Watch your neighbor: Strategic competition in waste collection and service quality

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Abstract:

Public procurement is frequently used to contract solid waste collection services. Incomplete contracts and transaction costs increase the need for monitoring and supervision. In such cases, competition by comparison can be a useful tool. In Barcelona, solid waste collection is regulated by competition, with four delivery zones being contracted out separately. Therefore, it is possible to make relative performance assessments, especially in the areas where the contracted firms operate close to each other. Private firms anticipate stronger competitive pressures near to competitors' zones, even after the contract has been awarded, and they compete on quality. This research studies the influence of the proximity between competitors on the quality of service delivery. Monthly data on the number of complaints regarding waste collection in the city's 73 neighborhoods between 2014 and 2019 is used to evaluate quality. Using count model approaches, out results show that higher quality is provided in neighborhoods closer to other neighborhoods served by a competing firm. Moreover, lower quality is delivered in peripheral neighborhoods, where comparison with competitors' neighborhoods is much harder, if at all possible. The results are consistent with the hypothesis that firms strategically manage quality performance and tend to deliver higher quality where they anticipate that monitoring by the regulator is easier. The findings add to the existing knowledge of competition as a regulatory tool used

to obtain more information and providing useful insights to policymakers and regulators to better understand firms' behavior in quality delivery.

Keywords: Waste collection, management, competition, service quality

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1. Introduction

Empirical evidence on costs and efficiency in waste management services is abundant in the literature, with particular emphasis on public-private comparisons (see reviews in Bel and Warner, 2008; and Bel, Fageda and Warner, 2010). However, evidence available on service quality is much scarcer, most likely because measuring and monitoring quality is difficult and costly (Shrestha and Feiock, 2011). Lack of knowledge on service quality under different delivery regimes is a relevant issue, because it is not only costs, but also quality what matters for social welfare. This public-policy related concern is reinforced by the solidly grounded theoretical insight that private producers have the incentive to use quality reduction as a cost reduction device, in order to increase financial profits (Hart, Shleifer, and Vishny 1997; Levin and Tadelis 2010).

The primary objective of this research is to increase the existing knowledge on quality under private delivery of the waste collection service. To do so, we explore the influence of competition by comparison on the quality of service in the city of Barcelona, where regulation by competition was introduced in the last few decades by means of a 'split auction' (Auriol and Laffont, 2002; Grimm et al., 2006). The market is divided into four exclusive waste collection zones. Although contracts are awarded for several years, the local authority monitors performance throughout the whole contract.

There is no evidence available in the literature to date as to whether firms strategically prioritize quality of waste collection services in certain areas of their concessions, due to competitive pressures. Furthermore, this research explores quality performance in waste collection from the citizens'

perspective, based on data on citizen complaints at a neighborhood level, which is another new development within the field of waste management studies.

The main research question is: Do firms behave strategically when delivering quality, according to the relative strength of competition? The easiest parts of the city to make relative performance evaluations are those where firms operate closer to each other. As firms can anticipate where competition by comparison is stronger, they may behave strategically in terms of quality delivery. Two hypotheses are formulated regarding our main research question: 1) Firms deliver higher quality in areas in their service zone that are closest to competitors' delivery zones; 2) firms deliver lower quality in the peripheral areas of their delivery zone, that are further from their competitors' zones.This research offers a fresh perspective for policymakers. The results show that market fragmentation can be a useful policy in large cities, not only for increasing competition in the bidding process, but also dynamically fostering competition in quality delivery. As competition by comparison makes it easier to evaluate relative performance, it alleviates the problem of asymmetric information that regulators face when contracting external firms. Moreover, an important practical lesson is drawn as well: the regulator should pay special attention to monitoring service quality in peripheral zones. In these areas, because of the distance from competitors, firms may neglect quality if monitoring is not effective enough.

Before addressing the details of our empirical modelling and implementation, in the next we provide a review of existing theoretical and empirical evidence that provides the framework within which the empirical work is conducted, and the results obtained are interpreted.

2. Theoretical and empirical background

Two strands of the literature are particularly useful to frame our research, so that we can formulate hypothesis that we later empirically test and interpret according to the relevant theoretical insights.

First, competition for contracts and incentives for service quality; second, measurement of quality in public services.

2.a Competition for contracts, firms' incentives and service quality

Growing dissatisfaction with purely public production of local services during the 1970s and 1980s paved the way to an increase in privatization and contracting out of public services in the final quarter of the last century. Although other alternative delivery modes have gained traction more recently (Bel, Hebdon and Warner, 2018), the level of new contracting out is still very high (Gradus, Schoute, Budding, 2019; Warner and Hefetz, 2020).One major area of interest for scholarly research has been the discussion on its cost-saving potential. While the key argument for privatization in waste collection management has been cost savings, extensive review studies show that this goal has not been systematically reached (Bel, Fageda and Warner, 2010). Cost savings due to competitive bidding do not seem sustainable and potential costs savings gains are not sustained overtime (Bel and Costas, 2006; Gradus, Schoute and Dijkgraaf, 2018). Therefore, the appropriateness of competitive tendering has been questioned (Massarutto, 2007), and an increasing number of studies consider ownership as less relevant when cost savings need to be achieved, while emphasizing the role of competition.

Besides issues related to competition, contracting out creates a principal-agent relation characterized by uncertainty and asymmetric information that leads to a surge in transaction costs. Such additional costs arise at every stage of the contract, from negotiation through to the implementation, supervision and enforcement phases (Green and Laffont 1992, 1994; Williamson, 1999). Furthermore, private managers' incentives to use reduce quality reduction for toincrease profits (Hart, Shleifer and Vishny, 1997; Levin and Tadelis, 2010) are particularly strong with incomplete contracts, for which transactions costs are higher, as quality performance indicators are difficult to define and measure (Dilger, Moffett and Struyk, 1997), and the contract is harder to manage (Brown and Potoski, 2003b,

2005; Hefetz and Warner, 2012). Therefore, it is more difficult for the regulator to both punish and reward quality performance, as opposed to cost-related indicators (Holmstrom and Milgrom, 1991).

