

Bolstering environmental (in)justice claims with a quasi-experimental research design



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ABSTRACT

Claims of environmental injustice are often confounded by the potential for reverse causality. An undesirable land use may concentrate minorities and poor people locally as the established population moves out and others remain or move in. This paper addresses the issue of causality for the case of waste incinerators in France with a before and after, matched control design. Site selection, population migration, and the capacity and emissions of incinerators have mutually reinforcing effects that can exacerbate environmental injustice. We develop a predictive model of incinerator siting in France and use it to identify a viable twin location for every incinerator site, similar in most aspects, except the twins were not selected to host a facility. In turn, these matches enable us to construct explicit counterfactuals and measure the true impact of incinerators on demographic change. We find solid evidence that concentration of immigrants influences incinerator location and weak evidence for the converse, that incinerator location influences concentration of immigrant populations. We also find that concentration of immigrants greatly affects the operations of incinerators, with greater capacity and greater emissions at incinerators located near the highest concentrations of immigrant populations.

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1. Introduction

In the 1980s, environmental justice (EJ) research pointed to a crucial form of inequity when it showed that minority communities in the United States are significantly more likely than their white counterparts to live close to toxic sites, even when controlling for income (Bullard, 1983, 1990; United Church of Christ, 1987). Since then, the field has moved towards showing disproportionate exposure of disadvantaged communities to point and nonpoint pollution sources across the U.S. and resulting disproportionate health impacts; refining statistical and spatial analytical methodologies (for example, with regards to levels of analysis, accounting for spatial and temporal lags); applying and testing the EJ hypothesis in the context of other industrialized countries and of global north-south relations; and explaining the inequalities observed. EJ research remains centered in the U.S. (Reed and George, 2011), although its relevance to European social-ecological contexts has

been established (Laurent, 2011, 2014) and European scholarship on distributional inequities is burgeoning.

With regard to explanations for the inequalities observed, questions of causality have been addressed mainly by considering whether polluting activities such as toxic sites or highways are sited in predominantly disadvantaged or vulnerable communities (racial minorities, working class, immigrant communities depending on the context), or whether, in response to housing market dynamics, disadvantaged communities move to (or disproportionately stay in) polluted areas – which can be construed as an economically rational tradeoff of pollution for lower property values and rents (Been, 1994). Oakes et al. (1996) directly evaluated the alternative explanations with a before-and-after research design and found no significant evidence of discriminatory siting or demographic change in host census tracts after the siting. Been and Gupta (1997) and Pastor et al. (2001) also conducted longitudinal studies to test these hypotheses – the former with simple analyses, the latter with simultaneous modeling of siting and minority move-in. Both studies found no support for the market dynamics hypothesis and showed ethnically biased siting processes in the U.S. Both studies found significantly more environmental hazards sited near concentrations of Latinos, but not near concentrations of African Americans, suggesting that recency of immigration may be

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an important facet of minority status in biased facility siting.¹ Neither study modeled the site selection process in identifying control locations from which market responses are estimated; the controls should be the set of comparison neighborhoods that are similar to the hosting neighborhoods except they lack a hazardous waste facility. Pastor et al. (2001) include as the comparison group all other census tracts in Los Angeles County that lack toxic storage and disposal facilities. Been and Gupta (1997) acknowledge one should exclude from comparisons locations not viable to host a facility based on “a model of how facilities are sited” (p. 17), but the authors use all non-host census tracts available in a stratified sample across the U.S. We make a new contribution to the EJ literature in this paper with a predictive model of incinerator siting in France, which we use, in turn, to identify comparison locations viable for hosting an incinerator, sites similar to hosts in many aspects, except the control locations never hosted an incinerator.

Empirical tests of the unjust siting process versus market dynamics hypotheses have been insufficient in making causal claims because they fail to control for the possibility of multiple directions of causality both temporally and spatially. Particularly, they fail to account for the narrow set of spatially optimal locations for necessary facilities (for example, if municipal waste processing facilities such as landfills or incinerators are not sited in a community, they need to be sited in another nearby). They also fail to set adequate counterfactuals to assess what would have happened in the absence of facilities. Finally, they consider all toxic sites to be essentially similar and do not assess the type or quantity of emission produced. Yet, differentials in emissions (due to production scale and pollution controls) have the potential to worsen the impacts of unfair siting decisions.

This paper contributes to the literature on the causes of environmental inequalities by proposing a new quasi-experimental matched-sites methodology that accounts for both longitudinal impacts (pre- and post-siting characteristics of communities that received and did not receive polluting facilities) as well as spatially optimal locations from a transport cost-minimization standpoint. It also controls for irrelevant location alternatives that would otherwise confound the siting choice set and hence construction of counterfactuals. A quasi-experimentally identified twin location has similar characteristics to its matched host site and is itself viable to host a facility, except the twin location was not selected as a site for a facility. The twin location thus provides a proxy for observing the contrary-to-fact experience of the host site after the facility siting as if the host site never received the facility. Counterfactuals are essential terms in the calculus of the true impact from an intervention such as a facility on a response such as migration or property value. Last, this paper examines whether the capacity and quantity of emissions from toxic facilities contribute to environmental injustice in addition to the consideration of siting choices and demographic changes.

We examine the performance of the methodology in the context of waste incinerators sited and constructed in towns throughout France between 1965 and 2004. (Towns, or “communes”, constitute a fine level of analysis given that France, which is the size of Texas, has more than 36,000 communes.) This analysis builds on previous evidence of environmental injustice in France (Laurian and Funderburg, 2014; Laurian, 2008a,b). France does not collect data on race, so, as in previous studies, we focus on immigrant (foreign-born and foreigners) populations. Foreigners are recent immigrants not yet naturalized, while foreign-born populations

include a much broader number of immigrants, including many North Africans who immigrated in the 1960s. Both are vulnerable populations whose limited political clout and socio-economic capital reduce both their residential mobility and their ability to successfully oppose polluting facilities. We focus on the location of municipal waste incinerators because incinerators have significant health impacts and because data are available for the location and siting time for all incinerators sited since the 1960s, as well as for the capacity and emissions of incinerators.

We find solid evidence that proximity to foreign-born populations was a significant determinant of incinerator location in France. Incinerators were disproportionately sited in towns with high concentration of immigrants: each additional one percent increase in a town's foreign-born population increases the odds it has of receiving an incinerator by 29 percent, controlling for other factors affecting costs and benefits varying by location (Laurian and Funderburg, 2014). We find here that concentrations of immigrants also impact the operations of the facilities. By 2008, incinerators in towns with many immigrants had more burners and 71 percent greater capacity and emitted 89 percent more carbon dioxide (CO₂) than towns with low concentrations of immigrants.

We find weak evidence that incinerators subsequently caused demographic shifts or increased local concentrations of immigrants and we find no evidence that the established nonimmigrant population abandoned towns that received incinerators. There is some indication that immigrants were more likely to remain near incinerators: the number of immigrants in towns with incinerators declined significantly less than in comparably small towns serving as controls; small towns with incinerators did not experience the out-migration of foreigners to larger urban areas that towns without incinerators experienced.

The next section summarizes the arguments surrounding environmental injustice with a focus on the hypotheses that test EJ claims. Section 3 summarizes the literature on environmental risk perception and its implications for migration, property values and rents. In Section 4, we present our methodologies for disentangling the complex and reinforcing temporal and spatial processes generating environmental injustice and for testing the different claims. We identify the matched pairs (or twin towns) in Section 5, present our findings in Section 6 and conclude the paper in Section 7.

2. Claims of environmental (in)justice

Over the last 20 years, scholars have contentiously debated the causes of environmental inequality of numerous types of adverse exposure. The boundaries of public moral responsibility in liberal economies derive in some part from a determination of biased intent among decision makers versus a finding of responsibility among the deprived through rational choices, intentional informed tradeoffs of low housing costs for pollution. A category of environmental racism is reserved for cases when privileged actors target exposure based on race or ethnicity (United Church of Christ, 1987; Mohai and Bryant, 1992; Hamilton, 1995). Other scholars discount the importance of determinants, deeming all disproportionate exposure burdening racial or ethnic minorities a form of environmental racism (see Pulido, 2000, for example). The co-concentration of vulnerable peoples with noxious and other undesirable land uses that results, in the U.S., from white flight to the suburbs and disinvestment from central industrial districts, for example, demands a broadening of our public moral responsibility even though behaviors may lack clearly malicious intent. Yet, the causes of unequal distributions of health-harming exposure remain an important research topic because policy solutions often depend on addressing the determinants of inequity.

¹ Pastor et al. (2001) acknowledges recency of immigration as a potential factor in distributional inequality when the authors examine the churning of neighborhoods from predominately African American to predominately Latino.

Reversing and correcting environmental injustices requires understanding the causes of unequal distributions of risk. Most studies of environmental injustice focus narrowly on snapshot distributions of undesirable land uses near vulnerable populations. Such spatial analyses tend to show disproportionate risk exposure for low income households or peoples of color. Distributional injustices are documented for the locations of landfills (Bullard, 1983), hazardous waste facilities (United Church of Christ, 1987; Lejano and Iseki, 2001), manufacturing plants emitting hazardous compounds into air and water (Bowen et al., 1995; Mennis, 2005; Mennis and Jordan, 2005; Nixon et al., 2006; Bowen et al., 2009; Abel and White, 2011; Lam, 2012), nonpoint-source air pollution (D'souza et al., 2009; Padilla et al., 2014), waste incinerators (Bullard, 1983), or a variety of unwanted land uses (Been, 1994; Laurian, 2008a,b). More sophisticated examinations consider the demographics of a place before and up to the time the undesirable uses were sited and consider the distributions of political costs at the time of decision (for example, Hamilton, 1995; Laurian and Funderburg, 2014), while others also test for the confounding possibility that the location of the disamenity caused in-migration of disenfranchised people or out-migration of households with broader residential choices, leaving behind a concentration of the former (Oakes et al., 1996; Been and Gupta, 1997; Pastor et al., 2001). Hence, the direction of causality may be reversed. A local concentration of politically weak residents may present the site as a suitably low-cost location. Alternatively, siting the undesirable use may have instigated local deprivation. Or both possibilities may be true: that poor, minority neighborhoods were selected to host sites and poor, minority families moved in after the facility opened. One direction does not preclude the other.

