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Measuring performance concerning air and noise pollution: a comparison of Madrid's official data and results from a citizen survey

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Short bios

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Abstract

The main objective of this study is to analyse whether citizens' perceptions of noise and air pollution are related with objective measures of noise and air pollution in the urban context. Merging local services performance and air quality research, the study makes a contribution to theories on how objective and subjective measures relate, identifying differences in ease of perception between noise and air pollution and the effect of previous attitudes. The analysis is based on datasets from the city of Madrid. After matching territorial zones, we use correlation and OLS regression analysis. Only in the case of noise, there is a significant relation between the actual levels of pollution and citizen's perceptions, which is explained by differential characteristics of both types of pollution. Previous concern for the environment colours the assessment of local government actions as well as some personal characteristics and general attitudes towards the local community.

Keywords: Air quality - noise pollution - environmental indicators - objective performance – surveys - local government -citizen satisfaction

Introduction

Local governments collect an incredible amount of data on the performance of their services. In most of the cases, annual surveys act as snapshots that capture different aspects of citizen satisfaction. They also collect data on the technical performance of their services, the structure of the material and human resources, the processes they use to deliver the services and their outcomes. Improving public services' performance, their quality and accountability is at the centre of local government responsibilities (Montesinos and Brusca 2009; Pandeya and Oyama 2019).

In the Public Administration literature there is a debate that started in the eighties (Stipak 1979; Brown and Culter 1983; Parks 1984) about the relationship between objective performance indicators and the citizen evaluation of public services. Politicians and managers introduce reforms in public services but do not have the certainty that improved technical performance is captured by citizens. Better management over time should result in increased citizen satisfaction but there is uncertainty about the extent that technical reforms are visible for citizens and affect their satisfaction with public services. The majority of studies, on the convergence between objective measures and subjective perceptions studied local services (Licari, McLean, and Rice 2005; Van Ryzin, Immerwahr, and Altman 2008).

The research question of this study centres on the extent that citizens' perceptions of noise and air pollution are related with technical and objective measures of noise and air pollution in the urban environment. Answering this question, the study aims to extend the theory and contribute to the analysis of the convergence between subjective and objective measures of performance.

This is an important question for local governments for various reasons. First, because air quality and noise in the urban context is a main issue for local governments (Domingues et al. 2015; Mapar et al. 2017). We are currently at the highest historical level of population living in cities with the prospect of representing 60% of the world's population in 2030 (United Nations 2018) and cities are responsible for 70% of greenhouse gases. Pollution generated in cities is the main source of climate change in the world (United Nations Human Settlements Program 2011, IPCC 2021) and it has important effects on the health and quality of life of citizens (World Health Organization 2006).

Second, from a theoretical perspective, we know there is an association between citizen's perceptions and process and outcome quality measures for some local services but not for others (Stipak 1979; Brown and Culter 1983; Parks 1984, Kelly and Swindell 2002; Kelly 2003; Licari, McLean, and Rice 2005; Van Ryzin, Immerwahr and Altman 2008). In this study, we merged the literature on local services with environmental studies. We identify ease of perception of the annoyance produced by pollution to explain whether there will be convergence between objective and subjective measures of performance. We also focus on the need to pay attention to previous attitudes since individuals who are more concerned with a public problem, as in the case of pollution, will take the opportunity to express their feelings towards these issues when asked about their satisfaction with local government services.

Third, from practical perspective, for many local governments, it is easier to collect citizen satisfaction measures than complex technical quality measures for certain local services. Thus, it is relevant to study whether survey measures can be used as a

substitute or a complement of delivery process and outcome measures and when it is more likely that there is some correspondence.

In this research, we use datasets from the city of Madrid. This study combines technical measures of air quality and noise pollution with citizen evaluations of local services to control pollution. The city of Madrid measures the quality of air 24 hours a day through 24 stations and the level of noise through 31 stations distributed among its neighbourhoods. The city also conducts an annual survey on the quality of public services. We use the 2019 edition (N=8,578) and for the analysis we use correlation and OLS regression.

The findings are different for air and noise pollution. A result that is explained by the different characteristics of both types of pollution. Local government performance systems need to address elements of public services that are relevant to citizens since engaging them facilitates a better understanding of what they consider good performance or quality. However, perceptions are not sufficient for the performance analysis of some services. In this study, we advance the theory to determine whether their role can be more a complement or a substitute of other measures.