The most important concerns for local authorities when contracting out are the issues resulting from monitoring, information asymmetry and service quality (Warner and Hebdon, 2001). Therefore, apart from effective supervision, local governments are motivated to use other methods to obtain more information on performance. One such tool is competition (Brown and Potoski, 2003a), which can be used as a key monitoring device for gathering information (Holmstrom, 1982). It makes it possible to evaluate relative performance by comparison, which gives an indicator of individual effort (Sappington, 1991). This disciplinary role of competition, therefore, acts as an incentive not to increase costs or decrease quality.

Competition by comparison can be even more valuable if all the actors are influenced by common parameters, such as operating in the same jurisdictional context (Holmstrom and Tirole, 1989). In practice, this type of regulation by competition can be organized through 'split auctions' or 'dual sourcing' (see Auriol and Laffont, 1992; Grimm et al., 2006; Krzeminska, Hoetker and Mellewigt, 2013; Mols, 2010; Poulsen and Hansen, 2016). In such cases, several producers operate within the same jurisdiction. Consequently, firms are exposed to higher levels of competition by comparison. As well as the benefit of reduced dependence on a single provider (Alcalde and Dahm, 2019), firms' behavior might also change due to competitive pressure resulting from the split (Grimm et al., 2006).

However, competitive pressures are highest where comparison by the regulator and the users is easiest – where firms are operating close to each other. Conversely, by the same reasoning, the lowest competitive pressures are in areas that are far from competitors' zones, where it is more difficult for the regulator and users to make any relative evaluation by observing performance. As private firms can anticipate where it is easier and more difficult for the regulator and users to assess service quality,

they have the incentive to deliver better quality where competition by comparison is harder. Therefore, we formulate the following two hypotheses.

Hypothesis 1: Firms will deliver higher quality in their service areas that are closer to areas served by competitors.

Hypothesis 2: Firms will deliver lower quality in their service areas that are further from areas served by competitors.

2.b. Measuring quality in public service delivery

In a competitive market, price and competition can give information on the possible relations between cost and quality. However, this is not common in the case of local public services as most of them have quasi-market characteristics (Boyne, 1998; Lowery, 1998). Therefore, local governments regulate and monitor the quality of outsourced services, using tools such as citizen complaints, citizen satisfaction surveys, performance data and activity audits in the field (Brown and Potoski, 2003b).

Most empirical studies evaluating quality refer to the effects of ownership on the public-private dichotomy or competition (seeEstrin et al., 2009; and Comondore et al., 2009). A recent study on economic and quality effects of contracting out by Petersen, Hjelmar and Vrangbaek (2018) reviews 49 studies on local public services published between 2000 and 2014, of which 19 include quality as dependent variable. However, most of these studies do not include a measure of quality; only categorical variables of improvement, deterioration or no effect (e.g., Zafra-Gómez et al., 2016, for a recent example on waste collection).

Measuring quality is difficult and monitoring it is costly (Shrestha and Feiock, 2011). Citizen complaints and consumer satisfaction can be considered to reflect quality (Devereux and Weisbrod, 2006; Harvey and Green, 1993). Local governments and public managers use citizen complaints to

monitor and evaluate the quality of public services (Deichmann and Lall, 2007) and to assess the performance of public service managers (Brown and Potoski, 2004). Furthermore, citizen complaints constitute a form of continuous civic participation (White and Trump, 2018), which makes them a suitable source of information for identifying ways to improve public services (Okamoto, 2016).

Based on all these considerations, the quality of the solid waste collection service is assessed by means of the number of complaints. While there are studies on the quality of solid waste collection services based on citizen surveys and, in particular, service satisfaction surveys, (e.g., Purcell and Magette, 2010; Puche Regaliza et al., 2018),[1] no quality assessment based on citizen complaints has been published to date, to the best of the authors' knowledge. In this respect, this article provides an additional contribution to the literature.

3. Institutional and geographical context of solid waste collection in Barcelona

Private firms have managed the solid waste collection services in the city of Barcelona since the late nineteenth century. Beyond public procurement, at the beginning of the twenty-first century, regulation by competition was introduced by dividing the city into four concessional areas, each including either two or three city districts (see Bel and Sebő, 2020, for a detailed analysis). In large cities, such as Barcelona, this method[2] can improve competition for the contract without damaging

[1] Studies of quality in public services based on user satisfaction surveys have also been conducted for health services (Nolan et al., 2001; Barber, Gertler and Harimurti, 2007) and bus services (Stradling et al., 2007).

[2] Other examples include Odense in Denmark (split into four regions), Uppsala in Sweden (divided into regions where one tender is renewed each year), Phoenix in the USA, and Valencia and Madrid in Spain (OECD, 1999).

the scale of operations.[3] The current division of the city into zones is as follows (city districts included in parentheses): 1) West zone (Sants–Montjuïc, Les Corts, and Sarrià-Sant Gervasi); 2) North zone (Horta–Guinardó and Nou Barris); 3) Center zone (Ciutat Vella, Eixample, and Gràcia); 4) East zone (Sant Andreu and Sant Martí).

The contract now in place started in 2009. For the corresponding bidding process, firms were required to bid for each zone, even though it was pre-established that no firm would be awarded more than one service zone. As a result of the process, the contract for the West zone was awarded to Cespa, for the North zone to CLD, for the Center zone to FCC, and for the East zone to Urbaser. The contracts were initially intended to last until 2017, but they were extended until 2019, and have since been extended again, until August 31, 2021.

A new bidding process is underway, in which the division of the city into service zones has not been modified. As before, the contract for waste collection is bundled with the contract for street cleaning. Even though each firm can be awarded a maximum of one contract, they were required to bid for at least for two zones. Besides the four incumbent firms, two other firms have submitted bids. The final award of the contracts is expected to take place in December 2020. The criteria for evaluation established by the City Council combine price-related categories with environmental requirements. Interestingly, given the research conducted here, the evaluation does not include any significant user-related component.

[3] Most empirical studies on economies of scale in solid waste collection have found such economies to be fully exploited in jurisdictions of a population between 25,000 and 50,000 (Abrate et al., 2014; Bel and Costas, 2006 Chifari et al., 2017; Di Foggia and Beccarello, 2020; Dijkgraaf and Gradus, 2003; Dubin and Navarro, 1988; Greco et al., 2015; Simões, Carvalho, and Marques, 2012, 2013; Stevens, 1978).

