Environmental inequality in Austria: do inhabitants’ socioeconomic characteristics differ depending on their proximity to industrial polluters?

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Abstract
This is the first study to examine the existence of environmental inequality related to industrial facilities in Austria. Using distance-based methods, socioeconomic characteristics of inhabitants living in 1.0 km buffer zones around the 247 polluters registered in the European Pollutant Release and Transfer Registry are compared with those of inhabitants living elsewhere in Austria. While in Vienna no clear signs of environmental inequality can be found, in the rest of Austria people living in close vicinity to industrial sites are more often unemployed, have lower education levels and most notably, are twice as likely to be immigrants. Moreover, a logistic regression shows that the disparities concerning immigrants cannot solely be explained by other socioeconomic characteristics. The results of this study add to the evidentiary base concerning environmental justice disparities in Europe and suggests how application of distance-based methods can facilitate cross-national comparisons.

1. Introduction

Humanity’s high level of resource use does not just foster material wealth, it generates unintended side-effects for human health and ecosystems affecting their service provision for societies also leading to scarcity of critical resources (Fischer-Kowalski et al 2014, Steffen et al 2015). Within a finite world of resources and sinks this aggravating situation raises serious equity concerns at global, regional, national and local levels regarding who profits and who carries the burden of environmental degradation. Social inequities in the distribution of pollution from industrial facilities are but one prominent example. Such inequalities have been studied extensively in the US (Mohai and Bryant 1992, Roberts et al 2018) and have only recently begun in Europe (Laurent 2011, Padilla et al 2014). In this paper we discuss the growing concerns about social inequalities in the distribution of environmental hazards in the US and Europe, and present to our knowledge the first empirical analysis of environmental inequality in Austria. In so doing, we add to the evidence pertaining to environmental justice disparities in Europe and demonstrate how applying distance-based methods to create consistent geographic areas around hazardous sites can facilitate cross-national comparisons.

1.1. Environmental justice in the US and Europe

In the 1980s, unjust siting of hazardous waste treatment and storage facilities led to a fierce response by African-American and Latino communities in the US, marking the birth of the environmental justice movement (UCC 1987, Bullard et al 2007). Emerging as a social movement, environmental justice (EJ) was soon taken up by the scientific community as well (Bullard 1990, Bryant and Mohai 1992), leading to empirical documentation of the nation-wide links between racial and socioeconomic characteristics of communities and their proximity to waste sites,
industrial facilities, and other environmental hazards. Even though environmental justice became firmly established on US federal and state policy agendas decades ago (Bullard et al. 2007, Mohai et al. 2009b), the findings of recent studies continue to resemble those found at the outset in the 1980s, showing a structural overrepresentation of ethnic minorities and poor people in the immediate vicinity of a wide range of environmental hazards (Ash and Fetter 2004, Ringquist 2005, Bullard et al. 2007, Mohai et al. 2009a, Zwicky et al. 2014, Collins et al. 2016).

In contrast, in Europe the topic of environmental justice is just emerging within civil movements, politics and science (Agyeman 2002, Agyeman and Evans 2004, Laurent 2011, Padilla et al. 2014) and is still far from being on a regular agenda of public concern (Elvers et al. 2008) or within the European Union institutions (Laurent 2011). Some of the beginning steps include the 1998 Aarhus Convention, which ‘shall guarantee the rights of access to information, public participation in decision-making, and access to justice in environmental matters’ (UNECE 1998: 3). Additionally England and Scotland in particular have started to integrate EJ into social policy (Agymen 2002, Laurent 2011). German institutions recently started to address EJ as well, encompassing social policy, environmental policy and public health (Elvers et al. 2008).