The rest of this article proceeds as follows. The next section reviews performance measures, previous studies on the convergence between objective and subjective measures and the debates about ease of perception of noise and air pollution and the effects of previous attitudes towards the environment. Next, we describe technical and survey data and the matching of territorial zones. In the fourth section, we present the

analysis and results. The last section concludes and discusses the implications of the findings.

Theoretical framework

Local government performance measurement is essential for improving the management of local public services. Both researchers and local governments have made a lot of progress to collect data, not only on the overall satisfaction of citizens with public services but on citizens' perceptions on different elements of local services. However, we lack knowledge on how overall satisfaction ratings or other citizens' perceptions are related with technical measures of performance. Understanding how citizens' perceptions are associated with other performance measures can help local governments and providers of public services, whether they are public, private or mixed, to improve the effectiveness and efficiency of their services.

Inherently objective and inherently subjective measures

Previous studies have centred on the distinction between objective and subjective measures of performance (Andrews, Boyne, and Walker 2006; Boyne et al. 2006; Schachter 2010; Andersen, Boesen, and Pedersen 2016). This distinction is based on the degree to which performance concerns "interior experiences and perceptions versus exterior observable phenomenon" (Andersen, Boesen, and Pedersen 2016, 5). Additionally, it can be argued that, in general terms, research on performance tends to favour objective measures of performance to subjective measures of performance. However, there is a lot of debate about the objectivity and subjectivity of measures. Some performance criteria like satisfaction with a public service are inherently

subjective because they express and internal feeling. But most of performance criteria can be measured objectively and subjectively. For example, the health status of a patient or the waiting time for a visit. Local governments have multiple potentially conflicting goals and focusing only on one aspect of performance is problematic. As indicated by Andersen, Boesen and Pedersen (2016), a priori, it is difficult to make a judgement in favour of inherently objective or subjective criteria as this decision depends on the conceptualization that different local governments and their stakeholders make of performance.

The relationship between the two types of measures

The relationship between inherently subjective and inherently objective measures of performance would appear to be mutually reinforcing. From this perspective, more resources, and better structural and process quality should produce better outcomes. If outcomes are better, citizens should notice it and be more satisfied with public services. More specifically, if citizens see, for example, that public services from their City repair and clean their streets very often, it is likely that this will have an influence on their perception of government services (Van Ryzin, Immerwahr, and Altman 2008). It may also even have an influence on their behaviour when they are called to vote (Boyne, James, and Petrovsky 2009; James and Moseley 2014). However, a majority of arguments in the literature sustain the opposite view. From this perspective, survey data has raised considerable skepticism on its validity as a measure of "true" performance (Im and Lee 2012). For many years, citizen's opinions were not considered a reliable source to capture actual improvements in the management of public services (DeHoog, Hoogland and Lowery 1990; Kelly 2003; Manary et al. 2013).

The most common criticism is that surveys reflect the characteristics of respondents (their age, socio-economic status, ethnic background, gender). Along similar lines of argumentation, it has been considered that surveys are a combination of rather general and intrinsically subjective assessments made of feelings, opinions and judgmental evaluations (Bouckaert and Van de Walle 2003). And, that the majority of users do not have the formal training and they only capture aspects of public services that could be easily influenced by factors unrelated to their effectiveness. In police services, for example, citizens can judge their experience in their encounters with officers but not the efficacy of the police to solve crimes (Parks 1984) the same way that patients of hospital services can value the "consierge" services but not the accuracy of the diagnostic and treatments (Tsai, Orav, and Jha 2015). Finally, it is also argued that citizen satisfaction with local services may be determined by their political leanings including voting for those who are in charge of managing public services (Hirschman 1970; Boyne, James, and Petrovsky 2009; James and Moseley 2014).