Contemporary environmental geographers recognize that states of injustice arise from reinforcing processes of industrial site selection, migration and location choices of established people, migration or immobility of vulnerable populations, and the operation of locally unwanted facilities. Perceived risk of exposure and concerns over territorial inequity drive effective opposition to siting among established groups (Llurdés et al., 2003; Cain and Nelson, 2013). In communities comprised of the less powerful, planning agencies often marginalize anti-incineration activism (Davies, 2003, 2005), which in turn discourages association and development of formal institutions of opposition (Foley and Edwards, 1996; Davies, 2008). Once initial battles are lost and an unwanted use is introduced to a community, resistance wanes and acceptance of monetary compensation increases, a process of “environmental blackmail” (Bullard, 1992) that enables extensions of the facilities and expansion of their operations and capacity (Ferreira and Gallagher, 2010).

Scholars of environmental justice analysis have begun to focus on the temporal ordering of these reinforcing explanations (Richardson et al., 2010). Fig. 1 presents a conceptual diagram of these reinforcing processes of environmental injustice. The facilities planner includes political costs in the calculus identifying the least cost site for a locally undesirable land use and disproportionately avoids localities concentrated with powerful people (Hamilton, 1995; Pastor et al., 2001; Laurian and Funderburg, 2014). Once a site is selected to house an unwanted facility, some from the local mobile and empowered population migrates out of its vicinity, while minorities and poor people may be attracted to the locale by lower land and housing prices reflecting uncompensated losses from the noxious use of the facility (Cameron and McConaha, 2006; Crowder and Downey, 2010). As Fig. 1 depicts, minority move-in and outmigration of the empowered population occur at multiple junctures in the process, as the facility is operated for its unwanted use in addition to the immediate period after site selection. The facility continues to interact with its milieu as an educated, powerful population seeks to limit its operations, restrict its



Fig. 1. Reinforcing processes of environmental injustice.

capacity, and diminish volumes of effluent, while a minority population may lack similar wherewithal. Reciprocally the operations also impact the constitution of local populations as mobile people emigrate and minority populations immigrate or remain. The cycle renews as the site selection decisions of additional noxious facilities for which political costs matter in an ongoing process of cumulative causation leading further to injustice and despair (Myrdal, 1957; Maruyama, 1963; Galster, 1992).

We move forward in this paper in the spirit of Noonan's (2008) critique of the lack of causal explanations in the environmental justice literature for various distributions of deprivation and specifically, the lack of an explicit counterfactual to the policy intervention modeled. Indeed, the counterfactual in our analysis is the migration and residential location decisions of foreigners, in particular, but also those of the established population, in towns that opened incinerators had they never opened an incinerator, which is of course contrary to fact. If little difference exists in the concentration of immigrants in a town with or without its incinerator, previous claims of environmental injustice are bolstered. These previous claims are supported by evidence that towns with high concentrations of immigrants had statistically larger probabilities of opening an incinerator, holding all else constant at the time of siting (Laurian and Funderburg, 2014). In examining the capacity and emissions of incinerators, we re-open previous arguments pertaining to the potential for lax regulations in minority and poor communities (Viscusi and Hamilton, 1999; Sigman, 2001; Gray et al., 2010) as a potential explanation for higher cumulative risks from air toxics and higher pollutant emissions in minority communities (Morello-Frosch et al., 2001; Padilla et al., 2014).

3. Risk perception, residential choice, and the price of housing

Environmental discrimination is embedded in mutually reinforcing processes of risk perception and acceptance, residential choice and migration, and the simultaneous adjustment of housing prices at alternative locations. Recognition and belief in the potential for harm from a nuisance and anticipation of consequences factor into the decision and ability to situate a technological hazard (Easterling, 1992), resident decisions to stay or leave after the siting

is determined (Slovic, 1987; Hunter, 2005), and likewise the bid-rent for a place, which simultaneously deters some populations and attracts others (Farber, 1998). At the same time these changes create and replicate social perceptions as stigma or ideal (Bush et al., 2001). In this section, we describe how environmental risk perceptions develop, their relationship to migration and the concentration of poor and minorities near nuisances, and the value of land, which regulates, and is determined by, the flow of different populations to and from the affected area as well as the expansion of additional unwanted uses.

3.1. Perceptions of risks

Community perceptions of environmental risks derive from understanding among members, communication by experts, cultures and contexts, and experiences with the particular hazard. Psychological and socio-cultural perspectives and approaches to risk perception research converged over the last 35 years to elucidate common factors; although no universal set of predictive rules can be attained that is applicable to every situation (Bickerstaff, 2004). Bickerstaff (2004) documents advancements in perceived risk assessment from its early exclusive focus on examinations of individual cognitive and attitudinal processes to a field that now encompasses study in communication of risk-related information and the socio-cultural value systems that shape community attitudes and enable local decisions about risk acceptability. Modern theory of risk perception extends beyond scientific calculus of direct exposure probabilities to the formation of values deeply ingrained in worldviews (Dake, 1991, 1992; Peters and Slovic, 1996).

Most people in the U.S. perceive waste incinerators as high risk, consistent with other hazardous waste management alternatives, and identify incineration as the least acceptable technology for their local communities. In a survey eliciting attitudes about six alternative hazards, more respondents rated incineration as high risk – a greater than 50–50 chance of accidental exposure or catastrophic event – than the number of respondents similarly concerned about nuclear power (Rogers, 1998). The same study identified waste incineration as the least favored technology for location in the respondent's community (Rogers, 1998). The phenomenon that some land uses are unacceptable to a community at any price inspired the language of LULUs, locally unwanted land uses (Popper, 1985). Reservations about incinerators are warranted. Evidence suggests people living near incinerators have increased risk of cancer of the stomach, colon, liver, and lungs and for all cancers combined (Elliott et al., 1996). Local studies of incinerators in France and Italy find an elevated risk for non-Hodgkin's lymphoma and soft-tissue sarcoma (Viel et al., 2008; Biggeri and Catelan, 2005). On the other hand, outcomes have been inconsistent across investigations of congenital malformations such as facial cleft and renal dysplasia despite multiple reports of increased risk of birth anomaly among people living near incinerators (Porta et al., 2009). A study in Japan found no statistically excessive reproductive disorders within two kilometers of an incinerator (Tango et al., 2004). A different investigation inferred an elevated risk of respiratory diseases near incinerators, especially among children (Miyake et al., 2005), but another study found no similar statistical association (Shy et al., 1995). Due to perceived potential for such maladies, incinerators and other technological hazards can impose considerable psychological distress on people who live near them (Lima, 2004; Downey and Willigen, 2005; Santiago-Rivera et al., 2007; Marques and Lima, 2011).

The perception of risk is shaped by complex social, economic, and political factors in addition to the distribution of pollution and its direct physical consequences (Bickerstaff, 2004). Disproportionate distributions of environmental hazards near vulnerable people

share some similarities to the inequitable allocations of other urban goods such as access to housing, jobs, education, and healthcare (Schweitzer and Stephenson, 2007). In its most basic form, risk perception involves a direct encounter with a physical nuisance, an eyesore of dirt, filth, smog or other forms of visible pollution (Bickerstaff and Walker, 2001; Wakefield et al., 2001). Yet, the distribution of perceived risk is distinguished by perceived characteristics of a hazard (Bickerstaff, 2004). People have difficulty determining the magnitude of a hazard and amplify perceived risks when toxins are invisible and health effects are uncertain. Technological hazards evoke fear and dread when risks are involuntary, uncontrollable, or unknown (Slovic, 1987). Perceived risks among lay persons exceed the scientific assessments of danger estimated by experts (Cvetkovich and Earle, 1992; Treichel, 2000). Through a process of habituation, local residents often reduce perceptions of risk over the long term after they have had time to become familiar with a new facility. For example, residents of Oporto, Portugal living close to an incinerator (within 2 km) had a heightened perception of risk before the facility opened and the difference in perception from those living further away diminished during the period the incinerator operated (Lima, 2004). Perceived risks also tend to be higher among low-income and minority people and the lowest among white males (Flynn et al., 1994; Boholm, 1998; Finucane et al., 2000). Social and economic impacts of environmental hazards are heightened by distrust in institutions, media coverage, perception of dread, and lack of agency (Kasperson et al., 1988; Renn et al., 1992).

Perceptions of risk are an important determinant of organized opposition to siting of technological hazards, but capacity and resources also matter. Risk perceptions can be exploited by opposition groups in anti-siting campaigns (Kasperson et al., 1992; Schively, 2007). Generally, opponents are wealthier, older, more educated, and more likely to attend public meetings (Mansfield et al., 2001), opposite attributes to ones empirically associated with heightened risk perception noted in the previous paragraph. A burgeoning research into political mobilizations contesting siting and operation of facilities informs about the complex dynamics at play in disputes in France (McCauley, 2009; Luneau, 2012), Greece (Botetzagias and Karamichas, 2009), Italy (Norese, 2006; Lami and Abastante, 2014), Spain (Llurdés et al., 2003), and the United Kingdom (Davies, 2008; Leonard et al., 2009; Rootes, 2009; Ferreira and Gallagher, 2010).

3.2. Residential choice and migration

Residential choice and migration are intertwined with the magnitudes of risk perceived at alternative locations. Home sales and leases reveal preferences for a location that include a tolerance or acceptance for the environmental bads impacting real estate. A sufficient explanation for migration is needed if minorities move near polluting facilities after siting, the notion described pejoratively that “minorities simply flock to the nuisance” (Lejano and Iseki, 2001, p. 58). Segregation arising from white flight, racial discrimination in leasing, selling, financing, and insuring, affordability, and other constraints on minority housing choices is central to understanding environmental injustice (Hite, 2000; Schweitzer and Stephenson, 2007). One reason poor and minority people remain in homes near hazardous facilities is they lack alternative choices of location (Hunter, 2005). Hunter (2005) summarizes the contribution of classical migration theories to understanding reasons that vulnerable people concentrate near environmental hazards. Pollution is a source of stress in a community, along with congestion, poverty, crime and violence, that shapes perceived risk (Kondo et al., 2014). Human beings differ in their ability to control, eliminate, or reduce exposure to nuisances and residential mismatches may lead to strains that cause individuals to look hastily

for alternative habitats, or conversely, to strengthen attachments to an unsuitable place (Wolpert, 1966).