Also the number of empirical studies exploring environmental inequalities in Europe on a regional or national scale is growing (Padilla et al. 2014, Mitchell et al. 2015, Rüttener 2018). These studies have examined the distribution of ambient air pollutants (Mitchell and Dorling 2003, Diekmann and Meyer 2010, Braxis and Linhartova 2012, Richardson et al. 2013, Fecht et al. 2015, Moreno-Jiménez et al. 2016) and proximity to hazardous sites (Laurian 2008, Viel et al. 2011, Raddatz and Mennis 2013, Laurian and Funderburg 2014, Rüttener 2018) and have employed other indicators of environmental quality such as the Multiple Environmental Deprivation Index (Pearce et al. 2010), perceived exposure to pollution (Best and Rüttener 2017) and access to green space (Kabisch and Haase 2014).

In both the US and Europe a range of diverse social characteristics such as income, level of education, occupational status, housing and others on different scales have been examined and found to be significant (Diekmann and Meyer 2010, Laurent 2011, Richardson et al. 2013, Rüttener 2018). Yet the evidence of environmental inequalities is less clear in Europe than in the US. For example, often times wealthier areas in European countries have been found to experience more pollution than poorer areas (Deguen and Zmirou-Navier 2010, Richardson et al. 2013, Hajat et al. 2015). Scholars have argued that European societies have less spatial segregation and therefore environmental inequalities are less evident (Agyeman 2002, Diekmann and Meyer 2010), and that the heterogeneity and diversity of European societies and the historical socioeconomic makeup of cities might also be a reason for the inconsistent findings, along with the methodological diversity applied in those studies (Padilla et al. 2014).

Furthermore, the historical origins of racial discrimination and the connections between civil rights and the EJ movement in the US have also shaped the focus and methods of EJ research there. Indeed, in most US studies, race and ethnicity are a key aspect for assessing whether environmental inequalities exist (Mohai et al. 2009b, Bullard and Wright 2012). Although the relatively smaller number of European studies do not focus on racial and ethnic differences per se, an increasing number have focused on immigrant status, country of birth or citizenship status and have found statistically significant environmental disparities based on this variable (see, e.g. Laurian 2008, Diekmann and Meyer 2010, Raddatz and Mennis 2013, Kabisch and Haase 2014, Laurian and Funderburg 2014, Padilla et al. 2014, Moreno-Jiménez et al. 2016, Rüttener 2018). Laurent (2011, 1849) points out that ‘environmental justice issues are not likely in Europe to be perceived, analyzed and framed in racial and ethnic terms… environmental justice was born in the context of the broader civil rights movement and was thus ‘racialized’ from the onset in the US.’ Nevertheless, Rüttener (2018: 199) has argued that for ‘minorities’ in Germany based on citizenship status (and presumably elsewhere in Europe), it is likely that ‘the same mechanisms apply as discussed in the American literature’. We believe this is an interesting argument that warrants further investigation in future studies.

Indeed, to date explanations for why environmental inequalities exist that are specific to the European context have yet to be developed. Instead, European studies have relied mostly on the American literature (Hajat et al. 2015, Rüttener 2018). In the American context, it has been argued (Pastor et al. 2001, Mohai and Saha 2015a, 2015b) that environmental disparities are the result of one (or both) of two processes. Either (a) there has been a historical pattern of disproportionately placing new polluting facilities and other locally unwanted land uses (LULUs) in low-income and ethnic minority neighborhoods at the time of siting (the ‘disparate siting’ hypothesis) or (b) the facility triggers demographic changes after siting which result in the concentration of poor people and ethnic minorities around the site (the ‘post-siting demographic change’ hypothesis). A combination of economic, socio-political, and discriminatory factors are thought to drive these two processes (Mohai et al. 2009b).

Economic factors include the desire of industry to reduce the costs of doing business by siting new facilities where land values are low and where sources of labor live nearby (Mohai and Bryant 1992, Ringquist 2003). Such areas are coincident with where poor people and minorities live. The promise of jobs may also
attract new arrivals of poor and working class residents to the area. Socio-political factors include imbalances in social capital, resources, and political clout between wealthy and poor communities. Since the siting of new sources of pollution, hazardous waste sites, and other LULUs often generates community opposition, government and industry decision makers seek the ‘path of least resistance’ by targeting poor, rather than wealthy, communities for such land uses (Bullard and Wright 1987, Saha and Mohai 2005).

