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39th meeting of the European Economic Association & 76th European meeting of the Econometric Society

Zeroing in on the Zero Waste City

Rotterdam, Netherlands, August 26, 2024

Jane Torbert, in collaboration with Prof. Melanie Krause, PhD

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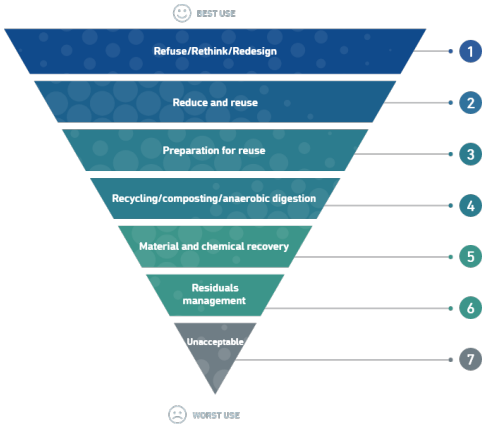
What is zero waste?



Zero waste refers to the conservation of resources throughout the entire life cycle of a product — from raw material sourcing to production to disposal

- abolish incineration
- end/ minimize landfilling
- resource (re)extraction/ recover value added
- increased recycling and composting
- efficient manufacturing
- conscious energy consumption

Zero Waste Europe

- Movement started in 1997 by school teacher, Rossano Ercolini (Current President of ZWE and Zero Waste Italy)
- Officially founded in 2013 as European regional branch of the Global Alliance for Incinerator Alternatives (GAIA)
- Network includes **480+ municipalities** in **16 European countries**
- Connects and supports 35+ national member NGOs (170+ local groups) from all around Europe

▸ More ▸ Zero Waste Commitment

Research Questions

Are we able to predict which cities are likely to become zero waste, and can we identify which characteristics make a city likely to become zero waste?

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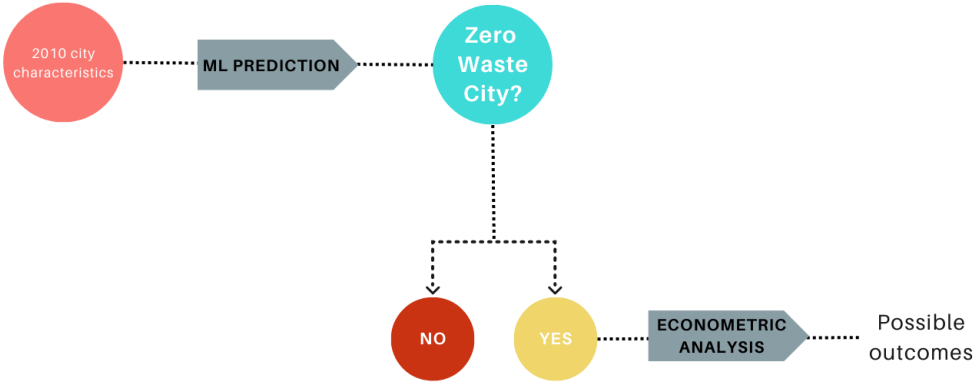
Given that cities are *Zero Waste*, to what extent does the initiative act as a commitment device? How do overall municipal waste totals and recycling rates compare to cities who have not committed to the *Zero Waste* strategy?

Twofold analysis



Process Flow

Contents

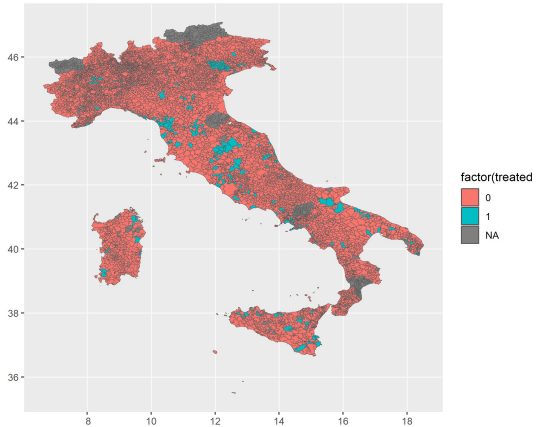
Our Novel Data

We exploit

- detailed municipal-level waste data for all of Italy
- including 310 treated cities
- between 2010 and 2020

We also consider a number of socio-economic, geographic, and institutional factors including education, age share of population, migration, GDP, hydrogeological risk, heating and cooling degree days, tourism, and waste collection type.

