	(0.221)
Thursday	12.900***	13.750***	26.699***	0.108***	4.309***	1.809***
	(0.421)	(0.329)	(0.685)	(0.007)	(0.429)	(0.227)
Friday	11.666***	13.827***	25.571***	0.097***	5.121***	2.390***
	(0.384)	(0.321)	(0.655)	(0.007)	(0.383)	(0.229)
Saturday	4.528***	5.849***	10.351***	0.029***	1.631***	1.276***
	(0.283)	(0.248)	(0.485)	(0.005)	(0.344)	(0.198)
January	0.778	-7.805*	-12.808	-0.024	25.775***	-4.173
	(5.217)	(4.314)	(8.938)	(0.091)	(5.108)	(2.736)
February	-6.847	-7.062*	-20.342**	-0.034	25.621***	-4.371*
	(4.818)	(3.969)	(8.257)	(0.084)	(4.863)	(2.517)
March	-13.166***	-9.887***	-28.693***	-0.063	18.945***	-4.889**
	(4.357)	(3.593)	(7.465)	(0.076)	(4.192)	(2.255)
April	-21.689***	-19.025***	-45.723***	-0.125*	11.129***	-8.771***
	(3.927)	(3.194)	(6.685)	(0.068)	(3.689)	(2.023)
May	-26.084***	-24.318***	-54.056***	-0.172***	5.954*	-9.920***
	(3.517)	(2.825)	(5.957)	(0.061)	(3.200)	(1.783)
June	-30.447***	-28.191***	-62.410***	-0.244***	1.146	-10.143***
	(3.152)	(2.493)	(5.294)	(0.054)	(2.943)	(1.604)
July	-33.419***	-31.660***	-67.869***	-0.251***	-6.534***	-11.566***
	(2.791)	(2.157)	(4.636)	(0.048)	(2.285)	(1.378)
August	-36.531***	-36.449***	-75.762***	-0.301***	-12.677***	-13.347***
	(2.403)	(1.812)	(3.950)	(0.041)	(1.887)	(1.167)
September	-32.779***	-26.851***	-62.086***	-0.219***	-11.456***	-11.112***
	(1.983)	(1.445)	(3.219)	(0.033)	(1.479)	(0.939)
October	-22.209***	-14.866***	-39.071***	-0.103***	-5.638***	-7.691***
	(1.665)	(1.094)	(2.588)	(0.027)	(1.224)	(0.748)
November	-10.439***	-7.380***	-19.135***	-0.032	-0.348	-4.064***
	(1.302)	(0.735)	(1.916)	(0.020)	(0.918)	(0.507)
2013	-2.538	6.904	12.154	0.010	-31.822***	3.657
	(5.671)	(4.716)	(9.757)	(0.010)	(5.689)	(2.941)
2014	-8.337	13.845	20.798	0.016	-59.809***	6.932
	(11.248)	(9.370)	(19.357)	(0.197)	(11.135)	(5.809)

2015	-17.974	19.791	24.699	0.079	-86.436***	11.117
	(16.887)	(14.045)	(29.039)	(0.295)	(16.802)	(8.171)
2016	-35.010	19.763	13.458	0.032	-120.455***	8.733
	(22.482)	(18.706)	(38.662)	(0.393)	(22.204)	(11.542)
Temperature	0.522***	0.842***	1.497***	0.007***	1.506***	0.461***
	(0.064)	(0.054)	(0.110)	(0.001)	(0.068)	(0.033)
Atmospheric	0.169***	0.084***	0.206***	0.003***	0.108***	0.062***
pressure	(0.010)	(0.009)	(0.017)	(0.0002)	(0.015)	(0.005)
Cumulative	0.006	0.156***	0.164***	0.0004	-0.083***	-0.058***
rainfall	(0.020)	(0.018)	(0.036)	(0.0004)	(0.031)	(0.011)
Relative	0.058***	-0.144***	-0.116***	-0.001***	0.0135***	0.032***
Humidity	(0.015)	(0.011)	(0.024)	(0.0002)	(0.013)	(0.007)
Wind speed	-4.812***	-6.172***	-10.958***	-0.037***	-0.585***	-0.909***
	(0.168)	(0.137)	(0.284)	(0.002)	(0.173)	(0.081)
N-NE	-1.202	-1.390	-3.871**	0.025	-0.348	-0.044
	(1.231)	(0.850)	(1.972)	(0.019)	(1.048)	(0.673)
N-E	-2.014**	-1.282*	-3.369**	0.046**	0.886	0.289
