STOCKHOLM SCHOOL OF ECONOMICS
Department of Economics
5350 Master's thesis in economics
Academic year 2019–2020

Environmental Justice and Political (Dis)Engagement : A study of France

Camille Habé (41553)

Abstract: A wide range of studies have documented the Environmental Injustice situations - particularly in the United States. In France, where inequalities and the environment have been brought to the light by a growing number of demonstrations, more recent data was needed. I use official socio-demographic data and the Registre des Emissions polluantes (Register of polluting facilities) to study the correlation between pollution and poverty. Using OLS regressions, I find that there is a disproportionate exposure to industrial pollution at the expense of the less well-off in densely populated areas, but that this relationship may be reversed in rural areas. The differentiation appears at a very local level and at the municipal level but cannot be observed from the inter-municipal level. As a second stage, I study abstention as an aggravating factor for Environmental Injustice and find that abstention to the latest presidential election appears to be positively correlated with the presence of polluting facilities too, and a comparatively higher effect than poverty. Using a linear regression with an interaction term, I find that abstention seem to have a higher effect, the higher the poverty rate in the area.

Keywords: environmental justice, social deprivation, abstention, industrial pollution, inequalities

JEL: D63, I32, Q53, Q56

Supervisor: Pamela Campa
Date submitted: 18 May 2020
Date examined: 27 May 2020
Discussant: Filip Mellgren
Examiner: Magnus Johannesson

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1 Introduction

Ever since the crisis of the *gilets jaunes* in France, it has become widely accepted that poverty and environmental degradation are two intrinsically connected issues. Triggered by the proposal of a fuel tax hike, the demonstration was an occasion for a broad layer of the population to express its feeling of rejection; of being forgotten, and of having to unjustly bear the burden of environmental policies. This demonstration generated heated discussions and calls for *social justice* and for a *fair transition*, claiming that transitions that are not progressive would face the risk of being again violently rejected by the population. Yet, there is surprisingly little information on environmental inequalities in France that would help define the scope for a fair transition.

This paper aims to shed some light on one aspect of environmental inequalities in France, by identifying populations more exposed to environmental degradation, focusing on industrial pollution. I build upon the literature of Environmental Justice which documented a heterogeneity of exposure to pollution at the expense of poor populations. This literature "*established this inequitable exposure to nuisance as a stylized fact of social sciences*" in the United States (Banzhaf and al., 2019), with a focus on the political economy around Environmental Justice, questioning whether some communities may have a diminished ability to engage in collective action to oppose the siting of facilities. To engage in this discourse, I answer the two following questions : (1) are economically deprived populations more exposed to polluting facilities in France? and (2) is a low level of political engagement an aggravating factor for Environmental Justice ?

In France, one national study using data from 1999 found a correlation between industrial installations and economic deprivation at the municipal scale (Laurian, 2008a) but more contemporary evidence was needed. I expand this study further by reproducing the analysis at several spatial scales with bigger datasets. I merge data from 10,000 facilities listed in the Registre des Emissions Polluantes (Register of polluting facilities) by the Ministry of Environment and from 7,200 potentially polluted sites from the Registre Basol with financial characteristics of the neighbouring households at a few km^2 level, at the municipality level and the inter-municipality[1] level. Using an OLS model, I observe correlation between proximity to a polluting facility (or polluted site) and economic deprivation. Then, I use abstention during the latest presidential election as a proxy for political disengagement and observe whether abstention is an aggravating factor for Environmental Justice. The reasoning behind this is that population bargain about the presence of facilities and

[1]Inter-municipalities (*Inter-communalités* in French) are legal entities to which several municipalities delegate competences on topic such as water, waste or roads. It is the second smallest administrative level in France after the municipality

that political engagement of the population may decrease their presence. Moreover, political disengagement of a poor population may duplicate the effect of poverty of the siting. This provides more robust and recent evidence for any correlation as well as information about how this correlation evolves geographically. This is, to my knowledge, also the first contribution about the political economy of Environmental Justice in France.

Results suggest that the number of facilities listed as emitting facilities is strongly correlated with poverty in densely populated areas at the gridded data level and the municipal level. At the municipal level, a 5% higher poverty rate is associated with 1 more facility in the area of the municipality. The correlation disappears at the inter-municipality level but I find a strong relationship between the number of facilities and the level of inequality. Interestingly, abstention appears to have an even stronger effect on the number of facilities than poverty and to have an effect that increases when poverty is higher.

Due to the numerous potential confounding factors, this thesis does not aim to provide any causal evidence for differentiated exposure. Yet, even without identifying the causal factors, these results have strong implications for civil society and decision makers. It provides ground for future research on the political economy of Environmental Justice as well as arguments for remedy policies for affected areas.

The article is organised as follows: The first section is the introduction. In the second section, we go through the literature in order to understand which mechanisms and theories have been introduced to explain Environmental Justice and its dynamics. The third section is dedicated to the theoretical framework and hypotheses. We present the data in the fourth section. The empirical strategy and results concerning environmental justice in France are presented in section 5, and we go through the empirical strategy and results for voter turnout and Environmental Justice in section 6. In section 7 we discuss the limitations of this study and we conclude in section 8.

2 Literature review

2.1 Definition

Environmental Justice is a North American concept which arose from the civil right movements in the 60's, when activists started to observe that minorities were usually exposed to more pollution than the rest of the population (for a chronology of the movement, see Cole and Foster,

2000). Initially focused on the siting of waste facilities, the definition of Environmental Injustice evolved to include broader inequalities in exposure to industrial pollution, enforcement of laws and regulations and access to decision making (Bullard, 1996). Confirmed by scholars (see Bezdek, 1995, Banzhaf and al., 2019), Environmental Injustice became an issue recognized by public entities in the United States in 1990 with the establishment of an Environmental Equity Work-group by the EPA. The Environmental Protection Agency has now integrated Environmental Justice concerns within its action and defines Environmental Justice as the need to make sure that "*no group of people [...] bear a disproportionate burden of environmental harms and risks, including those resulting from the negative environmental consequences of industrial, governmental, and commercial operations or programs and policies*".

Environmental Justice never became as salient in Europe as in the United States and studies about Environmental Injustice in the European context are more scarce, but evidence on both sides of the Atlantic converge to the same results: the poor and non-white populations tend to live in areas with less environmental quality (Mitchell, 2019). The scarcity of studies on Environmental Justice could be explained partly by the fact that geographical data about local pollution became available later in Europe (the Toxic Release Inventory started in 1987, while reporting on polluting emissions started only in 2003 in France). However, this could also be the consequence of different understandings of the concept of Environmental Justice. Firstly, Environmental Justice in Europe is less linked to the question of race, which make it a less polemical topic than in the United States. Moreover, in the United States, Environmental Justice concerns arise mainly from an unequal burden of industrial pollution (the so called Locally Undesirable Land Uses), while in Europe Environmental Justice can also include access to green space, right to tranquility or noise. This makes Environmental Justice an issue that has a less clear definition in Europe than in the United States.