The choice to move or stay also depends on the relative utility, or satisfaction, one enjoys at a current location compared to that which could be received at the next best alternative. “Dissatisfaction can result from a change in the needs of a household, a change in the social and physical amenities offered by a particular location, or a change in the standards used to evaluate these factors” (Speare, 1974, p.175). Yet, U.S. counties with more environmental hazards do not lose more residents to out-migration than counties that lack hazards (Hunter, 1998). People persist in residential locations subjected to environmental risk because (Kates, 1962, p. 135)

1. They do not know about the hazard and are therefore not unduly concerned.
2. They know about the hazard, but personally do not expect a future event, and therefore are not unduly concerned.
3. They expect a future event, but do not expect to bear a loss, and are therefore not unduly concerned.
4. They expect to bear a loss, but not a serious one, and are therefore not unduly concerned.
5. They expect to bear a serious loss and they are concerned. Therefore they have undertaken or are planning to undertake some action to reduce such losses.

Additionally, residents may expect a loss but accept the costs in exchange for gaining locational benefits (Graves, 1983; Mueser and Graves, 1995). Administrators of one of the poorest communities in the U.S. actively recruited incinerators and other waste management facilities during the 1970s and 1980s after experiencing severe job losses in other industries and failure to recruit other businesses. The village of Robbins, a Chicago suburb governed entirely by African Americans, successfully courted the incinerator for the promise of nearly \$2 million in rent payments each year (Pellow, 2002, pp. 91–92). Similar pressures of “environmental blackmail” (Bullard, 1992) have been noted in France; decentralization of waste management strategies has advantaged proponents of incineration in small towns where economic development is a priority and proponents have greater capacity and access to resources to overwhelm anti-incineration campaigns (McCauley, 2009). Incentives and subsidies can produce distortions that induce excessive entry in incineration markets and over-capacity (Massarutto, 2015). The amount of actual payments to Robbins declined to around \$400,000 after the state of Illinois repealed its Retail Rate Law, a generous tax credit program, and neighboring communities declined to send their waste to the burner for incineration; the waste-to-energy plant’s owner declared bankruptcy and closed the incinerator in 2000.

3.3. Price of housing

Neoclassical economic theory suggests changes in perceived risk and migration simultaneously adjust housing prices. Real estate owners lower acceptable sale and lease prices and potential buyers and leasers reduce willingness to pay (bid-rents) for properties near unwanted facilities, effects moderated by preferences for risk avoidance relative to preferences for other characteristics of housing. Preferences for avoiding risk are revealed through market transactions. Studies in the empirical literature estimate the marginal utility using hedonic regression analysis, case-control group studies, and contingent valuation surveys (Farber, 1998). In general, polluting industrial facilities and brownfields have been shown to negatively impact nearby property values in France

(Sauvage, 1997; Letombe and Zuindeau, 2001, 2005; Travers et al., 2009). Farber (1998) summarizes the findings of 25 studies measuring the property value impacts from real and perceived environment risks in the U.S. One study that estimates effects of waste incinerators finds no statistical relationship between home values and the nuisance (Zeiss and Atwater, 1989). Zeiss and Atwater (1989) contend that changes in property prices may be an inappropriate means of gauging economic harm from environmental hazards due to prevalent violations in assumptions governing hedonic analysis, that supply is fixed and buyers have sufficient information about the hazard. Two studies of homes near an incinerator in North Andover, Massachusetts find significant price effects attributed to the nuisance (Kiel and McClain, 1995a,b). Kiel and McClain (1995a) distinguish effects during the pre-rumor, rumor, construction, online, and operation stages of the waste-to-energy plant. The authors find effects are much larger after the plant opened than during its construction phase and effects are not statistically significant prior to construction (Kiel and McClain, 1995a). Using repeated sales data, Kiel and McClain (1995b) find house appreciation rates are significantly slower near the incinerator only after the plant is operating, which suggests a long-run negative economic impact extending seven or more years after the plant comes online.

The literature offers a variety of explanations for differential impacts estimated across studies. Summarizing effects across different studies may not be meaningful due to changes in risk perceptions over time due to increased environmental consciousness (Farber, 1998). But an analysis of effects on home prices after National Priorities Listing finds a negative impact of home prices near some of the 57 superfund sites and no impact near others even though time periods are similar (Kiel and Williams, 2007). The central contribution of the convergence of traditionally quantitative perspectives about risk with richly qualitative understandings of the social, political, economic, and cultural milieu within communities is that perceptions and their impacts are indelibly contextual. Perceived risks are modified by media attention (McCluskey and Rausser, 2001), characteristics of a site and its potential to reward a workforce (Kiel and Williams, 2007), and the socio-cultural details of individuals and groups in the vicinity (Bickerstaff, 2004). Quasi-experimental research design can retain sensitivity to these and other contextual differences. Quantitative and qualitative forms of analysis may proceed once comparison groups are identified. We now describe a quasi-experiment that addresses the question about whether minority concentration near incinerators in France can be explained by migration after their siting.

4. Methods

We develop a quasi-experimental research design to test the responses of established and immigrant populations to a new waste incinerator opening in the local town. Our strategy is to identify a twin French town that has never opened an incinerator for every French town that hosts an incinerator, whereby the only important difference between the pair is the incinerator in the “intervention” town and the lack of one in the “control” town.

4.1. Quasi-experimental design

We use propensity score matching (Rosenbaum and Rubin, 1983; Dehejia and Wahba, 1999, 2002) to identify the twin town with local and regional demographic and economic characteristics that best approximates each host town’s characteristics at the time of siting. The twin town that serves as a control for a town hosting an incinerator is the town most similar to the host in population, employment, unemployment, industry mix, immigrant concentra-

tion, and regional context, except the twin was not selected to host a facility. We then perform paired *t* tests of the differences-in-differences estimator δ_{DD}^y , measuring the average impact of incinerators on the constitution of French towns, called communes in France. Similar approaches have been used for measuring the impact of minimum wage laws on employment (Card and Krueger, 1994) and the impact of new highway extensions on population and employment (Funderburg et al., 2010). Mathematically, our design is expressed as

$$\delta_{DD}^y = \overline{y\Delta}_{after}^{I'=1} - \overline{y\Delta}_{before}^{I'=1} - \left(\overline{y\Delta}_{after}^{I'=0} - \overline{y\Delta}_{before}^{I'=0} \right) \quad (1)$$

$$\log \left[\frac{\pi(I_{i,t} = 1)}{1 - \pi(I_{i,t} = 1)} \right] = \alpha_{t-7}(\mathbf{I} + \mathbf{W})_{i,t-7} + \mathbf{W}\mathbf{X}_{i,t-6}\beta_w + X_{i,t-6}\beta_x + \epsilon$$

where *y* is the demographic or economic dependent variable of interest—established population, immigrant population, or employment. Immigrant population is measured two ways—as the number of foreign born persons in a town and as the number of persons in a town born abroad. Established population is the difference from total population after subtracting the two measures of immigrant people and employment is the total number of employed persons in a town. Our interest is in the average impact of incinerators on net migration or employment so each $y\Delta$ is the difference in population or employment from one census to the next for the particular category and the four categories from which differences are taken are incinerator towns ($I' = 1$) before and after the incinerator opened and their twin towns ($I' = 0$) before and after the paired incinerator town's incinerator opened.

We use the selection Eq. (1) to estimate the propensity for each town to open an incinerator within six years of a census, given the value of town demographic and economic characteristics at the time of the most recent census. The dichotomous dependent variable necessitates the logistic functional form. In other words, $I'_{i,t} = 1$ in Eq. (1) if an incinerator opened in the town within six years of the census reporting variables $\mathbf{X}_{i,t-6}$; otherwise, $I'_{i,t} = 0$ (Laurian and Funderburg, 2014). The $t-6$ operationalization assumes that the most recent census reported prior to an incinerator opening best represents the conditions prevailing at the time of incinerator siting. The specification is necessary due to irregular intervals between French censuses, from seven to nine years during our study period 1968–1999. Our approach enables comparability of the estimators across censuses. Longer lags would assume an earlier census reflects siting conditions better than the recent census; shorter lags omit incinerators from estimation. Our imposed regularity allows us to compare estimates and test for the length of the planning process across censuses in the event siting decisions take longer than six years.²

The spatial logistic regression Eq. (1) is structured to account for the extreme rarity of the incinerator events. The number of incinerators that opened in France within six years of a census across all five censuses during the study period is 107; while the number of French communes varied between 35,788 and 36,107. Hence, the average probability across the five censuses would be around 5.94×10^{-4} if the selection of incinerators were completely random. Eq. (1) accounts for the rarity of events by rapidly diminishing the estimated probability for a town that already has an incinerator in its immediate region composed of itself depicted in identity matrix *I* and its nearest 100 neighboring towns accounted for in the weights matrix *W* (Laurian and Funderburg, 2014). Given that the

siting decision involves a cost comparison across viable sites in a particular region, Eq. (1) also controls for the average value of the census characteristics for the 100 nearest towns $\mathbf{W}\mathbf{X}_{i,t-6}$. Sensitivity tests examined alternative *k* nearest neighbor weights at *k* = 25, 50, 100, and 200 and found that 100 nearest neighbors performed best in approximating French decisionmaking in the regional siting of incinerators; although estimates from the spatial logistic regression were not sensitive to the particular weights matrix used (Laurian and Funderburg, 2014). The demographic and economic variables included in matrix *X* are the natural logarithm of population, the log of employment, the percent of the town's workforce employed in manufacturing, the percent of a town's workforce that is unemployed, the percent of the town's population that is foreign born, and the percent born abroad.

