Environmental quality and migratory responses

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Abstract

This study investigates the relationship between pollutant releases and neighborhood characteristics using data from The Canadian census and the National Pollutant Release Inventory. The results suggest that the siting decisions of facilities in Ontario are more likely driven by economic factors rather than discriminatory factors based on socio-demographic characteristics of neighborhoods. The results provide evidence in support of the Tiebout (1956) and minority move-in hypotheses, indicating migratory responses to the pollution levels. The policy implications of these results stress the need for a better dissemination of information about and monitoring of toxic pollutant releases in neighborhoods.

Keywords: Pollution releases, neighborhood characteristics.
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1 Introduction

The correlation between the distribution of toxic pollutant releases and neighborhood characteristics has been in the center of environmental economics and environmental justice debates for the past four decades. While some authors argue that the pattern of pollutant releases can be explained best by the siting decision of polluting facilities, others argue that minority move-in is the main force behind the correlation between toxic pollutant releases and neighborhood characteristics. Under the first premise, polluting firms locate in poor neighborhoods in order to take advantage of lower land prices, lower service costs, and weaker political opposition. In contrast to this argument, the second premise argues that as affluent households move out of neighborhoods with higher pollution levels, poor or minority households that are willing to trade-off higher pollution levels with lower housing costs will move in. This argument implies that the sorting decision of households across locations is the main explanatory factor for the correlation between pollutant releases and some socio-demographic characteristics of neighborhoods.

The correlation between pollutant releases in and socio-demographic characteristics of neighborhoods indicates that deprived neighborhoods receive a smaller share of benefits from production and consumption, even though they bear a bigger share of toxic pollutant releases (Buzzelli, 2008). While the presence of pollutant releases justifies government intervention, understanding the underlying cause of the correlation is crucial in designing and implementing effective environmental policies. Under the first premise, for example, a policy maker may want to implement local ordinances, zoning bylaws or permitting procedures to prevent polluting facilities from relocating to or having excessive pollution levels in a deprived neighborhood (Paster, Sadd and Hipp, 2001). However, if households are fairly mobile, this policy can result in gentrification where affluent households may purchase properties in the now-less-polluted neighborhood, and by rehabilitating and transforming the neighborhood, they displace the most vulnerable households (Atkinson, 2002). Therefore, the advocates of the minority move-in hypothesis argue that the design and implementation of policies mentioned above may end up hurting the same people they intend to help (Banzhaf and Walsh, 2004, 2008). Instead, they argue that as long as all the safeguards that are necessary to minimize the risk of population exposure to hazardous chemicals are in place, the only role for a policy maker is to ensure that people have access to information about toxic pollutant releases, enforce environmental standards, and monitor toxic pollutant releases in neighborhoods (Paster, Sadd and Hipp, 2001; Banzhaf and Walsh, 2004).

The results of studies that investigate the relationship between the distribution of pollutant releases and neighborhood characteristics are mixed; but nonetheless, they weigh in favor of the existence of such relationships. For example, Anderton et al., (1994) reported that treatment, storage, and disposal of hazardous waste sites are more likely to be found in tracts with Hispanic groups, but reported no nationally consistent and statistically significant differences based on racial or ethnic composition of tracts. They suggested that while environmental risk may be distributed differently across demographic groups, this is more likely due to differences between geographic locations such as rural versus urban areas or suburbs versus central business district areas that results in unequal environmental circumstances. Eckerd (2011) reported no relationship between the extent of gentrification and environmental improvement for cleanup of hazardous wastes sites in Portland, Oregon. In contrast, Ash and Fetter (2004) found that blacks not only tend to live in more polluted cities, but they also live in more polluted neighborhoods within cities. In addition, while Hispanics, on average, live in less polluted cities, they live in more polluted areas within cities (Ash and Fetter, 2004).

The results of studies that investigate whether polluting firms and policy makers respond to public concerns and neighborhood characteristics weigh in favor of the existence of such responses. For example, Antweiler and Harrison (2003) reported that firms abate their pollution in response to green consumerism upon dissemination of information about toxic pollutant releases. Hamilton (1995) reported that upon the first release of information about toxic pollutant releases, firms that reported large pollutant releases experienced negative abnormal returns. Arora and Cason (1995) found that public information and awareness about firms' toxic pollutant releases are important factors in explaining the participation in voluntary pollution reduction programs. In addition, large firms with the greatest toxic pollutant releases and industries with greater consumer contact are the most likely participants of voluntary programs (Arora and Cason, 1996). Hamilton and Viscusi (1999) argued that while for most hazardous waste sites it is not justifiable to adopt the most stringent cleanup options since they do not expose population to high risks, the sites that do pose risk receive inadequate attention. They further suggested that this is mostly because the government responds to political factors rather than actual risk (Hamilton and Viscusi, 1999). Pargal et al. (1997) argued that even when formal regulatory mechanisms are weak or absent, communities will use informal channels to achieve their preferences.

The notion that polluting firms or governments may have reacted to consumers, political factors, or neighborhood characteristics has led some authors to argue that the siting decision of polluting firms is the main force behind the pattern of pollutant releases. For example, Sadd et al. (1999) reported that in addition to income, industrial land-use, percentage of residents employed in manufacturing and population density that played roles in the distribution of toxic airborne releases, minority residents tend to be disproportionately located in neighborhoods with higher toxic airborne releases. Morello-Frosch et al. (2001) reported that while the potential lifetime cancer risks associated with air emissions are mostly attributable to transportation and small source polluters rather than large source polluters, race plays an explanatory role in risk distribution. Paster et al. (2001) argued that siting of polluting facilities matters more than minority move-in to the neighborhoods adjacent to hazardous wastes treatment, storage, and disposal facilities. They found that controlling for other factors, "minorities attract toxic storage and disposal facilities and not the other way around" (Paster, Sadd and Hipp, 2001).

