Electoral Competition, Party System Fragmentation, and Air Quality in Mexican Municipalities

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Abstract: This paper studies how electoral competition and party system fragmentation affects local environmental public goods provision. When the effective number of political parties is too low, there is not enough competition to incentivize service provision by the incumbent. Increasing the number of parties in this scenario strengthens electoral competition and the incentive for the incumbent to deliver public goods. However, when the number of political parties are too high, the system becomes too fragmented to produce beneficial outcomes in public goods provision. We therefore expect a U-shaped relationship between the effective number of parties and local air pollution. Based on a Mexican municipal panel data of 1999, 2004, 2009, and 2014, our empirical analysis confirms this theoretical expectation: PM2.5 pollution goes down with the effective number of parties before the latter reaches the value around three; after this point, air pollution goes up with the effective number of parties.

Key words: air pollution; party system fragmentation; public goods; Mexico.

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Introduction

There is often thought to be a positive link between electoral competition and public goods provision. The basic argument rests on theories of electoral accountability, which posit that elections offer citizens the opportunity to influence policy outcomes by removing under-performing representatives (Austen-Smith and Banks 1989). However, empirical studies testing the connection between electoral competition and public goods provision often present mixed empirical support. We argue that one reason is that most studies overlook the effect of another important factor associated with electoral politics: party system fragmentation.

When the effective number of political parties is too low, there is not enough competition to incentivize services provision by the incumbent. Increasing the number of parties strengthens electoral competition and public goods provision. However, when the number of political parties is too high, the system is too fragmented to produce beneficial outcomes in public goods provision because a more fragmented party system often represents more veto players and a higher level of heterogeneity in policy preferences, which presents more obstacles for policy making and implementation. We test our theory in local environmental public goods provision – proxied by local air quality (PM2.5) – in Mexican municipalities. Using a panel of 1999, 2004, 2009, and 2014, we find a U-shaped relationship between the effective number of parties in Mexican municipal elections and local PM2.5 level: air pollution goes down with the effective number of parties before the latter reaches around three; after this point, air pollution goes up with the effective number of parties.

One empirical contribution of this paper is that it assesses the relationship between electoral politics and the provision of a much less studied, pure(r) public good. Past studies often use social spending and infrastructure projects as measures of public goods. However, the ability

to target social programs and infrastructure projects to specific constituencies reduces their "public good" nature. Environmental public goods, on the other hand, are some of the purest types. Moreover, the disperse nature of clean air and the trade-off between providing environmental public goods and protecting the local economy makes clean air a more difficult public good to politicize for electoral benefit.[1]

Moreover, this paper contributes to the literature on the political foundations of pollution. One focus of this literature is on the connection between political regime types and pollution, often contrasting democracies with autocracies. Overwhelming theoretical propositions favor democracies as a better system for the environment: e.g., political competition for office, often higher in democracies, increases the influence of environmental pressure group activities (Binder and Neumayer 2005). However, no clear pattern has emerged from empirical studies as results depend on the performance indicators used, what other variables are controlled for, and how democracy is measured (Grafton and Knowles 2004; Bernauer and Kuobi 2009). Such mixed empirical findings motivate recent studies to move beyond a simple democracy-autocracy dichotomy: some examine variations within democracies regarding institutional factors such as proportional vs. majoritarian electoral rules and presidentialism vs. parliamentarianism (Fredriksson and Millimet 2004). Our paper contributes to this much more nuanced view of political institutions' environmental impacts by showing that even within a democratic system,

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[1] Environmental public goods also have significant distributive implications. E.g., small and informal producers emit more particulates per unit of GDP, making them targets for anti-pollution policies. However, low profits and a lack of credit make it difficult for them to adjust production methods (Backman and Barrister 1998).

more electoral competition is not always good for the environment because more effective

number of parties might fragment policy formation and implementation.

Finally, we make an empirical contribution to a recent literature that studies within-country

air pollution: we move away from recent studies' focus on China and present a study of Mexico.

Regarding what causes variations in air pollution *within* a country, in the case of PM2.5, research

on political and socioeconomic explanatory factors has been scarce until recently (Li et al. 2016;

Jiang et al. 2018; Yang et al. 2018). Interestingly, all these studies are based on China. We do not

know whether their empirical results travel to other developing countries.[2] Furthermore, these

studies often use prefecture cities as the unit of analysis: Chinese prefectures are very large

administrative areas that often have millions of residents. Our unit of analysis – municipalities in

Mexico – is a much smaller administrative unit.

Mexico is a useful case for a few reasons. First, it presents a difficult test because it is a

newly democratic regime and a country eager to develop its economy. However, there is good

reason to believe that municipal governments play an active role in pollution control. The

Mexican constitution grants municipalities the ability to develop ecological policies, the power

to deal with low-level ecological emergencies and risks, the responsibility of preventing

pollution, managing solid waste disposal, and evaluating and regulating environmental impacts

of urban growth (Assetto, Hajba, and Mumme 2003). The environmental law passed in 1988

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[2] They also often present mixed empirical results. In Li et al. (2016), PM2.5 in China is driven by

factors such as economic development, urbanization, and industrialization. Yang et al. (2018)

find that natural factors contribute more than socioeconomic factors. In Cao et al. (2019), only

urbanization and taxi per capita emerge as statistically significant.

decentralized significant authority over environmental policy to municipalities.[3] It charges them

with monitoring and ensuring the application of federal environmental regulations.