The Environmental Justice movement did not just document a situation, it also called for political action in order to reduce this unequal burden. When an unequal exposure is documented, it is not always obvious how to determine whether it represents an injustice and whether it requires a policy response. This would depend on the chosen definition of justice. Justice could be defined as equality of exposure, of risk, situational fairness, the protection of basic needs or even equality of marginal benefit for environmental quality (OECD, 2009). Equality of exposure means that all individuals have the same environmental quality. Equality of risk is different from equality of exposure, since individuals may be affected differently by exposure. As an example, individuals with lung troubles face more risk when exposed to one unit of air pollution than healthy individuals. Equality of risk would require identifying population at risk and reducing their exposure. Situational fairness would mean that environmental quality should remain the same over time, because as people move

into a new area, quality of the surrounding environment is an implicit calculation in their decision and those people should have access to the same standards for as long as they remain there. Protection of basic needs necessitates defining some threshold of environmental quality to which everybody should have access. Equality of marginal benefit for environmental quality considers what individuals may be willing to exchange environmental quality for, and considers that there is some injustice (and need for action from the social planner) if the distribution is not at the equilibrium. But no matter the definition chosen by decision makers, the first step to identify Environmental Injustice areas is to document the differentiated exposure in the first place.

2.2 The consequences of unequal exposure

The argument of many of the activists calling for a response from policy makers is that disproportionate exposure may have important consequences on the health, livelihood or political stability of the populations who experience it.

It appeared particularly worrying once it was also acknowledged that polluting facilities may have an impact on health-marginalised populations which tend to have an lower initial health stock and less ability to invest in defensive goods. Among the potential health effects of living near industrial or hazardous waste sites are perinatal negative outcomes, respiratory and heart diseases, psycho-social stress and mental health impacts (Morello-Frosch and al., 2011). As a consequence, even with equal exposure, combined effects of exposure and socioeconomic factors can be stronger for marginalized populations (Morello-Frosch and al., 2011). Using Hsiang and al.'s model (2019), the damage function of a population can be described as a function of both exposure (which is a physical measure) and a vector of socio-economic attributes (that can also be called vulnerabilities), which translates exposure into welfare changes. Measures of vulnerability include the ability to enact avoidance behaviours (such as staying inside), buy defensive instruments (such as an air conditioner) or the baseline health. In all those cases, poorer populations tend to have higher vulnerabilities. This model illustrates how, if there is an inequitable distribution of pollution damage, minorities may bear a double burden. But it also illustrates how policies, if efficient at tackling those Environmental Injustice, could be twice as progressive.

Among the very vulnerable populations lie the children. Indeed, young children exposed to such some specific stress end up bearing the consequences their whole life. As an example, cardiovascular disease can be liked to childhood negative events or even prenatal stress (Morello-Frosch and al., 2011). Moreover, economists have found that fetal shocks may have impact on several later

outcome such as education attainment or income (Almond and Currie, 2011). In particular, Persica and al. (2016), found that children living within a two miles radius of a Superfund site were more likely to repeat a grade, have lower score or are more likely to be diagnosed with a cognitive disability than their siblings conceived after those sites have been cleaned up. This brings Banzhaf and al. (2019) to consider that Environmental Justice Areas may create or reinforce poverty traps for the population.

There is, to my knowledge, no study about the direct political consequences of Environmental Injustice. However, I hypothesize that Environmental Justice probably increases political instability. The population may (rightly?) feel abandoned by decision makers once they realize they bear a disproportionate burden of exposure to pollution and this could reduce trust in politics and in democracy in general.

2.3 Conceptual framework

2.3.1 A broad overview of the mechanisms

Finding a causal effect for differentiated exposure is out of the scope of this thesis, but it is important to have an overview of the potential mechanisms that could lead to such a situation. In the case of Environmental Justice, there are many theories about why this unequal burden arises, yet very few evidence in favor of either of them. Following the classification of Banzhaf and al. (2019), the mechanisms can be organized into four mains categories : disproportionate siting, coming to the nuisance, coasean bargaining and the political economy.

It is probable that during the decision-period for the siting of a facility, a company will disproportionately tend to choose a location near economically impoverished populations or minorities. If this could be the results of pure discrimination, but other -and more subtle- reasons may be at play. Access to cheap land, proximity to transportation networks or low wage labour would probably also attract facilities in economically deprived areas. Wolverton (2009) found evidence that so-called *input-related factors* play a more important role in the plant's location decision than socio-economic indicators of the neighborhood population. Still, expectation of less opposition and less enforcement in minorities areas may influence their choice as well.

After the siting of a plant, movements of the population may also produce Environmental Justice situations. According to the Tiebout model (1956), minorities may be *coming to the nuisance*, attracted by cheaper land or employment opportunities, while wealthier populations may

be the only ones affording to leave the polluted area. Moreover, once the population has become poorer, there could be a peer sorting mechanism that would attract even more economically deprived population.

The interaction between those two first mechanisms can be described as a situation of Coasian bargaining. The Coase theorem states that negotiation between producers and recipients of an externality always lead to an efficient outcome when property rights are well-defined and transaction costs are very low. In our case, this would mean that facilities offer goods (such as employment opportunities or local investments) in exchange for the right to locate in the area, until it becomes too expensive for the facility to produce more externality. There, it stops. This regulates pollution to a level that is efficient both for the population and for the company. If this mechanism is at play, it means that the disproportionate exposure is efficient, and, according to the previous definitions of justice, the existence of a *injustice issue* may be debatable. In other words, this would mean that a social planner would not need to be concerned by the disproportionate exposure. However, Coasian bargaining rely on important assumptions, that are not always clearly fulfilled. Timmins and Vissing (2014) as an example, find it "*hard to sustain*" the argument in favor of Coasian efficiency when studying lease negotiations for shale gas. Indeed, property rights may not always be clearly defined nor transaction cost may be higher for some population.

This leads to the political economy mechanism. The political economy encompasses the all the channels through which the unequal exposure may be the result of differentiated political power to avoid this exposure. Some population may have extra difficulties to bargain due to language or educational barriers, lack of information or even lack of access to political networks. As an example, authorities who choose to accept the siting of a plant (such as mayors) may not fully represent the interests of marginalized populations and there could be less enforcement activities in those areas, creating an incentive for the companies to produce more externalities than in the equilibrium. In other words, some populations may lack Social Capital to avoid pollution. Social Capital can be defined as the ability to cooperate and coordinate to achieve their goals (Oström, 1990). It includes networks, norms, trust, knowledge and civic skills. Since measuring Social Capital is not straightforward, proxies have often been used : trust in institutions, involvement in local groups, solidarity or reciprocity (Van Staveren, 2003).

2.3.2 Politics and Environmental Justice

The political economy around polluting companies is particularly relevant for policies because it may contradict the idea that differentiated exposure is the efficient outcome of a bargaining

between the populations and the companies. Indeed, if poor populations have less Social Capital than others or than the companies, this is a clear violation of the low transaction condition of the Coase Theorem. In particular, if minorities do not actively participate in political processes (for any kind of reason : language barrier, distrust or lack of time or energy,...) this would create a double incentive to site in a poorer area (lower compensation and lower risk of political opposition). Hence, a lower Social Capital in areas of acute exposure to polluting companies can be a good indicator of Environmental Injustice. This is why, Serret and Johnstone (2006) argue that policies should focus on the procedural justice dimension of Environmental Justice. They argue that policies should aim at providing ways for the population to decide whether they accept to be exposed and in exchange for what -in other terms, to ensure lower transactions costs and clear property rights. Procedural Justice requires the creation of channels for public participation on the one hand, and active participation of the public on the other hand.