Nonetheless, the results from studies that apply the Tiebout (1956) hypothesis to investigate the correlation between neighborhood characteristics and environmental quality weigh in favor of the minority move-in hypothesis. The Tiebout hypothesis suggests that to maximize well-being, households will move and choose a neighborhood that offers their optimal bundle of taxes and public goods. This implies that changes in the provision of local public goods and the underlying taxes will capitalize in property values. For example, Oates (1969) reported that while local property values have a negative relationship with the effective tax rate, they have a positive relationship with expenditure per pupil in the public schools. In regard to local toxic pollutant releases, this means a trade-off between pollutant releases and housing costs. Applying this concept, Banzhaf and Walsh (2004, 2008) argued that when a polluting firm moves into a neighborhood, the outward migration due to higher pollution levels will differ across income groups. In addition, they argued that poor households may move into the neighborhood accepting lower environmental quality in exchange for lower housing costs. This, in turn, will change the income and demographic composition of the neighborhood that can explain the observed ex post correlation between neighborhood characteristics and environmental quality (Banzhaf and Walsh, 2004; 2008). Cameron and Crawford (2003) also reported evidence of minority and single parent households move-in near hazardous wastes sites.

This study investigates the relationship between pollutant releases in a neighborhood and the neighborhood characteristics using data from the National Pollutant Release Inventory (Environment Canada, 1994-2010) and the Canadian census (Statistics Canada, 1996, 2001 and 2006). The objective of this study is threefold. The first objective is to investigate if the probability of having a facility with pollutant releases to the air in a neighborhood is correlated with the neighborhood characteristics. The second objective is to examine if the pollution levels and/or the types of pollutant releases to the air in a neighborhood are correlated with the neighborhood characteristics. The last objective is to determine if there are migratory responses to the pollution levels and/or the types of pollutant releases to the air in a neighborhood.

We find no evidence suggesting discriminatory actions in regard to the entry decisions of firms in Ontario. The entry decision of firms seems to be mainly determined by economic factors such as the unemployment rate, the average value of dwelling, and the size of family in a neighborhood. In addition, when the probability of observing pollutant releases by existing facilities in a neighborhood is considered, demographic factors such as the percentage of immigrants, the median family income, and the rent to owned ratio of dwellings become significant. The fact that these factors do not affect the entry decisions of firms, but have a significant impact on the probability of observing pollutant releases in a neighborhood, provides evidence in support of the minority move-in hypothesis. Regarding the pollution levels and/or the types of pollutant releases in a neighborhood, the results show that the main explanatory factors seem to be the size of firms and the percentage of individuals with a university degree. Furthermore, regarding the size of population in a neighborhood, everything else being equal, the entry of a polluting facility seems to be associated with an increase in the size of population, whereas an increase in the pollution levels of existing firms appears to be associated with a decrease in the size of population. These results also provide evidence in favor of the Tiebout (1956) and minority move-in hypotheses. The policy implications of these results stress the need for a better dissemination of information about and monitoring of toxic pollutant releases in neighborhoods.

2 Empirical Model

The first objective of this study is to investigate if the probability of having a polluting facility in a neighborhood is correlated with the neighborhood characteristics. In particular, we are interested in investigating (a) whether the probability of having new pollutant releases to the air in a neighborhood without a polluting facility or pollutant releases to the air in the past is correlated with the neighborhood characteristics, and (b) if the probability of having pollutant releases to the air in a neighborhood is correlated with the neighborhood characteristics. These scenarios are represented by the following two equations:

a) Equation for entry:

$$\begin{aligned} y_{it} &= \alpha + FAC_{it}^{'}\delta + SD_{i(t-1)}^{'}\beta + \varepsilon_{it} \\ y_{it} &= 1 \quad \text{if } P_{it} > 0 \text{ and } P_{i(t-1)} = 0, 0 \text{ otherwise} \end{aligned} \tag{1}$$

b) Equation of having pollutant releases:

$$\begin{aligned} y_{it} &= \alpha + FAC_{it}^{'}\delta + SD_{i(t-1)}^{'}\beta + \varepsilon_{it} \\ y_{it} &= 1 \quad \text{if } P_{it} > 0 \text{, } 0 \text{ otherwise} \end{aligned} \tag{2}$$

where indices i and t indicate neighborhood and time, respectively; SD and FAC represent matrices of socio-demographic and facility specific variables, respectively; and P is the aggregate level of pollutant releases to the air. It is assumed that firms make locational and production decisions in advance and hence, the decision about entry, or the pollution levels are assumed to be correlated with the socio-demographic variables in the previous census period.