4. Empirical strategy

4.1. Methodology

Our empirical strategy aims to analyze the differences in quality delivered in neighborhoods by firms due to pressure from competitors. Quality is (negatively) measured by complaints, with more complaints indicating lower quality. To answer our research question, we look at the types of borders of a given neighborhood. In this section, we explain how the two types of borders are divided and coded, then a description of the main variables is presented. Last, we construct our main models. Data collection and model estimations are explained in the subsequent sections.

Neighborhoods that share a border with other neighborhoods in which a different firm holds the contract to collect waste are categorized as neighborhoods with a *Concessional Border*. In this type of neighborhood, two (or more) firms operate directly next to each other, so this is where the maximum competitive pressures on quality exists. Firms can anticipate that, in terms of the regulator's monitoring, it is easy to compare complaints in these neighborhoods to assess comparative quality. Therefore, there will be incentives for the firms to deliver a higher quality of service in the neighborhoods where comparability with other firms is high. A negative relationship between the number of complaints and the *Concessional Borders* variable is expected.

The opposite effect is expected for complaints in the neighborhoods where quality comparisons with other firms are more difficult. With this in mind, the variable *Peripheral Borders* is defined to refer to neighborhoods that have borders with other municipalities or with the sea (given the geography of the city of Barcelona). As opposed to concessional borders, firms have incentives to provide lower service quality in peripheral neighborhoods, because the regulator has far lower capacity to compare quality with other firms' neighborhoods. Therefore, a positive association between the number of complaints and the *Peripheral Border* variable is expected.

Map 1 shows the 73 neighborhoods of Barcelona and indicates whether a neighborhood has a concessional border, peripheral border, neither or both. There are five neighborhoods that have both types of border: Barceloneta (Ciutat Vella district); Vila Olímpica (Sant Martí district); Trinitat Vella (Sant Andreu district), Sant Genís dels Agudells (Horta-Guinardó District), and Tibidabo, Vallvidrera i les Planes (Sarrià-Sant Gervasi district). Note, however, that the last two cases (neighborhoods separated by a white line in top-left area of Map 1) are adjacent and border no residential areas (as shown on Map SM1 retrieved from city council's official street map , in the Supplementary Materials). Therefore, both neighborhoods are coded only as peripheral.

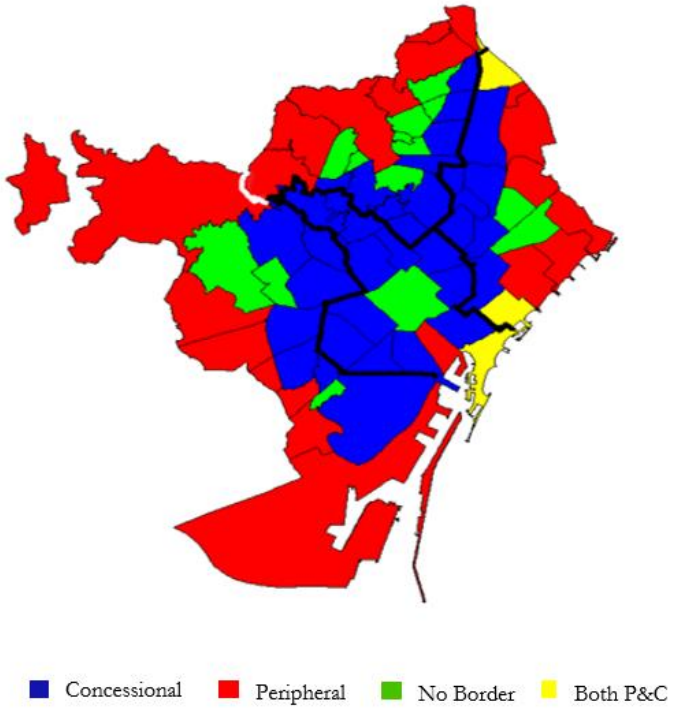

Figure 1: Neighborhoods and type of borders in Barcelona. **Source:** Authors', based on city council information.

As quality is assessed based on complaints, it is crucial to take into account different socio-economic and political factors that affect people's predisposition for making complaints. First, wealthy citizens tend to demand higher service quality, and a higher level of education allows greater awareness of quality, which is a precondition for initiating a complaint (Thomas, 1982). Therefore, citizens who give more feedback on service delivery, whether positive or negative, tend to come from the wealthier and more educated population sectors (Loeffler and Bovaird, 2016). While data on income at neighborhood level in Barcelona is only available up to 2017, data on educational attainment is up to date and available for the whole period covered by our analysis, and it is well known that educational attainment tends to have a strong correlation with income. The level of educational attainment in the neighborhood is assessed by means of the *Higher Education* variable. This variable is expected to have a positive correlation with the number of complaints.

Turning now to socio-political factors, it is firstly considered that governments are seen as liable for the quality of service delivery, even if services are delivered by external firms. If citizens' expectations have not been met, local politicians are liable for sanctions, and citizens can punish governments by voting against the incumbent (James et al., 2016). However, not all citizens are equally empowered to punish local governments by voting; only those who have the legal right to vote. Spanish and the other EU citizens have the unconditional right to vote in local elections in Spain.[4] Therefore, given that their

[4] Other than European Union members, a few countries have signed treaties with Spain that reciprocally allow their respective citizens residing in the other country to vote in the local elections. However, in such cases, the right to vote is subject to strong procedural limitations and requirements of years of residence. As a result, electoral participation is much lower. In the last local election in Spain (June 2019), 466,181 foreigners entered the electoral census (10% of total foreign adult population in Spain). Only 16,648 of these were citizens of non-

potential level of political participation and punishment for low quality is higher, both firms and local regulators have incentives to pay more attention to quality delivered in neighborhoods where political participation can be higher. The resulting expectation is that neighborhoods with a higher share of citizens with the right to vote (*Political Participation*) receive a better service quality, which results in fewer complaints.

Furthermore, it is worth taking into account that identifying with political parties can strongly bias perceptions on the quality of the service (James and Van Ryzin, 2017; Jilke, 2018); supporters of the local government tend to be more satisfied with service delivery, whereas supporters of parties in opposition tend to be less satisfied. It should be noted, however, that when actual performance is evaluated -as it is in in this research, through the number of complaints- partisan biases can be less relevant (Tilley and Hobolt, 2011). Hence, no clear expectation exists regarding this variable (*Votes*).