The spatial logistic regression results for Eq. (1) are reported for each of the five censuses in Table 1. These results are similar to findings reported by Laurian and Funderburg (2014); minor differences are attributed to the inclusion of both measures of immigrant population in the regressions of the current paper.

Table 1 presents solid evidence that concentration of immigrants influenced incinerator location in the six years following the 1968 and 1999 censuses. A one percent higher proportion of a town's population that is foreign raised that town's odds of receiving an incinerator by 21 percent during the six years following the 1968 census and a one percent higher proportion that is foreign born increased the odds by 23 percent in the six years following the 1999 census. Both effects are significant at the 95 percent confidence level. Conversely, a higher proportion of immigrants in nearby competitor towns lowers the probability an incinerator locates within the town's own borders (Laurian and Funderburg, 2014). Also important for our purposes, the logistic curves fit the data well in each of the five regressions. The X^2 associated with the likelihood ratio is significant at the 99.9 percent confidence level in all five models and the Hosmer–Lemeshow test fails to reject the null hypothesis of differences in fit across deciles of the predicted probability for four of the five regressions.³ All the variables testing significant in each of the five models bears the expected sign.⁴

4.2. Propensity score matching

We use nearest available neighbor propensity score matching within calipers (Rosenbaum and Rubin, 1985; D'Agostino, 1998; Smith and Todd, 2005) to identify for every French town that opened an incinerator a twin commune with an estimated propensity closest to that estimated for the incinerator town, given values of the census variables at the time of incinerator siting. Hence, the only material difference between each pair of towns is that the identified control neither had nor opened a waste incinerator, while the incinerator town opened an incinerator during the six years following the census. Nearest available neighbor matching at best assures a local optimum, meaning that the absolute value of the difference in propensity scores is minimized.

The benefit of the particular algorithm is that cases (the incinerator towns) are mapped one-to-one to their controls, which allows for the paired *t* tests of the differences-in-differences estimator above and econometric controls for matched pair fixed

² A test of all time-lagged census variables predicting incinerators that opened between 2000 and 2005 reveals no information loss from excluding the earlier censuses and retaining only the most recent census. Hence, the assumption implied by the $t-6$ operationalization is empirically supported. We thank an anonymous referee for suggesting the lagged test.

³ Our purpose here is to identify best matches for incinerator towns rather than duplicate the hypothesis tests by Laurian and Funderburg (2014) so we are not overly concerned about the results of the Hosmer–Lemeshow test for 1999. Across the censuses, both measures of immigrant population clearly provide useful information determining the location of incinerators so we need to include both variables in the matching procedure regardless of the fact that excluding one results in satisfactory results for the Hosmer–Lemeshow tests in 1999.

⁴ A detailed discussion of the hypotheses is presented by Laurian and Funderburg (2014).

Table 1
Spatial logistic regression results for Eq. (1).

Variable	Coefficient (standard error)				
	<i>t</i> – 6 = 1968	<i>t</i> – 6 = 1975	<i>t</i> – 6 = 1982	<i>t</i> – 6 = 1990	<i>t</i> – 6 = 1999
Intercept	–23.81** (4.69)	–21.34** (4.42)	–8.22* (3.92)	–14.25* (5.26)	–21.05** (4.01)
(I + W) <i>y</i> _{<i>i,t</i>–7}	–110.80 (127.40)	–5.46 (14.25)	–7.95 (15.16)	–6.08 (8.20)	–127.40* (58.27)
Log(<i>population</i>) _{<i>i,t</i>–6}	1.97 (2.49)	1.02 (2.31)	0.10 (2.74)	–0.35 (2.87)	–0.35 (0.46)
W Log(<i>population</i>) _{<i>i,t</i>–6}	3.26 (4.36)	2.42 (4.27)	–4.84 (4.68)	1.87 (5.38)	3.19* (1.47)
Log(<i>employment</i>) _{<i>i,t</i>–6}	–0.35 (2.44)	0.08 (2.26)	1.26 (2.72)	1.56 (2.83)	1.27** (0.38)
W Log(<i>employment</i>) _{<i>i,t</i>–6}	–3.07 (4.16)	–2.31 (4.09)	4.56 (4.59)	–1.79 (5.24)	–2.60* (1.21)
% <i>manufacturing</i> _{<i>i,t</i>–6}	–0.04 (0.03)	–0.03 (0.02)	–0.03 (0.02)	–0.02 (0.03)	–0.02 (0.02)
W % <i>manufacturing</i> _{<i>i,t</i>–6}	–0.01 (0.04)	0.07 (0.04)	0.03 (0.03)	–0.04 (0.05)	0.04 (0.07)
% <i>unemployed</i> _{<i>i,t</i>–6}	–0.10 (0.27)	0.03 (0.13)	0.06 (0.08)	–0.03 (0.09)	0.01 (0.07)
W % <i>unemployed</i> _{<i>i,t</i>–6}	0.61 (0.57)	0.41 (0.40)	–0.36 (0.20)	–0.12 (0.20)	–0.02 (0.13)
% <i>foreigners</i> _{<i>i,t</i>–6}	0.21* (0.09)	0.01 (0.08)	0.08 (0.10)	0.07 (0.08)	–0.20 (0.14)
W % <i>foreigners</i> _{<i>i,t</i>–6}	–0.30 (0.31)	–0.04 (0.30)	–0.43 (0.26)	–0.21 (0.27)	0.19 (0.31)
% <i>born abroad</i> _{<i>i,t</i>–6}	–0.16 (0.12)	0.08 (0.08)	–0.08 (0.12)	0.08 (0.08)	0.23* (0.09)
W % <i>born abroad</i> _{<i>i,t</i>–6}	0.13 (0.23)	–0.12 (0.21)	0.24 (0.19)	–0.09 (0.19)	–0.21 (0.19)
Log likelihood	–99.31	–97.75	–149.19	–118.59	–116.50
Likelihood ratio(for all $\Pr > \chi^2 < 0.001$)	156.06	83.30	186.90	102.75	121.54
Pseudo <i>R</i> ²	0.44	0.30	0.39	0.30	0.34
Hosmer–Lemeshow Fit ($\Pr > \chi^2$)	2.82 (0.95)	2.32 (0.97)	16.61 (0.09)	14.12 (0.08)	16.05 (0.04)
Akaike info. criterion	226.62	223.50	326.38	265.18	261.01
Number of obs	35,937 (21 Y=1)	35,788 (15 Y=1)	35,943 (30 Y=1)	36,107 (20 Y=1)	35,826 (21 Y=1)

* $p < 0.05$.

** $p < 0.01$.

effects discussed below. The difference between propensities is not always minimal because a unique control (next available nearest) is matched to each case, whereby the same control's estimated propensity might otherwise be closest to estimates for more than one case. The result is also not globally optimal in that other assignments can produce a smaller average difference or smaller average absolute value difference between propensity scores in aggregation of the pairs when the distance in propensity scores of the case and control in any one pair can be very large. The caliper is the maximum distance the propensity score of the control is allowed to depart from the propensity score of the case. We use an adaptive caliper that adjusts to the number of significant digits in the case's propensity score. If the propensity score is 0.50, the caliper is 10^{-1} . If the propensity score is 0.05, the caliper is 10^{-2} . If the propensity score is 5×10^{-5} , the caliper is 10^{-5} . An adaptive caliper is necessary due to some very small propensities resulting from the rarity of events. For example, a fixed caliper of 0.1 would match a control with a propensity score of 5×10^{-5} to an incinerator town with a propensity score of 0.05 while their characteristics are very different.

Although a unique control town is matched to each incinerator town in each of the census time periods, we allow the same control town to be matched to towns that opened incinerators in different intercensal periods. The key to the quasi-experiment is to assign as a control a commune that met all the right conditions at the

time incinerator towns were selected, except only the control town wasn't chosen. Hence, it serves as a viable twin that didn't receive the intervention. The process is analogous to a forecast. Conditions change between censuses and the regional maps where incinerators are located are redrawn. To account for the conditions at the time of siting, we identify best matches separately for each of the five time periods. A commune with a predicted high probability of receiving an incinerator that neither receives one within its borders nor within its region of competitor towns will likely have a higher propensity in the future, making it an excellent candidate to use again as a match for town that opened an incinerator after a later census.

4.3. Matched pair fixed effects regression model

As Table 1 indicates, 65 of the 107 incinerators that opened during the six years following a census opened shortly after the censuses of 1975, 1982, and 1990. These 65 cases meet the conditions of the differences-in-differences experiment above, having at least one pre-intervention observation measuring net migration or employment growth for an intercensal period and at least one post-intervention observation also measuring the change in census variables from census to census. However, the cases that opened incinerators immediately following the 1975 and 1982 censuses have three and two post-intervention observations, respectively,

and for census years 1982 and 1990 there are two and three pre-intervention observations, respectively. Hence, more statistical power can be gained by pooling the time periods together in the regression

$$\log y_{i,t} = \alpha_j + \beta_1 \text{Post1} + \beta_2 \text{Post2} + \beta_3 \text{Post3} + \beta_4 \log y_{i,t-1} + \sum_{t=1}^{T-1} \alpha_t \text{Cens}_t + \sum_{m=1}^{M-1} \alpha_m \text{Dept}_m + u_{i,t} \quad (2)$$

Eq. (2) is a matched pair fixed effects regression model that tests for impacts of incinerators on subsequent changes to population, employment, and minority concentration, similar to the differences-in-differences estimator but for longer term effects. The impact of an incinerator on net migration or employment growth is distinguished into near term and long term effects one, two, and three intercensal periods following the opening of the incinerator, captured by indicator variables Post1, Post2, and Post3 that are equal one if the observation is for an incinerator town one, two, or three censuses after its incinerator opened, respectively, and zero otherwise.