In the US, discriminatory factors based on race and ethnicity are also believed to play a role (Mohai et al 2009b). For example, discriminatory zoning decisions have designated African-American and other people of color neighborhoods for mixed residential and industrial uses, which in turn have led to a disproportionate siting of industrial facilities where they live (Cole and Foster 2001, Taylor 2014). In addition, discrimination in the housing market has constrained the ability of African-Americans and other people of color to move to environmentally more desirable neighborhoods, confining them further to places where pollution is concentrated. In Europe, immigrant status may work in the same discriminatory way as race and ethnicity in the US (Rüttenauer 2018).

1.2. Overcoming challenges in making cross-national comparisons

A number of challenges exist in comparing the findings of EJ studies across European countries and with the US. For example, information about race and ethnic characteristics collected in the US are not collected in European countries (Laurian 2008, Moreno-Jiménez et al 2016). Furthermore, demographic information is collected at varying geographic scales across European countries and these do not necessarily match the geography of census tracts, block groups, and zip code areas employed in the US. Demographic characteristics may also be measured differently from country to country.

Mohai and Saha (2006, 2007, 2015a, 2015b) have advocated for the use of distance-based methods in quantitative EJ analyses in order to overcome the inconsistencies and difficulties posed by the varying sizes and shapes of census units in the US and the shortcomings of the earlier, more traditional method of conducting EJ analyses termed ‘unit-hazard coincidence’, which merely matches the hazard with the location of a census unit without taking into account the hazard’s location within the unit. Mohai and Saha have demonstrated that this approach leads to significant underestimations of the concentration of poor people and racial and ethnic minorities near hazardous sites.

In contrast, distance-based methods have three important advantages (Mohai and Saha 2006): (1) they take into account the precise geographic locations of environmental hazards, rather than merely match the hazards with census units without specifying their locations within the units. (2) The demographic characteristics near the hazards are determined within a uniform distance (or radius) from the hazard (typically from 0.5 to 3.0 miles in existing research). (3) The circular areas of a specified radius created by distance-based methods ensure that the neighborhoods around the hazards are all of a uniform size and shape.

Mohai and Saha (2006) have described several distance-based approaches which we believe can also be applied in European EJ analyses. Two they have recommended that have received wide attention are the 50% areal containment and the areal apportionment methods. The 50% areal containment method considers every geographic census unit (such as a census tract or zip code area) as being part of the host neighborhood where at least 50% of the unit’s area lies within a certain radius of the facility. The demographics of the host neighborhood are then determined by combining the populations of these units. The demographic characteristics of the host neighborhood are then compared against the demographic characteristics of the geographic areas that lie beyond the specified radius. The second method, areal apportionment, considers every geographic unit that lies even slightly within the radius as being part of the host neighborhood. However, the demographics of the host neighborhood are determined by including only the proportion of each unit’s population that is equal to the proportion of the unit’s area lying within the specified distance. Again, the demographic characteristics of the host neighborhood (i.e. the area within the specified radius) are then compared against the demographic characteristics of the geographic areas beyond the specified radius (see Mohai and Saha 2006, for details of these methods).

In Europe, the smallest geographic units with demographic data vary significantly from 100 inhabitants in Ireland1 to units with sometimes more than 100 000 inhabitants in Poland6. The advantage of distance-based methods can be extended to create uniform geographic areas around hazardous sites in the European studies for which demographic information can be collected and assessed.