Previous studies in local government

The initial studies linking objective and subjective measures in public services (Stipak 1979; Brown and Culter 1983; Parks 1984) were developed in the US on police services. They found a weak or no relationship between objective police service indicators and the citizen evaluation of these services. A second wave of studies collected evidence regarding the correspondence between objective and subjective measures of performance at the urban level using citizen ratings of park quality and street condition and professional assessments by trained observers (Licari, McLean, and Rice 2005). Van Ryzin, Immerwahr and Altman (2008) replicated these studies for

street cleaning in New York, where the city government had a well-established objective measure and a series of sample surveys of city residents. They found a high level of correlation between the two types of measures for a municipal service that is quite visible and tangible. At the same time, new studies on police and fire-fighting services found that the overall correspondence between objective performance data and citizen surveys appeared to be either weak (Kelly and Swindell 2002) or non-existent (Kelly 2003). The differences in the results indicated that in some services, management improvement is less visible to external actors, while in other services, objective change in the quality of service provision is more visible and better known, hence producing an indirect effect on citizen satisfaction. More recently, Charbonneau and Van Ryzin (2012) returned to the objective-subjective debate examining data from New York schools. In this study, the authors were able to use outcome measures instead of input-output indicators and they managed to disaggregate objectively measured performance and satisfaction to a smaller geographic level, which was a key element in their study hypothesizing there is a link between the two types of measures. They found that official measures of school performance predict aggregate parental satisfaction even after controlling for school and student characteristics.

Previous studies on air quality

A number of environmental studies on air quality have looked at the relationship between subjective perceptions and the measured concentration of pollutants. The main conclusion is that perceptions of air quality are not significantly correlated with air quality (Brody et al. 2004; Semenza et al. 2008). Some studies, however, found a correlation between objective exposure levels and risk perception, but they use city

averages for exposure levels (Rotko et al 2002) or studied cities during times of severe haze pollution (Huang et al 2017). In a related research stream, some studies showed how air pollution affects life satisfaction or self-reported happiness (Bickerstaff and Walker 2001). Most of these studies measured air pollution through citizen's perceptions (Liao, Shaw, and Lin 2015; Li et al. 2018). Similarly, other studies relate perceptions of pollution, economic activity and housing markets. Chasco and Le Gallo (2013) found a greater impact of perceptions of air quality and noise levels on housing prices than those of the actual measurements of decibels and pollutants in the air. Thus, previous studies confirm that local environmental factors influence public perceptions and that both perceptions and actual measurements of air and noise pollution may be taken into account for the evaluation of different aspects of life in cities and their management by local governments.

Theory development and hypothesis

Convergent validity between objective and subjective measures is more likely when services are more simple or visible (for example, street cleanness, Van Ryzin, Immerwahr and Altman, 2008) and less likely when services are more complex or citizens do not observe how the service is produced (crime resolution, Kelly and Swindell 2002, Kelly 2003). A similar characteristic can be found in environmental studies when they use annoyance levels to reflect a displeasure caused by either odour or noise. For example, Atari, Luginaah, and Fung (2009) use odour annoyance as a proxy for air quality and they reach the conclusion that it can be used to capture the variability of pollution between different areas.

Therefore, ease of perception, annoyance or visibility should be included as an important trait in the analysis of objective and subjective measures of performance. The higher the salience of a problem, the more it will have a direct impact on the experience of citizens. A high level of noise or, similarly, a bad odour, will directly affect citizen's experience and consequently their satisfaction with the service that is supposed to control it. When the experience is pleasant, citizens will tend to assimilate it to their expectations and it is less likely they react. However, in the case of a negative experience, citizens could exaggerate their response. In accordance with the theories relating expectations with public services, perceived performance and satisfaction (Van Ryzin 2004, 2013; James 2009, 2011) a negative evaluation of public services is the likely product of the difference between expectations and perceived performance. On the opposite, when the problem is less visible or not noticeable at all, it should not have an impact on the citizen and consequently on the evaluation of the local service.

The annual plan of the City of Madrid sets an average level of 40 μg/m3 for NO2. Since this source of pollution is invisible and odourless unless it achieves a concentration higher than 188 μg/m3 (WHO 2010), we hypothesize that convergence between inherently objective and inherently subjective measures will be less likely to happen with air pollution. Noise pollution, which is mostly caused by heavy traffic, is easier to be perceived by citizens (Fyhri and Klæboe 2009). Therefore, we expect that:

> H1. Technical measures assessing noise pollution will be positively associated to citizen's perceptions of noise pollution.

H2. Technical measures assessing air quality will not be associated to citizen's perceptions of air quality or, if they are associated, it will be with a lower probability than in the case of noise pollution.