Additionally, scale-related control variables were included. Firstly, *Population,* for which a positive effect on the number of complaints is expected. Secondly, *Net Density* (which measures the population density in the area allocated for residential use only), for which no precise expectation exists. The basic structure of our count model is as follows:

$$Quality = F(BorderStatus, Higher\ Education, Political\ Participation, Vote\ for\ Governing\ Party, Population, Net\ Density) \quad (1)$$

As stated, several neighborhoods meet the conditions of having both a *Concessional Border* and a *Peripheral Border*. Therefore, two different specifications are considered:

EU countries with a reciprocal agreement, according to data from the Spanish Statistical Institute (INE; see https://www.eldiario.es/desalambre/voto-inmigrante-extranjeros-legalmente-espana_1_1636823.html).

$$Complaints_{it} = \beta_0 + \beta_1 Concessional\ Border_{\ i} + \beta_2 Higher\ Education_{it} + \beta_3 Political\ Participation_{it} + \beta_4 Votes_{it} + \beta_5 Population_{it} + \beta_6 NetDensity_{it} + \varepsilon_{it} \quad (2)$$

$$Complaints_{it} = \beta_0 + \beta_1 Peripheral\ Border_{\ i} + \beta_2 Higher\ Education_{it} + \beta_3 Political\ Participation_{it} + \beta_4 Votes_{it} + \beta_5 Population_{it} + \beta_6 NetDensity_{it} + \varepsilon_{it} \quad (3)$$

4.2 Data

The Open Data BCN portal makes many datasets of different types accessible online. The collection of complaints in Barcelona resembles the *NYC 311 online* complaint program in New York, which was originally a non-emergency phone number available to citizens for reporting problems. Similar platforms were later developed, such as *Cambridge iReports* in the USA; *FixMyStreet* in the UK, and *SeeClickFix* and *CitySourced* -both location-independent-, among others (Offenhuber 2015). These platforms can be seen as tools for co-production of local services (Brudney and England, 1982; O'Brien, 2016), as is the Open Data BCN dataset on queries and complaints.

Complaints in the city of Barcelona have been recorded since 2013, and the registry is up to date. The database is formed of 31 categories, each of which is divided into subgroups. This research was interested in subgroups related to waste collection in the city. This data contains detailed information on date, time, and location of the calls (district, neighborhood and ward, mostly geolocated). Therefore, it has been possible to aggregate the number of complaints made about the waste collection service at a neighborhood level. Map 2 shows the number of complaints made in each neighborhood (per 1,000 inhabitants) in the year 2019, the last for which information is available for the whole year.

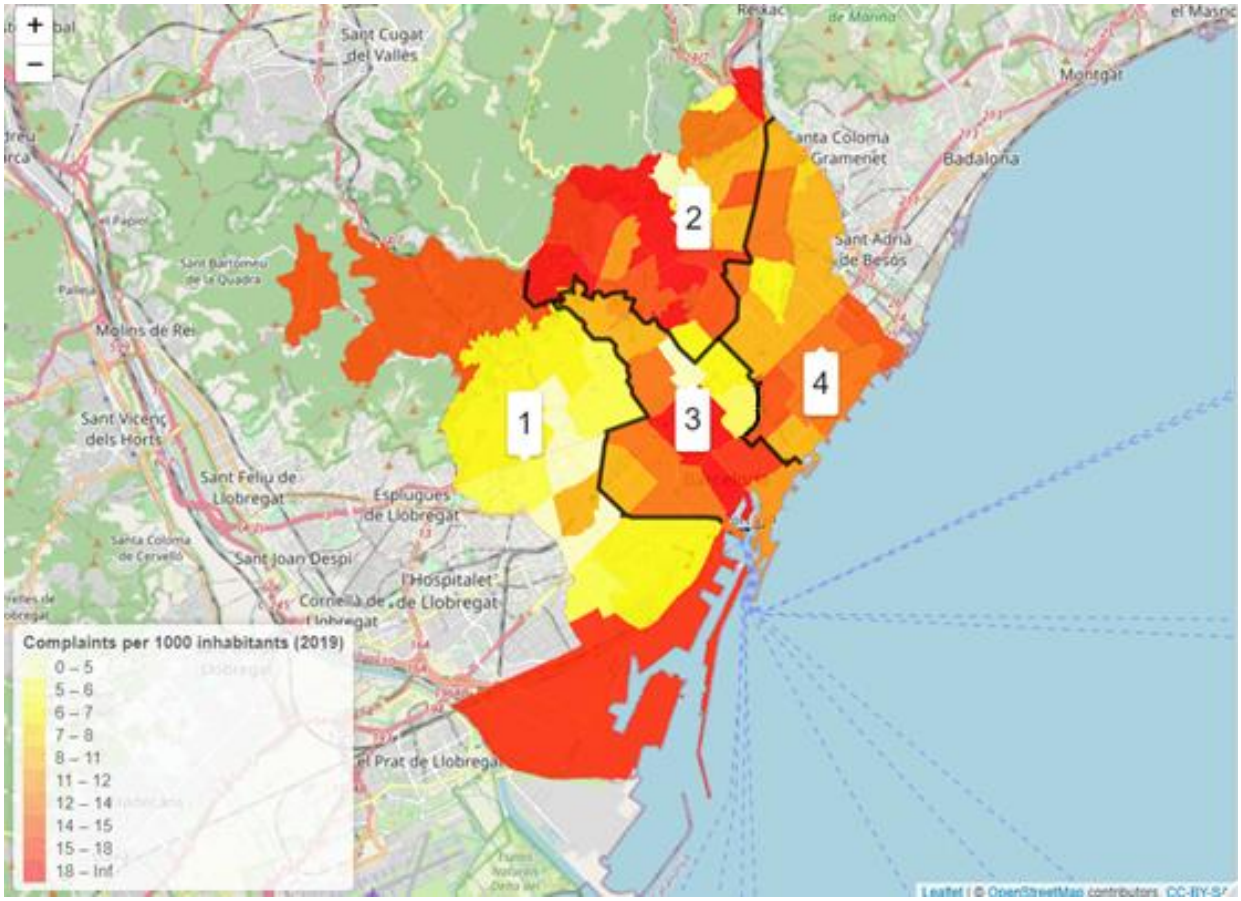

Figure 2: Complaints on the waste collection service in each neighborhood of Barcelona, year 2019. **Note:** (1) indicates Western zone; (2) Norther zone; (3) Center zone; and (4) East zone. **Source.** Authors' based on Open Data BCN

The period under analysis is 2014-2019, the first and last year with information available for the whole year. For this period, monthly observations of complaints are available for each neighborhood. For socio-economic, socio-political, and demographic variables, the data is yearly from 2014 to 2019. In the case of voting for the party in government, three election years were included in the data: 2011, 2015 and 2019. In the years in which elections were held, the outcomes starting from July of that year were considered (as newly elected local governments take office in June). The variables and their sources are described in Table 1. All sources are publicly available online: Open Data BCN, Official city statistics (bcn.cat), and Regional statistics (idescat.cat). Table 2 displays the descriptive statistics

Table 1. Description of the variables used in the estimations.