Political participation, in the form of voter turnout, is one way of measuring Social Capital in a population that has already been used in the Environmental Justice Literature, particularly as a proxy of the potential for political opposition (Hamilton, 1995). In 1995, Hamilton found that this was the variable that seemed to have the strongest impact against expansion of commercial hazardous waste processing capacity, before socio-economic variables or percentage of non-white population. Indeed, a politically active population will be more informed, will have more ability to enter collective action and is more prone to start political opposition to a polluting company. The potential for political opposition may be extremely relevant for the siting of a company as it can generate non-negligible costs for companies : they can delay installation, increase the compensation costs or bring this topic to court..

Empirically, Social Capital is usually associated with wealth (Van Staveren, 2003, Rydin and Pennington, 2010). Moreover, it is widely accepted that in industrial countries, less well off populations tend to vote less (Lijphart, 1997, Gallego, 2010) and that abstention could be linked with distrust toward political elites (Le Monde, 2004). On the other hand, poverty may be a consequence of lower political participation as well, due to a lower political accountability in those areas. Indeed, Nannicini and co-authors (2013) found that areas with a lower Social Capital tend to punish less elected officials that misbehave and interpret these a channel through which social capital may affect economic well-being. Lower Social Capital and poverty thus appear to be largely embedded.

2.4 Environmental Justice in the French context

Recent events brought the questions of environmental inequalities at the forefront in France : in 2017, the ministry of Environment became the ministry of ecological and solidarity transition, in 2019, the *gilets jaunes crisis* was the results of a feeling of injustice when it comes to environmental regulations ; protesters were claiming that the new tax would affect more the rural and poor areas of France, where people are heavily dependent on the car to move.

Moreover, several cases of unequal exposure to pollution have been documented concerning outdoor pollution and noise in the biggest cities like Paris, Marseille or Lille (Rizk, 2003), which were usually the consequence of traffic more than industrial pollution. Among the population affected by the heatwaves of 2003, low skilled worker appears to be over-represented and poor neighborhoods have been identified as less suited to face those events due to less green space and higher buildings (Giraud and Man, 2017).

Yet, there is very little information about Environmental Injustice related to industrial pollution. France is often considered to be in a process of deindustrialisation and industrial pollution is often presented as a feature of the past rather than of the present (Croisé and al., 2018). Sill, the testimonies of inhabitants living near some emitting facilities narrate the lack of information around the toxicity of the products emitted and the fear for their health. They particularly insist on the dependency of their area toward those facilities for employment and the difficulty to make local public powers take action (France Info, 2019) In 2008, a study on Environmental Justice confirmed the over-representation of polluting facilities in deprived areas in 1999, which also had a higher proportion of immigrants (Laurian, 2008a). Since then, there has been no study about Environmental Justice at the national scale. Other papers focused mainly on the relationship between waste incinerators and immigrants population in specific regions (Laurian and Funderburg, 2012, Schwartz and al., 2015). Their results were in line with previous literature, indicating that Environmental Justice issues existed in France.

None of those studies focused on the political economy dimension of Environmental Justice. Yet, unequal political participation and unequal distrust in political processes seem to be another feature of France. Individuals that are unemployed, poorer or with a lower degree tend to be more distant to the political sphere, less convinced of the utility of voting and less prone to identify with a political party (Mayer, 2013, INSEE, 2017). Moreover, France is famous for the habit of its inhabitants to engage into collective action, suggesting that the political economy around Environmental Justice may be even more relevant. The *gilets jaunes* demonstrations are one example of local col-

lective action, but other forms of opposition exist. As an example, there are important occupations of land by activists in order to oppose a project in one area, called the ZAD[2]. In 2019, a journalist started to gather information on local conflicts around projects that may affect the environment and found at least 260 of them. Hence, France appears to be an interesting setting to study Environmental Justice through the prism of the political economy.

3 Theoretical framework

3.1 A simple model

I assume that firms are profit maximising and pollution is a by-product of production. Not polluting is a cost for the firm, that is to say the firm decides to produce (and pollute) until the marginal benefit of producing one more unit equals the marginal cost. Hence, following the siting theory, the choice of the siting is made according to a cost/benefit analysis where they take into account the cost of the land or proximity to transportation networks (in other words, characteristics of the area a) and how much effort the company will have to make in order to become acceptable for the population e. The probability of siting decreases with the effort. We obtain :

$$P(siting = 1) = f(a, e)$$

As variables having an effect on the effort it will cost to the company, there is political engagement y and poverty p. I follow the Coasian bargaining theory that considers that the poorer the population, the lower the compensation needs to be to become acceptable for the population. Hence, poverty has a negative effect on the effort, that is to say it has a positive effect on the probability of siting. Political engagement, on the contrary, increases the effort, in accord with the political economy theory. Hence, political engagement has a negative effect on the probability of siting.

$$e = g(y, p)$$

Finally, I hypothesize that political engagement has a stronger effect when the level of poverty is higher - in other words, that there is an interaction effect. Indeed, when the level of poverty is

[2]Zone to defend - *Zone à défendre* in French -The ZAD of Notre Dames des Landes became nationally famous and was successful in preventing the construction of a new airport

very low, the compensation is already high and the probability of siting low, so political engagement may not decrease the probability of siting any further, while when poverty is important, political engagement may have a stronger effect.

The implications for the theoretical framework is that presence of polluting facilities should increase with poverty and decrease with political engagement.

3.2 Objective of the thesis

There are two main goals to this thesis. Firstly, I aim at producing more recent data in order to document Environmental Justice in France. Indeed, the only national study about Environmental Justice has been produced more than ten years ago, with data from 1999 (Laurian, 2008a) and demand for a fair transition require the documentation of environmental inequalities. Secondly, I see whether Environmental Injustice issues are also associated with lower voter turnout, which would have important consequences for decision makers and policies aimed at tackling Environmental Justice.

Hence, I will answer two main questions :
(1) Are economically deprived population more exposed to polluting facilities in France ?
(2) Is a low political engagement an aggravating factor for Environmental Justice ?

4 Data

4.1 Measuring economic deprivation

Environmental Justice can be described as a "messy challenge" (Mitchell, 2019). Indeed, finding evidence of Environmental Injustice is usually addressed by finding a correlation between minorities and pollution. However, it remains unclear how to define minorities or deprived population. As an example, in the United States minorities neighborhoods is often translated into proportion of non-white inhabitants in an area (Austin and Schill, 1991, Lavelle, 1992, Bullard, 1993). In Europe, the focus is more concentrated toward economically deprived populations (Mitchell and Dorling, 2003, Laurian, 2008a, Martuzzi and al., 2010). Yet, in France, the *gilets jaunes* from rural areas described themselves as a *forgotten population* compared to the population of the city. Hence, the mere concept of minority can include very different populations.

The socio-economic indicators I use are produced by the Institut National de la statistiques et des Etudes Economiques (INSEE) for the year of 2016 [3]. I have different variables for different spatial levels of analysis. Indeed, various scholars (Mennis, 2002, Laurian, 2008) argue that Environmental Justice evidences are reliable only if indication of their existence exist as several scales. Moreover, Mennis (2002) insist that doing the analysis at several scales may shed light on *demographic patterns that lie at the root of the environmental justice debate.*

At the lowest level of analysis, I use gridded data of the percentage of low income [4] households in the Metropolitan area in France. The lowest unit in this case is 200 m^2, however for confidentiality reasons, in areas where the density is very low [5], units are enlarged until there are enough households. Hence, I obtain a gridded map of France with 24.431 units of 200 m^2, 57,229 of 1 km^2, 48,404 of 2 km^2, 11,784 of 4 km^2 and a thousand units of more than 4 km^2, for a total of 142.921 observations.