The second objective is to investigate the correlation between the pollution levels and/or the types of pollutant releases to the air in a neighborhood and the neighborhood characteristics. To do this, we investigate if past neighborhood characteristics are correlated with the current pollution levels and/or the types of pollutant releases to the air in the neighborhoods. This is represented by:

$$P_{it}^{j} = \alpha_i + \gamma_t + FAC_{it}^{'}\delta + SD_{i(t-1)}^{'}\beta + \varepsilon_{it} \tag{3}$$

where, as before indices i and t indicate neighborhood and time, respectively; SD and FAC represent matrices of socio-demographic and facility specific variables, respectively. In addition, P is defined as the aggregate level of pollutant releases for each one of the pollution groups $j \in \{A, B, C, D, N\}$.[1]

The last objective is to determine if there are migratory responses to the pollution levels and/or the types of pollutant releases to the air in a neighborhood. We investigate if the average

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[1] These groups are as follows: (A) human carcinogen, (B) probable human carcinogen which includes (B1) probable human carcinogen with limited evidence of carcinogenicity in humans and (B2) probable human carcinogen with sufficient evidence of carcinogenicity in animals, but lack of evidence in humans, (C) possible human carcinogen, (D) not classifiable as to human carcinogenicity, and (N) none of the above.

pollutant releases to the air between census years are correlated with the size of population. Following Banzhaf and Walsh (2008), this can be represented as:

$$\ln\left(pop_{it}\right) = \alpha_0 + \alpha_2 \Delta I_{it}^{Enter} + \alpha_2 \Delta I_{it}^{Exit} + \sum_{j=A}^{N} \gamma_j P_{it}^{j} + FAC_{it}^{'}\delta + SD_{it}^{'}\beta + \varepsilon_{it} \tag{4}$$

where, indices i and t indicate neighborhood and time, respectively; SD and FAC represent matrices of socio-demographic and facility specific variables, respectively; P is the aggregate level of pollutant releases to the air for each one of the pollution groups $j \in \{A, B, C, D, N\}$. In addition, pop_{it} is the size of population; ΔI_{it}^{Enter} is an indicator variable that takes the value of one if a neighborhood without prior pollutant releases to the air experiences pollutant releases to the air at time t and zero otherwise; and ΔI_{it}^{Exit} is an indicator variables that take the value of one if a neighborhood with prior pollutant releases to the air experiences no pollutant releases to the air at time t and zero otherwise.

3 Data

Forward Sortation Area (FSA) is used to identify a set of well-defined neighborhoods in order to investigate the relationship between the location of polluting facilities, the pollution levels, and the types of pollutant releases to the air, and the socio-demographic composition of the neighborhoods.[2] Data for pollutant releases compatible with the defined neighborhoods were retrieved from the National Pollutant Release Inventory (NPRI) (Environment Canada, 1994-2010). Aggregated pollutant releases to the air are grouped based on their toxicity levels using toxicity weight data from the U.S. Environmental Protection Agency (U.S. EPA) (U.S. Environmental Protection Agency, 2011) and weight of evidence classification for carcinogens from the U.S. EPA (U.S. Environmental Protection Agency, 1986). Data for socio-demographic characteristics of neighborhoods were retrieved from the Canadian census (Statistics Canada, 1996, 2001 and 2006). In what follows, we briefly discuss these data sets.

3.1 National Pollutant Release Inventory

Data for pollutant releases were retrieved from Environment Canada's National Pollutant Release Inventory (NPRI). According to Environment Canada, NPRI is "Canada's legislated, publicly accessible inventory of pollutant releases to air, water and land, and disposals and transfers for recycling" (Environment Canada, 1994-2010). Pollutant releases to the air are grouped into five groups based on their toxicity levels as: (A) human carcinogen, (B) probable human carcinogen, (C) possible human carcinogen, (D) not classifiable as to human carcinogenicity, and (N) none of the above.

Figure 1 depicts the average annual pollutant releases to the air in each one of these groups from 1994 to 2009. It is important to mention that the number of pollutants in each group is not fixed over time (see for example, changes to the National Pollutant Release Inventory over

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[2] Forward Sortation Area is a major urban or rural geographic area in which all postal codes start with the same three characters. While the boundaries of FSA can change from one census year to the next, we could not find any indication in the census dictionary of Statistics Canada that would suggest major changes to FSA and hence, we assumed that these changes are negligible.

Time (Environment Canada, 2012)). On average, these groups have experienced a decline in pollutant releases over time with the exception of group (N). However, the main reason for the reported increase in pollutant releases in group (N) is the inclusion of seven criteria air contaminants in 2002. These are carbon monoxide, oxides of nitrogen, sulphur dioxide, total particulate matter (TPM), particulate matter less than or equal to 2.5 Microns ($PM_{2.5}$), particulate matter less than or equal to 10 Microns (PM_{10}), and volatile organic compounds (VOCs).

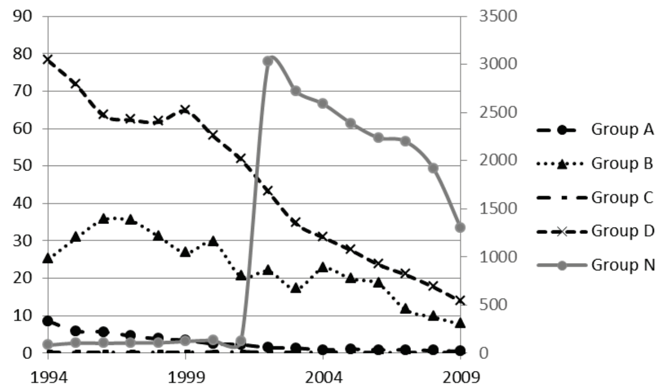

Figure 1: The average annual pollutant releases to the air (tonnes) based on the U.S. EPA toxicity groups from 1994-2009

In group (A), benzene has the highest share of pollutant releases followed by vinyle chloride. Overall, pollutant releases in group (A) experienced a 94 percent decline from 1994 to 2009. Pollutant releases in groups (B) and (C) showed a 69 and a 33 percent decline during the same period of time, respectively.[3] Group (D) showed an 82 percent decline in pollutant releases from 1994 to 2009. Pollutant releases in group (N) revealed a 57 percent decline in 2009 compared to 2002 levels when seven criteria air contaminants were included, but they were 1400 percent higher than 1994 levels due to the inclusion of seven criteria air contaminants.