1.3. Environmental justice in Austria

In Austria, the evidence-based discussion about environment, distribution and justice is just beginning (Wukovitsch 2016). In 2014, Statistics Austria published a document connecting the data from the Community Statistics on Income and Living Conditions (EU-SILC) with a representative household survey which inquired about people’s subjective perceptions of environmental burdens (Statistik Austria 2014). Their main parameter for assessing inequalities was household income, showing that

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1. Laurian 2008
2. Moreno-Jiménez et al 2016
3. Statistik Austria 2014
4. European Commission 2016
5. http://data.cso.ie/datasets/index.html#education.
6. http://stat.gov.pl/en/topics/population/population/.
people in the lowest third of income consider themselves more often exposed to noise pollution, odor, exhaust gases, dust and soot, as well as to a higher level of these pollutants (Laneberger 2015). Recently, some institutions such as the Chamber of Labor of Lower Austria (the official representation of employees) and the ‘Armutskonferenz’ (a network of social organizations and educational institutions) initiated events addressing EJ and published leaflets that inform the public about the general connection between social and environmental aspects in Austria (De Schutter et al. 2017).

We believe there is a great deal of potential in harmonizing information about the demographic characteristics near hazardous sites, such as polluting industrial facilities, across European countries using distance-based methods. In this paper we apply distance-based methods in the first quantitative national study of environmental inequality in Austria. Specifically, our study uses the European Pollution Release and Transfer Registry (E-PRTR) as the data source pertaining to polluting industrial facilities and hence is comparable to US studies using the Toxic Release Inventory (see, e.g. Ringquist 1997, Daniels and Friedman 1999, Mohai et al 2009a; see also table 1 for some comparison characteristics). Our study applies a distance-based approach by creating circular buffer zones around industrial facilities as the units of analysis. Yet, it does not depend on approximations employing two-dimensional geographic units and 50% areal containment or areal apportionment approaches. Instead, we employ demographic data based on the precise point locations of Austrian households within specified circular buffer zones around the E-PRTR facilities and random point locations. The demographics of the households within the specified buffer zones were aggregated by and provided to us by Statistics Austria and therefore represent the demographics of exactly the people living in the specified zones. It also includes ethnic characteristics, specifically the country of birth. This allows a comparison to the results of US studies while also being able to relate to the context of European studies.

2. Methods

Data concerning emission sources is provided by the European Pollutant Release and Transfer Register (E-PRTR), a publicly accessible register with key environmental data from industrial facilities in Europe (EEA 2016). For this study, the 247 facility reports in Austria from 2013 are chosen as the basis for the analysis. By applying geographic information systems (GIS), the coordinates that are reported in the E-PRTR facility reports are used to determine the location of the facilities. In a next step, circular buffer zones with a 1.0 km radius around industrial facilities are created as the units of analysis.

Data concerning socioeconomic characteristics of the Austrian population are taken from the Register-based Labor Market Statistics 2013 (German: ‘Abgestimmte Erwerbsstatistik’) at Statistics Austria. For the Register-based Labor Market Statistics and a few other databases, Statistics Austria provides aggregated data of any requested polygon, independently from administrative boundaries. Georeferenced data for individuals is used as a basis for aggregated information for all requested polygons (Statistik Austria 2016). This allowed us to generate the data for precise 1.0 km circles without being dependent on allocation methods, such as 50% areal containment or areal apportionment.

Table 1 describes the variables that were calculated for each 1.0 km buffer zone. Due to the lack of income data, the unemployment rate is used as a proxy for economic status. In addition, we examined percent less than Matura (the Austrian matriculation exam at the end of secondary education), percent with University degree, and average living space per person in square meters (m²). ‘Percent immigrant’ describes the share of residents born outside of Austria minus the EU-15 states and Switzerland, Norway, Iceland and Liechtenstein. The assumption is that people born in those countries have a similar social and economic background as those born in Austria, and thus are generally not viewed as a disadvantaged group. For example, Germans are the biggest group of immigrants in Austria since 2010 (Bundeskanzleramt Österreich 2016). Also it should be noted that the numbers of immigrants represent the situation for 2013, before the more recent migration wave triggered by war and violence in the Middle East.