The second level available is the municipality. At this level, the share of poor households is not available, and since the gridded data is not made according to municipalities, it is not possible to aggregate the previous data to the municipality level. There are however other indicators of socio-economic deprivation available at the municipality level. I use the share of population with a low education level [6], the unemployment level, the share of households with at least a car and the aging index. Other variables of interest such as population, population density, surface and population change are also available at the municipality level. There are 34,970 municipalities in France. They cover the whole territory, and there is no land in France that is not part of a municipality. Municipality can vary greatly in size [7] but 90% of the municipalities have less than 4,000 inhabitants and their size is on average smaller than 20 km^2. Municipalities also have decision power on the siting of facilities in their area and gather local taxes from the presence of a facility, which makes them interesting level of analysis.

Finally, I use data at the inter-municipality level. Share of individuals living under the poverty line is available at this level, as well as an inequality indicator, defined as the ratio of income between the 1st and the 9th decile in France.

[3] There is no publicly available data about about race in France. Hence, I am not able to include this factor in the analysis. Laurian, in 2008, had access to racial data and found that it was positively correlated with the presence of polluting facilities too.

[4] INSEE measures poverty as having a lower income than 60% of the median income in France.

[5] Less that 11 households

[6] Defined as having less than a high school diploma

[7] Paris is just as much of a municipality that a very small town of a few hundred inhabitants

Since this paper does not aim to find a causal effect of poverty of the presence of a facility, but to identify a correlation, I will limit the controls to variables that have to do with number of individuals and surface of the area. Indeed, other controls (such as proximity to main roads, price of the land or even historical presence of facilities in the area) - which could be of interest - may capture part of the correlation between social deprivation and the presence of a facility and distort the relation I am trying to observe.

4.2 Measuring exposure to pollution

Exposure to pollution or environmental quality are textbook examples of *goods* that can hardly be quantified (for a discussion about measuring environmental quality, see Pommerehne 1988). The main focus of this thesis, exposure to pollution, will be captured by living near a polluting facility, even though many other aspects would be of importance (such as the toxicity and quantity of pollutants they emit).

I will use two data-sets that should give a good overview of the distribution of industrial pollution in France. The first one is the *Registre des Emissions Polluantes* of 2016 that contains a list of 10,042 facilities considered to be *emitting* [8]. Quantities of pollutants emitted are unfortunately only available for half of those facilities and are self reported. Since it is not clear why some facilities do not have the quantities they emitted reported, I am not able to use this part of the dataset. One advantage with this data set is however that there is the exact geographical coordinates. Hence I am able match it with the gridded data about poverty.

The second data set I will use is called the Registre BASOL, which contains the list of the polluted soils and areas *"that required action from public powers"*. It contains 7,287 observations on the whole territory, of which I could merge 7,174 with municipalities. Those sites have been polluted by former industries, accidents and/or accumulation of pollutants over the years. It mainly contains sites where industries have left. It represents more localised pollution than the IREP data set. If the Ministry of environment considers that this type of pollution does not have a direct effect on the neighborhoods, but that it may affect some populations in case of small exposure over a lifetime and that it could affect water reserves.

[8] Those include industrial installations, the biggest treatment plants and biggest industrial breeding facilities.

4.3 Measuring political participation

For simplicity, I use abstention during the first round of the presidential election of 2017 in France rather than turnout as my independent variable[9] to measure political participation. Abstention is produced by the Ministry of Interior and is available at the municipality level. Abstention in the presidential election is a frequently used predictor of alienation from the political process, or even life dissatisfaction, in France (Algan and al., 2019). Indeed, presidential elections are by far the most important and most followed elections in France. Abstention for presidential elections tend to be quite low [10] compared to other elections. However, it is important to note that voters turnout is calculated as a percentage of the registered individuals who actually came to vote, whether their vote was blank or not. I do not include blank votes in the abstention, since blank votes represent individuals who somehow still participate to the political process by making the effort of going to vote. Moreover, voting is not mandatory in France and around 10 to 15% of the population was never registered in the voting list. This means that they do not appear in the abstention numbers. Non registered individuals are often very young and mobile, anarchists who refuse to be involved in politics or individuals that feel rejected from the political sphere (Le Monde, 2004).

In France, elections are always held during a week-end. Individuals are allowed to vote only in their municipality of residency. The president is elected by direct voting in a two round election. During the first round, all candidates can be chosen, then the two main candidates remain for the second round. In 2017, there were 4 main candidates which basically covered the whole political spectrum for the first round : Jean-Luc Melenchon represented the far-left, Emmanuel Macron the center, François Fillon the right and Marine Le Pen the far right [11]. This suggests that abstention is probably not due to a lack of representation on the political spectrum. On the contrary, uncertainty about the results may have increased participation, suggesting that abstention here is a relatively good measure of political participation and should not be distorted by a lack of stake or options.

[9] Abstention is exactly equal to 1-% turnout, hence this only changes the sign of my coefficient to a positive one

[10] The record was of 28% of abstention happened in 2002, it was 23% in 2017

[11] Benoît Hamon, the candidate of the left, is sometimes also included in this list, even though he ended up with a relatively low share of the votes.

Table 1: Summary statistics

	(1)	(2)	(3)
	Gridded data	Municipalities	Inter-Municipalities
Poverty rate (in %)	12.65		13.59
	(8.40)		(4.93)
Abstention (in %)		16.84	
		(4.99)	
Households w/ a car (in %)		92.04	88.63
		(5.51)	(5.33)
Low education (in %)		29.72	31.49
		(8.27)	(6.02)
Unemployment (in %)		9.74	11.15
		(3.94)	(3.10)
Aging index		107.51	98.85
		(102.06)	(38.50)
Inequalities			2.97
			(0.42)
Population		1897	52580
		(15071)	(220963)
Pop. density		163.11	154.76
		(734.40)	(375.64)
Area (in km^2)	1.508	18.09	500.78
	(1.22)	(147.55)	(1419.311)
Observations	142,921	34,968	1,261

Standard deviations in parentheses

5 Empirical strategy and results about Environmental Justice in France

One of the key challenge to study Environmental Justice is to define proximity to a facility. To do so, a *unit hazard coincidence* approach can be chosen, with the municipality as an example. Those geographic units may vary greatly in size or facilities may lie at the border of those geographical units, inducing measurement errors that can greatly bias the results. This is called the Modifiable Areal Unit Problem. Hence *distance based approaches* are usually favoured (Banzhaf and al., 2019), mainly by including in the "exposed" population -all those within a certain buffer around the facility. Moreover, the smallest spatial unit is usually favoured in order to avoid *ecological fallacy* (Banzhaf and al., 2019). Indeed, ecological fallacy happens when the areal unit chosen is too big and that the effect observed does not describe well underlying dynamics within the unit. Following this recommendation, the gridded data will be favoured, as being a remarkably small of unit analysis. However, since results are very sensitive to the spatial level chosen, Laurian (2008b) recommends running regressions at different levels to test their robustness to different specifications. Hence, my main specification will include producing several buffers around the facilities and consider that the population of a spatial unit that intersects with those buffers can be considered exposed. I will, however, also use the unit hazard coincidence at the municipality and inter-municipality level. This will give information about how the correlation evolves with distance and indicate whether my results are sensitive to the spatial unit chosen.