It is important to re-emphasize that the objective of this study is to investigate whether the presence of a polluting facility in a neighborhood as well as the types and the amount of pollutant releases to the air are correlated with the neighborhood characteristics. If the only source of pollution in a neighborhood was transboundary pollution, for example, one would be able to test the validity of the minority move-in hypothesis since the pollution levels could be considered as an exogenous factor to the neighborhood characteristics. However, in the absence of such knowledge, one can only investigate the correlation between the pollution levels and/or the types of pollutant releases in a neighborhood and the neighborhood characteristics. The results can then be used to infer the validity of the siting decisions of facilities or the minority move-in hypotheses. In addition, this is different from investigating whether the actual pollution levels in a neighborhood and the neighborhood characteristics are correlated. The notion is that

[3] The highest shares of pollutant releases in group (B) are acetaldehyde, acrylonitrile, bis (2-ethylhexyl) phathalate, butadiene: 1, 3-, carbon tetrachloride, chloroform, dichloromethane, ethylene oxide, formaldehyde, propylene oxide, sulphuric acid, and tetrachloroethylene. The highest shares of pollutant releases in group (C) are cresol, cresol: m-; cresol: o-, cresol: p-, decabromodiphenyl oxide, dichlorobenzene: p-, naphthalene, trichloroethane: 1, 1, 2-, and vinylindene chloride.

while the residents of a neighborhood may not be able to influence the transboundary pollution because they do not have control over the choices made in a nearby neighborhood, they have some degree of autonomy in their own neighborhood. Finally, data for pollutant releases to the air are from sources that report to NPRI. Releases from other sources such as mobile or small stationary sources are absent in the data.

3.2 Census

Data for socio-demographic characteristics of neighborhoods were retrieved for Ontario, Canada from the Canadian census in 1996, 2001, and 2006 (Statistics Canada, 1996, 2001 and 2006). Table 1 provides a summary statistics for these variables based on neighborhoods with or without listed facilities in NPRI for all environmental media such as land, water, and air.

Table 1: Summary statistics for the socio-demographic variables in Ontario, Canada ($2006)

	1996			2001			2006		
Variables	(1) NPRI	(2) None NPRI	%Δ (1)-(2)	(1) NPRI	(2) None NPRI	%Δ (1)-(2)	(1) NPRI	(2) None NPRI	%Δ (1)-(2)
Population	25333.12	17311.92	46.3%***	26068.16	17259.14	51%***	25922.04	16769.8	54.6%***
Family Size	3.06	2.85	7.4%***	3	3.02	-0.8%	2.96	3.01	-1.7%**
Unemployment rate (%)	9.39	8.35	12.6%***	6.33	5.61	12.8%***	6.45	6.18	4.4%
Median Family Income ($)	62416.9	69088.39	-9.7%***	66699.6	78314.06	-14.8%***	72800.0	87140.85	-16.5%***
Dwelling ($)	208480.1	247899.4	-15.9%***	210959.9	256534.5	-17.8%***	281194.6	375956.5	-25.2%***
Rent ($)	817.41	857.09	-4.6%*	805.57	820.82	-1.9%	814	914.21	-11%***
Rent/Owned	0.72	0.76	-4.8%	0.6	0.62	-4.1%	0.51	0.54	-6.5%
Bedrooms	2.69	2.74	-2.1%	2.71	2.79	-2.7%	2.77	2.86	-3.2%
Immigrants (%)	22.73	23.6	-3.7%	23.96	24.38	-1.7%	24.28	27.69	-12.3%*
University (%)	22.51	28.34	-20.6%***	23.47	31.94	-26.5%***	24.08	32.82	-26.6%***
N	255	248		298	211		396	113	

* significant at 0.1, ** significant at 0.05, *** significant at 0.01

As can be seen in Table 1, the number of neighborhoods with listed facilities in NPRI grew by an annualized rate of 5.5 percent from 255 neighborhoods in 1996 to 396 neighborhoods in 2006.[4] During the same period of time, the average size of the population in forward sortation areas in Ontario grew by 1.17 percent per year. This growth was not equally shared between neighborhoods with or without polluting facilities. Neighborhoods with polluting facilities experienced an annualize growth rate of about 0.58 percent from 1996 to 2001, followed by a modest decline rate of about 0.11 percent per year from 2001 to 2006. In contrast, neighborhoods without a polluting facility experienced annualized decline rates of 0.061 and 0.56 percent from

[4] There can be three reasons for this increase. The first reason is the launch of a new or the relocation of an existing facility to a neighborhood without a previous facility. The second potential reason is a change to the regulation that may set lower thresholds for the existing pollutant releases or require new pollutant releases to be reported to NPRI. And the last reason is the increase in the production of an existing facility that may put the facility above the threshold and require it to report to NPRI.

1996 to 2001 and from 2001 to 2006, respectively. These figures reveal that not only the number of areas without a polluting facility is declining in Ontario, but the population in these areas is also declining. On average, areas with polluting facilities are more populous than areas without a polluting facility and the difference appears to grow wider over time.