For the descriptive analysis, the socioeconomic characteristics of the aggregate of people living within the 1.0 km circles around industrial facilities are compared with characteristics of the aggregate of people living in other areas.

| Table 1. Population and industrial characteristics for Austria, European Union (EU28) and the USA in 2016. |
|---------------------------------------------------------------|
| Population in million | Austria | EU28 | USA |
| Population density (population km²⁻¹) | 105 | 116 | 33 |
| GDP share of industry sector in % | 21.6 | 19.3 | 15.8 |
| GDP/cap in USD | 44 498 | 32 384 | 57 436 |
| Major industrial (TRI or PRTR) facilities | 247 | 28 758 | 21 849 |
| Major industrial facilities per million people | 31 | 56 | 68 |

Sources: European Environment Agency (https://prtr.eea.europa.eu/#/home), UN Statistics Division (https://unstats.un.org/unsd/demographic-social/), US Environmental Protection Agency (https://epa.gov/toxics-release-inventory-tri-program), and US Census Bureau (https://census.gov/data.html).
living in the total area of Austria beyond the 1.0 km circles. For a more detailed understanding, we also analyzed separate important geographical areas, such as Vienna, other smaller urban areas, and rural areas. We found the number of industrial facilities in each of the areas to be 18, 127, and 102, respectively.

In addition to the 247 industrial facilities, 294 points were randomly selected throughout Austria as a comparison population of points and the demographics within 1.0 km were analyzed (see figure 1). The approach of generating random geographic points to create a comparison population of alternate facility locations to contrast with the actual facility locations is modeled after that taken by Mohai and Saha (2007). The random points were generated using stratified random sampling. The strata reflect three categories of population densities as well as the nine provinces of Austria, to assure random points lie within areas that indeed could be chosen for siting. We used the 5 km × 5 km reference grid provided by Statistics Austria as a starting point. In a first step we calculated mean population density for each 5 km × 5 km cell by intersecting a fine scaled (125 m × 125 m) population density grid. Numbers of mean population density were aggregated to three classes using the Jenks algorithm (ESRI 2013), additionally a class representing no population was added. Further we included information of the extent of the nine Austrian provinces (Vienna, Lower Austria, Upper Austria, Burgenland, Styria, Carinthia, Salzburg, Tyrol and Vorarlberg). This approach resulted in 34 strata, each reflecting the spatial pattern of the population densities found in the nine provinces. In order to create a comparable set of random points we defined the number of facilities in a given stratum as the target for allocating the random points. After

| Variable                        | Description                                                                                                                                 |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Percent immigrants              | Percentage of population born in the following countries or regions: Bulgaria, Estonia, Croatia, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Czech Republic, Hungary, Cyprus, former Yugoslav, Turkey, Africa, America, Asia, Oceania, or stateless, unclear, unknown |
| Percent unemployed              | Percentage of population registered as unemployed in relation to total labor force (total labor force = unemployed + employed)                |
| Percent less than matura        | Percent of 15–64 year-old residents with less than Matura (the Austrian matriculation examination at the end of secondary education)             |
| Percent university degree       | Percent of 15–64 year-old residents with a University degree                                                                                   |
| Average living space per person | Mean living space available per main residence                                                                                                 |

Table 2. Demographic and socioeconomic variables used for the year 2013.

Figure 1. Distribution of E-PRTR facilities and random points in Austria.
excluding the buffered areas of the facilities we applied the 'create random points' algorithm provided by ArcGIS (ESRI 2013).

Using a binomial logistic regression, the effects of immigration rates, unemployment rates, average living space, University degree rates and the three geographical areas (i.e. Vienna, other urban, and rural) were evaluated on the likelihood that a location hosts an E-PRTR facility. Specifically, the value of the dependent variable is ‘1’ if the point is at the location of an industrial facility and ‘0’ if it is a random point.