5.1 Using gridded data

5.1.1 Creating buffers around the facility

I use the qGIS software to match the gridded data with the geocoded location of the facilities. Due to data restrictions, I focus this part of the analysis on the metropolitan area of France [12]. The 8452 remaining listed facilities are well dispersed in the metropolitan territory.

I then create buffers around the facilities and compare the share of poor households for the population within a buffer and the population outside. Results are very sensitive to the size of the buffer chosen. Most of the papers use 2 km around a facility (Laurian, 2011, Eliott and al., 2011)

[12] Non-metropolitan regions of France represent 17% of the total area of France but they gather only 4% of the population. Since those areas are less densely inhabited, units tend to be much bigger than in the metropolitan regions. Moreover, data is often missing for the socio-economic indicators.

but the choice of a buffer is always somehow arbitrary. Ideally, one would want to choose the size equivalent to the distance at which a facility and indicators of the populations interact with each other. Since I assumed that facilities made a choice based on the efforts that they will have to make in order to become acceptable for the population, we would want to have buffers which include the population that would be compensated, and that population only. I will assume further, that companies compensate according to the pollutants they emit and how far they can spreads around the facilities. Previous studies have found that toxic air emissions tend to affect air quality within 1 mile [13] around the facility. Due to the diversity of pollutants in my dataset [14] and time restrictions, I am not able to model myself the dispersion of the pollutants. This is why I use circular buffers around facilities. I run the same equations for buffers of 1, 2 and 3km, and consider that my results are conclusive only if results are consistent across specifications.

Moreover, since I do not have individual data but aggregated data for a spatial unit, my units don't perfectly overlap with the buffer. I present results for the polygon containment method (Mennis, 2002) - which considers all units that overlap at least partially with the buffer as *treated units*. This method has some important limitations, because the population may be concentrated in a corner of the unit that may not actually lie inside the buffer or because there may be important differences between one corner and the other [15]. However, the reader should keep in mind that the unit chosen are particularly small, which minimizes this risk. In addition, spatial segregation is considered to be smaller in Europe than in the United States (Andersson and al., 2018), suggesting that in such a small unit there is probably not two types of population segregated each in one corner. The number of time the unit lies at least partially within a buffer is my dependent variable.

5.1.2 Results

Table 2 presents the results for the linear regression of the number of times the unit lies at least partially within the buffer of a facility divided by the size of the unit (in km) on the percentage of poor households in the area. I divided the number of times a unit lies within the buffer of a facility by the size of the facility because the bigger the unit, the more chances it had to cross with a buffer.

The results indicate that a bigger share of poor households, is usually associated with being

[13] Roughly 1.6 km.

[14] There are several type of pollutants in my dataset : air pollutant but also water pollutant and soil pollutants

[15] Other methods, like the buffer containment method assume a homogeneous distribution of the population within the unit and takes into account a percentage of the areal unit within the buffer, which is as much questionable. Mennis (2002) argue that there is no ideal method since nobody knows how one method really affects the results.

Table 2: Exposure on poverty (at the gridded data level)

	(1km)	(2km)	(3km)
Poor households (in %)	0.0955***	0.190***	0.219***
	(30.70)	(37.87)	(32.63)
Constant	0.734***	2.305***	4.949***
	(15.53)	(30.30)	(48.58)
Observations	142921	142921	142921
Adj. R^2	0.0065	0.0099	0.0074

The dependent variable is measured by the number of times a unit crosses with a buffer divided by the size of the buffer. t statistics in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

located within the buffer of a facility, for buffers of the size of 1, 2 or 3 km (each column corresponds to the size of its buffer). The correlation is more important when the buffer is widened which may be due to the fact that buffers of 1 and 2 km don't capture the whole area that is affected by the facility. Indeed, poverty and presence of facilities may be correlated in areas bigger than a few kilometers, as an example if the decision to accept of not a facility in their area is made at the communal level.

In terms of magnitude too, results are significant. Indeed, if we take the example of units of 1 km^2, results suggest that a 10% higher poverty rate is usually associated with being in the buffer of one more facility. To put this into perspective, the average share of poor households in metropolitan France is around 12,64%, with a standard deviation of 8,4%. 10% of the units of the gridded data have more than 25% of poor households and those numbers can increase up to 70-80%. However, the share of poor households does not appear to explain a large variation (Adj R^2¡0.01) of the number of facilities suggesting that there are a large range of factors that influence the presence of facilities.

Unit sizes may present an important caveat to my model, since the biggest the unit, the bigger chances to be at least partially within a buffer. Moreover, dividing the number of facilities by the size of the unit complicates the interpretation of the results. Hence, I run the regression separately for each unit sizes[16]. This also provides some more information about the relation between Environmental Justice issues and population density. Results are presented in table 7 and 8 in the

[16]Reminder : Units can be 200m^2, 1km^2, 2km^2, 4km^2, 8km^2, 16km^2 and 32km^2

Appendix A.

Interestingly, when running this regression separately for each unit sizes available, this correlation is still positive for the smallest units, but becomes negative for units of more than 2 km^2, suggesting that Environmental Justice Issues exist mainly in densely populated areas in France, but that presence of facilities may be associated with a more wealthy population in very rural areas. It is not clear how to interpret the negative correlation in rural areas. It could be that populations in rural areas are so poor that the presence of a facility is associated with better economic outcomes for the population thank to jobs, or because the units are too big to catch any meaningful correlation. Still, there is a positive correlation in the two smallest units, which concentrate a large share of the population, since 65% of the households live in units of 200 m^2 or 1 km^2.

Those results are robust to limiting the *treated unit* to unit that were entirely contained in a buffer, suggesting that the results are not dependent on the type of buffer chosen. Those results are also robust to changing the OLS (linear) model to a Poisson (a log-linear) model. Indeed, the OLS has the advantage of being easily interpretable, but a linear model may not well describe my data, as is indicated by the low R^2 value. Poisson regressions tend to be adequate for count variables as they assume a Poisson distribution of the outcome variable, so it is an adequate alternative model for a robustness check. I present in the Appendix B.1 the results for the Poisson model.

5.2 At the municipality and inter-municipality levels

5.2.1 Municipalities

I then matched the facilities with the municipality in which they lie to study the interaction between indicators of economic deprivation and presence of facilities. 4934 municipalities had at least one facility listed in the IREP in 2016 and 30.030 had none. Since there are more than 10,000 facilities in France, this means that municipalities which have at least a facility listed have on average 2 listed facilities. Some municipalities have more than 20 listed facilities, up to 42.

I start by calculating the means of each variable (share of low educated inhabitants, unemployment rate, median income, population density, population, changes in the population and surface of the municipality) for municipalities without any listed facility and for those with at least one. I then run a t-test in order to see if the difference between the two means is statistically significant.

Municipalities with at least one facility appear significantly different from municipalities with-

Table 3: Comparison of municipalities with and without facilities (means)

	(1)	(2)	(3)
	No facility	Facilities	t-test
Households w/ car (in %)	92.94011	89.15146	***
			(46.02)
Aging index	110.34038	90.31892	***
			(12.79)
Unemployment (in %)	9.55093	10.93738	***
			(-23.06)
Low education (in %)	29.54691	30.82478	***
			(-10.06)
Pop. density	105.66949	512.65349	***
			(-36.76)
Population change (in %)	0.18481	0.36486	***
			(-6.85)
Area	15.44081	34.19257	***
			(-8.28)
Observations	30015	4932	34947

Households w/ car is the % of households owning at least one car. Low education is the % of the population with less than a high school degree. Population change is the % of increase of the population over the five years before 2017. Area is the size in km^2 of the municipality. t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

out any facility. Indeed, they have a lower median income, higher unemployment rate, higher low education rate, much higher population density, their population grows faster and they have a bigger surface. This seems consistent with the result of the previous section, which suggested that Environmental Injustice seem to concern more densely populated areas.