On the other hand, it is reasonable to assume that citizen's previous attitudes towards the environment influence their perceptions (Hart and Nisbet 2012). The literature of Public Administration is clear about how prior beliefs affect the way citizens judge performance of public services. The majority of studies compare public and private services and conclude that citizens tend to perceive more negatively the performance of public providers (Wilson 1989; Andersen and Hjortskov 2016; Hvidman 2019). Prior beliefs about the problem might (or might not) moderate citizen's judgements of interventions oriented towards controlling the problem (Baekgaard and Serritlew 2016; Marvel 2016). We also know that the stronger the environmental identity is the more polarized opinions tend to be (Elliott, Seldon, and Regens 1997; Hart and Nisbet 2012).

Citizens concerned with pollution in the city should be more attentive to changes in the state of pollution and to the local government's interventions to control and improve air quality and vice versa. If pollution is very noticeable, and therefor annoying, the effect of prior attitudes is more likely to have a negative impact on subjective perceptions and citizens more concerned with the environment will react more strongly. If their level of concern is very high, they could be very unsatisfied with the local government when it is rather obvious that pollution is out of control.

Therefore,

H3. Citizen's concern for the environment will moderate the relationship between technical measures assessing noise pollution and citizen's perceptions of noise pollution.

Other factors influencing citizen's perceptions

Other factors besides actual air and noise pollution may influence citizen's perceptions. Their opinions on what local governments do should vary with some personal characteristics such as gender, age, ethnic, education (Lægreid and Christensen 2005) or socio-economic status (James 2009; Dahlström, Nistotskaya, and Tyrberg 2018). Citizens supporting the Mayor and the administration in charge of the City at the time of the survey could be inclined to give more favourable opinions on the efforts to control air and noise pollution as an effect of partisan bias (Jilke and Baekgaard 2020; Jilke 2018). Citizen's perceptions can also be influenced by their values and beliefs about society and their general stand with regard to public services (DeHoog, Hoogland and Lowery 1990; Jorgensen and Bozeman 2007; Marvel 2016; Hvidman 2019). Finally, citizen's may respond differently when they are asked about their city or their neighbourhood depending on their community attachment and the feelings they may have in relation to their place of residence (DeHoog, Hoogland, and Lowery 1990; Bickerstaff and Walker 1999; Gonzalez 2005). In sum, the analysis will take into account 1) personal characteristics, 2) political orientation, 3) attitudes towards public services, and 4) community attachment.

Context, data and methods

For this study, we use data from the city of Madrid[1]. As a major conurbation in Europe, Madrid suffers from both air and noise pollution but the extension of these two

[1] Data on air and noise pollution from: https://datos.madrid.es/portal/site/egob/menuitem.c05c1f754a33a9fbe4b2e4b284f1a5a0/?vgnextoid=41e01e007c9db410VgnVCM2000000c205a0aRCRD&vgnextchannel=374512b9ace9f310V

problems is rather diverse over its territory. Every three and five years, Madrid updates city plans to control air quality and noise levels. Air quality is controlled systematically 24 hours a day with 24 stations located in different sectors. The noise level is controlled through 31 stations which are also distributed in different areas of the city. Madrid publishes data since 2001 on a daily basis and as monthly averages for noise levels and air pollutants. Additionally, the City also conducts a "Survey of quality of life and satisfaction with public services" since 2006 with editions every year or every two years. In this study, we used the 2019 survey[2] before the impact of the COVID19. We replicated the analysis for 2017 and we found the same results (see Annex 1). In the 2019 survey, 8,578 people were surveyed, approximately 400 per city district, achieving a representative sample of the population. The criteria for selecting the respondents was that they were 18 years or older and had lived in Madrid for at least six months. For this study we discarded citizens with less than one year. The survey specifically asks about the citizen's satisfaction with the air pollution and noise control services of the City.

gnVCM100000171f5a0aRCRD

https://datos.madrid.es/portal/site/egob/menuitem.c05c1f754a33a9fbe4b2e4b284f1a5a0/?vgnextoid=b8c427a272e4e410VgnVCM2000000c205a0aRCRD&vgnextchannel=374512b9ace9f310VgnVCM100000171f5a0aRCRD&vgnextfmt=default