3. Results

Table 3 provides a descriptive comparison of the demographics within and beyond 1.0 km of the 247 E-PRTR facilities in Austria as a whole and separated into the three geographical areas. For Austria as a whole, differences between areas within 1.0 km and beyond 1.0 km of E-PRTR facilities are in the expected direction for all variables. For example, the immigrant, unemployment, and less than Matura percentages in areas of Austria within 1.0 km of a E-PRTR facility are all larger than in areas beyond 1.0 km (18.9% versus 11.8%; 9.0% versus 6.7%; 75.2% versus 73.6%, respectively). At the same time, the percentage with University degrees and average living space per person are smaller (10.9% versus 11.9% and 42.5 m² versus 48.9 m², respectively).

For Vienna these differences tend to be smaller, however, and the patterns less clear. For example, the unemployment percentage within 1.0 km of E-PRTR facilities in Vienna is only slightly higher than the percentage beyond 1.0 km (11.7% versus 11.4%). At the same time, the average living space per person within 1.0 km of the facilities in Vienna is only slightly smaller than that beyond 1.0 km (38.5 m² versus 39.3 m²). Furthermore, the immigrant percentage within 1.0 km of facilities in Vienna is actually somewhat smaller, rather than larger, than beyond 1.0 km (24.5% versus 26.4%).

In contrast, demographic differences within and beyond 1.0 km of E-PRTR facilities in both the other urban areas outside Vienna and rural areas are more pronounced and in the expected direction. For example, in the other urban areas outside Vienna, the immigrant, unemployment, and less than Matura percentages within 1.0 km of E-PRTR facilities are all greater than beyond 1.0 km (18.7% versus 13.1%, 8.4% versus 6.6%, and 77.4% versus 69.9%, respectively), while at the same time the percentage with University degrees is smaller (10.0% versus 14.4%). In the rural areas, the immigrant, unemployment, and less than Matura percentages within 1.0 km of facilities are also all greater than beyond 1.0 km (10.4% versus 5.6%, 6.5% versus 5.0%, and 82.1% versus 80.6%, respectively), while at the same time the percentage with University degrees is smaller (6.8% versus 7.7%).

Data for living space for the other urban areas outside Vienna and for rural areas were not available from Statistics Austria and are thus not shown in table 3. However, we were able to obtain these data for areas within 1.0 km of E-PRTR facilities in the other urban and rural areas. These were 42.9 m² and 47.8 m², respectively.

Because of the importance of race and ethnicity in US EJ studies and the consistency with which immigrant status has been found to be significant in European EJ studies, we took a closer look at the countries of birth of all residents. As argued above, not every person born in a foreign country faces the same situation in Austria. Results in figure 2 support the expectation that residents born in countries which were part of the EU before 2004 (EU-15) do not live at disproportionate rates around industrial facilities. In rural areas, they comprise almost identical percentages within 1.0 km and beyond 1.0 km of industrial facilities (2.6% versus 2.7%, respectively). In Vienna and urban areas outside Vienna, these percentages are even slightly less within 1.0 km of facilities compared to beyond (3.2% versus 4.0% in Vienna; 3.3% versus 4.0% in other urban areas).

Moreover, the biggest groups of immigrants are those born in countries that joined the EU after 2004, in former Yugoslavia and in Turkey. Figure 2 reveals that the percentages of these immigrants are higher within 1.0 km of facilities than beyond 1.0 km in both the rural areas and urban areas outside of Vienna, where most of the industrial facilities are located (229 out of 247 facilities). As before, the immigrant percentages within 1.0 km of the 18 facilities located in Vienna are slightly smaller than the immigrant percentages beyond 1.0 km.

3.1. Logistic regression

A binomial logistic regression was performed using the demographic data within 1.0 km of E-PRTR facility and random point locations for the entirety of Austria to ascertain the effects of immigration rates, unemployment rates, University degree rates, average living space, and geographical variables on the likelihood that a location is a host for a E-PRTR facility. Percent less than Matura was excluded because of multicollinearity problems with the University degree rate.

Table 4 shows the results for Models 1–3. In Model 1, immigration rate was the only independent variable and a statistically significant ($p < 0.001$) predictor of E-PRTR facility locations. With an odds ratio of 1.099, an increase of the immigration rate by 1% within 1.0 km of a point location increases the odds of it hosting a facility by 9.9%.