Since I do not have the share of individuals living under the poverty line at the municipal level, I build a poverty index out of the other indicators. To do so, I use the variables that I have both at the municipal and inter-municipal level and that could be related to poverty : share of population with a lower degree, share of unemployment, population, aging index, population density and share of households with at least a car. I run a linear regression of poverty on those variables at the inter-municipality level. I drop population and population density, since they are not significant. Together, unemployment rate, low education, aging indicator and share of households with at least a car explain 75% of the variation of poverty in the inter-municipal level [17]. Then, I use that same linear combination of variables but this time aggregated at the municipal level and predict the share of individuals living under the poverty line. I obtain an index that varies between -7 and 169 that I winsorize at 0.005 to avoid extreme outliers. I obtain a poverty index that varies between 0.6 and 33.5, with a mean of 11.55, pretty much in line with both the share of poor households at the gridded data level and the share of individuals living under the poverty line at the inter-municipality level. The average poverty index for municipalities with no facility is 11.28 and it increases to 13.06 for municipalities with at least one facility. This difference is statistically and economically significant.

I then run the following regression :

$$facilities_m = \beta_1 * povertyindex_m + \beta_2 * popdensity_m + \beta_3 * population_m + \epsilon_m \quad (1)$$

With $facilities_m$ being the number of facilities in the municipality per km^2 and $povertyindex_m$ is the index I built.

Table 4 presents the results with two main alternatives. The column 1 presents the results for the equation (1). In column number two, I restricted the sample to municipalities with at least one facility. In the column 3 and 4, I present the results for the same regression but using the number of polluted sites instead of polluting facilities.

Again, results are consistent with the hypothesis that a poorer population is associated with

[17] I obtain poverty = 10.38067 + 0.9412116*unemployment + 0.2074903* low education + 0.0234672*aging index - 0.1802071* households with at least a car, Adj. $R^2 = 0.7575$

Table 4: Exposure on poverty index, population and population density (at the municipality level)

	Facilities		Sites	
	(1)	(2)	(3)	(4)
	Full sample	Restricted sample	Full sample	Restricted sample
Poverty index	0.00116***	0.00215***	0.00147***	0.00327***
	(15.82)	(5.59)	(18.47)	(5.22)
Population	2.29e-07***	-5.07e-07***	1.32e-07***	-4.56e-07***
	(7.42)	(-7.62)	(3.96)	(-4.96)
Pop. density	3.76e-05***	5.87e-05***	5.64e-05***	6.65e-05***
	(59.25)	(30.64)	(82.37)	(28.14)
Constant	6.67e-04	0.0921***	-0.00912***	0.0899***
	(0.70)	(16.94)	(-8.94)	(9.24)
Observations	34839	4930	34839	3271
Adj. R^2	0.13	0.19	0.21	0.22

Exposure is measured by the number of facilities or sites divided by the size of the municipality. Poverty index has been built using the share of household owning at least one car, unemployment, low education and aging indicator. In column 1 and 2, the dependent variable is measured by the number of facilities per km^2. Column 3 and 4 it is the number of polluted sites. Column 1 and 3 present the results for the full sample. Column 2 and 4 present the results restricting the sample to municipality with at least one facility or site. t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

more polluting facilities and robust to alternative specifications, but this time, a much larger share of the variation seem to be explained (R^2 oscillates between 0.13 and 0.22) thanks to the introduction of the control variables population and population density. If 0.00121 may not appear very large, it must be reminded that the number of facilities per km^2 is, by construction, very low so it is natural that coefficients appear low too. Indeed, 90% of the municipality have less than 0.05 facilities per km^2. It is interesting to focus on the results when restricting the sample to municipalities with at least one facility. Indeed, 30,000 municipalities don't have any and 5,000 have at least 1 facility, but with on average 2 per municipality. This could suggest that municipalities with at least 1 facility have some important difference with municipalities with none, and that they are more comparable between themselves. Wolverton (2009) as an example, found that the preexisting facilities were significantly correlated to the installation of new ones, no matter the controls. It could be because it signalled the presence of a low resistance community, was the signal for a zoning laws or because it implied agglomeration economies. Results are robust to this new specification and coefficient are even bigger.

Here too, I run the same regression changing the OLS for a Poisson regression and present results in the Appendix B. Interestingly, the results are a little bit different with the Poisson regression : poverty is positively correlated only when there is no control for the area of the municipality. This would suggest that the size of the municipality has an even bigger role that what the OLS regression was indicating.

In order to obtain results that are easier to interpret, I run the following regression

$$facilities_m = \beta_1 * povertyindex_m + \beta_2 * popdensity_m + \beta_3 * population_m + \beta_3 * area_m + \epsilon_m \quad (2)$$

With $facilities_m$ the number of facilities per municipality and $area_m$ the area of the municipality in km^2 . The only difference with the previous equation is that this time I assume a linear relation with the number of facilities and the area, which may well not be the case. However, this has the advantage to give numbers that are straightforward to interpret. One more point in the index of poverty is in this case associated with an increase of 0.2 facilities per municipality. This suggests that a 5% points higher poverty index (that is to say, one standard deviation) is associated with one more facility in the municipality. This result is robust to limiting the sample to municipalities with at least one facility, the coefficient increases even to 0.69. To see the detail of the result, see Table 9 in Appendix A.

5.2.2 Inter-municipality

Does this correlation holds at the inter-municipality level ? The inter-municipality level is interesting to study since there are polluting facilities in more than 90% of the inter-municipalities, with a big variation in numbers of facilities. Hence, I do not have the problem that I had at the municipal level, in which I worried that municipalities with no facility may be structurally different from those with at least one.

I run the two following equations, which are very similar to the equations at the municipal level, with the only difference that I also have access to an indicator for inequality at this level of analysis.

$$facilitiesperkm_i^2 = \beta_1 * poverty_i + \beta_2 * popdensity + \beta_3 * population_i + \epsilon_i \quad (3)$$

$$facilitiesperkm_i^2 = \beta_1 * inequalities_i + \beta_2 * popdensity + \beta_3 * population_i + \epsilon_i \quad (4)$$

Where $facilitiesperkm_i^2$ is the number of facilities per km^2, *poverty* is the share of individuals living under the poverty line,*inequalities* is the income ratio between the first and the ninth decile in the area and *population* is the number of individuals living in the municipality.

I present the results in table 5 for the number of facilities per km^2 and sitesper km^2, without restricting the sample.

This time, poverty rate is not significantly correlated with the number of facilities or polluted sites. This could suggest that there is some ecological fallacy that would hide Environmental Justice Issues at the inter-municipality level. Moreover, this indicates that policies that would screen at the inter-municipality level would probably fail to identify and address Environmental Injustice. The ecological fallacy theory is further supported by the correlation between inequalities and number of facilities. The ratio of income level between the first and the 9 decile varies between 2 and 7 while the number of facilities per km^2 between 0 and 0.3.

6 Empirical strategy and results for abstention

Since there seems to be some evidence for the existence of Environmental Justice issues in France, it is possible to wonder which other characteristics may be aggravating this situation. I

Table 5: Exposure on poverty and inequalities (at the inter-municipality level.)