Municipalities are responsible to address all environmental problems not already reserved for

federal or state authorities.[4] Additionally, Mexicans care about air pollution. Survey data from

the World and European Value Surveys reveal that in 2005, the ratio of Mexicans choosing the

environment to those choosing economic development almost reached 2:1, well above the

response ratios in similar countries. More recently, Rodríguez-Sánchez (2014) shows that on

average, a Mexican household head would pay \$46.90 to \$283.61 (constant 2000 dollars) for a

one-unit reduction in particulate matter emissions per year.[5]

Party System Fragmentation and Public Goods Provision

We aim to explain subnational variation in environmental public goods provision. Past studies

focus on public goods that suffer from some degree of rivalry and crowding effects: these often

include infrastructure, education, health care, and social welfare. Air quality, on the other hand,

is one of the purest public goods. It is less subject to crowding effects or rivalry; non-

excludability is also less of a concern. Moreover, social spending and infrastructure projects can

be targeted to specific groups, making them club goods. While the location of polluting activities

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[3] https://www.gob.mx/semarnat/articulos/la-lgeepa-eje-rector-del-sistema-juridico-ambiental-de-mexico?idiom=es, accessed May 22, 2020.

[4] Most municipalities can pass environmental regulatory ordinances and sanction violations of those ordinances.

[5] One-unit reduction in PM here is close to one standard deviation reduction.

may be strategically placed (Monogan, Konisky, and Woods 2017), air quality is often difficult to direct towards a specific constituency.

There are several theories linking political factors to public goods provision. Some, such as the selectorate theory (Bueno de Mesquita et al. 2003),[6] are more relevant to explain cross-country variation. Rather than review all theories, we focus on an approach related to electoral competition and party system fragmentation.

More Electoral Competition, More Public Goods? The basic intuition from the electoral democratic theory posits that competitive elections offer citizens the opportunity to influence government representatives by threatening to remove the incumbent for poor performance and by selecting representatives who are competent and share the public's preferences. Competitive elections force politicians to address constituent demands. Political survival requires that politicians perform well. E.g., Fox (1994) argues that competition breaks down clientelist bonds, leading to more social spending as candidates and officials come under greater scrutiny. Wittman (1989) shows that political competition pushes governments toward efficient outcomes by lowering the opportunism of politicians. Becker (1983) finds that even in the presence of pressure groups, competition should cause governments to correct market failures.

However, this electoral democratic thesis has received mixed empirical support, particularly regarding developing countries. For Mexico, studies conducted at the state level

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[6] Selectorate theory posits that as the size of the winning coalition increases, a ruler will rely more on public goods because the relative price of doing so falls compared to buying support with private goods.

often find a positive connection between electoral competition and public goods provision (Hecock 2006). Studies conducted at the municipal level, however, often reveal null result. E.g., Cleary (2007) finds no connection between electoral competition and sewer and water coverage. Moreno-Jaimes (2007) is unable to find a discernable relationship between electoral competition and basic service provision. Euler (2014) shows that competition has no positive relationship with the provision of public services. The only exception that we know of is Hiskey (2003), which shows that municipalities that lack political competition are associated with lower public services provision.

Subnational level studies based on non-Mexican cases also show mixed empirical results. In Arvate (2013), electoral competition increases student enrollment, the number of teachers, and free immunizations in Brazil. Pereira and Melo (2009), on the other hand, find that the influence of electoral competition on social spending depends on the degree of checks and balances within Brazilian states, while Cavalcante (2013) simply finds no such effect. Sánchez Torres and Pachón (2013) find competition increases public goods in Colombian municipalities. Galasso and Nannicili (2011) and Paola and Scoppa (2010) show that political competition results in the election of better prepared officials in Italy. Ashworth et al. (2014) associate electoral competition with positive municipal policy outcomes in Flanders. However, Chhibber and Nooruddin (2004) show that in India, greater competition is not necessarily beneficial.

The Often-Overlooked Party System Fragmentation: We argue that one reason for such mixed empirical findings is that most studies focus on the competition and accountability mechanism, while overlooking another important characteristic of the party system – fragmentation. The intuition here is that when the number of parties is too low – the extreme case

would be a one-party dominance system such as Mexico under the PRI – there is not enough competition to incentivize service provision by the incumbent. Fagen and Tuohy (1972) provides one illustrative example, that of Jalapa, Veracruz: in the PRI era, the mayor candidates often were chosen by the governors; municipal governments were highly influenced by state-level and even national-level leaders. Since the mayor was accountable to his/her superiors (but not to the people), the channels through which people could articulate their grievances were severely limited. This centralized policymaking model fits into one extreme case in our theory, i.e., when the effective number of political parties is at its lowest level – a one-party rule in which there is little incentive for the incumbent to respond to popular demands.

However, with an increasing number of parties in electoral competition, even the previously dominant political party would have a stronger incentive to deliver public goods. Since Fagen and Tuohy's study, many events happened in Mexican politics such as the decentralization process since 1983 and PRI's failure in the national election at the turn of the century. In many ways, the centralized decision making model has been transformed by decentralization and electrol competition (Grindle 2007). For instance, based on our election data, the percentage of municipalities governed by a PRI single-party rule has decreased from about 65.6% in 1999, 44.8% in 2004, 25.5% in 2009, and to 6.3% in 2014. The winning parties started to face real pressures from opponents. If a party seeks re-election, or a mayor aspires to advance his/her political career, they need to respond to local demands for public goods like roads, education, health care, and environment protection.

Nevertheless, as the number of parties gets bigger, the effect of party system fragmentation, which often reduces public goods provision, gradually comes into play (Banerjee and Hankla 2014). There are two mechanisms by which party system fragmentation undermines public

goods provision: one concerns the issue with credit sharing and the other the number of veto players.

First, a larger effective number of parties often means more players in the governmental policy making process. This creates a typical collective action problem among parties involved. On the one hand, each party shares the credit for public goods provision regardless who contributed (more) to the provision; their share of the reward, that is, the votes in future elections, can only be partially internalized with a diminishing margin. Hence, for each party, a better strategy is to free ride in advocating and providing public goods while at the same time, direct more resources to its key constituencies (often via private goods) for more secure rewards (Milesi-Ferretti, Perotti, and Rostagno 2002). This very nature of credit-sharing lowers the incentive for political parties to provide public goods.[7]

The second mechanism by which fragmentation hurts public goods provision is closely connected to the veto player framework. A more fragmented party system often represents more veto players and/or a higher level of heterogeneity in policy preferences. When it comes to policy making and implementation, this heterogeneity often produces more veto points and makes it more difficult for different parties to reach an agreement regarding, for instance, what public goods to provide, whom to provide with, and how to provide (Alt and Lowry 2000).