	(1.027)	(0.748)	(1.650)	(0.018)	(0.972)	(0.503)
E-NE	-2.582***	-3.177***	-4.454***	0.051***	0.700	0.104
	(0.933)	(0.669)	(1.495)	(0.016)	(0.805)	(0.463)
E	-1.039	-4.077***	-3.861**	0.066***	1.211	0.416
	(0.978)	(0.688)	(1.556)	(0.017)	(0.821)	(0.477)
E-SE	0.030	-4.182***	-2.208	0.068***	2.212**	0.361
	(1.071)	(0.748)	(1.702)	(0.019)	(0.999)	(0.491)
S-E	0.937	-2.925***	0.549	0.060***	0.681	0.783
	(1.243)	(0.858)	(1.941)	(0.019)	(0.891)	(0.543)
S-SE	1.050	-0.524	2.323	0.072***	1.294	1.130**
	(1.158)	(0.837)	(1.844)	(0.021)	(0.887)	(0.537)
S	2.094**	-0.003	4.262**	0.066***	2.181***	0.990*
	(1.061)	(0.771)	(1.713)	(0.018)	(0.851)	(0.512)
S-SW	2.342**	0.035	4.666***	0.054***	2.925***	1.328***
	(1.038)	(0.736)	(1.630)	(0.017)	(0.846)	(0.492)
S-W	2.171**	0.792	5.709***	0.051***	2.395***	1.593***
	(0.937)	(0.662)	(1.481)	(0.015)	(0.795)	(0.461)
W-SW	1.196	-0.189	3.482**	0.030**	1.056	1.190***
	(0.909)	(0.630)	(1.426)	(0.014)	(0.763)	(0.444)
W	0.616	-1.183*	0.414	0.015	-0.508	0.220
	(0.925)	(0.619)	(1.432)	(0.015)	(0.763)	(0.453)
W-NW	-0.618	-3.976***	-2.946**	-0.012	-0.607	-0.142
	(0.929)	(0.628)	(1.448)	(0.015)	(0.790)	(0.463)
N-W	-1.272	-4.884***	-4.594***	-0.020	0.306	-0.529
	(0.949)	(0.635)	(1.457)	(0.015)	(0.910)	(0.477)
N-NW	-1.423	-2.976***	-3.206*	-0.002	0.267	0.967*
	(1.073)	(0.721)	(1.647)	(0.016)	(0.979)	(0.562)
Time	-0.011	-0.037***	-0.070***	-0.0002	0.071***	-0.021***
	(0.016)	(0.013)	(0.027)	(0.0003)	(0.016)	(0.008)
$Time^2$	0.00002***	0.00001***	0.00003***	5.88e-08**	4.42e-06***	6.75e-06***
	(1.76e-06)	(1.10e-06)	(2.74e-06)	(2.54e-08)	(1.22e-06)	(7.31e-07)
No Obs.	19795	19761	19259	8663	7382	9495
F-Test	119.63***	241.98***	166.19***	70.56***	53.58***	51.28***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Robust Standard errors to heterokedasticity and autocorrelation in brackets. (***) 1%, (**) 5%, (*) 10%.

Table A2. Effects of cruise entrances in the pollution levels

	NO	NO_2	NO_X	CO	PM_{10}	$PM_{2.5}$
Constant	-139.629***	-14.288	-102.594***	-2.291***	-134.212***	-43.271***
	(11.504)	(9.997)	(19.401)	(0.187)	(16.006)	(6.265)
Entrance	**10.868*** **	**8.539*** **	**15.081*** **	**0.334*** **	**1.300* **	**1.640*** **
	(0.686)	**(0.593)**	**(1.159)**	**(0.015)**	**(0.697)**	**(0.337)**
Entrance*Km	**-3.772*** **	**-2.879*** **	**-4.901*** **	**-0.108*** **	**-0.642*** **	**-0.656*** **
	(0.223)	**(0.194)**	**(0.378)**	**(0.005)**	**(0.229)**	**(0.110)**
Entrance*Km^2	**0.310*** **	**0.227*** **	**0.382*** **	**0.008*** **	**0.059*** **	**0.057*** **
	(0.017)	**(0.015)**	**(0.029)**	**(0.0004)**	**(0.017)**	**(0.009)**
Monday	9.137***	10.225***	19.320***	0.090***	2.944***	0.856***
	(0.331)	(0.269)	(0.544)	(0.006)	(0.397)	(0.194)
Tuesday	11.624***	12.170***	23.568***	0.097***	4.186***	1.077***