Variable	Description	Periodicity	Source
Complaints	Total number of complaints per month in a neighborhood	Monthly data 2014-2019	OpenData BCN
Concessional Border	Dummy standing for neighborhoods where two firms meet, with residents near both neighborhood borders		Own elaboration
Peripheral Border	Dummy standing for peripheral neighborhoods, either bordering with another municipality or with the sea		Own elaboration
Higher Education	Number of inhabitants having finished at least pre-university as the share of population who entered the educational system	Yearly data 2014-2019	OpenData BCN
Political Participation	Number of Spaniard or EU citizens as the share of total inhabitants in the neighborhood	Yearly data 2014-2019	bcn.cat
Votes	Pro-mayor list votes in the local elections as the share of total votes	Data for last election held	bcn.cat
Population	Total number of inhabitants in the neighborhood	Yearly data 2014-2019	idescat.cat
Net Density	Net density (inhabitants/residential hectares)	Yearly data 2014-2019	bcn.cat

Table 2. Descriptive Statistics

	West-Cespa				North-CLD			
Variable	Max	Min	Std. Dev.	Mean	Max	Min	Std. Dev.	Mean
Complaints	78	0	11.23	12.63	166	0	13.32	9.97
Concessional Border	1	0	0.49	0.41	1	0	0.48	0.37
Peripheral Border	1	0	0.49	0.41	1	0	0.45	0.29
Votes	51.90	4.80	12.19	23.42	40.30	8.50	8.66	28.05
Higher Education	0.82	0.15	0.18	0.62	0.61	0.20	0.12	0.39
Political Participation	0.97	0.78	0.04	0.91	0.97	0.71	0.05	0.89
Population	47,928	1,145	13,407	24,305	37,216	529	10,204	37,216
Net Density	1,121	19	316	570	1,181	85	282	619
	Center-FCC				**East-Urbaser**			
Variable	Max	Min	Std. Dev.	Mean	Max	Min	Std. Dev.	Mean
Count of Complaint	444	0	23.07	26.11	132	0	12.88	13.65
Concessional Border	1	0	0.34	0.87	1	0	0.50	0.53
Peripheral Border	1	0	0.34	0.13	1	0	0.50	0.47
Votes	39.70	17	6.41	26.74	37.80	10.70	6.14	27.10
Higher Education	0.77	0.39	0.09	0.63	0.78	0.19	0.14	0.48
Political Participation	0.94	0.61	0.08	0.86	0.95	0.73	0.05	0.90
Population	58,642	7,307	15,903	32,649	57,961	2,482	12,662	22,585
Net Density	1,155	328	231	741	1,511	380	238	827

To check the potential relevance of multicollinearity issues, the variance inflation factor (VIF) was computed for each of the two specifications, and for all four concessional areas, each managed by a different firm. The highest mean VIF was 2.56 (Center zone-FCC, estimation for concessional borders). The maximum individual VIFs were 4.76 and 4.39, both for *Higher Education* in Center zone-FCC, concessional and peripheral estimations respectively. All other individual VIFs were well below 4. Thus, no relevant multicollinearity problems exist in the estimations. Results for mean and individual VIFs are displayed in Table SM1, in the supplementary materials.

5. Estimations and results

Given that the number of complaints made on the service in each neighborhood was used to analyze quality variations related to competition by comparison, the outcome variable is discrete: the count of the event -complaint made- (Green, 2018). To estimate the count model, negative binomial regression was used. Negative binomial regression generalizes the Poisson model by loosening the assumption that the variance is equal to the mean, an assumption that is rarely satisfied. The outcome variable has a variance higher than its mean, which indicates an issue of overdispersion, which can be dealt with by using negative binomial regression (Hilbe, 2014). The maximum likelihood method was used to estimate the regression coefficients. In all estimations time controls are used.

The results of the first set of estimations, for the models for each concessional area/firm analyzing concessional borders, are displayed in Table 3. In all four estimations, alpha is higher than zero, thus confirming that overdispersion is present. The p-value for the chi-square ($p<0.0000$ in all cases) shows that the overall model is robust for every regression.

Table 3. Results of the Estimation of the Influence of Concessional Borders on the Count of Complaints.

DV: Count of Complaints	West-Cespa	North-CLD	Center-FCC	East-Urbaser
Concessional Border	-0.03399	-0.14351***	-0.52823***	-0.40212***
	(0.04541)	(0.03909)	(0.05534)	(0.02927)
Higher Education	1.16754***	1.60189***	1.41065***	2.85124***
	(1.14437)	(0.19791)	(0.45433)	(0.17563)
Political Participation	-3.19041***	-1.92718***	-3.57416***	-4.51974***
	(0.61271)	(0.43374)	(0.39154)	(0.40552)
Votes	0.00311**	-0.00470	0.00639**	0.01213***
	(0.00145)	(0.00337)	(0.00250)	(0.00391)
Population	0.00005***	0.00007***	0.00003***	0.00004***
	(1.81e-06)	(1.98e-06)	(1.18e-06)	(1.02e-06)
Net Density	-0.00034***	-0.00021***	-0.00020*	0.00028***
	(0.00010)	(0.00007)	(0.00010)	(0.00005)
Constant	3.08090***	1.85752***	4.45095***	3.15011***
	(0.70739)	(0.39272)	(0.23204)	(0.34204)
Alpha	0.12691	0.22230	0.12360	0.08132
	(0.01334)	(0.01343)	(0.01395)	(0.00795)
Time effects	YES	YES	YES	YES
Nr of observations	1,224	1,728	1,080	1,224
Wald chi	2,694.82	3,582.70	2,761.03	4,021.81
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.1726	0.1792	0.1481	0.1924
Log pseudolikelihood	-3,589.22	-4,746.71	-3,858.46	-3,572.03

Note: *** indicates significance at 1% level; indicates significance at 5% level; * indicates significance at 10%. In parenthesis robust standard errors.