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[7] There might also be an issue of blame-sharing. When public goods provision is poor, an uninformed voter often cannot identify the exact culprit. This voter is more likely to blame every party (Volkerink and De Haan 2001). The larger the number of political actors, the more difficult it is for voters to assign responsibility. However, we do not have enough qualitative evidence to support this mechanism in Mexican local elections. Future research is needed to verify this.

Hence, the efficiency and effectiveness of public policy are often undermined as the system becomes over-fragmented.

In Mexican municipal politics, since decentralization and the end of the PRI rule, the winning party often has to work with opposition parties and a more pluralist municipal council. The muncipal government (*ayuntamiento*) is composed of an elected mayor, elected councilors (*regidores* and *sindicos*),[8] and the appointed department heads. The *regidores* and *sindicos* are collectively reponsible for rule-making and overseeing the government. In addition, the *sindicos* act as the legal representatives and monitor budgets and expenditures. When it comes to decision-making or approval of regulations, the mayor, councilors, and department heads compose a council (*cabildo*). If there are many parties on the councils, the mayor's party may have to negotiate and trade support with its alliances and opponents. When mayors and some councilors disagree, gridlocks occur. The strength to stall largerly depends on the makeup of the councils. In some cases, the council meetings will be long without reaching an agreement. Sometimes the higher-level government (not necessarliy dominated by the mayor's party) will have to intervene.[9] More effective parties on the municipal councils will bring more veto players and veto points. Just as Grindle (2007: 78) summarized, "More competitive elections often left behind divided councils, partisan bickering over the allocation of municipal resources, and administrators frustrated by gridlocked decision making."

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[8] The number of councilors largely depends on municipal population and resources. In Grindle's study of 30 middle-size municipalities, the number varied from six to twenty-two, with an average of twelve.

[9] Mayors sometimes are forced to resign by the council or angry citizens.

In sum, for a less fragmented party system, an increase in the effective number of parties fosters public goods provision because it increases accountability by electoral competition. When the number of effective parties gets bigger, the effects associated with fragmentation become more salient. In Mexican municipalities, we expect a U-shaped relationship between the effective number of parties and air pollution: a system with too few parties lacks competitive pressure while a system with too many parties suffers from fragmentation; neither is good for environmental public goods. We are not the first to suggest a non-linear relationship between the effective number of parties and public goods provision. Lizzeri and Persico (2005) show formally that as the number of political parties increases, electoral incentives push parties towards private goods provision. Using data from Indian state elections, Banerjee and Hankla (2014) show an inverted-U shaped relationship between the effective number of parties and public goods provision in education spending, road construction, and local revenue accumulation.

What Can Mexican Municipalities Do About Air Pollution?

The Mexican federal system consists of three independent tiers of government: federal, state, and municipal.[10] All three have responsibilities related to environmental protection. Recently efforts to decentralize environmental regulation has brought municipal governments to a higher degree of political prominence. Municipal governments have an active and decisive role in combating air pollution by working both alone and in tandem with other municipal governments or state governments to control and monitor the sources of air pollution.

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[10] There are over 2,400 municipalities.

Municipal governments' day-to-day routine tasks have an important impact on local air pollution. These include permitting, monitoring emissions, zoning, maintaining parks and green spaces, urban planning, and the implementation of a public transportation system. Regarding permitting, local governments can prevent potential sources of local air pollution. Power plants contribute 2.89% of the total emissions of PM10 and 6.51% of the PM2.5 in Mexico. Gutierrez (2015) finds that a small-scale power plant increases local air particulate matter concentrations by 1.8 to 2.1%. Municipal governments can prevent such heavy-polluting small-scale power plants. Regarding the usefulness of urban parks in reducing air pollution, Baumgardner et al. (2012) focus on Mexico City and find that total annual air quality improvement by the park's vegetation was approximately 1% for O3 and 2% for PM10. Even decisions about how a municipality handles solid waste can have a strong effect on air pollution: garbage burning is an important source of PM2.5, contributing 3–30% PM2.5 mass on average in Mexico City (Li et al. 2012).

Municipal governments can also play an active hand in minimize air pollution when it comes to the monitoring and regulation of vehicle emissions. Many municipalities have taken it upon themselves to minimize the effects of pollution from vehicles. E.g., the municipal government of Ecatepec in the state of México began to assess the presence and make-up of local air pollution and to invest in environmental monitoring stations (Fernandez Román 2009). The mayor of Mexicalí, in December of 2016, began a process of expanding monitoring stations to ensure that air quality in the entire municipality can be monitored (Molina 2016). In Ciudad Juarez, air pollution in the late 1990's led municipal governments to begin a vehicle emissions testing program to remove inefficient vehicles from the streets (National Institute of Ecology 1998).

Finally, Ciudad Juarez and other municipalities also worked to reduce emission from brick kilns (Blackman and Barrister 1998). Many cities have also begun to regulate the operation of businesses and building practices to ensure that new homes are built with more efficient insulation to help minimize emissions from heating and cooling (National Institute of Ecology 1998).[11]

Data

PM2.5: Our dependent variable is the municipal annual average concentration levels of particulate matter of 2.5 micrometers or smaller, measured in micrograms per cubic meter (logged). We use satellite-derived PM2.5 data (Boys et al. 2014),[12] which is provided in grid-cells with 0.1×0.1 decimal degree resolution, about 11km by 11km. We re-sampled the grid data so that each grid is evenly divided into 100 smaller grids. We overlaid the resampled PM2.5 grids over the polygons representing Mexico's municipalities, taking the average concentration levels of all grids falling within a municipal polygon. The resulting average PM2.5 level at the municipal level is our dependent variable.