Eq. (2) also includes controls for the demographic or economic activity in the previous census $\log y_{i,t-1}$, time effects for the census in which the value is observed Cens_t , and spatial fixed effects for the French department in which the commune is located Dept_m . The model includes dummy variables for three of the five censuses; 1968 is lost to the inclusion of the lagged dependent variable and 1999 is the reference census. France has 94 contiguous departments in the main part of its territory, where most of the approximately 36,000 communes are located. Incinerators are located in 66 of these departments and 59 departments have incinerators that opened within six years of a census, as operationalized in the current paper. To the extent more than one incinerator town or controls are located in the same department, the department provides useful information in the form of a spatial fixed effect. A unique aspect of Eq. (2) is the matched pair fixed effects α_j , which yields a separate constant term for each match, an incinerator town and its twin (see O'Keefe (2004) for an example of matched pair fixed effects for zip codes and Funderburg and MacDonald (2010) pursuant to residential parcels). The Post# variables then measure how log points of the dependent variable depart from a paired expectation when an incinerator town opens its incinerator because control communes are always valued zero in the Post# variables.

4.4. Method of comparisons across incinerators

For the last part of our analysis, we examine whether incinerators are operated differently in communes with large concentration of new immigrants when compared to incinerators located in towns with small concentration of immigrants. By definition, both types of town have received the incinerator intervention so a quasi-experimental design is not possible in this instance. Instead, we classify incinerator towns as unambiguously high concentration, unambiguously low concentration, or ambiguous according to four measures of immigrant population. The four measures include the percent of the town's population that is foreign born in 1999, the percent born abroad, the change in the percent foreign born between 1968 and 1999, and the change in percent born abroad. We consider the value of a measure high if it is greater than the 3rd quartile for all towns and low if the measure is lower than the 1st quartile for all towns. We categorize an incinerator commune as having an unambiguously high concentration of immigrants when one or more of these measures exceeds its 3rd quartile and none of the measures is below its median. We categorize an incinerator town as having an unambiguously low concentration of immigrants

when one or more of the measures is below its 1st quartile and none of the measures is above its median.

Emissions and other operations data are notoriously difficult to acquire for a broad cross-section of municipal solid waste incinerators in France (Nzihou et al., 2012). Although our data have some problems, they provide interesting insight into varying burdens of operations on neighboring communities that differ in political power represented as concentrations of immigrants. The data for the number of burners and total capacity at each site come from the National Center for Independent Information on Waste (CNIID). The CNIID data are good quality, with only two missing values for capacity and no missing values for number of burners. There are also no obvious instances of data entry error. The data on CO₂ emissions come from the French Registry of Polluting Emissions (IREP). The IREP data unfortunately have several missing values and a few obvious data entry errors in emissions over time. These are obvious because the values are not the same scale as other values in the time series for the same incinerator and are also out of scale with other incinerators in France. Still, these extreme values are limited to years 2009 and 2010 in the time series.⁵ We avoid problems with the extreme values and minimize missing values in the emissions data by focusing our analysis on years 2006 through 2008.

We evaluate possible differences in operations (emissions and capacity) between the high and low concentrations of immigrant people groups with a simple one-tailed *t*-test, assuming unequal variances. The hypothesis and basis for a one-tailed test is that operations will be greater where immigrant populations are most concentrated and hence political opposition is weaker. We now discuss the findings of our analyses.

5. Incinerator towns and their twins

An important product of this research is identification of twin towns for communes throughout France that currently accommodate a waste incinerator. Each twin town is similar to its paired incinerator town in economy and demographics and similar in terms of the region in which it is situated. Fig. 2 maps the locations of incinerators and the twin towns we identified in two rounds of propensity-score matches.

Our spatial propensity score matching model worked well. The model weights information about the 100 nearest neighboring towns into the estimated probabilities of receiving an incinerator. The first round of matching identified 102 twin towns for 102 of the 107 French communes that received an incinerator within six years of a census. The model worked well at emulating the regional site selection process and 13 of the towns initially identified as controls later opened an incinerator after a subsequent census. These 13 accurate predictions are displayed in Fig. 2. Hence, our model demonstrates good predictive capability, confirming it to be a reasonable “model of how facilities are sited” (Been and Gupta, 1997, p. 17).

The Appendix provides a complete list of the 107 study towns with an incinerator by the year that the incinerator opened and the matches we are able to identify. With 1968 census data and locations of incinerators that opened before 1975, our first round (incidentally) predicted incinerators that opened in Besançon in 1976, Brest in 1988, and in Nancy in 1995. With 1975 census data and incinerators that opened before 1982, it predicted the incinerator that opened in Montauban in 1986. The first round incidentally predicted the openings of incinerators in Haguenau in 1990, in Lons-le-Saunier in 1994, in Chartres in 1998, in Mulhouse in 1999,

⁵ Specifically, the extreme values and apparent data entry errors are for Rosiers-d'Egletons in 2009 and Guichainville, Paillé, and Taden in 2010.

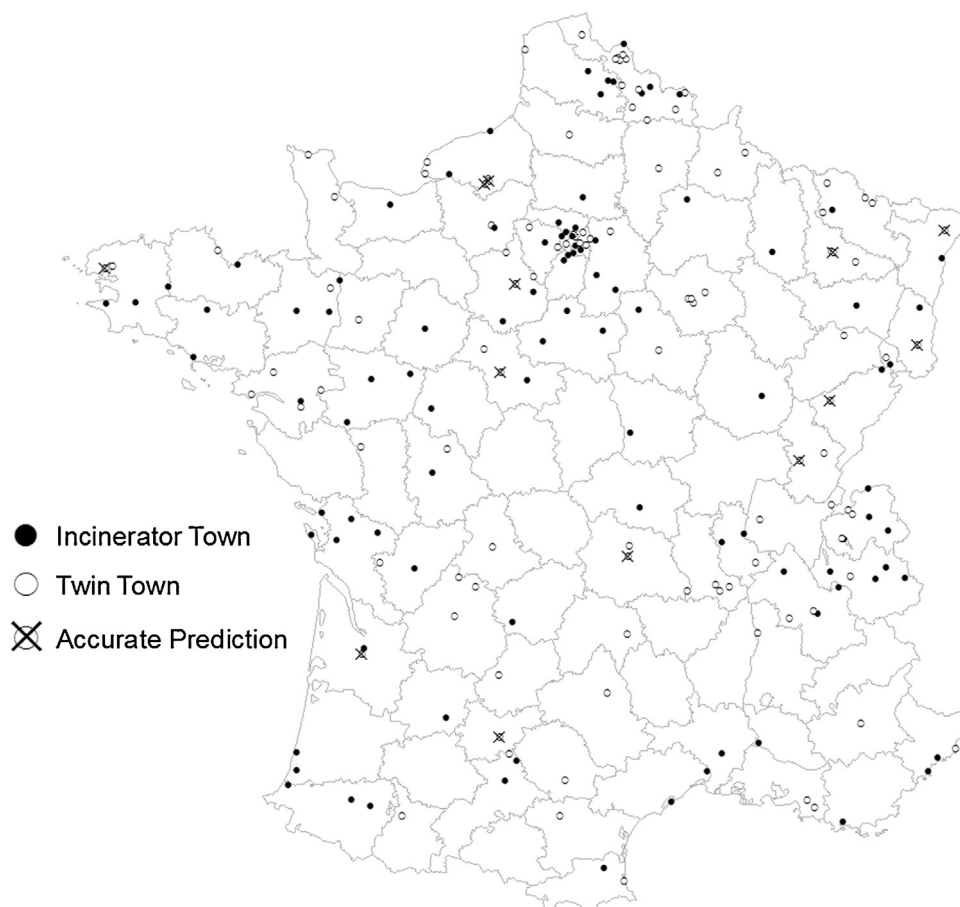


Fig. 2. French incinerator towns and their twins.

and in three communes in 2000, Blois, Le Grand-Quevilly, and Rouen, using only census data available in 1982 and knowledge of incinerator locations available in 1988. With 1990 census data, the model predicted Bègles, which opened an incinerator in 1998 and the model predicted an incinerator at Clermont-Ferrand based on the 1999 census, 14 years before an incinerator opened there in 2013. Accurate predictions are ineligible controls, identified in the Appendix with parentheses indicating the year their incinerator opened.

Receipt of the intervention eliminates a town from eligibility to be used as a control so we ran the model a second time to identify second best twins for the 13 incinerator towns initially matched to a twin that subsequently acquired an incinerator. Unfortunately, no second match was found within the caliper 10^{-x} for the significant digit of the propensity score for three of these. The complete list of matches in the Appendix also identifies the twin towns assigned from the second round. In the end, we were able to identify 99 control communes for 99 of the 107 intervention towns that opened an incinerator within six years of a census.

5.1. Match quality

The incidental prediction of 13 incinerator locations provides one indicator of the quality of our matching model. Another indicator is the difference in key variables between the incinerators and their controls. We examine these differences in Table 2. We find no meaningful difference between the 99 incinerator towns and the 99 control towns for any of the census variables included in our

matching model. The mean incinerator town is slightly larger than the mean control commune in terms of population and employment, yet the median incinerator town is slightly smaller than the median control town. Indeed, the difference in the largest town's size for the two groups explains the difference in means while their third quartiles are reasonably close.

As important to our discussion is how well the two groups compare regionally. A key contribution of this paper is our use of the spatial information directly in the matching process. The average population of an incinerator town's 100 nearest neighboring towns (WPopulation) is very close to the average population of the control town's 100 nearest neighbors. Not only do we assure that the control town is assigned by having own demographic qualities closest to an intervention town, we also ensure it has the same regional context as well. Such regional comparisons are very important to a quasi-experiment for environmental justice purposes such as the incinerator location problem under study due to the regional nature of siting and migration decisions.

6. Findings

Results from the paired *t* tests reveal that the incinerators have had no statistically significant effect on employment growth or net migration of the established population in the census period after they opened. The test results provide weak evidence that immigrant populations were more concentrated in incinerator towns after incinerators were sited than their concentrations would be had the incinerator never been sited. Table 3 displays the results.

Table 2
Match quality.