[2] Survey data from: https://www.madrid.es/portales/munimadrid/es/Inicio/El-Ayuntamiento/Calidad-y-Evaluacion/Percepcion-Ciudadana/Edicion-2019/?vgnextfmt=default&vgnextoid=7d062d7c2bd6a610VgnVCM2000001f4a900aRCRD&vgnextchannel=f22ff49c4495d310VgnVCM2000000c205a0aRCRD

Dependent, independent and control variables

The 2019 survey on quality of life and satisfaction with public services provides the two indicators on citizen satisfaction that are used as dependent variables. The survey specifically asks to rate from 0 to 10 the level of satisfaction with the actions and services that the City takes to control air pollution and to control the level of noise.

The main explanatory variable for the citizen's evaluation of the performance of the noise control is the objective noise level measured by the thirty-one stations over the territory. The study uses the average noise level during the year immediately preceding the survey, considering the measurements made during the evening and night, between 7 pm and 7 am. We selected this time range to make sure the citizens value the noise at their place of residence. In the case of air quality, the main explanatory variable is the measurement of Nitrogen Dioxide (NO2). The main source of this pollutant is the combustion engine and the presence of NO2 correlates with the presence of other pollutants (World Health Organization 2006).

The two type of variables do not exactly measure the same, as in one case it is objective pollution and in the other case, whether citizens attribute pollution or noise (or the absence of it) to the city control services. This is why we do not expect a strong correlation between satisfaction measures and objective measures. However, when citizens consider that the air is clean or that their neighborhood is quiet, it is reasonable to assume that they believe the City is doing a good job and vice versa, the same way that parents who believe that their children learn in school they tend to express their satisfaction with their teachers and the opposite.

In order to identify those citizens with an underlying concern for the environment, the study uses the survey question on what problems citizens consider “main problems” in the city. We coded them with a "1" if they spontaneously mentioned “environment” and we coded with a “0” all the other answers. We created a second variable with the same coding system for those who specifically mentioned noise or air quality problems.

For the sociodemographic control variables, the study uses sex, age, country of birth (dichotomous variable for those born in Spain and for the rest of the countries), educational level (“1” to “9”, the lowest number corresponding to the lowest level of education) and income level ("1" to "9" for income ranges). With regard to political orientation, ideology was included in the survey with the traditional scale of 1 to 10, with the lowest number being 1 representing the extreme left. The survey also asked for the general evaluation of the governing party at the time of the survey. Finally, the study uses the items that express general attitudes of citizens towards public services, taxes and attachment to their neighbourhood. For this last question, the survey asks citizens to rate their level of satisfaction and their quality of life in the neighbourhood where they live. For the attitudes of citizens concerning public services, the study uses two items, one on the level of information the citizen has about them, and one on the citizen evaluation of local services according to the local taxes paid.

Methods

Before proceeding with the statistical analysis, we created two maps, one for the noise levels in different parts of the city and one for air pollution (for variograms and predictions, see Annex 2). In each census section where we locate the respondents, we

have an objective value for noise and one for air pollution. Following the methods proposed by Montero, Chasco, and Larraz-Iribas (2010), the Kriging geo-statistical data interpolation technique allows to assign a value to each point on the map based on the weighted distance between the different stations.

Figure 1 and 2 about here.

We observe certain similarities in the distribution of the air pollutant and noise with a clear decrease of both towards the north. In the map for the noise, a clear peak can be observed in the city centre. The minimum noise levels are 53.96dB and they are located in El Pardo, a predominantly reserved natural area in the outskirts of the city. The maximums levels of noise are in the central almond of Madrid, in the districts of Centro, Arganzuela, Retiro, Salamanca, Chamartín, Tetuán, and Chamberí, with peaks at 64.02dB. Regarding NO2 levels in the air, the minimums are 22.50µg / m3 and the maximums are 45.90µg / m3 towards the south of the city but with a more homogeneous distribution in general.

Having a value for air and noise pollution throughout the city and not only in the specific points of the stations, it is possible to relate the levels of noise and air pollution with the subjective evaluation made by citizens positioned in the centre of each census section and to group respondents by neighbourhood. Since our dependent and independent variables are numerical we use correlation for bivariate analysis, and OLS regression for multivariate analysis.