The choice of PM2.5 rather than other local air pollutants is a function of data availability: we need detailed municipal level measures of air pollution; PM2.5 satellite data is only publicly available annual average data as far as we know. PM2.5 concentration is a particularly important

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[11] These studies are often based on case studies of a few municipalities; we should be cautious when it comes to generalization to other municipalities.

[12] The data captures annual average PM2.5 concentration; it is not based on observations sampled by season or other factors.

measure of air pollution. Exposure to fine particles is associated with premature death as well as increased morbidity from respiratory and cardiovascular disease.

Figure 1 shows the municipal annual average PM2.5 concentration levels in Mexico for 1999, 2004, 2009, and 2014. Over the years, Mexico has managed to lower PM2.5 pollution. However, we still see significant within-country variation. In 1999 air pollution affected a large swath of the eastern and west central parts of the country, concentrating around large urban areas. Some of the most polluted municipalities include those surrounding the Mexico City, Ciudad Juárez, the largest city in north central Mexico near the US border, and municipalities surrounding Saltillo in the northeast. By 2014, this distribution of air pollution has shifted significantly. Levels of air pollution in the northeast have decreased, while pollution has become more concentrated in southern and south-central parts of the country.

[Figure 1 here]

Measuring the Effective Number of Parties: In Mexico, municipal governments are run by a popularly elected municipal council. Members of this council are elected for three year terms via open list proportional representation. Mayors are not independently elected, instead are chosen from the party that won the most votes in the last election. Mayors have not hisotrically been able to seek reelection.[13]

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[13] A recent constitutional amendment has changed this rule to allow for two consecutive terms in office. However, this was not in effect for the elections studied in this paper.

In municipal elections, the *effective number of parties* counts the number of parties that participated in the election and, at the same time, weights that number by the relative electoral strength of each party. When two parties equally split the vote 50%-50%, there are two parties, but if one party receives 70% of the votes and another 30%, the relative weakness of the second party causes the *effective number of parties* to fall to 1.43 based on the new index proposed by Golosov (2010). This paper measures the effective number of parties using the index proposed by Golosov (2010): $N_i = \sum_i^x 1/(1 + (s_1^2/s_i) - s_i)$, where s_i is the vote share of party *i* in the latest previous election and s_1 is the largest vote share.[14] This effective number of party variable is time lagged by at least one year: for example, for the 2014 panel, election results from the nearest election before 2014 were used.

Control Variables: We include a variable meassuring the *margin of victory* between the first and second place party (coalition). This variable is also time lagged in the same way as the effective number of parties variable. The margin of victory often provides an intuitive indicator of electoral competition. However, highly competitive elections may also cause incumbents to secure political support through clientelistic networks (Magaloni, Diaz-Cayeros, and Estevez 2007). Even in the face of narrow margins of victory, when a juristiction elects multiple representatives, the total number of votes needed for victory may diminish even though the voting margins remain the same. This may encourage politicians to cater to the interests of

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[14] Election data are from official municipal election results, most downloaded from the Centro de Investigación para el Desarrollo Electoral data base: http://cidac.org/base-de-datos-electoral/. When necessary, election results were supplemented by data from state election commissions.

specific constituents (Lizzeri and Persico 2005). Moreover, in the case of city council elections, where multiple council members are elected from a single constitunecy, it can easily mispecify the degree of competition. Imagine two municipalities. The first has two parties splitting the vote 55% - 45% (margin of victory is 10%). In the second, three parties split the vote 41% - 30% - 29% (margin of victory is 11%). In the latter, the *margin of victory* is higher, but there is clearly more competition with three parties.

Several other factors might influence environemntal public goods. First, voters in richer communities (*GDP per capita*) might tend to be more preoccupied with the provision of clean air. Similarly, it is likely that the amount of financial resources available to local governments plays an important role in the provision of clean air, which requires personel and infrastructure to monitor and regulate and fiscal resources to implement.[15] As such, we control for *Municipal Resources*, measured by net municipal revenue per capita.

Our models include several measures of economic activities. The level of economic activity is measured by municipal GDP per km^2 (*GDP Density*).[16] Since municipalities vary by size and our measure of air pollution is a density over area size measure, we need to control economic activity in reference to the surface area. Mexico's evironmental law reserves the regulation of numerous industries for federal authorities and, while municipal authorities are charged with monitoring all industries, they have little control over the operation and regulation of the

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[15] Boulding and Brown (2014) show that resources allow incumbents to increase voter mobilization through the provision of public goods.

[16] Economic data are taken from the 1999, 2004, 2009, and 2014 Economic Census, available at http://www.inegi.org.mx/est/contenidos/proyectos/ce/.

following industries: chemicals and paints, petroleum and petrochemicals, cellulose and paper, metals, glass, cement and asbestos, and energy production. We include the variable *Density of Federally Regulated Production*, which measures the average value of production of these industries per km^2.

The physical character of municipalities influences air quality.[17] Although we often associate rural communities with cleaner air, for any given level of economic activity, urban centers are often more efficient. We control for the percent of municipal surface area covered by urban structures.[18] Larger municipalities can benefit from economies of scale when providing public goods (Dagney and Hicks 2011). Larger populations also decrease the utility of clientelistic networks (Wang and Kurzman 2007) and has been shown to shift municipalities towards meritocratic bureaucracies (Ruhil 2003). On the other hand, there is little empirical support for economies of scale in the provision of public goods for all but the smallest municipalities (Dollery and Fleming 2006; Holzer 2009). Summary statistics are in Table 1.

[Table 1 here]

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[17] Physical character variables (e.g., elevation) affect local air pollution. But they are time-invariant variables. Because of municipal fixed effects, we cannot include them in the analysis.

[18] Data from the "Descarga Masiva" page of the Instituto Nacional de Estadística y Geografía de Méxicoavaiable: http://www3.inegi.org.mx/sistemas/descarga.