The key variable is *Concessional Border*, which allows us to check Hypothesis 1. In three concessional areas (North (CLD), Centre (FCC) and East (Urbaser)), neighborhoods that border other concessional areas show negative signs (they have less complaints), and all coefficients are significant at the 1% level. The Western concessional area (CESPA) is the only exception, as the coefficient for its neighborhoods with concessional borders has a negative sign, as expected, but the coefficient does not significantly differ from zero.

Table 4 displays the results for the estimations of the models with neighborhoods with a peripheral border, which is the key variable in these estimations as it allows us to check Hypothesis 2. The North (CLD), Centre (FCC) and East (Urbaser) concessional areas have a higher number of complaints (positive sign) in peripheral borders, and coefficients are strongly significant, as in the previous case: at the 1% level for FCC and for Urbaser, and at 5% for CLD. As before, once again, West (CESPA) is the only exception: a positive sign (as expected) for the neighborhoods with peripheral borders is found, but its coefficient does not significantly differ from zero.

Results for the key variables in the estimations in Tables 3 and 4 tend to confirm our two hypotheses overall: quality delivered is higher in neighborhoods (lower number of complaints) that are closer to competitors' concessions (H1), where customer comparison with quality in other concessional areas is easier. Conversely, quality is lower (higher number of complaints) in neighborhoods that are geographically peripheral (2), where customer comparison with firms in other concessional areas is more difficult.

Table 4. Results of the Estimation of the Influence of Peripheral Borders on the Count of Complaints.

DV: Count of Complaints	West-Cespa	North-CLD	Center-FCC	East-Urbaser
Peripheral Border	0. 04259	0.11541**	0. 57992***	0.28565***
	(0. 04255)	(0.04465)	(0. 06623)	(0.03776)
Higher Education	1. 21592***	1.68717***	2.59359***	2.32295***
	(0.15663)	(0.19628)	(0.37558)	(0.17365)
Political Participation	-3.22445***	-1.91162***	-4.42607***	-2.58081***
	(0.58569)	(0.44378)	(0.33990)	(0.41050)
Votes	0.00314**	-0.00478	0.00419	0.01743***
	(0.00146)	(0.00342)	(0.00259)	(0.00401)
Population	0.00005***	0.00007***	0.00003***	0.00004***
	(1.43e-06)	(1.72e-06)	(1.26e-06)	(1.07e-06)
Net Density	-0.00033***	-0.00015	-0.00065***	0.00072***
	(0.00009)	(0.00009)	(0.00009)	(0.00006)
Constant	3.05356***	1.74684***	4.19191***	0.85919**
	(0.53319)	(0.41728)	(0.22822)	(0.35968)
Alpha	0.12747	0.22591	0.12413	0.10069
	(0.01343)	(0.01334)	(0.01248)	(0.00887)
Time effects	YES	YES	YES	YES
Nr of observations	1,224	1,728	1,080	1,224
Wald chi	2,752.13	3,571.30	2,991.85	3,648.68
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.1726	0.1786	0.1514	0.1794
Log pseudolikelihood	-3,588.99	-4,749.99	-3,850.27	-3,629.58

Note: *** indicates significance at 1% level; **: indicates significance at 5% level; * indicates significance at 10%. In parentheses robust standard errors.

Regarding the control variable included in the estimations, results are almost identical for both specifications. In all estimations in Tables 3 and 4, *Higher Education* and *Population* show a stable and significant positive association with complains, whereas it is negative in the case of *Political Participation*. Results for these three v*ariables in all eight estimations are according to expectations. In the case of Votes for the Mayor's Party*, results are less systematic, but *Votes* tend to be associated with more complaints, when statistically significant. Results for *Net Density* show a random pattern regarding sign and significance, so no clear and stable effect can be concluded.

6. Robustness check

The robustness of our results can be checked with another technique that can be used to estimate an over-dispersed Poisson distribution, such as the Generalized Linear Model (GLM). Using this approach, the value of k is identified for which the deviance-based dispersion equals 1 (Hardin and Hilbe, 2018). Tables 5 and 6 present the results for the GLM estimation of models for *Concessional Border* and for *Peripheral Border*, respectively. The results obtained are almost identical to those obtained with negative binomial regressions, which suggests that the results obtained are robust to the estimation technique. The only relevant difference is found in the estimation for the peripheral borders specification for West-Cespa. Precisely, the coefficient for the *Peripheral Border* variable is now positive and statistically significant at the 1% level (while it was not significant with negative binomial regression). With GLM, all four estimations for peripheral borders are consistent with H2, as more complaints (indicating lower quality of the service) are made in the neighborhoods where comparison with other concessions is more difficult.

Table 5. Results of the estimations for concessional borders. Generalized Linear Model

DV: Count of Complaints	West-Cespa	North-CLD	Center-FCC	East-Urbaser
Concessional Border	-0.05113	-0.10099***	-0.56122***	-0.40050***
	(0.04512)	(0.03845)	(0.04986)	(0.03161)
Higher Education	1.52882***	1.90457***	1.64525***	3.21657***
	(0.16860)	(0.21930)	(0.45226)	(0.21946)
Political Participation	-2.97407***	-2.40828***	-3.95644***	-5.26783***
	(0.63239)	(0.47475)	(0.39164)	(0.50601)
Votes	0.00400**	-0.00539	0.00576**	0.01341***
	(0.00165)	(0.00354)	(0.00251)	(0.00456)
Population	0.00005***	0.00007***	0.00003***	0.00004***
	(1.85e-06)	(2.00e-06)	(1.21e-06)	(1.22e-06)
Net Density	-0.00020**	-0.00019**	-0.00005	0.00035***
	(0.00010)	(0.00008)	(0.00010)	(0.00006)
Constant	2.54848***	2.11644***	4.59085***	3.5233***
	(0.58100)	(0.42693)	(0.25562)	(0.40267)
Time effects	YES	YES	YES	YES
Nr of observations	1,224	1,728	1,080	1,224
AIC	6.76444	6.01866	8.30163	6.90479
BIC	-7,793.40	-11,532.37	-6,789.33	-7,826.83
Log pseudolikelihood	-4,061.84	-5,122.13	-4,404.88	-4,147.73

Note: *** indicates significance at 1% level; indicates significance at 5% level; * indicates significance at 10%. In parentheses robust standard errors.