Bulgaria, Estonia, Croatia, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Czech Republic, Hungary, and Cyprus.
Table 3. Demographic disparities around industrial facilities in Austria, 2013.

|                | Austria       | Vienna        | Other Urban   | Rural         |
|----------------|--------------|--------------|--------------|--------------|
|                | All          | Within 1 km of facilities | Beyond 1 km | All          | Within 1 km of facilities | Beyond 1 km | All          | Within 1 km of facilities | Beyond 1 km |
| Population     | 8499 759     | 7918 372     | 1761 738     | 1590 334     | 2653 749     | 303 724       | 2350 025     | 4084 272     | 106 259       | 3978 013     |
| % Immigrants    | 12.3         | 11.8         | 26.4         | 13.1         | 18.7        | 13.1          | 14.4         | 7.7          | 6.8           | 7.7          |
| % Unemployed    | 6.9          | 6.7          | 11.4         | 5.0          | 6.5         | 5.0           | 7.7          | 6.8          | 7.7           |              |
| % Less than Matura | 73.8       | 62.0         | 62.0         | 80.6         | 82.1        | 80.6          |              |              |                |              |
| % University degree | 11.9       | 18.8         | 14.4         | 7.7          | 6.8         | 7.7           |              |              |                |              |
| Average living space per person (m2) | 48.5      | 48.9         | 39.3         | 42.9         |              |              |              |              |                |              |

*Living space data consistent with the other variables are not available from Statistics Austria.*
In Model 2, the other socioeconomic variables such as unemployment rate, average living space and University degree rate were added as independent variables to the base model. The immigration rate remains statistically significant ($p < 0.001$), with a slightly lower odds ratio of 1.072. Average living space and the University degree rate are also both statistically significant ($p < 0.01$). An increase in both variables is associated with a decreased likelihood of hosting an E-PRTR facility. Overall, this model shows that even after controlling for other socioeconomic factors, immigration status remains the most important variable in predicting a facility location.

Model 3 includes the geographical variables ‘Vienna’ and ‘Other Urban’ into the model. ‘Rural areas’ is the reference category and thus omitted. Results in Model 3 indicate that inclusion of the geographical variables in the regression does not change appreciably the outcomes. Although the statistically significant odds ratio of 2.387 indicates urban areas outside Vienna are more likely than rural areas to have industrial facilities, the odds ratios for immigration
rate, University degree rate, and average living space are only slightly changed and remain statistically significant. We furthermore examined interaction terms between the geographical variables and immigration rates but did not find them to be statistically significant and are thus not included in the table. Overall, results in model 3 show that even after controlling for geographical differences, the immigration rate remains the strongest predictor of industrial facility location, along with the University degree rates and average living space.

4. Discussion and conclusions

Inspired by the environmental justice movement and the extensive body of literature in the US and the subsequent interest in this issue in Europe, this paper aimed to lay the empirical foundation for presenting data for Austria in a comparable way to the US and to foster further studies and discourses about EJ in Europe. It breaks new ground in two ways: it is the first study to examine the patterns of environmental inequality around industrial sites analogous to the US in Austria. It also applies distance-based methods in conducting an EJ analysis in the European context. The superiority of distance-based methods in estimating demographic characteristics within uniform, circular distances around environmentally-hazardous sites over the more traditional unit-hazard coincidence method has been thoroughly analyzed and demonstrated in prior studies (Mohai and Saha 2006, 2007, Bullard et al 2007, Mohai 2008, Chakraborty et al 2011, Mohai and Saha 2015b). Furthermore, because distance-based methods produce units of similar size and shape, their application has considerable potential to enable cross-national comparisons in the future.