In areas with polluting facilities, the average size of a family declined by 0.33 percent per year from 1996 to 2006. In contrast, the average size of a family in areas without a polluting facility experienced a growth rate of about 1.18 percent per year from 1996 to 2001, followed by a modest decline rate of about 0.04 percent per year from 2001 to 2006. This resulted in the average size of a family in areas with polluting facilities to switch from being 7.4 percent higher in 1996 to being 1.7 percent lower in 2006 when it is compared to areas without a polluting facility. The unemployment rate in 1996 was about three percentage points higher than the two other census years. On average, the unemployment rates were about 12 percent higher in areas with polluting facilities as compared to areas without a polluting facility in 1996 and 2001. The difference declined to 4.4 percent in 2006 and was statistically insignificant. The average of median family income in areas with or without polluting facilities, respectively, grew by 1.66 and 2.61 percent per year from 1996 to 2006. In 1996, the average of median family income in areas with polluting facilities was 9.7 percent lower than the one in areas without a polluting facility. The difference grew over time to 14.8 and 16.5 percent in 2001 and 2006, respectively.

In both areas, the average value of dwelling remained fairly constant from 1996 to 2001, but experienced a sharp increase from 2001 to 2006. During the period from 2001 to 2006, the average value of dwelling increased by 6.65 and 9.31 percent per year in areas with or without polluting facilities, respectively. In 1996, the average value of dwelling in areas with polluting facilities was 16 percent lower than the one in areas without a polluting facility and the difference grew steadily over time to 25 percent in 2006. The average gross rent in areas with or without polluting facilities, respectively, declined by 0.29 and 0.84 percent per year from 1996 to 2001, but experienced positive growth rates of 0.21 and 2.27 percent per year from 2001 to 2006, respectively. This indicates that while during the period from 1996 to 2001, the average gross rent in areas without a polluting facility declined 3 times faster than the one in areas with polluting facilities; during the growth period from 2001 to 2006, it grew almost 11 times faster. In addition, in 1996, the average gross rent in areas with polluting facilities was 4.6 percent lower than the one in areas without a polluting facility. The difference was statistically insignificant in 2001, and it was 11 percent lower in 2006. The average ratio of rented to owned dwelling was not different between areas with or without polluting facilities. However, the ratio steadily declined by 3 percent per year from 0.74 in 1996 to 0.51 in 2006.

The percentage of immigrants in both areas grew from 1996 to 2006. However, in areas with polluting facilities, the growth rate slowed down from 1.07 percent per year from 1996 to 2001 to 0.26 percent per year from 2001 to 2006. In contrast, in areas without a polluting facility, the growth rate accelerated from 0.66 percent per year from 1996 to 2001 to 2.7 percent per year from 2001 to 2006. The difference between percentage of immigrants in areas with or without polluting facilities was statistically insignificant in 1996 and 2001; however, the difference grew to -12 percent in 2006. From 1996 to 2001, the percentage of population with a university degree grew by 0.85 and 2.53 percent per year in areas with or without polluting facilities, respectively; thereafter, the growth rate was 0.5 percent per year for both areas. The percentage of population with a university degree in areas with polluting facilities was, on average, 20 percent lower than the one in areas without a polluting facility in 1996. This difference grew to more than 26 percent in 2001 and 2006.

In summary, the number of areas with polluting facilities in Ontario is rising. While they are more populous, the size of family in these areas is declining. These areas tend to have a higher unemployment rate and a lower median family income. On average, the value of dwelling and the gross rent are lower in these areas. Finally, while the percentage of immigrants and the percentage of population with a university degree in both areas are in the rise, these percentages are lower in areas with polluting facilities. These figures portrait a story that is consistent with the Canadian immigration system that requires specific points for education, skill, and financial background.

4 Results

In what follows, we first investigate whether the probability of having a facility with pollutant releases to the air in a neighborhood is correlated with the neighborhood characteristics. Next, we examine if the pollution levels and/or the types of pollutant releases to the air in a neighborhood are correlated with the neighborhood characteristics. And finally, we determine if there are migratory responses to the pollution levels and/or the types of pollutant releases to the air in a neighborhood.

4.1 The probability of observing pollutant releases in neighborhoods

The first objective of this study is to investigate (a) whether the probability of having new pollutant releases to the air in a neighborhood without a polluting facility and/or pollutant releases to the air in the past is correlated with the neighborhood characteristics, and (b) if the probability of having pollutant releases to the air in a neighborhood is correlated with the neighborhood characteristics. These scenarios were represented by Equation (1) and (2), respectively. Table 2 presents the number of neighborhoods with or without listed facilities in NPRI based on pollutant releases to the air. From 1996 to 2001, 45 new neighborhoods without prior pollutant releases have experienced pollutant releases to the air. By 2006, the number of new neighborhoods that experienced pollutant releases to the air increased by another 142 neighborhoods. In contrast, only 9 neighborhoods reported exits by 2001 and the number decreased by another 4 neighborhoods by 2006.

Table 2: Neighborhoods with or without listed facilities in NPRI based on pollutant releases to the air.