	(0.413)	(0.325)	(0.677)	(0.007)	(0.475)	(0.222)
Wednesday	13.482***	13.493***	27.262***	0.112***	4.809***	1.656***
	(0.456)	(0.336)	(0.730)	(0.007)	(0.425)	(0.220)
Thursday	12.845***	13.741***	26.618***	0.110***	4.241***	1.775***
	(0.415)	(0.328)	(0.678)	(0.007)	(0.426)	(0.226)
Friday	11.723***	13.868***	25.643***	0.098***	5.137***	2.406***
	(0.384)	(0.321)	(0.654)	(0.007)	(0.383)	(0.229)
Saturday	4.535***	5.869***	10.354***	0.030***	1.634***	1.281***
	(0.283)	(0.248)	(0.484)	(0.005)	(0.343)	(0.198)
January	0.523	-7.973*	-13.148	-0.029	25.719***	-4.150
	(5.217)	(4.313)	(8.937)	(0.091)	(5.104)	(2.736)
February	-7.156	-7.272*	-20.750**	-0.041	25.553***	-4.361*
	(4.817)	(3.967)	(8.254)	(0.084)	(4.859)	(2.517)
March	-13.439***	-10.008***	-28.934***	-0.067	18.912***	-4.864**
	(4.358)	(3.593)	(7.465)	(0.076)	(4.189)	(2.255)
April	-21.723***	-19.073***	-45.761***	-0.129*	11.190***	-8.686***
	(3.931)	(3.196)	(6.692)	(0.068)	(3.691)	(2.025)
May	-26.046***	-24.326***	-53.987***	-0.175***	6.028*	-9.826***
	(3.521)	(2.827)	(5.963)	(0.061)	(3.204)	(1.784)
June	-30.446***	-28.204***	-62.394***	-0.247***	1.190	-10.078***
	(3.155)	(2.494)	(5.298)	(0.054)	(2.946)	(1.605)
July	-33.381***	-31.651***	-67.806***	-0.253***	-6.486***	-11.498***
	(2.793)	(2.157)	(4.639)	(0.048)	(2.287)	(1.378)
August	-36.477***	-36.428***	-75.681***	-0.303***	-12.611***	-13.282***
	(2.405)	(1.813)	(3.954)	(0.041)	(1.888)	(1.168)
September	-32.653***	-26.799***	-61.908***	-0.220***	-11.366***	-11.032***
	(1.984)	(1.446)	(3.221)	(0.033)	(1.481)	(0.940)
October	-22.043***	-14.798***	-38.837***	-0.105***	-5.525***	-7.593***
	(1.666)	(1.094)	(2.589)	(0.027)	(1.220)	(0.747)
November	-10.365***	-7.354***	-19.028***	-0.032	-0.300	-4.018***
	(1.306)	(0.736)	(1.920)	(0.020)	(0.919)	(0.507)
2013	-2.242	7.107	12.546	0.017	-31.761***	3.631
	(5.670)	(4.715)	(9.756)	(0.099)	(5.684)	(2.941)

2014	-7.792	14.221	21.525	0.030	-59.712***	6.864
	(11.249)	(9.368)	(19.356)	(0.197)	(11.127)	(5.810)
2015	-17.181	20.334	25.762	0.098	-86.299***	11.012
	(16.889)	(14.042)	(29.040)	(0.295)	(16.791)	(8.718)
2016	-34.010	20.434	14.799	0.054	-120.284***	8.587
	(22.486)	(18.703)	(38.665)	(0.392)	(22.190)	(11.544)
Temperature	0.521***	0.841***	1.496***	0.007***	1.507***	0.461***
	(0.064)	(0.054)	(0.110)	(0.001)	(0.068)	(0.033)
Atmospheric	0.168***	0.083***	0.205***	0.003***	0.108***	0.062***
pressure	(0.010)	(0.009)	(0.017)	(0.0002)	(0.015)	(0.005)
Cumulative	0.006	0.155***	0.164***	0.0004	-0.083***	-0.058***
rainfall	(0.020)	(0.018)	(0.037)	(0.0004)	(0.031)	(0.011)
Relative	0.059***	-0.143***	-0.116***	-0.0006***	0.0136***	0.033***
Humidity	(0.015)	(0.011)	(0.024)	(0.0002)	(0.013)	(0.007)
Wind speed	-4.820***	-6.176***	-10.974***	-0.037***	-0.580***	-0.908***