	On poverty		On inequalities	
	(1)	(2)	(3)	(4)
	Facilities	Sites	Facilities	Sites
Poverty (in %)	-3.61e-05	2.83e-04		
	(-0.21)	(1.58)		
Inequalities			0.0135***	0.0178***
			(6.48)	(8.43)
Population	6.72e-08***	7.87e-08***	6.04e-08***	7.02e-08***
	(17.35)	(19.75)	(15.31)	(17.47)
Constant	0.0195***	0.00894***	-0.0207***	-0.0398***
	(7.73)	(3.45)	(-3.35)	(-6.32)
Observations	1244	1244	1244	1244
Adj. R^2	0.19	0.22	0.24	0.28

Exposure is measured by the number of facilities (or sites) divided by the size of the inter-municipality of the inter-municipality. Inequalities is measured by the ratio between the average income of the first and the 9th decile of the population.

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

focus on political engagement -in this case disengagement- that I capture using abstention during the last presidential election. All this section is done using data from the municipal level and using the same poverty index as in section 5.2.1.

I run two equations :

$$facilities_m = \beta_1 * index_m + \beta_2 * abstention_m + \beta_3 * popdensity_m + \beta_4 * population + \epsilon_m \quad (5)$$

$$facilities_m = \beta_1 * index_m + \beta_2 * abst._m + \beta_3 * index_m * abst._m + \beta_4 * popdensity_m + \beta_5 * pop. + \epsilon_m \quad (6)$$

Where abstention is the percentage share of abstention among the registered voters, index is the index is build to describe economic deprivation and facilities is the number of facilities per km^2. The variable $index * abstention$ captures the interaction between poverty and abstention.

Results appear in Table 6.

In the first two columns, we have the correlation between poverty and abstention without interaction, one time not controlling for population and population density and the second controlling for those variables. We see clearly that even when controlling for the population and population density, both abstention and poverty are positively correlated with the presence of facilities in the area of the municipality [18]. Since both poverty and abstention are expressed in percentages and have similar standard deviations (respectively 5.68 and 4.99), we can even compare the intensity of the effect, which appears higher for abstention. This is in line with the findings of Hamilton (1995), who concluded that the potential for collective action may be a stronger predictor for the presence of polluting facilities than poverty. This would have important implications for the field of Environmental Justice, which focused on race and poverty, while political participation was seen as a side factor.

Adding the interaction term between abstention and poverty changes the sign of the coefficient for both poverty and abstention but the interaction term is significant and positive. This suggests that when abstention is very low, poverty appears that be a deterring factor on the presence of facilities. In the same way, when poverty is equal to 0 abstention appears to play no role. However, the joint effect of each of this variable and of the interaction term rapidly turns positive. Indeed, the effect of poverty for levels of abstention higher than 13% (which is the case in 75% of the municipalities in France). The effect of abstention is positive for levels of poverty index higher than 0.75%, which is the case more than 99% of the time. This suggests that poverty may not be correlated with the presence of facilities when abstention is low enough.

[18] Again, those coefficients may appear very small but the reader should not forget that by construction the outcome variable is small (the mean number of facilities per km^2 is 0.2)

Table 6: Exposure on poverty and abstention (at the municipality level)

	No interaction		W/ interaction	
	(1)	(2)	(3)	(4)
	No controls	Controls	No controls	Controls
Poverty index	8.57e-04***	6.31e-04***	-0.00248***	-0.00172***
	(9.89)	(7.71)	(-10.68)	(-7.83)
Abstention (in %)	0.00243***	0.00171***	-1.38e-04	-9.61e-05
	(24.35)	(17.99)	(-0.71)	(-0.53)
Abstention*Poverty			1.86e-04***	1.32e-04***
			(15.47)	(11.52)
Pop. density		3.57e-05***		3.53e-05***
		(55.69)		(54.94)
Population		2.28e-07***		2.25e-07***
		(7.36)		(7.26)
Constant	-0.0300***	-0.0215***	0.0134***	0.00903**
	(-18.39)	(-13.90)	(4.14)	(2.95)
Observations	34245	34245	34245	34245
Adj. R^2	0.03	0.13	0.04	0.14

Exposure is measured by the number of facilities divided by the size of the municipality. Poverty index has been built using the share of household owning at least one car, unemployment, low education and the aging index. Abstention is the share of individuals registered on voting lists but who did not vote during the presidential elections of 2017

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In order to understand better the coefficients, we can compare municipalities with a poverty index level of 10 and another one of 20%. In the first case, an increase of one unit in abstention is associated with -0.000517+10*(0.000214)=0.001623 more facilities per km^2. In a municipality with a poverty level of 20%, one unit of abstention more is associated with 0.003763 per km^2. This suggests that, abstention has a stronger effect when poverty is higher.

7 Caveats

Even if this paper presents findings of correlation between poverty and the presence of facilities that are robust to several specifications and spatial scales, it has the important drawback that all this is only descriptive. Those results present a landscape of how the relation between poverty and presence of facilities evolves, but does not allow us to conclude on causal mechanisms that could have led to this situation.

One of the main limitation was the absence of historical data, notably about the date of the siting, which could have been used as a variation for causal effect. Indeed, I used data from 2016 (or 2017 for population change and abstention), but this does not bring information about what were the causes. I assumed that poverty and abstention had an effect on the siting of a facility and most of my interpretation rely on this assumption, but it could just as much be the presence of a facility which had started to have an effect on the level of poverty or the level of political participation, or a confounding factor affecting both.

8 Conclusion

This thesis offers more recent evidence about the existence of disproportionate exposure to industrial pollution in France. A positive relationship between poverty and proximity to a polluting facility is observable at the gridded and the municipal level, but not at the inter-municipal level. This suggests that the difference is generated at a very local level and that policy response would have to be extremely local too, or they risk to fall into the ecological fallacy. Moreover, areas more exposed to industrial pollution appear to have a higher share of poor individuals, but also to be more densely populated and to include bigger cities.

In line with previous research, abstention appears to be positively correlated with the presence of polluting facilities at the municipal level too. Interestingly, the share of abstention seem to have a stronger correlation with exposure to industrial pollution than poverty and to have an increasingly high effect, the higher the poverty level. This would suggest that political dis-engagement is indeed an important factor for Environmental Injustice and would justify more research focusing on the political economy around Environmental Justice.

Since this thesis could not capture a causal effect, it cannot explain how this differentiated exposure arise. However, it paves the way for further research on Environmental Justice in France. France is a fertile ground for political opposition and the news show that environmental inequalities are becoming an increasing concern for the population. There is thus demand for political action against environmental inequalities as well as situations that are worth studying for the Environmental Justice perspective. Further studies could focus on the health outcomes of population more exposed to industrial pollution or focus on variations due to a stronger political opposition in certain areas.

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A Additional tables

Table 7: Exposure on poverty for each unit size (at the gridded data level)

	(1)	(2)	(3)	(4)
	200m	1km	2km	4km
Poor households (in %)	0.0965***	0.0561***	-0.0302***	-0.0449***
	(20.30)	(27.85)	(-28.87)	(-22.20)
Constant	6.544***	1.431***	1.333***	1.548***
	(80.57)	(54.32)	(80.91)	(43.51)
Observations	24431	57229	48404	11784
Adj. R^2	0.017	0.013	0.017	0.040

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Exposure on poverty for each unit size (at the gridded data level)

	(1)	(2)	(3)
	8km	16km	32km
Poor households (in %)	-0.0647***	-0.0814**	-0.384
	(-7.32)	(-3.28)	(-0.98)
Constant	2.216***	2.503***	13.56
	(12.80)	(5.37)	(1.92)
Observations	986	69	18
Adj. R^2	0.050	0.125	0.000

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Exposure on poverty, population, population density and area (at the municipal level).