The main question this study addressed is whether industrial facilities are unequally distributed within Austrian society. By analyzing the 1.0 km buffers around all 247 E-PRTR facilities in Austria in 2013, we found inequalities concerning the sociodemographic makeup of those areas. While in Vienna disparities are smaller, the situation outside of Vienna fits the results of other US and European studies. Even after controlling for geography (i.e. Vienna, other urban areas, and rural areas), neighborhoods within 1.0 km of facilities include more immigrants, fewer people with University degrees, and smaller living spaces than areas beyond.

Looking closer at the immigrants, it becomes clear that some immigrant groups carry a higher environmental burden than others. In Austria outside Vienna, people born in Turkey, former Yugoslavia and new EU countries live around facilities at disproportionate rates, in some cases with a factor up to 2.7. In contrast, people born in EU-15 member states are less likely to live in the vicinity of industrial facilities. The importance of immigration status shares similarities to race and ethnicity in US studies, where racial and ethnic disparities in the distribution of environmental hazards cannot be explained by socioeconomic differences alone (Mohai et al 2009b).

The results of this study and others conducted in Europe show that environmental inequalities exist, begging the question why a social movement focused on environmental justice does not exist in Europe such as in the US. In Austria, opposition against environment and health impacting projects has been mainly generated by mainstream environmental NGOs or local resident groups, mostly denouncing the impairment of livelihood and health, but barely linking these issues to questions of social class or race (Wendering 2016). In the US, the EJ movement emerged in the wider context of the Civil Rights Movement (Agyeman 2002, Bullard et al 2007). By then, racial and ethnic minorities, especially African-Americans, had considerable experience in building structures to organize and make themselves heard. Immigrants in Austria are not as organized as racial and ethnic minorities in the US, so they lack the power of making themselves heard in the public discourse. Moreover, due to an almost non-existent environmental justice debate, there is little they can make reference to. Thus far EJ scholarship in Europe has relied on theoretical arguments that have originated in the US. Future research will need to determine whether these are applicable in the

| Table 4. Logistic regression models predicting facility locations based on socioeconomic and geographic variables. |
|---------------------------------|---------------------------------|---------------------------------|
| % Immigrants                   | 1.099*** (1.07, 1.13)           | 1.072*** (1.04, 1.11)           |
| % Unemployed                   | 1.044 (0.98, 1.11)              | 1.056 (0.99, 1.13)              |
| % University degree            | 0.947** (0.91, 0.99)            | 0.934* (0.89, 0.98)            |
| Average living space per person (m²) | 0.961** (0.94, 0.99)        | 0.966* (0.94, 0.99)            |
| Vienna                         | 0.685 (0.27, 1.75)              |                                 |
| Other Urban                    | 2.387*** (1.52, 3.75)           |                                 |
| Constant                       | 0.317***                         | 3.633                           |
| -2 log-likelihood              | 683.97                           | 615.53                          |
| Model χ²                      | 62.74***                         | 86.17***                        |

Note: OR = odds ratio; CI = confidence interval
*P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001.
European context and whether other explanations are more relevant. It will also need to address why an EJ movement has not emerged in Europe to the extent it has in the US.

Often it is asserted that environmental justice is not a major issue in Europe or Austria because inequalities are not as great as in the US (Agyeman 2002, Diekmann and Meyer 2010, Padilla et al 2014). This study showed, however, that they do exist to a certain level, and even reflect similarities to racial, ethnic, and socioeconomic inequalities in the US. From here on, it leaves many open questions: what are possible explanations for this situation? What role does the historical pattern of both the industry sector and urban development and planning play? Are there differences in results for different sectors? Which came first, the industrial facilities or the socially disadvantaged people?

Case studies and longitudinal studies alike will be needed to further investigate the mechanisms lying behind this issue. Understanding the causes of environmental disparities is not only of interest to academics. With an adequate understanding about the extent and depth of environmental disparities and about how they are produced, we can attempt to aid social movement actors and policymakers who might seek to remedy these problems. This is needed for an implementation of sustainable development goals and lies at the core of environmental justice (Agyeman and Evans 2004).

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