Table 6. Results of the estimations for peripheral borders. Generalized Linear Model

DV: Count of Complaints	West-Cespa	North-CLD	Center-FCC	East-Urbaser
Peripheral Border	0.11983***	0.11106**	0.65302***	0.25066***
	(0.04571)	(0.04722)	(0.06031)	(0.03730)
Higher Education	1.70153***	1.98792***	3.04677***	2.64540***
	(0.18526)	(0.21578)	(0.38733)	(0.21395)
Political Participation	-3.36134***	-2.30952***	-4.88924***	-3.24471***
	(0.62838)	(0.49579)	(0.34925)	(0.48779)
Votes	0.00416**	-0.00524	0.00367	0.01815***
	(0.00168)	(0.00358)	(0.00255)	(0.00459)
Population	0.00005***	0.00007***	0.00003***	0.00004***
	(1.55e-06)	(1.78e-06)	(1.27e-06)	(1.23e-06)
Net Density	-0.00022**	-0.00012	-0.00053***	0.00076***
	(0.00009)	(0.00010)	(0.00009)	(0.00007)
Constant	2.72006***	1.91821***	4.23713***	1.25800***
	(0.55945)	(0.46733)	(0.25064)	(0.39473)
Time effects	YES	YES	YES	YES
Nr of observations	1,224	1,728	1,080	1,224
AIC	6.76311	6.01867	8.29181	6.92195
BIC	-7,795.03	-1,1523.36	-6,799.92	-7,805.84
Log pseudolikelihood	-4,061.02	-5,122.13	-4,399.57	-4,158.23

Note: *** indicates significance at 1% level; indicates significance at 5% level; * indicates significance at 10%. In parentheses robust standard errors.

7. Discussion and policy implication

This research has empirically addressed a main research question: how firms managing the waste collection system in a jurisdiction with fragmented service areas will deliver quality depending on competition by comparison posed by other firms in the city. Our results show strategic behavior of the firm in response to competitive pressures. Those neighborhoods that share a border with another neighborhood that belongs to a different delivery zone tend to have a lower number of complaints, reflecting a higher quality of service provided by the firm, which is consistent with our Hypothesis 1. This is due to the fact that comparing performance is easier for regulators and citizens in this type of neighborhood. While there can be no price competition in the concessional borders, firms can compete on quality.

Conversely, the opposite effect is found in peripheral neighborhoods that share borders with neighboring municipalities or with the sea, where the number of complaints related to quality is higher, thus reflecting a lower quality of the service, consistent with our Hypothesis 2. In peripheral neighborhoods, firms do not face significant competition by comparison. They can only be compared with concessionaires in neighboring municipalities, and even this is only possible in a limited number of peripheral neighborhoods. Most peripheral neighborhoods have borders with the sea (south-east of the city), with mountainous areas (north and north-west of the city) or with the Besòs River (east of the city).

The only concessional area that has many neighborhoods bordering neighborhoods in other municipalities with a significant population (thus forming an urban continuum) is the West zone (Cespa). Interestingly, this is the only zone in which the peripheral neighborhoods do not show a significantly higher number of complaints in our preferred estimation (negative binomial regression).

It should be noted, however, that, even in this zone, Hypothesis 2 (more complaints in peripheral neighborhoods) holds when a General Linear Model is estimated, as shown in Table 6.

Although the importance of quality is widely acknowledged, the reform of local public service management in the last few decades has emphasized cost considerations, as has academic research on solid waste collection. One of the main reasons for lagging quality is that its measurement can be very costly, if at all feasible. Additionally, private firms may have the incentive to decrease quality in order to save costs. Hence, moral hazard issues can arise (Grossman and Hart, 1983)

This increases uncertainty and information asymmetry between firms and governments, which makes contracts more incomplete. Thus, effective monitoring and supervision are strongly required (Hart, Shleifer and Vishny, 1997; Levin and Tadelis, 2010; Simon, 1991). Due to the principal-agent conflict of interests, agency costs arise if the firm is not guided by the principle of loyalty and equity (Frydlinger and Hart, 2020). New approaches in this line of research investigate the possibility of establishing a partnership mentality and relationship-building (Frydlinger, Hart and Vitasek, 2019). Nevertheless, empirical research seems to confirm that mainly measurable quality indicators are positively correlated with privatization; otherwise, public delivery is of higher quality thus reinforcing the notion of incomplete contracts (Alonso and Andrews, 2016).

Enhancing competition by means of fragmentation of zones and their corresponding contracts within a jurisdiction is a management tool that several cities have used. This is particularly suitable for larger cities, where fragmentation does not damage economies of scale, as shown for the case of Barcelona in Bel and Sebő (2020), and a dynamic form of competition is beneficial (Porter 1998). Fragmentation increases the opportunities for firms other than the major players to compete (Pavel and Slavik, 2018), thus contributing to alleviating the significant problem of the trend towards concentration in the waste management market (see Antonioli and Massarutto, 2012; Bel and Fageda, 2011).

While split auctions (Auriol and Laffont, 2002; Grimm et al., 2006) in solid waste collection have mainly been used for cost containment, this research has shown that they can also be useful for quality monitoring and supervision. As well as price comparisons in the bids for the contracts, quality comparison can be undertaken as an ongoing task. In that regard, local governments can benefit from information provided by users, such as complaints made for quality-related reason, to compare relative performance in the quality of the service delivered. This enables the regulator to monitor 'agents with other agents' (Varian, 1990).

The most straightforward place to compare agents is bordering areas that they share with each other. In this regard, the empirical results obtained in this article have significant policy implications. Firms behave strategically and provide better quality of service in the areas were comparison with other competitors is easier. In other words, firms prioritize the quality of service where they can be compared by the regulator with another supplier on the market (for which users' complaints can be used). However, firms pay much less attention to areas where comparison is more difficult, which have been classified here as peripheral neighborhoods. Consequently, if local governments want to achieve similar levels of quality across the city, they must devote more efforts to monitoring performance in quality directly in neighborhoods where firms face lower competition by comparison.