Analysis

Table 1 presents the main descriptive statistics of the two dependent variables. For the 8.304 cases, the averages for noise control is 5.16 and for air control 5.38 with standard deviations of 2.65 and 2.67. The histograms of the two variables suggest a normal distribution with a unimodal shape –with mode at 5– and a symmetric appearance supported by an obliquity close to zero in both cases. The kurtosis of both variables is close to 3, also coinciding with a normal distribution, without atypical values. The normal distribution of our dependent variables confirms the use of linear regression.

Table 1 about here

The correlation analysis between the two main dependent variables (air and noise pollution and the independent variable (citizen's perceptions) shows a non-significant relationship between the evaluation of the air pollution control service and the levels of the NO_2 in the atmosphere in line with hypothesis 2 and this is a final result with regard to air pollution. In relation to noise pollution, the empirical test gives a highly significant result –with a confidence interval of 99 %. Despite showing a weak correlation, being significant and with a negative sign, we can consider that a lower level of objective noise in the territory could imply greater satisfaction with the noise control services on the part of the citizens. In order to confirm this hypothesis, we performed the multivariate analysis with clusters at the neighbourhood level.

Table 2 shows the results of the estimation of the effect of the objective noise in the citizens' evaluations of noise control by the City government. The empirical analysis

proceeds in four steps. We present four consecutive models of linear regressions, where groups of independent variables are added. The first model includes the technical measure of decibels in the area, the second includes the concern for environmental issues. The third model includes demographic control variables and the fourth is the most complete model including political orientation and prior attitudes towards the neighbourhood and the services provided by the local government.

Table 2 about here

In the four models, the objective noise measurement is highly significant with a negative coefficient, confirming the bivariate analysis and hypothesis 1. However, considering environmental problems a priority does not have a moderation effect on the relationship between inherently objective and subjective measures, what leads to reject hypothesis 3. Previous attitudes factor in the evaluation of the City's efforts to control noise pollution. Citizens who spontaneously mention environment or more specifically noise pollution as a priority problem tend to give worse evaluations in surveys while, on the opposite, citizens who do not have this concern or mention other problems before noise or air quality will more likely give a better evaluation of noise control. This means that those with environmental concerns with regard to the City where they live give worse evaluations of services in charge of controlling air quality and noise independently of the state of pollution. Their underlying beliefs, which tend to be rather stable, influence their responses.

With regard to the socio-demographic variables, the level of studies, the country of birth and the level of income are significant. The higher level of studies, the less satisfaction with the noise control. This result may be due to a greater knowledge of the

environmental situation or about the services provided by the City council. Those not born in Spain have a better consideration of noise control. The significance of the income level disappears with the inclusion of all controls.

The political ideology variable is significant and positively correlated, which implies that the more positioned to the right in the ideological spectrum, the better the evaluation of the noise control by the City. This may be because the Madrid City was governed by a conservative party for many years and citizens with a leftist leaning are more aware of environmental problems. Dissatisfaction with the neighbourhood is associated with a negative evaluation of the noise control. Likewise, the level of information on the activities carried out by the city council, as well as the satisfaction with the taxes paid and services received, both correlate positively with the perception of noise control by the city. In the last model, the R-squared coefficient increases significantly from 0.027 to 0.078.

Discussion and conclusions

Studying performance management of environmental issues like noise and air pollution is relevant, not only because this is a major public problem for local governments, but because it provides insights on the different ways that objective and subjective measures of performance can be related and may substitute one another.

Air quality is not perceived in the same way as noise levels due to the intrinsic nature of both types of pollution. In the absence of odour, air pollution becomes invisible and difficult to perceive. It does not have a direct effect on citizen's and, from this perspective, it is not experienced as an annoyance. Noise pollution, on the contrary, is

more evident for citizens who can value the levels of uproar produced by the city at different times during the day and the week. This characteristic can be applied to other public services directly experienced by citizens.

Local governments need to find out what elements of public service are relevant to citizens and to engage them in their evaluation to have a better understanding of what they consider a good service. In those instances that citizens can form their own criteria about the performance of public services, local governments should pursue crossing objective and subjective data. On the opposite, in cases where citizens have more difficulty to observe public services or experience the consequences of the quality of their management, the analysis of their performance will be more dependent on the technical measurement by administrative services. Citizens will also depend on the efforts of their local governments to share this information with them to find out about, for example, how clean the air they are breathing is.