Year	Enter	Exit	With pollutant releases to the air	Without pollutant releases to the air	Total
1996	-	-	206	297	503
2001	45	9	242	267	509
2006	142	4	380	129	509
Total	186	13	828	693	-

A Probit model is used to investigate the correlation between the probabilities of having pollutant releases to the air in a neighborhood and the neighborhood characteristics. Table 3 reports the regression results for these models. The second column shows the results for the first scenario, i.e., the probability of having pollutant releases to the air in a neighborhood without prior releases; and the last column shows the results for the second scenario, i.e., the probability of having pollutant releases to the air in a neighborhood with prior releases. The likelihood ratio tests indicate that the panel estimator is not different from the pooled estimator for model (a) and reject the pooled estimator in favor of fixed effect estimator for model (b). It is important to point out that the correlation between having a facility with pollutant releases to the air in the current year and neighborhood characteristics in the previous census year does not necessary mean causal relationship.

Table 3: Estimation results for Probit model.

Variables	(a) Entry	(b) Having pollutant releases
Constant	-0.0417	1.607***
Employee	-0.000332***	0.000216***
Family size	0.336***	0.637***
Unemployment rate	-0.103***	-0.156***
Median family income	-5.9E-06	-0.0000135**
Average value of dwelling	-0.00000260***	-0.00000511***
Rent	-0.00027	-0.0006
Rent to owned ratio	-0.0267	-0.125*
Immigrants	0.00342	0.0149**
University	0.01	0.00437
N	1004	1004
R^2	0.1353	
Log Likelihood	-416.1	-523.6

[*] significant at 0.1, [**] significant at 0.05, [***] significant at 0.01

As can be seen in Table 3, part (a), the probability of polluting facilities entering a neighborhood without prior pollutant releases to the air is negatively correlated with the number of employees working in these facilities, which is a proxy for the scale of production, indicating that large facilities are less likely to relocate. This can be partly due to the large moving costs or some fixed local factors such as access to roads, ports, raw materials, just to name a few, that make relocating expensive for these facilities. But it can also be due to the resistance from neighborhoods or the existence of local bylaws that make it hard for large facilities to relocate.

The size of family is positively correlated with the probability of entry. This indicates that firms are more likely to locate to neighborhoods that have large families. The coefficient for the unemployment rate reveals a negative correlation between the probability of entry and the unemployment rate in a neighborhood. As Rappaport (2012) stated there are three factors that can explain the negative correlation between the unemployment rate in a neighborhood and the probabilities of new facilities entering the neighborhood. First, the skills of workers in the neighborhood with high unemployment rate may not match the needs of facilities that are potential candidates to relocate, or the needs of facilities in the neighborhoods with low unemployment rate may not match the skills of workers who are currently residing in the neighborhoods with high unemployment rate. Second, some intrinsic characteristics of neighborhoods make both households and firms unwilling to move. And lastly, high moving costs reduce the mobility of households and facilities (Rappaport, 2012). Finally, as expected, the probability of entry is negatively correlated with the average value of dwelling indicating that facilities are more likely to relocate to neighborhoods with low land prices. These results suggest that the entry decisions of facilities are correlated with economic factors such as the average value of dwelling, the unemployment rate, and the number of employees rather than with socio demographic factors such as the percentage of immigrants.

The results in part (b) of Table 3 show the correlation between the probability of having pollutant releases to the air in a neighborhood and the neighborhood characteristics. Unlike part (a), the probability of observing pollutant releases to the air is positively correlated with the number of employees. This indicates that large facilities are more likely to be associated with pollutant releases, as expected. The probability of having pollutant releases to the air in a neighborhood is negatively correlated with the unemployment rate in the neighborhood indicating that facilities are more likely to reside in neighborhoods that experience higher economic activities.

Contrary to what one may expect, the probability of having pollutant releases is negatively correlated with the rent to owned ratio of dwellings in a neighborhood. This might appear surprising because homeowners are expected to be more concerned about how pollutant releases in their neighborhoods may capitalize in the value of their houses; therefore, they are expected to be more resistant to having polluting facilities in their neighborhoods. However, if the pollution releases are already capitalized in the value of houses, the lower house prices may motivate the existing renters, as well as the newcomers to the neighborhood, to buy a house which can result in a negative relationship. The coefficients for the percentage of immigrants and the size of family in a neighborhood indicate a positive correlation between these variables and the probability of having pollutant releases in the neighborhood. While the same relationship is true for the percentage of population with a university degree, the result is statistically insignificant. Finally, the probability of having pollutant releases in a neighborhood is negatively correlated with the median family income and the average value of dwelling in the neighborhood. Overall, these results suggest a lower probability of having pollutant releases in the neighborhoods with a higher median family income and a higher average value of dwelling. While the same relationship is true for gross rent, the result is statistically insignificant.

These results suggest that the siting decisions of facilities in Ontario are more likely driven by economic factors such as lower land prices rather than by socio-demographic characteristics of neighborhoods such as the percentage of immigrants. In addition, these results weakly support the minority move-in hypothesis since certain factors such as the percentage of immigrants, the rent to owned ratio of dwellings, and the median family income are significantly correlated with the probability of having pollution in a neighborhood even though they are insignificant for the entry.

4.2 The pollution levels and the type of pollutants released in neighborhoods

In this section, we investigate the correlation between pollution levels and neighborhood characteristics. The objective is to investigate if the current pollution levels and/or types of pollutant releases to the air in a neighborhood are correlated with the neighborhood characteristics in the previous census year. This scenario is represented by Equation (3). Table 4 shows the results for the regression of the current pollutant releases on the neighborhood characteristics in the previous census years. Hausman test (Hausman, 1978) did not reject the random effects model for pollutant releases in group B, D and N, but rejected the random effects in favor of the fixed effects for group A and C. Breusch and Pagan (1980) Lagrange Multiplier test rejected pooled regression for pollutant releases in groups B and D, but not for group N. The time fixed effects test failed to reject that the time effects are equal to zero for pollutants groups B and C.