This article adds to the existing literature in several ways. Firstly, quality of the waste collection service is evaluated by locating feedback data and aggregating it at a micro level. Moreover, strategic behaviors of firms are explored, looking at the divergence in the quality that they deliver. While the quality of the service has been evaluated here based on citizen complaints, other dimensions of quality in waste service collection, and waste management overall, have not been considered, particularly indicators related to environmental improvement and the fight against climate change, such as different recycling programs (Lavee and Khatib 2010, Lavee and Nardiya 2013), or improving the combinations of energy and material recovery (Massarutto, De Carli, and Graffi 2010). With advancing knowledge in the

different dimensions of service quality in waste management, future research will be better equipped to undertake a more comprehensive approach to this issue.

8. Conclusion

This study has analyzed the effects of competition by comparison on the behavior of firms with respect to quality in the waste collection services that they provide in the city of Barcelona. More specifically, this research illustrates the incentive to decide quality levels strategically in service delivery based on the distance from competitors, taken as a proxy for competitive pressure. The results from the empirical analysis show that firms offer different quality levels according to the level of competition they face, this depending on whether relative performance evaluations are easier or difficult to make.

Our results suggest that waste companies devote more effort to provide service quality in the areas closer to areas served by competitors, where quality is more directly comparable with that of competitors, because this could influence valuations in future tendering processes. Insufficient o badly planned supervision by local authorities might be allowing companies to reduce efforts in neighborhoods that are more distant to competitors' zones, containing in this way overall costs in the own concessional area, but creating a persistent lag in service quality.

These findings are particularly relevant to both practitioners and policymakers. Local authorities can improve information asymmetry on service delivery by splitting the market, reducing the need to introduce costly monitoring tools. In addition, competition can be managed to promote service quality and direct monitoring by regulators must be emphasized in peripheral areas of the city where citizens have less opportunity to compare quality between different private providers.

Lack of information on other dimensions of quality, other than complaints received, have limited the possibility of conducting a more comprehensive study of spatial variations in the quality of waste collection services. In this regard, having additional data available on other important quality variables would allow a higher level of generalizability of the results to be achieved. In particular, future research on the strategic behavior of firms should be conducted using data on the environmental impacts of waste collection and waste management, given the relevance of this urban service in terms of tackling the challenge of fighting climate change.

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SUPPLEMENTARY MATERIALS

Table SM1: Variance Inflation Factor analysis

Variable	West-Cespa	North-CLD	Center-FCC	East-Urbaser
Concessional Border	2.43	1.63	1.74	1.48
Higher Education	1.96	1.54	4.76	2.00
Political Participation	3.57	1.53	3.22	1.78
Votes	1.14	1.04	1.21	1.03
Population	2.90	2.25	1.92	1.23
Net Density	3.31	1.76	2.49	1.16
Mean VIF	2.55	1.62	2.56	1.45

Variable	West-Cespa	North-CLD	Center-FCC	East-Urbaser
Peripheral Border	1.73	1.40	1.49	2.07
Superior Studies	2.35	1.61	4.39	1.71
Political Participation	3.16	1.53	2.87	1.53
Vote	1.14	1.05	1.21	1.02
Population	1.83	1.76	2.32	1.26
Net Density	2.81	2.05	2.29	1.77
Mean VIF	2.17	1.57	2.43	1.56

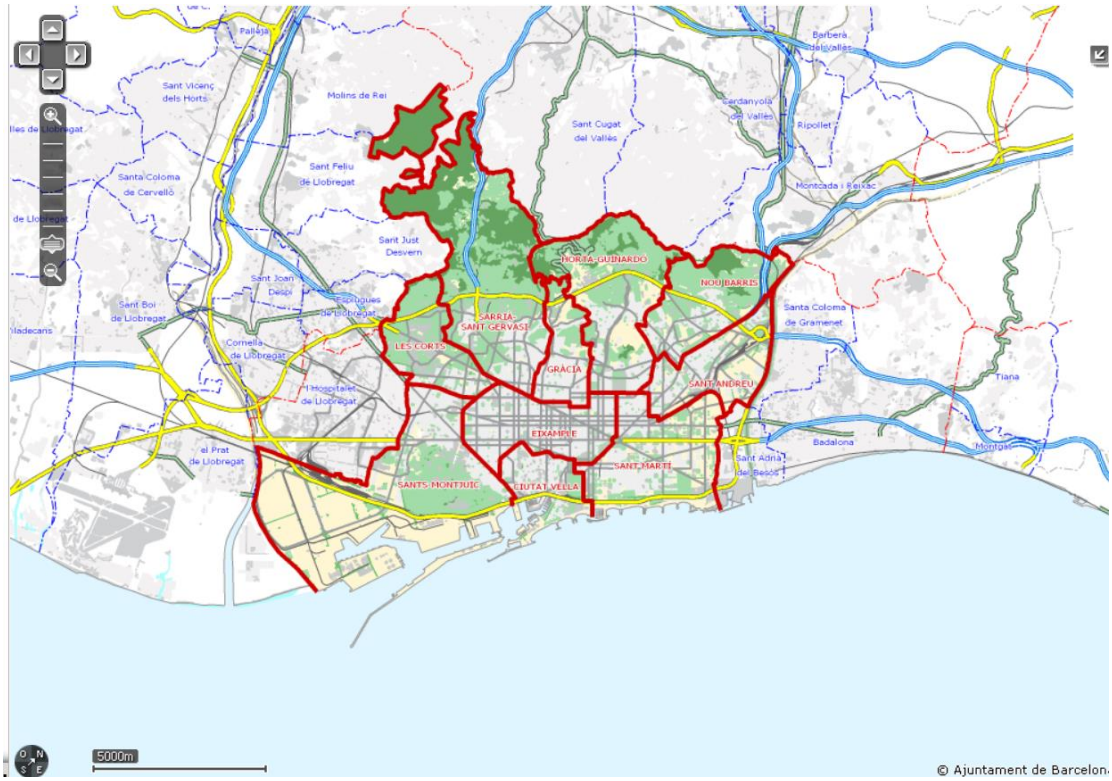

Figure SM1: Neighborhoods of Barcelona and residential areas.