Variable	99 Control towns ($I^* = 0$)			99 Incinerator towns ($I^* = 1$)		
	Mean (median)	Maximum (3rd quartile)	Minimum (1st quartile)	Mean (median)	Maximum (3rd quartile)	Minimum (1st quartile)
Propensity	4.629×10^{-2} (1.585×10^{-2})	3.541×10^{-1} (6.083×10^{-2})	1.500×10^{-5} (2.060×10^{-3})	4.823×10^{-2} (1.586×10^{-2})	4.331×10^{-1} (6.046×10^{-2})	2.053×10^{-5} (2.059×10^{-3})
Population	34,955 (21,976)	205,052 (45,375)	160 (4072)	37,214 (19,147)	241,760 (50,229)	184 (2492)
Employment	15,398 (8400)	126,447 (20,717)	64 (1675)	16,278 (7840)	93,604 (23,288)	56 (1380)
Unemployed	4,090 (1475)	36,946 (4718)	0 (251)	3,950 (1505)	30,379 (5417)	0 (166)
Manufacturing	9,187 (4219)	77,389 (14,314)	0 (1165)	8,756 (5627)	56,873 (11,351)	0 (763)
Foreign Born	3,241 (1015)	25,556 (2836)	0 (152)	2,979 (1516)	16,661 (4080)	0 (64)
Born Abroad	4,170 (1727)	26,183 (4800)	0 (288)	4,959 (2124)	43,312 (6932)	0 (164)
WPopulation	5,205 (1819)	47,068 (3670)	219 (851)	4,535 (1773)	49,071 (3711)	355 (979)
WEmployment	2,205 (659)	21,658 (1402)	85 (324)	1,903 (633)	22,699 (1281)	146 (380)
WUnemployed	455 (117)	4,774 (405)	3 (48)	339 (117)	4,911 (292)	5 (57)
WManufacturing	1,421 (520)	10,294 (1292)	28 (231)	1,240 (448)	10,952 (867)	88 (217)
WForeign born	549 (85)	7,548 (252)	1 (19)	422 (69)	7,741 (245)	2 (20)
WBorn abroad	789 (125)	10,281 (379)	4 (33)	649 (103)	10,585 (311)	6 (44)

Specifically, average net migration of persons born abroad into the 20 towns with an incinerator that opened between 1990 and 1996 slowed less dramatically (from an increase of 80 to a decrease of 32) than in the twin towns (from an increase of 524 to an increase of 61). Hence, it would be wrong to conclude that the incinerators caused immigrants to remain in these towns because the average population declined in the post-intervention intercensal period while it increased among the twins. Instead the difference in differences is explained by much larger net migration in the pre-intervention period for the control towns than for the incinerator towns. Although the estimated t for the test of 1.90 is statistically significant at a 95 percent confidence level for a one-tailed test, the result is explained entirely by a much greater decline in net migration to control towns following the opening of incinerators in intervention towns.

Large calculated t values (in absolute value) are also reported in Table 3 for employment growth and net migration of the population that is born abroad among the 29 towns that opened an incinerator between 1982 and 1988 and their twins. In both these cases, however, the direction of the estimated effect is counter to the hypothesis so is not statistically significant for the one-tailed test. The tests are for an increase in employment growth and an increase in net migration of foreigners attributed to the incinerator. The differences-in-differences, however, are both negative.

6.1. Matched pair fixed effects regression results

A limitation of the paired t test of the differences-in-differences estimator is that it allows for exactly one pre-test and one post-test period. The matched pair fixed effects regression model pools all the cases and controls and allows for multiple pre-test observations and multiple post-test observations, increasing the degrees of freedom and the power of the test. By pooling multiple post-incinerator observations, we can also test for longer term effects of the incinerators beyond the first intercensal period following the opening. The set of Eq. (3) below summarizes the regression results

for key test variables in Eq. (2).⁶

$$\begin{aligned}
 \log(\text{EPOP}_{i,t}) &= \alpha_j - 0.009\text{Post1} - 0.003\text{Post2} + 0.002\text{Post3} \\
 &\quad (0.026) \quad (0.035) \quad (0.056) \\
 &+ 0.457\log(\text{EPOP}_{i,t-1}) + \dots + u_{i,t} \\
 &\quad (0.034)^{***} \\
 \log(\text{EMP}_{i,t}) &= \alpha_j + 0.086\text{Post1} + 0.326\text{Post2} + 0.075\text{Post3} \\
 &\quad (0.048) \quad (0.063)^{***} \quad (0.102) \\
 &+ 0.305\log(\text{EMP}_{i,t-1}) + \dots + u_{i,t} \\
 &\quad (0.060)^{***} \\
 \log(\text{FrnBrn}_{i,t}) &= \alpha_j - 0.085\text{Post1} - 0.175\text{Post2} - 0.098\text{Post3} \\
 &\quad (0.094) \quad (0.123) \quad (0.199) \\
 &+ 0.097\log(\text{FrnBrn}_{i,t-1}) + \dots + u_{i,t} \\
 &\quad (0.043)^* \\
 \log(\text{BrnAbd}_{i,t}) &= \alpha_j - 0.039\text{Post1} - 0.081\text{Post2} - 0.142\text{Post3} \\
 &\quad (0.072) \quad (0.095) \quad (0.154) \\
 &+ 0.142\log(\text{BrnAbd}_{i,t-1}) + \dots + u_{i,t} \quad (3) \\
 &\quad (0.045)^{**}
 \end{aligned}$$

where $\text{EPOP}_{i,t}$ is the established population, $\text{EMP}_{i,t}$ is employment, $\text{FrnBrn}_{i,t}$ is foreign born population, and $\text{BrnAbd}_{i,t}$ is population born abroad. The estimated coefficients are provided for each equation and the estimated standard errors are in parentheses. The intercepts α_j are not shown because they are unique for each matched pair. There are 63 matched pairs, 63 incinerator towns that have at least one intercensal period prior to the year the incinerator opened and at least one intercensal period after the year the incinerator opened.⁷ Other estimated coefficients omitted above but included in the regressions are for time (intercensal period) and space (department) effects (please see Eq. (2)). The models have 127 parameter restrictions. Pooling four censuses, we have 504

⁶ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

⁷ The same 63 cases and 63 controls assessed in the differences-in-differences tests presented in Table 3.

Table 3Paired *t* tests. $(\Delta \text{Incinerator}_{\text{after}} - \Delta \text{Control}_{\text{after}}) - (\Delta \text{Incinerator}_{\text{before}} - \Delta \text{Control}_{\text{before}})$.

	1968–75	1975–82	1982–90	1990–99	Difference
$\Delta \text{Population}$					
14 incinerators opened 1975–1981	545	–1,320			–1,865
their 14 twin towns	1,051	198			–853
Difference (<i>t</i> -stat in parentheses)	–505	–1,518			–1,012 (–0.69)
$\Delta \text{Employment}$					
14 incinerators opened 1975–1981	988	–782			–1,770
their 14 twin towns	924	–263			–1,187
Difference (<i>t</i> -stat in parentheses)	64	–519			–583 (–0.91)
$\Delta \text{Foreign born}$					
14 incinerators opened 1975–1981	639	325			–314
their 14 twin towns	635	160			–475
Difference (<i>t</i> -stat in parentheses)	4	166			161 (0.51)
$\Delta \text{Born abroad}$					
14 incinerators opened 1975–1981	440	42			–398
their 14 twin towns	474	85			–389
Difference (<i>t</i> -stat in parentheses)	–34	–43			–9 (–0.04)
$\Delta \text{Population}$					
29 incinerators opened 1982–1988		–1,982	–539		1,442
their 29 twin towns		–2,692	–648		2,044
Difference (<i>t</i> -stat in parentheses)		710	109		–602 (–0.93)
$\Delta \text{Employment}$					
29 incinerators opened 1982–1988		–906	–562		344
their 29 twin towns		–1,875	–750		1,125
Difference (<i>t</i> -stat in parentheses)		969	189		–781 (–2.13)
$\Delta \text{Foreign born}$					
29 incinerators opened 1982–1988		687	–9		–696
their 29 twin towns		282	–123		–404
Difference (<i>t</i> -stat in parentheses)		405	114		–291 (–0.83)
$\Delta \text{Born abroad}$					
29 incinerators opened 1982–1988		183	–175		–358
their 29 twin towns		–83	31		114
Difference (<i>t</i> -stat in parentheses)		266	–206		–472 (–1.75)
$\Delta \text{Population}$					
20 incinerators opened 1990–1996			79	729	651
their 20 twin towns			–577	56	634
Difference (<i>t</i> -stat in parentheses)			656	673	17 (0.04)
$\Delta \text{Employment}$					
20 incinerators opened 1990–1996			–25	4,819	4,844
their 20 twin towns			–115	2,033	2,149
Difference (<i>t</i> -stat in parentheses)			90	2,785	2,695 (1.50)
$\Delta \text{Foreign born}$					
20 incinerators opened 1990–1996			100	–182	–283
their 20 twin towns			381	–511	–892
Difference (<i>t</i> -stat in parentheses)			–281	329	609 (1.67)
$\Delta \text{Born abroad}$					
20 incinerators opened 1990–1996			80	–32	–112
their 20 twin towns			524	61	–464
Difference (<i>t</i> -stat in parentheses)			–445	–92	352 (1.90)

* $p < 0.05$.

observations; one census is lost to the lagged $\log y_{i,t-1}$. The lagged dependent variable and large design matrix produce a good fitting model; $R^2_{\text{Adj}} = 0.97$ and most of the fixed effects are statistically significant at a 95 percent confidence level.

As indicated in the results above, the lagged dependent variable is statistically significant for all four Eq. (3). Incinerators have statistically significant impact only in the case of employment among estimated coefficients reported in the set of Eq. (3) and the effect is realized only after two census periods (Post2). The longer term nature of the employment effect explains the lack of supportive

evidence with the differences-in-differences estimator. Yet any employment effect is also short-lived and disappears by the third census period (Post3).

No significant effect of the incinerators on population migration is found relative to the counterfactual that an incinerator town never received its incinerator. No *t*-statistic differs significantly from zero for $\Delta \text{Population}$ in Table 3 and coefficients are statistically close to zero for Post1, Post2, and Post3 in the equations for EPOP, FrnBrn, and BrnAbd among the set of Eq. (3). Neither the established nor the immigrant populations appear to be moving in

Table 4
Differences in operations.