ZW City Spread



Italian municipalities by treatment status

Summary Statistics

Treatment Status	0		1	
Variable	N	Mean	N	Mean
GDP per cap	81382	26518.78	1992	25804.37
Population Density	81351	304.08	1992	612.34
Regional Spread	81382		1992	
... CENTRAL	81382	13%	618	31%
... INSULAR	81382	9%	208	10%
... NORTHEAST	81382	17%	429	22%
... NORTHWEST	81382	40%	224	11%
... SOUTH	81382	21%	513	26%
Organic (tons)	53434	352.38	1680	672.10
Paper (tons)	76023	418.59	1958	1186.52
Glass (tons)	75374	245.27	1939	701.05
Plastic (tons)	74951	147.63	1943	465.75
Separately Collected	77815	52.49%	1971	63.58%
Waste per capita (tons)	78150	0.47	1971	0.46
MGMT cost per cap (unsorted)	34370	58.64	909	57.80
MGMT cost per cap (separated)	34370	44.03	909	62.83

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Predicting Zero Waste Status

Machine learning applications for classification using city characteristics from 2010 for ca. 7900 municipalities

Linear

- Logistic Regression

  Binary Outcome: Does city turn *Zero Waste* between 2010 and 2020?

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- Decision Trees

  Learns hierarchy of if/else questions

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Non-linear

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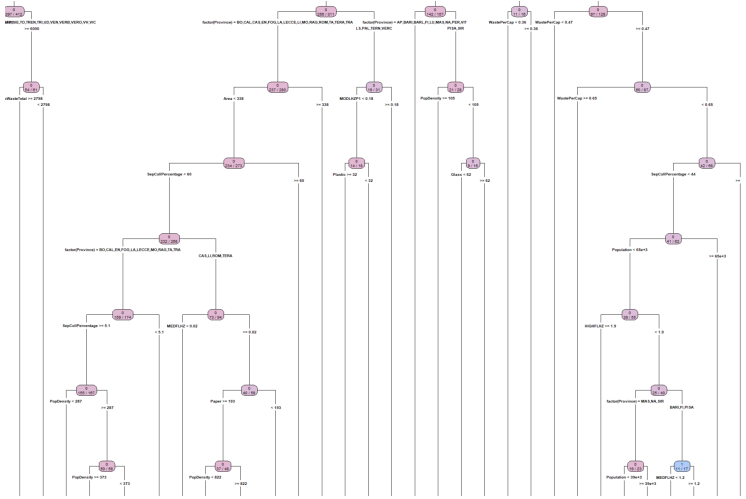
  Learns hierarchy of if/else questions

- Random forests

  Creates ensemble of decision trees

Decision Tree Example



Results

Confusion Matrices

	Logistic Reg.		*Decision Tree*		*Ran. Forest*	
	0	1	0	1	0	1
0	1324	60	1298	51	1325	59
1	1	3	27	12	0	4
N	1388		1388		1388	
Accuracy Score	95.60%		94.38%		95.75%	

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ML Results- Characteristic Importance

Switching Gears

So far we have tried to explain which cities become *Zero Waste*

↓

Contingent on a city committing to the *Zero Waste* initiative, we want to examine possible effects of this treatment

↓

Econometric analysis

Contents

Matching

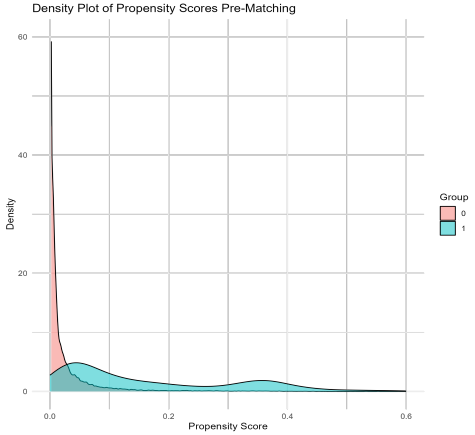
Using pre-treatment data we match treated cities to control cities

- Based on the features that come out of the machine learning analysis
- Propensity score matching

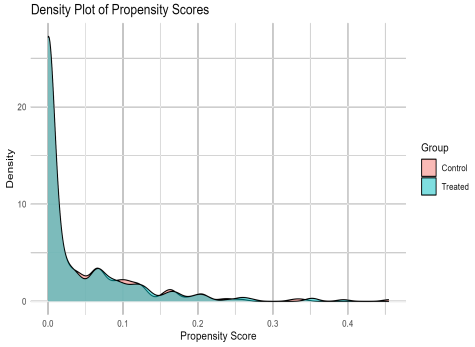
Match Performance

- 294 treatment-control municipal matches
- All but 11 matches are from the same province, with the remaining 11 in the same region (insular)
- 25 control cities have been used more than once (mostly insular)