Table 4: Estimation results for the regression of pollution levels on neighborhood characteristics

Variables	Group A	Group B	Group C	Group D	Group N
Constant	0.147	31.23	1.212	4.2	372.1
Year 2006	2.941**	5.615	0.258	-15.07**	2820.8**
Employee	-0.000464***	0.000327	-0.0000155*	0.000779	0.0753***
Family size	0.162	-0.285	-0.0278	0.303	-525.2
Unemployment rate	0.616**	2.312	0.0232	1.753	232.1
Median family income	1.96E-06	-0.00015	-0.00000633	0.000314	0.0194
Average value of dwelling	2.26E-05	2.63E-05	-0.00000273	-1.4E-07	-0.00058
Rent	-0.00581	0.00429	0.000636	0.0223	-0.56
Rent to owned ratio	0.779	-2.75	0.0111	-4.72	-297.9
Percentage of immigrants	0.0989	-0.572	-0.00328	0.66	-31.79
Percentage with a university degree	-0.142	-0.770**	-0.0207*	-1.306***	-51.64**
N	688	688	688	688	688
R^2	0.551	0.0195	0.078	0.147	0.0844

* significant at 0.1, ** significant at 0.05, *** significant at 0.01

As can be seen in Table 4, everything else being equal, pollutant releases were higher in groups A and N, and lower in group D in 2006. The number of employees is negatively correlated with pollutant releases in group A and C, positively correlated with pollutant releases in group N, and its correlation with other groups is insignificant. The results from Tables 3 and 4 suggest that large facilities are less likely to relocate, have higher pollutant releases, and are better equipped to deal with pollutant releases in group A (i.e., human carcinogen), and to some extend in group C (i.e., possible human carcinogen), since they have more resources.

The size of family in the previous census year has insignificant correlation with pollutant releases. The results suggest that while the probability of observing pollutant releases in a neighborhood is positively correlated with the size of family, the pollution levels are indifferent to or possibly negatively correlated with the size of family in the neighborhood. The coefficient for the unemployment rate shows a positive correlation between the unemployment rate and pollutant releases in group A, but no significant correlation with other groups. These results suggest that while the probability of observing pollutant releases in a neighborhood is negatively correlated with the unemployment rate, pollutant releases in group A (i.e., human carcinogen) are higher in neighborhoods with higher unemployment rates. The coefficients for the median family income, the average value of dwellings, the average gross rent, and the rent to owned ratio of dwellings indicate insignificant correlation between these variables and pollution levels. The results suggest that while the probability of observing pollutant releases in a neighborhood is negatively correlated with these variables, once a facility is in the neighborhood, these variables have insignificant correlation with pollutant releases.

The percentage of immigrants has insignificant correlation with pollutant releases. The results suggest that the probability of observing pollutant releases in a neighborhood is positively correlated with the percentage of immigrants in a neighborhood, but once a polluting facility is in the neighborhood the correlation between pollution levels and the percentage of immigrants appears to be insignificant. The percentage of individuals with a university degree is negatively correlated with pollutant releases. This indicates that while the probability of observing pollutant releases in a neighborhood is not correlated with the percentage of individuals with a university degree, neighborhoods with more individuals with a university degree experience lower pollution levels.

4.3 The population size and percentage of immigrants

Next, we investigate if the size of population in a neighborhood is correlated with the pollution levels or the types of pollutant releases to the air in the neighborhood. This scenario was represented in Equation (4). Table 5 shows the results for the regression of the size of population on the neighborhood characteristics as well as pollutant releases to the air. The second column presents the regression of population on pollutant releases, the third column expands the previous specification by adding neighborhood characteristics, and the last column replaces pollutant releases with a dummy variable that takes the value of one if the neighborhood has any pollutant releases to the air and zero otherwise. In all models, Hausman test (Hausman, 1978) rejects the random effects model. The joint time fixed effects tests reject that all time effects are jointly equal to zero. The discussion of the results in what follows is mainly based on the last column since the results are qualitatively similar among all specifications.

Table 5: Results for the regression of the size of population on pollutant releases

Variables	Without *SD* variables	With *SD* variables	With SD variables and pollution dummy
Constant	9.569***	7.023***	7.068***
2001	0.0976***	0.051	0.0525
2006	0.205***	0.111**	0.119***
Enter	0.0108	0.00456	0.0634***
Exit	-0.0554	-0.0113	-0.0517
Employee	-0.00000199**	-0.000000955**	-0.000000718*
Group A	-0.00056	-0.000590*	
Group B	4.48E-05	8.27E-05	
Group C	-0.00853*	0.0043	-0.0761**
Group D	1.62E-05	2.48E-05	
Group N	-0.00000102**	-0.000000888**	
Family size		0.156***	0.154***
Unemployment rate		0.0154*	0.0152*
Income		0.0000135***	0.0000136***
Value Dwelling		-5.7E-07	-0.000000572
Rent		0.000611***	0.000614***
Rent to owned ratio		0.0391	0.0389
Immigrants		0.0309***	0.0306***
University		-0.00298	-0.00323
N	1521	1517	1517
Adjusted R^2	0.119	0.536	0.537

* significant at 0.1, ** significant at 0.05, *** significant at 0.01

Table 5 shows that, everything else being equal, the size of population in neighborhoods is growing over time. The coefficient of ΔI_{it}^{Enter} is significant and positive, suggesting a positive correlation between the population growth and the entry of a polluting facility in a neighborhood. This result, combined with the findings from column (b) in Table 3, provides evidence in support of the minority move-in hypothesis in Ontario. Moreover, the size of population in a neighborhood is negatively correlated with the number of employees as a proxy for the scale of production. This indicates that neighborhoods with big facilities are, on average, less populous than other neighborhoods.