	High (<i>n</i> = 16) ¹ mean (s.d.)	Low (<i>n</i> = 12) ¹ mean (s.d.)	Difference (<i>t</i> -statistic)
Burners	2.04 (0.64)	1.78 (0.73)	0.27 (1.24)
Capacity	165,555 (182,502)	88,789 (82,536)	76,766* (1.85)
2006 CO ₂ Emissions	128,881 (139,746)	65,633 (48,564)	63,248* (1.79)
2008 CO ₂ Emissions	132,229 (129,493)	69,800 (56,732)	62,429* (1.79)

Notes: **p* < 0.05; *t*-tests are one-tailed, assuming unequal variances. ¹Sample size varies for missing values as indicated below (^ψ indicates incinerator town has missing value for one of the emissions years). Data on the number of burners and capacity at each incinerator (in kg/yr) are from the National Center for Independent Information on Waste (CNIID). Data on CO₂ emissions are from the French Registry of Polluting Emissions (IREP). Incinerator towns with high concentrations of immigrants include Argenteuil, Carrières-sous-Poissy, Cenon^ψ, Colmar, Créteil, Gien, Massy, Montereau-Fault-Yonne, Pithiviers, Saint-Ouen, Saran, Sarcelles, Sausheim, Sens^ψ, Strasbourg, and Villefranche-sur-Saône. Incinerator towns with low concentrations include Bourgne^ψ, Echillais, Guerville, Guichainville^ψ, Hénin-Beaumont, Labeuvrière, Monthyon, Pontivy, Rosiers-d'Egletons, Saint-Benoît-la-Forêt^ψ, Saint-Jean-de-Folleville, and Vert-le-Grand^ψ.

the wake of an incinerator location, calling into question the model depicted in Fig. 1. Indeed, if disproportionate siting of incinerators near immigrant populations concentrated at the time of siting is the only empirically supported explanation (see Table 1), then the claim of environmental injustice has been greatly bolstered. Exposure is not a choice mediated through migration and residential location. Perhaps surprising is that we find no evidence of departure by the established population in the wake of an incinerator opening nearby. That begs the question as to whether incinerators operate differently in towns where immigrant people are concentrated when compared to towns lacking concentrations of immigrant people. Are incinerators less of a nuisance in communes where the politically powerful live? To help answer this question, we now turn to our examination of capacity and CO₂ emissions at the various sites.

6.2. Operations across incinerators

Table 4 presents the results of our tests for differences in operations between incinerator towns with high concentrations of immigrant people and incinerator towns with low concentrations of immigrant people. In these data, incinerators are operated at higher capacity (inputs) and greater emissions (outputs) in communes with large concentrations of immigrant people than in towns with low concentrations of immigrants. The *t*-tests assuming unequal variances find the difference in means statistically significant for capacity and CO₂ emissions in 2006 and 2008, but not for the number of burners. Incinerators in vulnerable towns, where concentrations of immigrants are above the third quartile among all incinerator towns, have 1/3 of a burner more on average and nearly twice the capacity as incinerators in towns that have a low percentage of immigrants, below the first quartile.⁸ Similarly, the high immigrant population incinerator towns have nearly double the CO₂ emissions of the incinerators in the low immigrant population communes.

While these differences are striking, we caution that the data contain the problems detailed above in Method of Comparisons Across Operations in the Quasi-Experimental Design Section and in the notes of Table 4. Most problematic are the missing values for CO₂ emissions. Concerns may be offset somewhat by the degree of agreement with results using the capacity data. Still, our hope is that more data will be reported and so in the notes to Table 4 we provide a complete listing of the incinerator towns we identified with high and low concentrations of immigrants along with an indicator of missing values for one of the two years of CO₂ emissions. Second, CO₂ emissions are not a perfect substitute for emissions of toxic substances such as heavy metals, dioxins, and furans when assessing risk of exposure from operations. Yet the contributions of incinerators as a leading source of emissions of these toxins is well-established in North America and Western Europe (Floret et al., 2003; US EPA, 2006; Viel et al., 2008). While intensity of operations would concern an environmentally aware population nearby, total dioxin emissions in France have decreased despite an increase in the volume of waste incineration (INVS, 2006; MDD, 2010).

Last, the scale of the commune served by the incinerator provides a reasonable alternative explanation for differences in capacity and emissions. For all incinerators, both total town population and total employment are significantly correlated with capacity (*r* = 0.35** for both population and employment) and the number of burners (*r* = 0.48** for population and *r* = 0.47** for employment).⁹ Neither population nor employment is correlated with CO₂ emissions in either year (*r* = 0.18 for population and 2006 emissions, *r* = 0.14 for population and 2008 emissions, *r* = 0.20 for employment and 2006 emissions, and *r* = 0.17 for employment and 2008 emissions). On the other hand, percent foreign born and percent born abroad are significantly correlated with capacity (*r* = 0.37** for percent foreign born and *r* = 0.49** for percent born abroad) and CO₂ emissions in both years (*r* = 0.40** for percent foreign born and 2006 emissions, *r* = 0.39** for percent foreign born and 2008 emissions, *r* = 0.44** for percent born abroad and 2006 emissions, and *r* = 0.45** for percent born abroad and 2008 emissions). The relationship between scale and emissions appears to be weaker than the relationship between concentration of immigrants and emissions.

Establishing causality for differential volumes of CO₂ emissions is beyond the scope of this descriptive analysis and beyond the capability of these data. Persons born abroad appear to concentrate in larger incinerator towns and in some cases incinerators may provide greater capacity in larger towns to serve local demand. While the relationship between scale and capacity breaks down when considering only the incinerator towns most and least concentrated with immigrants, a considerable difference in average population and average employment remains. The average population of the most concentrated towns is 48,132, while the average population of the least concentrated towns is 11,031. Average employment in the most concentrated towns is 25,744, while in the least concentrated towns it is 6875. We leave for future research the question of a causal relationship between concentration of new immigrants and incinerator operations.

6.3. Discussion and limitations

In summary, we find solid evidence that concentration of immigrants influences incinerator location and weak evidence for the converse, that incinerator location influences concentration of immigrant populations. These outcomes are similar to the results for Latinos in the U.S. published by Been and Gupta (1997) and

⁸ Please see method of comparisons across operations in the quasi-experimental design section for the detailed operationalization of the high and low immigrant concentration groups.

⁹ * *p* < 0.05; ** *p* < 0.01.

Pastor et al. (2001). A French town with a one percent greater concentration of immigrants (foreign born or born abroad), *ceteris paribus*, is estimated to be 21–23 percent more likely to have opened a waste incinerator than towns with smaller immigrant populations and the effect persisted in 1968 and 1999. On the other hand, the one significant paired *t* test result supporting the market dynamics hypothesis (Been, 1994)—a statistically higher concentration of persons born abroad in the 20 incinerator towns that opened after the 1990 census—did not withstand additional scrutiny. We also find that concentration of immigrants impacts the operations of incinerators, with greater capacity and greater emissions at incinerators located near the highest concentrations of immigrant populations. By 2008, incinerators in towns with many immigrants had more burners and 71 percent greater capacity and emitted 89 percent more carbon dioxide (CO₂) than towns with low concentrations of immigrants. However, the scale of a town remains a potentially confounding variable and more research is needed before one could attribute to the effect to differences in regulation in minority and poor communities (Viscusi and Hamilton, 1999; Sigman, 2001; Gray et al., 2010).

The advantages of a quasi-experimental design have been noted, but the method also presents some limitations. First, causality can come into question if the values of unobservable variables change between the before-incinerator and after-incinerator periods in a way that is correlated with the process that selected the towns as sites for incinerators, as modeled in our selection equation (Dehejia and Wahba, 1999). In other words, the differences-in-differences estimator would not be independent of selection bias. Second, the method requires a long history. Our analysis requires two censuses before an incinerator opens and two censuses after, each to calculate net migrations or employment change before and after. Third, it may encounter the modifiable areal unit problem (MAUP) and have problems addressing the clustering of nuisances.

Data constraints with the French census prevent us from addressing these issues as elsewhere. Uneven time periods and fewer demographic and economic variables available as potential instruments prevent formal testing for selection bias as in Funderburg et al. (2010). The irregular time intervals and reporting by commune impose similar constraints preventing us from addressing the MAUP and clustering issues. Fortunately, the regional context of selecting hosts for incinerators in France presents an ideal situation for our method. A small number of locations are viable as hosts within a region among the vast number of French towns; if an incinerator is not sited in a particular community, it needs to be sited in another nearby. Where clustering or the MAUP is an issue, point pattern analysis can be used to account for clustering at multiple spatial scales and the counterfactuals can be established through repeated random sampling (Funderburg and Zhou, 2013). We now discuss some implications of our research and conclude the paper.

7. Conclusions

In this paper we conduct a quasi-experiment of employment growth and net migration of established and immigrant populations in French towns that opened an incinerator. The intervention state of having an incinerator is paired to a control state that models the counterfactual: how would the concentration of immigrants be different if the incinerator towns had not opened incinerators? We find no evidence that incinerators caused established populations to leave towns and weak evidence that net migration of foreigners from incinerator towns slowed in the wake of the opening of an incinerator. This contrasts sharply with statistical evidence that incinerators were disproportionately sited near concentrations of immigrants—foreign born or born abroad. Towns with higher con-

centrations of immigrants had higher probabilities of receiving an incinerator, given information available through the census at the time of siting and holding other factors constant. The lack of a migration or population retention explanation for the distributional inequity bolsters the claim of environmental injustice—the siting decision is the explanation for the deprivation. Last, we find some evidence of job gains caused by the opening of an incinerator in the longer term, but these effects do not persist beyond two censuses subsequent to the opening of an incinerator.

The claim that French incinerator policy has followed a path of least political resistance is further strengthened when we look at operations. We categorize incinerator towns into high and low concentrations of immigrants, whereby the former is above the third quartile for concentration among all incinerator towns and the latter is below the first quartile. We find dramatic differences in the average capacity and emissions between the two groups. The incinerators in towns with the most immigrants have more burners and much more capacity and emit much more CO₂ than incinerators in towns with few immigrants.