Match Performance



Density Plot Before Matching



Density Plot After Matching

Preliminary Regression Analysis

Difference-in-Differences Model Specification

$$Outcome_i = \beta_0 + \beta_1 * After_i + \beta_2 * ZeroWaste_i + \beta_3 (After * ZeroWaste) + \beta_4 * Controls_i + \epsilon_i, \quad (1)$$

for two outcomes, municipal waste per capita and separate collection rate, in municipality *i* before and after treatment, β_0 is the vertical intercept, $After_i$ is an indicator variable which takes the value 1 if municipality *i* is in the post treatment period and 0 otherwise, $ZeroWaste_i$ is indicator variable which takes the value of 1 if municipality *i* participates in *Zero Waste Europe* and 0 otherwise, and $After * ZeroWaste$ is an interaction term taking the value 1 when both are fulfilled. Controls include both socio-economic and geographical variables.

Initial Results

Difference-in-Differences Results- Municipal Waste Per Capita

	Dependent variable:
	MWPC (kg)
ZeroWaste	-3.549
	(9.607)
After	-7.641
	(25.615)
ZeroWaste*After	19.913
	(27.044)
Constant	150.517
	(139.474)
Controls Included?	Yes
Observations	995
Adjusted R^2	0.450
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Initial Results

Difference-in-Differences Results- Rate of Separate Collection

	Dependent variable:
	Separate Collection
ZeroWaste	4.128**
	(1.665)
After	-5.998
	(4.439)
ZeroWaste*After	10.179**
	(4.687)
Constant	3.129
	(24.170)
Controls Included?	Yes
Observations	995
Adjusted R^2	0.548
Note:	*p<0.1; **p<0.05; ***p<0.01

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Up Next

- Staggered Treatment DiD
- Dealing with endogeneity

Wrap Up

1. Predicted which Italian cities opt in to the *Zero Waste* initiative

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4. Matched treated cities to control cities based on the important characteristics that came out of ML
5. Compared those which opt in to those who do not in preliminary analysis
6. Find that waste is not reduced in absolute terms, but see rates of separation increase for participating cities

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THANK YOU!

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Global Alliance for Incinerator Alternatives, Zero Waste Europe, Mission Zero Academy

Objectives

- GAIA: global alliance of 800+ grassroots groups, NGOs, and individuals in 90+ countries envision just, incinerator-free world
- ZWE: foster transition to zero waste through establishing legislative, financial, and cooperative groundwork necessary
  - → Joint work with GAIA on plastic pollution, waste trade, climate, zero waste best practices, and incineration alternatives, etc.
- MiZA: subsidiary of ZWE, local liaise sharing up- and downstream zero waste solutions, resources, and information
  - → Joint work with ZWE to create two-fold fee-based certification for zero waste candidate cities (est. 2021)

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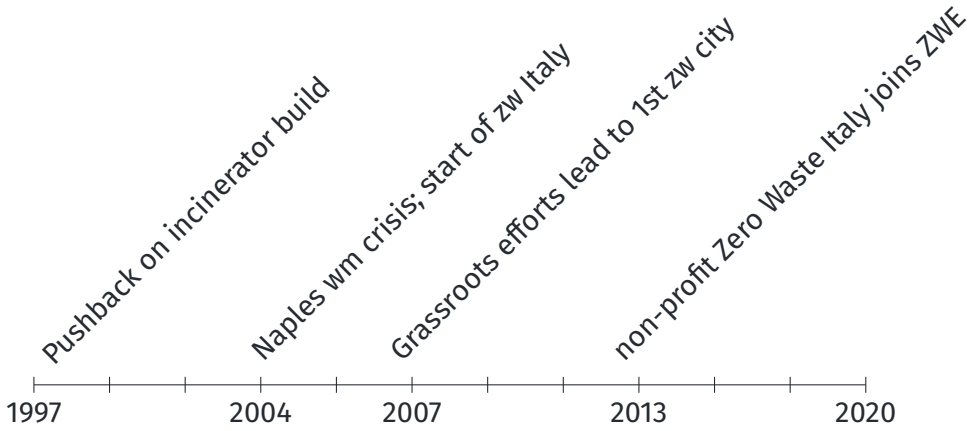
More on Founding



The Zero Waste Commitment

Submit commitment letter

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Adopt and implement collection program

↓

Publicly report progress

↓

Establish Zero Waste Advisory Board

↓

Audit discarded materials

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Continually improve

back