Empirical Findings

Our main analysis adopts municipal-fixed and year-fixed effects with standard errors clustered at the municipal level.[19] To take into account the influence of air pollution in neighboring municipalities, the average PM2.5 density of adjacent municipalities during the previous year is included as a spatial lag of the dependent variable.[20] Our panel data includes four time periods – 1999, 2004, 2009, and 2014 – because municipal level industrial and economic data are only available for these years. The five year period between the time periods guarantees at least one municipal election in between. For each year, we construct the effective number of parties and the margin of victory measures using the latest previous election outcome data. This makes sense because efforts by politicians to decrease air pollution may require a significant amount of time to take effect. The Federal District is not included because given that it is the country's capital, it would be impossible to separate the influence of local politics from pressures generated by members of the national government or issues of national prestige.

The size of municipalities varies greatly in Mexico – ranging from a few hundred people to 1,688,258 in population size in our sample. This raises the question of whether small municipalities have the means to have any meaningful impact on the environment. There is no theoretical information on what is a "good" population threshold here. Therefore, we

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[19] Because of fixed municipality effects, we only use the temporal, within-municipality change in effective number of parties to explain temporal, within-municipality change in PM2.5. However, our theory is not limited to comparing past with current administration: the comparison could be also between municipalities.

[20] To mitigate the simultaneity bias, the spatial lag is lagged by one year.

experimented with different thresholds, from all municipalities with available data, 1,000 people and above, 10,000 and above, all the way to 40,000 and above. Intuitively, larger municipalities have more resources to affect air quality, therefore we would have a better chance to detect any relationship between our variables and air pollution. The tradeoff, however, is that sample size decreases quickly as we increase the population threshold. This is important because we use municipal-fixed effects which use a lot of degrees of freedom.

Howevert, our main empirical result is robust to different thresholds and sample sizes. Indeed, in the first model specification in Table 3, we do not use any population threshold and include all municipalities with available data: here, we receive strong empirical support regarding the U-shaped relationship between the effective number of parties and PM2.5 pollution. In other words, we do not need to rely on population thresholds to obtain our main empirical result.

In the following, we pick an arbitrary population threshold – the third quartile of the municipal population size variable, 36,466 – and present and discuss results using this particular sample in Table 2. Table 3 also presents results when we do not use a threshold and when we use other thresholds: the main result concerning the relationship between the effective number of parties and air pollution always holds.

[Table 2 here]

[Table 3 here]

Table 2 presents four model specifications. The first model specification only includes *Effective Number of Parties* and *Effective Number of Parties^2*; no control variable is included. The second model specification adds in the spatial lag variable. The third model specification

adds other socio-economic control variables and the last model specification the margin of victory (%) variable. Across all model specifications, we find statistically significant associations between *Effective Number of Parties* variables and PM2.5 pollution levels. The signs associated with *Effective Number of Parties* and *Effective Number of Parties*^{2} indicate a U-shaped relationship: air pollution goes down with the value in the effective number of parties before the latter reaches around 3.3 (based on the last model specification); after this point, air pollution goes up with the value of the effective number of party variable. This U-shaped relationship confirms our theoretical expectation that more parties in local electoral competition increases environmental public goods, but only to a certain point after which the system becomes too fragmented so that public goods provision starts to decrease.

Interestingly, other than the urban area ratio variable, none of the control variables is statistically significant. Urban area is associated with higher level of pollution. This makes sense because we often associate urban areas with higher industrialization and higher energy consumption; they are also often transportation hubs. The reason why few control variables emerge as statistically significant might be because of the fixed municipality effects and the spatial lag variable. Fixed municipality effects reduce selection bias, but also eliminate large portions of variation in both the dependent and independent variables. This is especially the case for our analysis because of a short panel of only 4 years. The spatial lag variable is highly significant and takes away a lot of variation in the dependent variable.[21]

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[21] Also, few socioeconomic control variables indeed consistently emerge as statistically significant from recent within-country studies of PM2.5 (Li et al. 2016; Jiang et al. 2018; Yang et al. 2018).

Table 2 also suggests that *Margin of Victory* lacks a statistically significance. This is not surprising given that incumbents may win election with a wide margin by providing public goods, while closer margins of victory may induce politicians to shore-up support through targeted spending (Larreguy, Marshall, and Trucco 2015). Another reason might relate to the way this variable is operationalized: in situations where there are more than two parties in the play, *Margin of Victory* only captures vote difference between the top two parties even though the third and even fourth party might also capture significant amount of votes.

We conduct more robustness checks. One has to do with potential environmental impacts of a PRI rule. Mexican political system underwent a significant transition in 2000 during which the PRI lost the control of the central government. Did the regime change have any impact on air pollution? Did municipalities that are still under the PRI dominance perform differently? Even though we did not model national political transition as a variable, our regression analysis controls for its effect by including year fixed effects. Moreover, we code two more variables: *PRI* is a dummy variable indicating whether the municipal mayor elected is from the PRI – this is a PRI dominant town; a second dummy variable *PRI in Coalition* is a dummy variable indicating either the major is from the PRI or from a party coalition that includes the PRI – this is a municipality in which at least the PRI is in the governing coalition. We ran our analysis after adding these two variables. We find that neither has a statistically significant effect on PM2.5. At the same time, our main results regarding the effective number of party variables do not change. Detailed tests are presented in the online appendix, section A.

Finally, our regression includes two variables and their square terms: *Effective Number of Parties/Effective Number of Parties^2* and *GDP per capita/GDP per capita^2*; naturally, there is a high correlation between a variable and its square term. In case of a high correlation caused by

this, one simple solution is to "center" (or de-mean) this variable: subtract the mean of the variable from the original variable, take the square of this de-meaned variable, and then regress the dependent variable on the demeaned variables. Table 2 of the online appendix presents results from a regression using the de-meaned versions of these variables: our main result holds.[22]

Conclusion and Discussion

This paper studies how electoral politics influences the air quality of local jurisdictions. Instead of assuming a linear association between electoral competition and environmental public goods provision, we argue that there is a U-shaped relationship between the effective number of parties in municipal elections and local air pollution. Our empirical analysis of a Mexican municipal panel confirms our theoretical expectation.