	(1)	(2)
	Full sample	Restricted sample
Poverty index	0.0198***	0.0675***
	(20.69)	(13.25)
Pop. density	1.41e-04***	6.94e-05**
	(17.06)	(2.75)
Population	3.05e-05***	2.48e-05***
	(76.20)	(28.33)
Area	1.44e-04***	-9.97e-05
	(3.86)	(-1.05)
Constant	-0.0244*	0.920***
	(-1.99)	(12.85)
Observations	34839	4930
Adj. R^2	0.21	0.23

Exposure is measured by the number of facilities in the municipality.

In column 2, the sample is restricted to municipalities with at least a facility.

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B Poisson Regressions

The Poisson regression enters the Generalized Linear Model family and is recommended to model expected frequency, in particular when the dependent variable is a count variable. It is often used in Environmental Justice settings (see Chun and al., 2012). Since the biggest the areal unit, the more chance there is to include a facility, I use the size of the areal unit as an *offset variable* or *exposure variable*.

B.1 Gridded data level

I run the equation (7). Results appear in table 10.

$$ln(E(facilities|poverty) = a + beta_1 * poverty_u + ln(size_u) + \epsilon_u \tag{7}$$

Table 10: Poisson regression : Exposure on poverty (at the gridded data level)

	(1)	(2)	(3)
	1km	2km	3km
Poor households (in %)	0.0386***	0.0330***	0.0245***
	(218.09)	(278.08)	(250.41)
Constant	0.114***	1.088***	1.710***
	(33.10)	(493.15)	(992.50)
Observations	142921	142921	142921
LR Chi-Square test	40235.97	67278.62	56764.23
Pseudo R^2	0.025	0.023	0.014

The dependent variable is the number of times a unit crosses with a buffer around a facility. Each column corresponds to the size of the buffer. Size of the unit is controlled for by defining it as the offset variable. z statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10 presents the results of the regression for the different buffer. Column (1) is for a the buffer of 1 km, Column (2) for 2 km and (3) for 3km. In the three cases the chi-square tests

indicates that this specification is a significant improvement in fit over a null model with a $p < 0.001$ for all of them and the Wald test indicates that poverty is a significant predictor of the frequency of facilities, with a $p < 0.001$. The share of poor households appears to be positively correlated with the frequency of facilities However, the intensity of this effect appears to be modest : the Incidence Rate Ratio of the share of poor households on the frequency of facilities around the unit is respectively of 1.018, 1.012 and 1.003. This suggests that an increase of one unit in the percentage of poor households is associated with a frequency of facilities multiplied by 1.018, 1.012 or 1.003, which represents a increase between 0.3 and 1.8%.

B.2 Municipality level

I then run again a Poisson regression. This time, my dependent variable is a count variable of the number of facilities there is in the municipality. I use the size of the municipality as an *offset variable* here too, since I assume that the biggest the municipality, the more exposure there is to presence of a facility (simply because there is more space for it). I also control for population and population density.

$$ln(E(Nbfacilities|index)) = a + \beta_1 * index_m + \beta_2 * density_m + \beta_3 * population_m + ln(area_m) + \epsilon_m \quad (8)$$

I slightly change the model to a zero inflated Poisson regression to deal with the fact that 30.000 municipalities don't have any facility on their area and 5.000 have at least 1. This violates the Poisson distribution assumption of the dependent variable. The zero inflated Poisson regression let the data follow a double process where the data is first generated through a binary process (it takes either the value 0 or will become a count variable), then a second process for the count variable (which is the classical Poisson Regression). The previous results suggested that municipalities with at least 1 facility have some important difference with municipalities with none, suggesting that they may be more comparable between themselves than with municipality with none, which makes this model even more relevant.

The Zero Inflated Poisson regression is the following :

$$P(y_m = j) = \begin{cases} \pi_m + (1 - \pi_m)e^{\mu_m} & \text{if } j = 0 \\ (1 - \pi_m)\frac{\mu_m^{y_m} e^{-\mu_m}}{y_m!} & \text{if } j > 0 \end{cases} \quad (9)$$

$$\text{Where } \pi_m = \frac{\lambda_m}{1 + \lambda_m} \quad (10)$$

$$\text{And } \mu_m = e^{a+\beta_1 * index_m + \beta_2 * density_m + \beta_3 * population_m + ln(area_m) + \epsilon_m} \tag{11}$$

$$\text{And } \lambda_m = e^{a+\beta_1 * index_m + \epsilon_m} \tag{12}$$

y_m is the outcome variable, that is to say the number of facilities in a municipality. λ_m generates the first level of data (whether it is a 0 or it is part of the data that will follow a Poisson distribution) by generating π_m which is the frequency at which the outcome variable always takes the value 0. At a frequency of $1 - \pi_m$ the outcome variable follows a Poisson distribution (hence it can take the value 0 too) and is generated by μ_m. I ran this regression using only the poverty index as an explanatory variable for the first step and the index, population density, population and area as explanatory variables for the second one.

Results appear in table 11.

No matter if the area of the municipality is controlled for as a proxy for exposure or not, both models are a significant improvement to the null model where all those variables have a zero coefficient. Interestingly though, my poverty index is in this model negatively correlated with when the area of the municipality is included as a control for exposure and positively when not. This is not evidence for having a less poor population in areas with more facilities, but rather than the effect of poverty in the number of facilities is captured by the size of the municipality. In other terms, municipalities that have a higher poverty index tend to be bigger too, and the size factor may be a better predictor for the presence of facilities than poverty. Since the size of a municipality enters the features of the land mechanisms, this would be in line with the theory that, facilities tend to site following land features rather than population features, and that poor people just tend to do the same and happen to end up in the same area.

Another feature worth mentioning is that poverty does not seem to have a positive effect on the presence of facilities during the first process (when it "jumps" from 0 to more than 0), only afterwards (when explaining why it increases once we entered the "realm" of the municipalities with at least one facility). It could be that the need for compensation appears mainly when new facilities sum up to already existing ones, hence, that poverty because an important feature only where there are only facilities that are present.

Table 11: Zero-Inflated Poisson regression : Exposure on poverty, population density and population.

	(1) Controlling for the size	(2) Not controlling
Poverty index	-0.0394***	0.0585***
	(-27.52)	(31.36)
Pop. density	2.63e-04***	8.18e-05***
	(82.93)	(16.35)
Population	-1.09e-0.6***	9.35e-07***
	(-18.05)	(13.70)
Ln(area)	1	
	(exposure)	
Constant	-2.609***	-0.470***
	(-96.71)	(-14.10)
Inflate		
Poverty index	-0.0782***	-0.0215***
	(-20.38)	(-7.56)
Constant	1.689***	1.652***
	(32.89)	(37.41)
Observations	34839	34839
LR Chi-Square test	3566.96	1905.19

The dependent variable is the number of facilities in the municipality. In the first column, size of the municipality has been defined as the offset variable. In the second, there is not offset variable. Poverty index has been built using the share of household owning at least one car, unemployment, low education

z statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$