	(0.168)	(0.137)	(0.283)	(0.002)	(0.173)	(0.081)
N-NE	-1.190	-1.389	-3.879**	0.026	-0.315	-0.034
	(1.231)	(0.850)	(1.971)	(0.019)	(1.047)	(0.673)
N-E	-1.965*	-1.263*	-3.333**	0.047***	0.908	0.0306
	(1.030)	(0.749)	(1.652)	(0.018)	(0.971)	(0.503)
E-NE	-2.567***	-3.194***	-4.482***	0.050***	0.725	0.134
	(0.935)	(0.669)	(1.496)	(0.016)	(0.805)	(0.464)
E	-1.006	-4.086***	-3.824**	0.066***	1.199	0.420
	(0.980)	(0.689)	(1.557)	(0.017)	(0.820)	(0.478)
E-SE	0.036	-4.214***	-2.218	0.066***	2.195**	0.371
	(1.072)	(0.749)	(1.701)	(0.019)	(0.999)	(0.492)
S-E	0.956	-2.934***	0.535	0.060***	0.703	0.796
	(1.245)	(0.858)	(1.942)	(0.019)	(0.892)	(0.544)
S-SE	1.052	-0.545	2.309	0.072***	1.286	1.141**
	(1.162)	(0.837)	(1.847)	(0.021)	(0.886)	(0.538)
S	2.109**	-0.034	4.206**	0.063***	2.204***	1.022**
	(1.063)	(0.771)	(1.714)	(0.018)	(0.852)	(0.513)
S-SW	2.386**	0.042	4.703***	0.054***	2.937***	1.357***
	(1.041)	(0.736)	(1.632)	(0.017)	(0.846)	(0.493)
S-W	2.208**	0.801	5.717***	0.052***	2.422***	1.617***
	(0.940)	(0.663)	(1.484)	(0.015)	(0.794)	(0.461)
W-SW	1.202	-0.209	3.478**	0.029**	1.040	1.199***
	(0.911)	(0.630)	(1.428)	(0.014)	(0.763)	(0.445)
W	0.651	-1.180*	0.438	0.013	-0.490	0.244
	(0.928)	(0.619)	(1.434)	(0.015)	(0.762)	(0.453)
W-NW	-0.575	-3.966***	-2.908**	-0.012	-0.587	-0.117
	(0.931)	(0.629)	(1.450)	(0.015)	(0.790)	(0.464)
N-W	-1.216	-4.863***	-4.549***	-0.021	0.335	-0.496
	(0.952)	(0.636)	(1.458)	(0.015)	(0.910)	(0.478)
N-NW	-1.369	-2.966***	-3.162*	-0.002	0.276	0.985*
	(1.074)	(0.721)	(1.649)	(0.016)	(0.979)	(0.562)
Time	-0.012	-0.037***	-0.071***	-0.0002	0.071***	-0.021***
	(0.016)	(0.013)	(0.027)	(0.0003)	(0.016)	(0.008)
$Time^2$	0.00002***	0.00001***	0.00003***	6.25e-08**	4.44e-06***	6.76e-06***
	(1.76e-06)	(1.10e-06)	(2.74e-06)	(2.53e-08)	(1.22e-06)	(7.31e-07)
No Obs.	19795	19761	19259	8663	7382	9495

F-Test	119.21***	242.21***	166.26***	71.23***	53.82***	51.39***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Robust Standard errors to heterokedasticity and autocorrelation in brackets. (***) 1%, (**) 5%, (*) 10%.

Table A3. Effects of cruise departures in the pollution levels (with passengers)

	NO	NO_2	NO_X	CO	PM_{10}	$PM_{2.5}$
Constant	-139.640***	-10.175	-94.672***	-1.637***	-138.587***	-56.795***
	(11.686)	(10.016)	(19.764)	(0.187)	(15.646)	(6.207)
Departures	**1.080**	**2.913*** **	**5.518*** **	**0.031**	**1.304**	**1.781*** **
	(1.115)	**(0.838)**	**(1.796)**	**(0.022)**	**(0.922)**	**(0.519)**
Departures* Km	**-0.195**	**-0.791*** **	**-1.585*** **	**-0.012* **	**-0.445**	**-0.547*** **
	(0.363)	**(0.278)**	**(0.591)**	**(0.007)**	**(0.306)**	**(0.172)**
Departures* Km^2	**0.014**	**0.051** **	**0.120*** **	**0.001* **	**0.032**	**0.039*** **
	(0.028)	**(0.022)**	**(0.046)**	**(0.0006)**	**(0.023)**	**(0.013)**