The results also reveal that as expected, population is negatively correlated with pollutant releases in a neighborhood. When the levels of pollutant releases are considered, groups A (i.e., human carcinogen) and N (i.e., none of the above) are the only groups with significant coefficients, and they have the expected signs. These results indicate that migratory responses are strongest towards the most toxic and the most visible types of pollutants. The same results hold when variables that measure the levels of pollutant releases are replaced with a single pollution dummy (i.e., last column) indicating that, everything else being equal, higher levels of pollutant releases by existing facilities in a neighborhood would lead to a decline in the population of the neighborhood. This result provides evidence in support of the Tiebout (1956) hypothesis which postulates that households will move to locations that provide an optimal composition of public goods (i.e., environmental quality in this case) and taxes that maximizes their well-being. The coefficients for the average size of a family, the median family income, and the average gross rent reveal a positive correlation between these variables and the size of population in a neighborhood. In addition, the unemployment rate is positively correlated with the size of population indicating that neighborhoods with higher unemployment rates are more populous. To the extent that the increase in the size of population is determined by a higher fertility rate, having children reduces the opportunity cost of being unemployed which would result in a positive correlation between the size of population and the unemployment rate. Finally, the percentage of immigrants, as expected, appears to be positively correlated with the size of population in the neighborhood (Ng and Nault, 1997).

5 Conclusion

This study investigates the relationship between pollutant releases to the air in a neighborhood and the neighborhood characteristics using data from the Canadian census and the National Pollutant Release Inventory (NPRI). The objective of this study is threefold. The first objective is to investigate if the probability of having a facility with pollutant releases to the air in a neighborhood is correlated with the neighborhood characteristics. The second objective is to examine if the pollution levels and/or the types of pollutant releases to the air in a neighborhood are correlated with the neighborhood characteristics. The last objective is to determine if there are migratory responses to the pollution levels and/or the types of pollutant releases to the air in a neighborhood.

Pollutant releases are grouped into five groups based on their toxicity levels using the U.S. EPA weight of evidence classification for carcinogens (U.S. Environmental Protection Agency, 1986). These groups are: (A) human carcinogen, (B) probable human carcinogen, (C) possible human carcinogen, (D) not classified as to human carcinogenicity, and (N) none of the above. A closer look at the data revealed that pollutant releases in these groups have experienced sharp declines of anywhere between 33% in group C to 94% in group A from 1994 to 2009. In addition, census data revealed that the number of neighborhoods with listed facilities in NPRI is growing over time and on average they are more populous than neighborhoods without a polluting facility. Summary statistics also show that while the unemployment rate in areas with polluting facilities was higher the gap almost disappeared by 2006. The average family income and the average value of dwelling were lower in areas with polluting facilities and the gap is widening over time. The percentages of immigrants and individuals with a university degree were higher in areas without polluting facilities and the gap appears to grow over time.

The regression results suggest that the entry decision of a firm seems to be mainly correlated with economic factors such as the size of the firm, the unemployment rate, the average value of dwelling, and the size of family in a neighborhood, and not with the socio-demographic factors such as the median family income, the percentage of immigrants, the percentage of individuals with a university degree, and the rent to owned ratio of dwellings. These results indicate that firms do not discriminate among neighborhoods while making their siting decisions. In addition, the probability of observing pollutant releases in a neighborhood seems to be negatively correlated with the median family income, the average value of dwelling, and the rent to owned ratio of dwellings, while it is positively correlated with the size of polluting facilities, the percentage of immigrants, and the size of family. The fact that the percentage of immigrants and the median family income do not affect the entry decisions of firms, but have a significant impact on the probability of having pollutant releases by existing firms provides evidence in support of the minority move-in hypothesis.

Regarding the pollution levels and/or the types of pollutant releases in a neighborhood, the results show that the main explanatory factors seems to be the size of firms and the percentage of individuals with a university degree. Furthermore, regarding the size of population in a neighborhood, everything else being equal, the entry of a polluting facility seems to be associated with an increase in the size of population, whereas an increase in the pollution levels of existing firms seems to be associated with a decrease in the size of population. The size of population in a neighborhood also seems to be positively correlated with the median family income, the unemployment rate, the size of family, the average rent, and the percentage of immigrants in the neighborhood.

In conclusion, these results suggest that the siting decisions of polluting facilities in Ontario are more likely driven by economic factors rather than discriminatory factors based on socio-demographic characteristics of neighborhoods. The results provide evidence in support of the Tiebout (1956) and minority move-in hypotheses, indicating migratory responses to the pollution levels. Our findings are consistent with the findings of Banzhaf and Walsh (2008) who also reported evidence for the emigration of richer and/or immigration of poorer households due to pollution in a given location. The policy implications of these results stress the need for a better dissemination of information about and monitoring of toxic pollutant releases in neighborhoods.

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