Interestingly, we find that the variable commonly used in past studies, *Margin of Victory*, lacks a statistically significant association with PM2.5 levels. The result is consistent with past studies that find no association between political competition, measured as victory margin, and the provision of public services by Mexican municipalities. This has often been interpreted as evidence that electoral competition does not induce politicians to provide public goods. The non-linear relationship between the effective number of parties and air pollution revealed by this study, however, suggests that past studies might benefit from using additional measures of electoral competition.

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[22] For other variables, we calculate the variance inflation factor, which measure the inflation in the variances of the parameter estimates due to collinearities. Table 3 of the online appendix shows no sign of collinearity.

One important difference of our study is that we focus on a pure(r) public good while the focus of past studies, social programs and infrastructure projects, can suffer from crowding effects, rivalry, and excludability. Given the possibility that the relationship between electoral competition, party system fragmentation, and public goods provision might vary between types of public goods as a function of factors such as issue visibility and complexity, future research should test the effect of the effective number of parties on other types of public services.

Moreover, regarding the estimated turning point in the U-shaped relationship, most model specifications suggest that air pollution goes down with the effective number of parties before the latter reaches slightly higher than 3; after this point, more parties are associated with higher air pollution. It seems that having a third "effective" party creates the best scenario for environmental public goods provision. However, we do not have a theory as why this "slightly more than three-party" scenario is the sweet spot in the U-shaped relationship. Future research should look into the dynamics of local party competition as this might provide useful information that helps us to find answers to this question.

Finally, at the local level, other than our focus of electoral politics, one can think of many other relevant variables and explanations. For instance, enforcement of environmental regulations matters greatly for local environmental quality. Yet in many countries, factors such as low state capacity and poor infrastructure (Ryan 2014), lack of incentive for local officials to seriously enforce (McRae 2015), and corruption (Oliva 2015) weaken enforcement and reduce environmental quality. We controlled for some of these factors such as local state capacity (using municipal resources per capita), but more future empirical studies should investigate their effects at the local level.

References:

Alt, James, and Robert Lowry. 2000. "A dynamic model of state budget outcomes under divided partisan government." Journal of Politics 62(4): 1035-1069.

Arvate, Paulo Roberto. 2013. "Electoral Competition and Local Government Responsiveness in Brazil." World Development 43:67-83.

Ashworth, John, Benny Geys, Bruno Heyndels, and Fanny Wille. 2014. "Competition in the political arena and local government performance." Applied Economics 46 (19):2264-76.

Assetto, Valerie, Eva Hajba, and Stephen Mumme. 2003. "Democratization, Decentralization, and local environmental policy capacity: Hungary and Mexico." The Social Science Journal 40: 249-268.

Austen-Smith, David, and Jeffrey Banks. 1989. "Electoral Accountability and Incumbency." Models of strategic choice in politics 121:122.

Baumgardner, Darrel, Sebastian Varelab, Francisco Escobedo, Alicia Chacalo, and Carlos Ochoa. 2012. The role of a peri-urban forest on air quality improvement in the Mexico City megalopolis. Environmental Pollution 163: 174-183.

Bernauer, Thomas and Vally Koubi. 2009. Effects of Political Institutions on Air Quality. Ecological Economics 68(4): 1355-1365.

Banerjee, Sayan and Charles Hankla. 2014. "Party Systems and Public Goods: The Dynamics of Good Governance in the Indian States." Working paper.

Becker, Gary. 1983. "A Theory of Competition Among Pressure Groups for Political Influence." The Quarterly Journal of Economics 98 (3):371-400.

Binder, Seth and Eric Neumayer. 2005. Environmental Pressure Group Strength and Air Pollution: An Empirical Analysis. Ecological Economics 55(4) 527– 538.

Blackman, Allen, and Geoffrey Bannister. 1998. "Pollution Control in the Informal Sector: The

    Ciudad Juárez Brickmakers' Project." Working paper:

    https://media.rff.org/documents/RFF-DP-98-15.pdf.

Boulding, Carew and David Brown. 2014. "Political Competition and Local Social Spending:

    Evidence from Brazil." Studies in Comparative International Development 49(2): 197-216.

Boys, B.L., Martin, R.V., van Donkelaar, A., MacDonell, R., Hsu, N.C., Cooper, M.J.,

    Yantosca,R.M., Lu, Z., Streets,D.G., Zhang,Q., Wang,S. 2014. "Fifteen-year global time

    series of satellite-derived fine particulate matter". *Environmental Science & Technology*

    48(19): 11109-11118.

Bueno de Mesquita Bruce, Alastair Smith, Randolph Siverson, and James Morrow. 2003. The

    Logic of Political Survival. Cambridge: MIT Press.

Cao, X., G. Kostka, X. Xu. 2019. Environmental political business cycles: The case of PM2. 5

    air pollution in Chinese prefectures. Environmental Science & Policy 93: 92-100.

Cavalcante, Pedro. 2013. "A competiçãoeleitoralgeragovernosmais eficientes?Umestudo

    comparado das prefeituras no Brasil." Revista de Administraçao Pública 47 (6):1569-91.

Chhibber, Pradeep, and Irfan Nooruddin. 2004. "Do Party Systems Count?: The Number of

    Parties and Government Performance in the Indian States." Comparative Political Studies

    37 (2):152-87.

Cleary, Matthew. 2007. "Electoral Competition, Participation, and Government Responsiveness

    in Mexico." American Journal of Political Science 51(2): 1540-5907.

Dagney, Faulk, and Michael Hicks. 2011. Local Government Consolidation in the United States.

    New York: Cambria Press.

Dollery, Brian and Euan Fleming. 2006. "A Conceptual Note on Scale Economies, Size Economies and Scope Economies in Australian Local Government." Urban Policy and Research 24(2): 271-282.

Euler, Rogelio Alexander Ruiz. 2014. Electoral Competition, Income Inequality and Public Goods: A Sub-national Assessment, dissertation: https://escholarship.org/content/qt1tf252z5/qt1tf252z5.pdf.