PassengersXcruise	**10.331*** **	**3.547*** **	**8.282*** **	**0.392*** **	**2.920*** **	**1.851*** **
	(1.262)	**(0.857)**	**(1.986)**	**(0.021)**	**(1.104)**	**(0.591)**
PassengersXcruise *Km	**-3.917*** **	**-2.230*** **	**-3.565*** **	**-0.105*** **	**-0.167**	**-0.101**
	(0.335)	**(0.244)**	**(0.541)**	**(0.006)**	**(0.301)**	**(0.167)**
PassengersXcruise *Km^2	**0.327*** **	**0.190*** **	**0.281*** **	**0.008*** **	**0.028**	**0.021**
	(0.026)	**(0.019)**	**(0.042)**	**(0.0005)**	**(0.023)**	**(0.013)**
Monday	9.185***	10.238***	19.347***	0.089***	2.949***	0.869***
	(0.330)	(0.268)	(0.543)	(0.006)	(0.396)	(0.193)
Tuesday	11.673***	12.156***	23.614***	0.098***	4.252***	1.125***
	(0.413)	(0.323)	(0.678)	(0.007)	(0.470)	(0.220)
Wednesday	13.560***	13.494***	27.347***	0.112***	4.856***	1.717***
	(0.460)	(0.335)	(0.735)	(0.007)	(0.424)	(0.218)
Thursday	12.905***	13.706***	26.686***	0.111***	4.311***	1.841***
	(0.418)	(0.327)	(0.684)	(0.007)	(0.427)	(0.224)
Friday	11.701***	13.832***	25.580***	0.097***	5.135***	2.430***
	(0.382)	(0.319)	(0.654)	(0.007)	(0.380)	(0.226)
Saturday	4.584***	5.870***	10.374***	0.030***	1.659***	1.305***
	(0.282)	(0.247)	(0.484)	(0.005)	(0.344)	(0.195)
January	0.977	-6.339	-11.929	-0.083	23.908***	-4.946*
	(5.166)	(4.294)	(8.913)	(0.087)	(5.018)	(2.704)
February	-6.638	-5.020	-18.869**	-0.105	22.973***	-5.791**
	(4.771)	(3.958)	(8.237)	(0.080)	(4.755)	(2.505)
March	-13.043***	-9.282***	-28.360***	-0.088	17.636***	-5.109**
	(4.322)	(3.572)	(7.446)	(0.072)	(1.439)	(2.238)
April	-21.798***	-19.965***	-46.617***	-0107	12.398***	-7.687***
	(3.928)	(3.182)	(6.711)	(0.065)	(3.721)	(2.003)
May	-26.029***	-24.434***	-54.093***	-0.159***	6.207*	-9.674***
	(3.490)	(2.807)	(5.945)	(0.058)	(3.199)	(1.764)
June	-30.117***	-26.204***	-60.342***	-0.255***	-1.984	-12.057***
	(3.153)	(2.504)	(5.327)	(0.053)	(2.893)	(1.623)
July	-32.888***	-28.855***	-65.008***	-0.270***	-10.759***	-14.228***
	(2.862)	(2.207)	(4.769)	(0.048)	(2.292)	(1.436)

August	-36.068***	-33.792***	-73.016***	-0.317***	-16.572***	-15.966***
	(2.500)	(1.875)	(4.111)	(0.041)	(1.924)	(1.236)
September	-32.629***	-25.853***	-60.862***	-0.210***	-13.270***	-12.249***
	(1.980)	(1.448)	(3.235)	(0.032)	(1.476)	(0.948)
October	-22.202***	-14.623***	-38.622***	-0.094***	-6.267***	-8.028***
	(1.647)	(1.087)	(2.581)	(0.026)	(1.209)	(0.740)
November	-10.571***	-8.244***	-19.836***	-0.013	0.884	-3.285***
	(1.327)	(0.759)	(1.981)	(0.019)	(0.940)	(0.501)
2013	-2.540	6.623	12.370	0.048	-30.708***	3.441
	(5.629)	(4.688)	(9.733)	(0.095)	(5.604)	(2.910)
2014	-8.322	13.360	21.275	0.083	-58.087***	6.466
	(11.164)	(9.312)	(19.306)	(0.187)	(10.991)	(5.748)
2015	-17.769	20.262	26.399	0.0149	-86.201***	9.366