Quasi-experimental design contributes to analysis of environmental justice. A good design enables sensitivity to different contexts not possible in other forms of analysis. Although environmental justice research has been centered in the U.S., inequalities have been identified in various French contexts (Laurian, 2008a,b; McCauley, 2009; Luneau, 2012; Laurent, 2014; Laurian and Funderburg, 2014; Padilla et al., 2014) and EJ scholarship is burgeoning in Europe in general (Llurdés et al., 2003; Norese, 2006; Davies, 2008; Botetzagias and Karamichas, 2009; Leonard et al., 2009; Rootes, 2009; Ferreira and Gallagher, 2010; Lami and Abastante, 2014). Analyses need to be sensitive to context because socio-ecological differences impact perceptions of risk (Bickerstaff, 2004), residential choice and migration (Hunter, 2005), and housing prices near environmental hazards (Farber, 1998).

Quasi-experimental design can address important questions about causality if a predictive model of facility location drives the identification of comparison locations. Thirteen optimally matched control towns in our analysis were subsequently selected to host incinerators, suggesting a reasonable model for how facilities are sited (Been and Gupta, 1997).

Understanding the cause of unequal distributions of risk from the siting of incinerators is necessary for the improvement of facilities planning and management. Site selection is a lengthy and costly process. Where unjust exposure of vulnerable groups to risk is occurring, participatory processes for site selection involving discursive deliberation offer hope in enhancing competence in decision making as well as assigning responsibility for risk management to the impacted groups (Renn, 2004, 2006). These democratic forms of decision making need not diminish the role of expertise and technical analysis as a siting activity (Renn, 2006). Increasingly, democratic and participatory processes of site selection are integrated into multi-criteria decision analysis to bring stakeholders and decision makers together in cooperative discourse (Norese, 2006; Renn, 2004; Lami and Abastante, 2014). Policies that encourage cooperative discourse across minority groups and among recent immigrant groups are particularly important for addressing issues of environmental inequality (Pastor et al., 2001).

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Appendix.

107 Towns with incinerator by year incinerator opened and their matches.

Year	Incinerator town	Twin town
1968	Rennes, Ille-et-Vilaine	(No match found)
1969	Toulouse, Haute-Garonne Ivry-sur-Seine, Val-de-Marne	(No match found) Boulogne-Billancourt, Hauts-de-Seine
1970	Antibes, Alpes-Maritimes	Laon, Aisne

1971	Caen, Calvados Plouharnel, Morbihan Montereau-Fault-Yonne, Seine-et-Marne	(No match found) Wormhout, Nord Vincennes, Val-de-Marne	1988	La Rochelle, Charente-Maritime Montbéliard, Doubs Brest, Finistère	Lunéville, Meurthe-et-Moselle Sainte-Savine, Aube Blois, Loir-et-Cher (2000) Troyes, Aube Le Grand-Quevilly, Seine-Maritime (2000) Saint-Chamond, Loire Evreux, Eure Dreux, Eure-et-Loir
1972	Brive-la-Gaillarde, Corrèze Bénesse-Maremne, Landes Hénin-Beaumont, Pas-de-Calais Noyelles-sous-Lens, Pas-de-Calais Villejust, Essonne	Menton, Alpes-Maritimes Amagne, Ardennes Sedan, Ardennes Guipavas, Finistère Gabriac, Aveyron		Vitré, Ille-et-Vilaine Colmar, Haut-Rhin Thonon-les-Bains, Haute-Savoie Sens, Yonne	Marcq-en-Baroeul, Nord
1973	Le Mans, Sarthe Angers, Maine-et-Loire Dieppe, Seine-Maritime	Nancy, Meurthe-et-Moselle (1995) (No second match found) (No match found) Chelles, Seine-Maritime	1990	Echillais, Charente-Maritime Pontivy, Morbihan Mourenx, Pyrénées-Atlantiques Haguenau, Bas-Rhin Moutiers, Savoie	Reignier-Esery, Haute-Savoie Champagnole, Jura Douai, Nord
1974	Saint-Pierre-d'Oléron, Charente-Maritime Dijon, Côte-d'Or Meilars, Finistère Grenoble, Isère Strasbourg, Bas-Rhin Argenteuil, Val-d'Oise	Escaudain, Nord Amiens, Somme Gaignes, Finistère Saint-Nazaire, Loire-Atlantique Brest, Finistère (1988) (No second match found) Besançon, Doubs (1976) Boulogne-sur-Mer, Pas-de-Calais		Saint-Ouen, Seine-Saint-Denis	Cherbourg-Octeville, Manche Digne-les-Bains, Alpes-de-Haute-Provence Gaillard, Haute-Savoie
1975	Thiverval-Grignon, Yvelines	Bréviandes, Aube	1991	Amilly, Loiret Bayonne, Pyrénées-Atlantiques Valezan, Savoie Marignier, Haute-Savoie	Creutzwald, Moselle Saint-Denis, Seine-Saint-Denis Betton-Bettonet, Savoie Ars-sur-Moselle, Moselle
1976	Besançon, Doubs Châteaudun, Eure-et-Loir Messanges, Landes Labeuvrière, Pas-de-Calais	Saint-Denis, Seine-Saint-Denis Plan-de-Cuques, Bouches-du-Rhône Saint-Paul-la-Roche, Dordogne Busigny, Nord	1992	Sète, Hérault	Thoiry, Ain
1977	Nice, Alpes-Maritimes Pontcharra, Isère Douchy-les-Mines, Nord Valenciennes, Nord Chambéry, Savoie Carrières-sur-Seine, Yvelines	(No match found) Couzeix, Haute-Vienne Montauban, Tarn-et-Garonne (1986) Riom, Puy-de-Dôme Douai, Nord Mont-Saint-Aignan, Seine-Maritime Saint-Loup-sur-Semouse, Haute-Saône	1993	Planguenoual, Côtes-d'Armor	Pont-de-l'Isère, Drôme
1978	Sarcelles, Val-d'Oise	Aubagne, Bouches-du-Rhône	1994	Carhaix-Plouguez, Finistère Lons-le-Saunier, Jura	Bègles, Gironde (1998) Maxéville, Meurthe-et-Moselle Aubervilliers, Seine-Saint-Denis
1979	Surgères, Charente-Maritime	Cran-Gevrier, Haute-Savoie	1995	Orléans, Loiret Nancy, Meurthe-et-Moselle Passy, Haute-Savoie Avignon, Vaucluse Saint-Ouen-l'Aumône, Val-d'Oise	Mantes-la-Jolie, Yvelines Amiens, Somme Cerizay, Deux-Sèvres Aulnay-sous-Bois, Seine-Saint-Denis Saint-Flour, Cantal
1981	Paillé, Charente-Maritime Cenon, Gironde	Abjat-sur-Bandiat, Dordogne Châtelleraut, Vienne	1996	Briec, Finistère	Saint-Marcellin, Isère
1982	Bayet, Allier Saint-Benoît-la-Forêt, Indre-et-Loire Agen, Lot-et-Garonne Tarare, Rhône Epinal, Vosges	Saillant, Puy-de-Dôme Tréveneuc, Côtes-d'Armor Vendôme, Loir-et-Cher Lambertart, Nord Belfort, Territoire de Belfort	1999	Ouarville, Eure-et-Loir Lunel, Hérault Mulhouse, Haut-Rhin	Alzonne, Aude Périgueux, Dordogne Clermont-Ferrand, Puy-de-Dôme (2013) Freyding-Merlebach, Moselle
1983	Cholet, Maine-et-Loire Pontmain, Mayenne Tronville-en-Barrois, Meuse	Saint-Etienne, Loire Châtillon-sur-Chalaronne, Ain Oudon, Loire-Atlantique	2000	Blois, Loir-et-Cher Halluin, Nord Rouen, Seine-Maritime Créteil, Val-de-Marne	Auxerre, Yonne Thionville, Moselle Lille, Nord Castres, Tarn
1984	Villefranche-sur-Saône, Rhône Toulon, Var Poitiers, Vienne Rungis, Val-de-Marne	Chartres, Eure-et-Loir (1998) Fougères, Ille-et-Vilaine Vénissieux, Rhône Haguenau, Bas-Rhin (1990) Tarbes, Hautes-Pyrénées Boussois, Nord	2001	Bessières, Haute-Garonne Metz, Moselle Maubeuge, Nord Annecy, Haute-Savoie	Villemur-sur-Tarn, Haute-Garonne Saint-Etienne, Loire Douai, Nord Villeneuve-d'Ascq, Nord
1985	Pithiviers, Loiret Tignes, Savoie Saint-Thibault-des-Vignes, Seine-et-Marne	Lomme, Nord Villiers-sur-Marne, Val-de-Marne Saint-Symphorien-le-Château, Eure-et-Loir	2002	Nevers, Nièvre Bourogne, Territoire de Belfort	Cambrai, Nord Guenrouet, Loire-Atlantique
1986	Angoulême, Charente Bourgoin-Jallieu, Isère Vernou-en-Sologne, Loir-et-Cher Montauban, Tarn-et-Garonne Massy, Essonne	Versailles, Yvelines Rezé, Loire-Atlantique Heuqueville, Seine-Maritime Lons-le-Saunier, Jura (1994) Meaux, Seine-et-Marne Cognac, Charente	2003	Guichainville, Eure Calce, Pyrénées-Orientales Vaux-le-Pénit, Seine-et-Marne	La Fouillouse, Loire Rouilly-Sacey, Aube Saint-Cyprien, Pyrénées-Orientales
1987	Nantes, Loire-Atlantique Reims, Marne Pau, Pyrénées-Atlantiques	Mulhouse, Haut-Rhin (1999) Le Havre, Seine-Maritime (No match found) Rouen, Seine-Maritime (2000) Laval, Mayenne	2004	Nîmes, Gard Lasse, Maine-et-Loire Villers-Saint-Paul, Oise Arras, Pas-de-Calais Saint-Jean-de-Folleville, Seine-Maritime	Amiens, Somme Lavercantière, Lot Sassenage, Isère Evreux, Eure Saint-Hilaire-sur-Helpe, Nord