The lack of convergence validity between technical measures of air quality and citizen's perceptions does not imply that they are not both valuable separately. However, a significant relationship between objective and subjective measures gives greater validity to both types of measurements and local governments can be sure that the official "true" performance measure reflects an aspect that clearly matters to citizens.

The weight of the objective measures on the citizen's opinion is limited as there are other factors, which influence their perceptions. The analysis of an environmental issue revealed the relevance of previous attitudes towards the problem (Hart and Nisbet 2012). Citizens concerned with the environment tend to be more unsatisfied with public

services in charge of controlling and ameliorating the problem they experience. This is interpreted as an independent, additive effect to the effect of experiencing the annoyance, in our case because of city noise. On the opposite, those less concerned with the environment are probably less demanding with City services in charge of controlling pollution. Their level of concern is lower and they react to changes in the perceived quality of the environment but at a lower level. This relevance of previous attitudes should apply to other public services, like for example, those preventing security problems, keeping the streets clean or facilitating the mobility within the city.

Additionally, some personal characteristics also explain subjective perceptions as previously indicated by the literature on public services (Lægreid and Christensen 2005; James 2009; Dahlström, Nistotskaya, and Tyrberg 2018). In our sample, the level of education and the country of origin have an effect on the evaluation of the public pollution control services. More educated citizens and nationals, compared with migrants, are more likely to be tougher in their evaluations. The results of our analysis indicate that political attributes (Jilke 2018) are less important than general attitudes concerning public services (Marvel 2015; Hvidman 2019) and the appreciation for the place where people live (Bickerstaff and Walkner 1999; González 2005). Citizens leaning to the right appear to be less concerned about the efficacy of local government controls of noise pollution but the weight of this factor is relatively low. The lower effect of political attributes contrasts with civic attributes of citizens expressing a greater concern for the city in general, willingness to be informed and to contribute with taxes to maintain public services as well as a stronger attachment and identification with the neighbourhood where they live.

In practical terms, the analysis of convergence validity between objective and subjective measures is important for those in charge of performance management at the local level. Contrary to some prejudices against the use of surveys and subjective perceptions, in some cases, they can be a good measure of performance when no other data is available. In other cases, they need to be more cautious but certainly looking at the matching between the two types of measures will give them more certainty about what is a good performance of the services they manage, the extent their local governments contribute to ameliorate public problems and citizens are capturing the progress made.

This study uses data from the city of Madrid, and it is possible that the results in other cities are different. The levels of pollution vary considerably in big cities depending on the intensity of traffic, climate conditions and the actions taken to prevent and reduce pollution. In the European context, cities may pay penalties for air pollution above certain thresholds. Another limitation with respect to air quality comes from the fact that the data is not available for different time bands during the day as it is the case with noise pollution. The availability of the data at different times during the day and night would allow for more precision in the analysis. These are reasons that justify the continuation of this type of research in other cities with different levels of environmental problems. We also believe further research is needed with other public services to contribute to the debates on how inherently objective and subjective measures may be connected and how their use can be optimized for better local performance management. Most likely, these two types of measures are not a perfect match, but when they reflect the same underlying reality, they portray a more accurate picture of issues that matter to citizens.

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Annex 1

Table 3. OLS regression of citizens' evaluation of Madrid's noise control service in 2017