	(16.789)	(13.957)	(28.991)	(0.280)	(16.700)	(8.627)
2016	-34.632	21.172	16.211	0.099	-121.843***	5.845
	(16.789)	(18.589)	(38.625)	(0.374)	(22.113)	(11.430)
Temperature	0.518***	0.843***	1.472***	0.004***	1.544***	0.488***
	(0.063)	(0.054)	(0.110)	(0.001)	(0.068)	(0.033)
Atmospheric	0.170***	0.087***	0.203***	0.002***	0.106***	0.070***
pressure	(0.010)	(0.009)	(0.017)	(0.0002)	(0.014)	(0.005)
Cumulative	0.017	0.166***	0.161***	-0.0005	-0.071**	-0.046***
rainfall	(0.020)	(0.018)	(0.037)	(0.0004)	(0.031)	(0.011)
Relative	0.047***	-0.155***	-0.114***	0.0002	0.119***	0.025***
Humidity	(0.015)	(0.011)	(0.024)	(0.0002)	(0.014)	(0.007)
Wind speed	-5.155***	-6.434***	-11.041***	-0.032***	-0.848***	-1.047***
	(0.171)	(0.143)	(0.291)	(0.002)	(0.180)	(0.083)
N-NE	-1.024	-1.349	-3.818*	0.032*	-0.145	0.017
	(1.219)	(0.848)	(1.974)	(0.018)	(1.030)	(0.665)
N-E	-1.829*	-1.207*	-3.400**	0.048***	1.157	0.432
	(1.012)	(0.750)	(1.648)	(0.017)	(0.963)	(0.499)
E-NE	-2.377***	-3.041***	-4.525***	0.045***	0.972	0.221
	(0.918)	(0.670)	(1.493)	(0.015)	(0.791)	(0.459)
E	-0.691	-3.799***	-3.871**	0.051***	1.545*	0.594
	(0.964)	(0.689)	(1.553)	(0.016)	(0.807)	(0.473)
E-SE	0.243	-3.984***	-2.307	0.049***	2.473**	0.483
	(1.056)	(0.747)	(1.696)	(0.017)	(0.982)	(0.488)
S-E	1.066	-2.830***	0.433	0.044**	0.942	0.884*
	(1.228)	(0.856)	(1.932)	(0.018)	(0.877)	(0.538)
S-SE	1.152	-0.414	2.211	0.053***	1.421	1.215**
	(1.143)	(0.835)	(1.837)	(0.020)	(0.876)	(0.535)
S	2.147**	0.026	4.076**	0.051***	2.375***	1.089**
	(1.046)	(0.768)	(1.708)	(0.017)	(0.841)	(0.509)
S-SW	2.415**	0.056	4.535***	0.044***	3.097***	1.451***
	(1.022)	(0.734)	(1.625)	(0.016)	(0.832)	(0.487)
S-W	2.385***	0.923	5.704***	0.047***	2.626***	1.676***
	(0.923)	(0.660)	(1.481)	(0.014)	(0.777)	(0.456)
W-SW	1.440*	-0.054	3.539**	0.033**	1.265*	1.268***
	(0.894)	(0.628)	(1.425)	(0.014)	(0.744)	(0.439)
W	0.734	-1.150*	0.408	0.022	-0.485	0.252
	(0.911)	(0.617)	(1.433)	(0.015)	(0.741)	(0.446)
W-NW	-0.267	-3.801***	-2.706*	0.006	-0.580	-0.133

	(0.912)	(0.623)	(1.446)	(0.014)	(0.771)	(0.457)
N-W	-0.863	-4.648***	-4.252***	-0.008	0.440	-0.461
	(0.933)	(0.632)	(1.456)	(0.014)	(0.886)	(0.471)
N-NW	-1.233	-2.870***	-3.019*	0.007	0.373	0.945*
	(1.058)	(0.719)	(1.645)	(0.015)	(0.954)	(0.554)
Time	-0.011	-0.036***	-0.071***	-0.0003	0.067***	-0.020**
	(0.015)	(0.013)	(0.027)	(0.0003)	(0.015)	(0.008)
$Time^2$	0.00002***	0.00001***	0.00003***	8.64e-08***	6.82e-06***	7.19e-06***
	(1.78e-06)	(1.10e-06)	(2.77e-06)	(2.53e-08)	(1.25e-06)	(7.33e-07)
No Obs.	19795	19761	19259	8663	7382	9495
F-Test	117.68***	232.96***	157.29***	82.11***	52.38***	50.79***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Robust Standard errors to heterokedasticity and autocorrelation in brackets. (***) 1%, (**) 5%, (*) 10%.