Fagen, Richard, and William Tuohy. Politics and privilege in a Mexican city. Vol. 5. Stanford University Press, 1972.

Fernández Román, Emilio. 2009. "Transporte, principal causa de polución en Ecatepec." Working paper: http://archivo.eluniversal.com.mx/notas/618573.html.

Fox, Jonathan. 1994. "The Difficult Transition from Clientelism to Citizenship: Lessons from Mexico." World Politics 46(2): 1086-3338.

Fredriksson, Per and Daniel Millimet. 2004. "Comparative politics and environmental taxation." Journal of Environmental Economics and Management 48: 705–722.

Galasso, Vicenzo, and Tommaso Nannicili. 2011. "Competing on Good Politicians." American Political Science Review 105 (01):79-99.

Grafton, Quentin and Stephen Knowles. 2004. Social Capital and National Environmental Performance: A Cross Sectional Analysis. Journal of Environment and Development 13(4), 336-370.

Grindle, Merilee 2007. Going local: decentralization, democratization, and the promise of good governance. Princeton University Press.

Gutierrez, Emilio. 2015. Air quality and infant mortality in Mexico: evidence from variation in pollution concentrations caused by the usage of small-scale power plants. Journal of Population Economics 28(4): 1181-1207.

Golosov, Grigorii. 2010. "The Effective Number of Parties: A New Approach." Party Politics 16(2): 171–92.

Hiskey, Jonathan. 2003. "Demand-Based Development and Local Electoral Environments in Mexico." Comparative Politics 36(1): 41-59.

Hecock, Douglas. 2006. Electoral competition, globalization, and subnational education spending in Mexico, 1999-2004. American Journal of Political Science 50(4):950-961.

Holzer, Mark. 2009. Literature Review and Analysis Related to Optimal Municipal Size and Efficiency. Newark: Rutgers, School of Public Affairs and Administration.

Jiang, P., J. Yang, C. Huang, H. Liu. 2018. The contribution of socioeconomic factors to pm2.5 pollution in urban China. Environmental Pollution 233: 977-985.

Larreguy, Horacio, John Marshall, and Laura Trucco. 2015. "Breaking Clientelism or Rewarding Incumbents? Evidence from an urban titling program in Mexico." Working paper.

Li, G., C. Fang, S. Wang, S. Sun. 2016. The effect of economic growth, urbanization, and industrialization on fine particulate matter (PM2.5) concentrations in China. Environmental Science and Technology 50(21): 11452-11459.

Li, G., Lei, W., Bei, N., and Molina, L. T.: Contribution of garbage burning to chloride and PM2.5 in Mexico City, Atmos. Chem. Phys. 12: 8751–8761.

Lizzeri, Alessandro, and Nicola Persico. 2005. "A Drawback of Electoral Competition." Journal of the European Economic Association 3 (6):1318-48.

Magaloni, Beatriz, Alberto Diaz-Cayeros, and Federico Estevez. 2007. "Clientelism and

>   Portfolio Diversification: A model of electoral investment with appliactions to Mexico."

>   In *Patrons, Clients, and Policies: Patterns of democratic accountability*, ed. H. Kitschelt

>   and S. Wilkinson. Cambridge: Cambridge University Press.

McRae, Shaun. 2015. "Infrastructure Quality and the Subsidy Trap." American Economic

>   Review 105(1): 35–66.

Milesi-Ferretti, Gian Maria, Roberto Perotti, and Massimo Rostagno. 2002. "Electoral systems

>   and public spending." The Quarterly Journal of Economics 117(2): 609-657.

Molina, Óscar. 2016. "Buscará Municipio otra estación de monitoreo de calidad de aire,"

>   http://www.lacronica.com/EdicionEnlinea/Notas/Noticias/06122016/1157086-Buscara-

>   Municipio-otra-estacion-de-monitoreo-de-calidad-de-aire.html, accessed February 6, 2017.

Monogan, James, David Konisky, and Neal Woods. 2017. "Gone with the Wind: Federalism and

>   the strategic location of air polluters." *American Journal of Political Science* 61(2): 257-

>   270.

Moreno-Jaimes, Carlos. 2007. "Do Competitive Elections Produce Better-Quality Governments?

>   Evidence from Mexican municipalities, 1990–2000." Latin American Research Review

>   42(2):136-53.

National Institute of Ecology. Government of the state of Chihuahua. Government of the City of

>   Juárez. 1998. Programa de gestión de la calidad del aire de ciudad Juárez 1998-2002

>   http://www2.inecc.gob.mx/publicaciones/consultaPublicacion.html?id_pub=233, accessed

>   May, 2016.

Oliva, Paulina. 2015. "Environmental Regulations and Corruption: Automobile Emissions in

>   Mexico City." Journal of Political Economy 123(3): 686-724.

Paola, Maria, and Vincenzo Scoppa. 2010. "Political competition and politician quality: evidence from Italian municipalities." Public Choice 148(3):547-59.

Pereira, Carlos, and Marcus André Melo. 2009. "Las elecciones que hacen los gobernadores: Los roles de los 'checks and balances' y la competencia política." Studia Politicæ 17: 93-129.

Rodríguez-Sánchez, José Iván. 2014. "Do Mexicans care about air pollution?" Latin American Economic Review 23(1): 1-24.

Ruhil, Anirudh. 2003. "Urban Armageddon or Politics as Usual? The Case of Municipal Civil Service Reform." *American Journal of Political Science* 47(1):159-70.

Ryan, Nicholas. 2014. The Competitive Effects of Transmission Infrastructure in the Indian Electricity Market. Working paper.

Sánchez Torres, Fabio, and Mónica Pachón. 2013. "Decentralization, Fiscal Effort and Social Progress in Colombia at the Municipal Level, 1994-2009: Why Does National Politics Matter?" Inter-American Development Bank.

Volkerink, Bjørn, and Jakob De Haan. 2001. "Fragmented government effects on fiscal policy: New evidence." Public choice 109(3/4): 221-242.