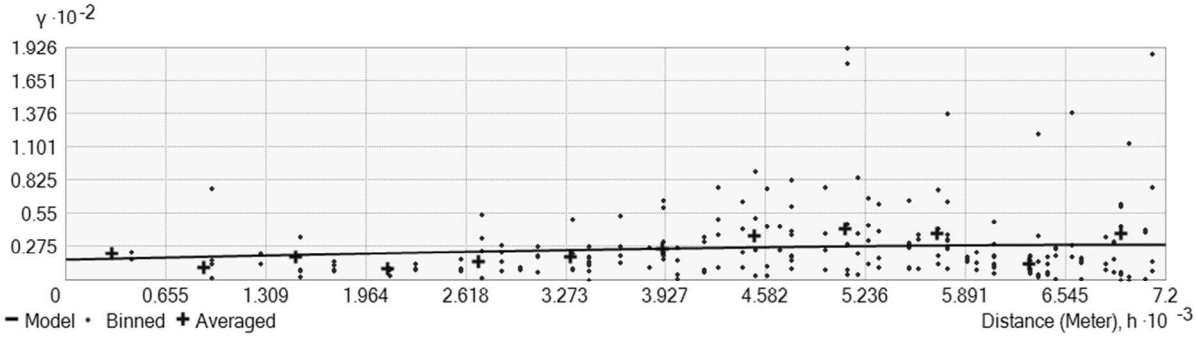
VARIABLES	Model 1	Model 2	Model 3	Model 4
Objective noise	-0.161***	-0.149***	-0.150***	-0.171***
	(0.0405)	(0.0397)	(0.0528)	(0.0560)
Priority noise problems	-	-1.944***	-2.227***	-1.764***
		(0.333)	(0.361)	(0.365)
Priority environmental issues	-	-0.234*	-0.191	-0.409**
		(0.120)	(0.174)	(0.179)
Female	-	-	0.236*	0.173
			(0.121)	(0.126)
Age	-	-	-0.00101	0.00270
			(0.00359)	(0.00453)
Educational level	-	-	0.00356	-0.0191
			(0.0189)	(0.0355)
Income level	-	-	-0.0610	-0.0524
			(0.0438)	(0.0522)
Not born in Spain	-	-	-0.499***	-0.260
			(0.152)	(0.187)
Political ideology	-	-		0.0427
				(0.0411)
Evaluation of the management of Mayor Manuela Carmena (Cat. Ref. "Very bad")				
2. Bad	-	-	-	-0.144
				(0.387)
3. Regular	-	-	-	0.595*
				(0.339)
4. Good	-	-	-	0.633*
				(0.374)
5. Very good	-	-	-	0.453
				(0.420)
Satisfied with the neighbourhood				-0.705***
				(0.166)
Tax/services ratio (Cat. Ref. "Not satisfied")				
2. Little satisfied	-	-	-	0.0213
				(0.211)
3. Neither satisfied nor dissatisfied	-	-	-	0.0829
				(0.222)
4. Quite satisfied	-	-	-	0.599**
				(0.232)

5. Very satisfied	-	-	-	1.314**
				(0.647)
Information about city council's activity (Cat. Ref. “Not at all”)				
2. Little				-0.0154
				(0.259)
3. Quite a bit	-	-	-	0.196
				(0.323)
4. A lot	-	-	-	0.0416
				(0.430)
Constant	14.70***	14.10***	14.77***	15.05***
	(2.469)	(2.422)	(3.138)	(3.325)
Observations	2,581	2,581	1,465	1,104
R-squared	0.017	0.042	0.064	0.111

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
None of the models exhibits multicollinearity problems (vif < 6 for the last model).

Annex 2

Graph 1. Variogram of the Kriging estimation of noise levels in Madrid.



Graph 2. Variogram of the estimation of kriging NO2 levels in Madrid.

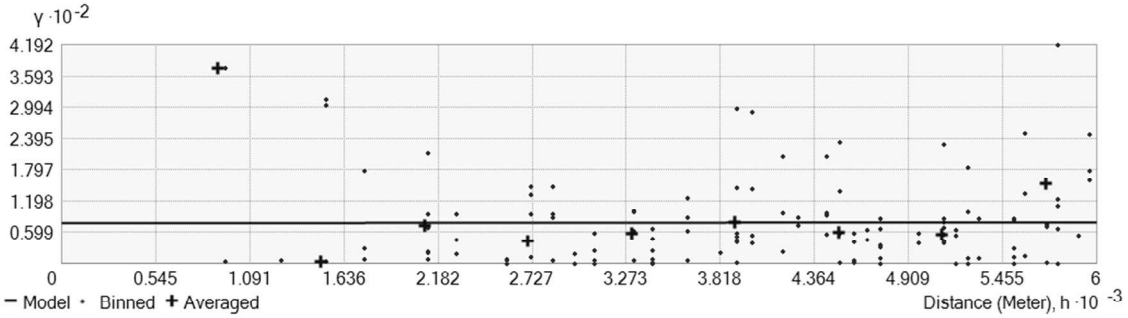


Figure 3. Predictions of kriging estimates of noise level (left) and NO2 (right).