Table A3. Effects of cruise entrances in the pollution levels (with passengers)

	NO	NO_2	NO_X	CO	PM_{10}	$PM_{2.5}$
Constant	-139.342***	-9.844	-93.936***	-1.636***	-138.345***	-56.613***
	(11.681)	(10.011)	(19.751)	(0.187)	(15.644)	(6.202)
Entrance	**0.968**	**3.178*** **	**5.849*** **	**0.034**	**1.249**	**1.752*** **
	(1.117)	**(0.832)**	**(1.783)**	**(0.022)**	**(0.984)**	**(0.518)**
Entrance *Km	**-0.184**	**-0.891*** **	**-1.734*** **	**-0.013***	**-0.441**	**-0.544*** **
	(0.364)	**(0.275)**	**(0.588)**	**(0.007)**	**(0.328)**	**(0.172)**
Entrance *Km^2	**0.013**	**0.059*** **	**0.132*** **	**0.001** **	**0.031**	**0.038*** **
	(0.028)	**(0.021)**	**(0.046)**	**(0.0006)**	**(0.025)**	**(0.013)**
PassengersXcruise	**10.339*** **	**3.356*** **	**7.990*** **	**0.390*** **	**2.908*** **	**1.841*** **
	(1.273)	**(0.855)**	**(1.988)**	**(0.021)**	**(1.135)**	**(0.594)**
PassengersXcruise *Km	**-3.924*** **	**-2.170*** **	**-3.475*** **	**-0.105*** **	**-0.169**	**-0.103**
	(0.340)	**(0.243)**	**(0.543)**	**(0.006)**	**(0.311)**	**(0.167)**
PassengersXcruise *Km^2	**0.327*** **	**0.186*** **	**0.274*** **	**0.007*** **	**0.028**	**0.021***
	(0.026)	**(0.191)**	**(0.043)**	**(0.0005)**	**(0.024)**	**(0.013)**
Monday	9.156***	10.238***	19.316***	0.089***	2.954***	0.871***
	(0.330)	(0.268)	(0.543)	(0.006)	(0.396)	(0.193)
Tuesday	11.606***	12.137***	23.534***	0.098***	1.192***	1.099***
	(0.410)	(0.323)	(0.675)	(0.007)	(0.473)	(0.219)
Wednesday	13.474***	13.469***	27.237***	0.112***	4.830***	1.691***
	(0.453)	(0.334)	(0.728)	(0.007)	(0.422)	(0.217)
Thursday	12.811***	13.676***	26.566***	0.111***	4.239***	1.806***
	(0.413)	(0.326)	(0.677)	(0.007)	(0.423)	(0.223)
Friday	11.714***	13.847***	25.613***	0.097***	5.146***	2.441***
	(0.382)	(0.319)	(0.654)	(0.007)	(0.380)	(0.226)
Saturday	4.552***	5.869***	10.339***	0.030***	1.662***	1.307***
	(0.282)	(0.247)	(0.483)	(0.005)	(0.342)	(0.195)
January	0.907	-6.392	-12.083	-0.084	23.887***	-4.950*
	(5.166)	(4.294)	(8.914)	(0.087)	(5.013)	(2.705)
February	-6.710	-5.086	-19.044**	-0.106	22.939***	-5.803**
	(4.771)	(3.958)	(8.237)	(0.080)	(4.750)	(2.505)
March	-13.091***	-9.320***	-28.472***	-0.089	17.628***	-5.110**

	(4.322)	(3.573)	(7.447)	(0.072)	(4.136)	(2.238)
April	-21.729***	-19.955***	-46.562***	-0.107*	12.465***	-7.641***
	(3.932)	(3.184)	(6.718)	(0.065)	(3.723)	(2.004)
May	-25.903***	-24.394***	-53.946***	-0.159***	6.289**	-9.614***
	(3.494)	(2.809)	(5.952)	(0.058)	(3.201)	(1.765)
June	-30.035***	-26.175***	-60.245***	-0.255***	-1.925	-12.010***
	(3.155)	(2.505)	(5.332)	(0.053)	(2.895)	(1.624)
July	-32.785***	-28.815***	-64.873***	-0.270***	-10.696***	-14.178***
	(2.864)	(2.209)	(4.774)	(0.048)	(2.293)	(1.437)
August	-35.962***	-33.748***	-72.876***	-0.317***	-16.494***	-15.911***
	(2.497)	(1.877)	(4.116)	(0.041)	(1.925)	(1.237)
September	-32.477***	-25.794***	-60.653***	-0.210***	-13.181***	-12.185***
	(1.980)	(1.450)	(3.238)	(0.032)	(1.476)	(0.948)
October	-22.019***	-14.552***	-38.372***	-0.094***	-6.161***	-7.955***
	(1.647)	(1.087)	(2.582)	(0.026)	(1.204)	(0.740)