Wang, Chin-Shou and Charles Kurzman. 2007. Dilemmas of Electoral Clientelism: Taiwan, 1993. *International Political Science Review 28*(2): 225–245.

Wittman, Donald. 1989. "Why Democracies Produce Efficient Results." Journal of Political Economy 97 (6):1395-424.

Yang, Y., J. Liu, Y. Lin, Q. Li. 2018. The impact of urbanization on China's residential energy consumption. Structural Change Economic Dynamics 9: 170-182.

Table 1: Descriptive Statistics.

	Mean	St. Dev.	Min	Max
PM2.5	10.40	4.57	1.45	42.05
Spatial Lagt-1	10.68	4.55	1.77	44.97
Margin of Victory (%)	16.33	16.93	0.007	100
Effective Number of Parties	2.39	0.77	1.00	6.73
Density of Economic Activity	16,291	113,106	0.06	3,072,234
GDP per capita	33.02	205.82	0.01	8,922
Municipal Resources per capita	2.62	2.26	0.03	36.54
Population	47,447	126,370	242	1,688,258
Urban Area Ratio	0.04	0.12	0.00	1.00
Density of Fed. Regulated Industries	154	1,486	0.00	68,513

Note: PM2.5 and Spatial Lag$_{t-1}$ are in micrograms/cubic meter; density of economic activity and density of fed. regulated industries are in 1000 pesos per km^2; GDP per capita and municipal resources per capita 1000 pesos per person.

Table 2: Testing the relationship between the effective numbre of parties and air pollution, using municipalities with population size larger than 36,466.

	Dependent variable: log(PM2.5)			
	(1)	(2)	(3)	(4)
Effective Number of Parties	-0.119^{***}	-0.046^{***}	-0.038^{**}	-0.040^{**}
	(0.043)	(0.015)	(0.016)	(0.016)
Effective Number of Parties^2	0.014^{*}	0.007^{**}	0.006^{**}	0.006^{**}
	(0.008)	(0.003)	(0.003)	(0.003)
Margin of Victory (%)				-0.0003
				(0.0002)
Density of Economic Activity (log)			0.872	0.908
			(2.595)	(2.645)
GDP per capita (log)			-0.880	-0.917
			(2.594)	(2.644)
GDP per capita (log)^2			-0.001	-0.001
			(0.002)	(0.002)
Municipal Resources per capita (log)			0.023	0.023
			(0.015)	(0.015)
Population (log)			-0.885	-0.921
			(2.598)	(2.648)
Urban Area Ratio			0.155^{*}	0.154^{*}
			(0.091)	(0.090)
Density of Fed. Regulated Industries (log)			0.001	0.001
			(0.003)	(0.003)
Spatial Lag$_{t-1}$		0.853^{***}	0.842^{***}	0.840^{***}
		(0.032)	(0.033)	(0.033)
Fixed municipal effects	√	√	√	√
Fixed year effects	√	√	√	√
Clustered s.e. (municipal)	√	√	√	√
N. of municipality	523	523	523	523
Observations	1,838	1,838	1,838	1,838
Adjusted R^2	0.814	0.951	0.952	0.952

Note: years covered by the analysis are 1999, 2004, 2009, and 2014; *p<0.1; **p<0.05; ***p<0.01.

Table 3: Testing the relationship between the effective numbre of parties and air pollution, using various municipal population thresholds.

	Dependent variable: log(PM2.5)					
	(1)	(2)	(3)	(4)	(5)	(6)
Effective Number of Parties	-0.027^{***}	-0.027^{***}	-0.028^{**}	-0.036^{***}	-0.039^{***}	-0.041^{**}
	(0.010)	(0.010)	(0.011)	(0.012)	(0.015)	(0.017)
Effective Number of Parties^2	0.003^{*}	0.003^{*}	0.004^{*}	0.005^{**}	0.006^{**}	0.006^{*}
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Density of Economic Activity (log)	0.098	0.101	-0.080	-0.354	0.172	1.926
	(0.166)	(0.167)	(0.194)	(0.674)	(0.941)	(3.291)
GDP per capita (log)	-0.095	-0.097	0.078	0.343	-0.179	-1.939
	(0.166)	(0.167)	(0.194)	(0.675)	(0.945)	(3.292)
GDP per capita (log)^2	-0.001	-0.001	0.0003	0.0001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Municipal Resources per capita (log)	0.003	0.003	0.012	0.014	0.016	0.020
	(0.006)	(0.006)	(0.007)	(0.010)	(0.013)	(0.017)
Population (log)	-0.098	-0.102	0.074	0.349	-0.183	-1.952
	(0.167)	(0.168)	(0.195)	(0.674)	(0.944)	(3.296)
Urban Area Ratio	0.122^{***}	0.121^{***}	0.128^{***}	0.129^{*}	0.157^{*}	0.154
	(0.035)	(0.035)	(0.048)	(0.074)	(0.088)	(0.095)
Density of Fed. Regulated Industries (log)	-0.0003	-0.0005	-0.002	0.0002	0.002	0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
Spatial Lag$_{t-1}$	0.908^{***}	0.908^{***}	0.874^{***}	0.877^{***}	0.848^{***}	0.833^{***}
	(0.016)	(0.016)	(0.020)	(0.025)	(0.030)	(0.035)
Fixed municipal effects	√	√	√	√	√	√
Fixed year effects	√	√	√	√	√	√
Clustered s.e. (municipal)	√	√	√	√	√	√
Population threshold	all with data	>1000	>10000	>20000	>30000	>40000
N. of municipality	2,007	1,990	1,345	879	626	484
Observations	7,347	7,270	4,795	3,086	2,200	1,664
Adjusted R^2	0.957	0.957	0.953	0.956	0.955	0.951

Note: years covered by the analysis are 1999, 2004, 2009, and 2014; *p<0.1; **p<0.05; ***p<0.01.

Figure 1: PM2.5 Levels in Mexican Municipals, 1999, 2004, 2009, and 2014, using 2010 boundaries (Municipios_2010).