November	-10.488***	-8.216***	-19.727***	-0.013	0.924	-3.255***
	(1.331)	(0.760)	(1.986)	(0.019)	(0.941)	(0.500)
2013	-2.467	6.690	12.548	0.049	-30.678***	3.448
	(5.629)	(4.688)	(9.733)	(0.094)	(5.599)	(2.910)
2014	-8.195	13.481	21.597	0.085	-58.051***	6.469
	(11.165)	(9.312)	(19.309)	(0.187)	(10.982)	(5.789)
2015	-17.564	20.444	26.897	0.151	-86.141***	9.374
	(16.791)	(13.958)	(28.995)	(0.280)	(16.656)	(5.627)
2016	-34.343	21.404	16.875	0.102	-121.770***	5.854
	(22.380)	(18.590)	(38.631)	(0.374)	(22.095)	(11.431)
Temperature	0.518***	0.844***	1.472***	0.004***	1.546***	0.488***
	(0.063)	(0.054)	(0.110)	(0.001)	(0.068)	(0.033)
Atmospheric	0.170***	0.086***	0.202***	0.002***	0.106***	0.070***
pressure	(0.010)	(0.009)	(0.017)	(0.0002)	(0.015)	(0.005)
Cumulative	0.017	0.166***	0.161***	-0.0005	-0.071**	-0.046***
rainfall	(0.020)	(0.018)	(0.037)	(0.0004)	(0.031)	(0.011)
Relative	0.046***	-0.155***	-0.114***	0.0002	0.120***	0.025***
Humidity	(0.015)	(0.011)	(0.024)	(0.0002)	(0.014)	(0.007)
Wind speed	-5.160***	-6.437***	-11.052***	-0.032***	-0.848***	-1.049***
	(0.171)	(0.143)	(0.290)	(0.0022)	(0.180)	(0.083)
N-NE	-1.026	-1.358	-3.832*	0.032*	-0.139	0.011***
	(1.219)	(0.848)	(1.974)	(0.018)	(1.031)	(0.665)
N-E	-1.824*	-1.220	-3.387**	0.048***	1.144	0.431
	(1.014)	(0.750)	(1.650)	(0.017)	(0.963)	(0.499)
E-NE	-2.370***	-3.068***	-4.532***	0.045***	0.968	0.212
	(0.919)	(0.669)	(1.494)	(0.015)	(0.791)	(0.460)
E	-0.643	-3.802***	-3.811**	0.051***	1.524*	0.586
	(0.965)	(0.688)	(1.554)	(0.016)	(0.806)	(0.473)
E-SE	0.283	-4.002***	-2.274	0.049***	2.448**	0.473
	(1.056)	(0.746)	(1.695)	(0.017)	(0.981)	(0.488)
S-E	1.069	-2.849***	0.427	0.044**	0.941	0.875
	(1.229)	(0.856)	(1.934)	(0.018)	(0.877)	(0.538)
S-SE	1.168	-0.427	2.221	0.054***	1.411	1.210**
	(1.145)	(0.835)	(1.840)	(0.020)	(0.875)	(0.535)
S	2.152**	-0.019	4.058**	0.052***	2.350***	1.073**
	(1.048)	(0.768)	(1.710)	(0.017)	(0.841)	(0.509)

S-SW	2.440**	0.049	4.566***	0.044***	3.088***	1.448***
	(1.024)	(0.733)	(1.627)	(0.016)	(0.832)	(0.488)
S-W	2.377***	0.903	5.693***	0.047***	2.614***	1.670***
	(0.925)	(0.659)	(1.483)	(0.014)	(0.777)	(0.456)
W-SW	1.471*	-0.066	3.565**	0.033**	1.242*	1.255***
	(0.895)	(0.627)	(1.426)	(0.014)	(0.744)	(0.439)
W	0.757	-1.163*	0.436	0.022	-0.497	0.246
	(0.912)	(0.616)	(1.435)	(0.015)	(0.741)	(0.446)
W-NW	-0.236	-3.809***	-2.671*	0.006	-0.575	-0.136
	(0.913)	(0.623)	(1.447)	(0.014)	(0.771)	(0.458)
N-W	-0.844	-4.661***	-4.231***	-0.008	0.439	-0.465
	(0.934)	(0.632)	(1.457)	(0.014)	(0.887)	(0.472)
N-NW	-1.194	-2.880***	-2.973*	0.007	0.359	0.933*
	(1.059)	(0.718)	(1.647)	(0.015)	(0.953)	(0.553)
Time	-0.011	-0.036***	-0.071***	-0.0003	0.067***	-0.020**
	(0.015)	(0.013)	(0.027)	(0.0003)	(0.015)	(0.008)
$Time^2$	0.00002***	0.00001***	0.00003***	8.68e-08***	6.83e-06***	7.19e-06***
	(1.78e-06)	(0.10e-06)	(2.77e-06)	(2.53e-08)	(1.25e-06)	(7.33e-07)
No Obs.	19795	19761	19259	8663	7382	9495
F-Test	117.30***	232.96***	157.25***	81.86***	52.59***	50.84***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Robust Standard errors to heterokedasticity and autocorrelation in brackets. (***) 1%, (**) 5%, (*) 10%.