Yardstick competition in the recycling of waste after the EU Waste Framework Directive: Evidence from Italian provinces

Supplementary Information

Supplementary Information Table of Contents

Appendix A: Descriptive statistics and first stage results

Table A1: Timing of local elections in Italy

Year	# provinces holding elections	% provinces holding elections on the total
2001	9	8.74
2002	10	9.71
2003	14	13.59
2004	63	61.17
2005	6	5.83
2006	10	9.71
2007	8	7.77
2008	19	18.45
2009	59	57.28
2010	8	7.77
2011	11	10.68
2012	1	0.97
2013	12	11.65
2014	10	9.71

Table A2: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Per-capita waste recovery	1,428	-2.174	0.949	-5.435	-0.774
Share of waste recovery	1,428	0.299	0.191	0.009	0.819
Neighbors' per-capita waste recovery	1,428	-2.130	0.852	-5.988	-1.077
Neighbors' share of waste recovery	1,428	0.295	0.172	0.006	0.707
1 year before election	1,428	0.200	0.400	0	1
2 years before election	1,428	0.225	0.418	0	1
3 years before election	1,428	0.230	0.421	0	1
Election	1,428	0.167	0.373	0	1
Neighbors 1 year before election	1,428	0.201	0.309	0	1
Neighbors 2 years before election	1,428	0.227	0.324	0	1
Neighbors 3 years before election	1,428	0.231	0.320	0	1
Neighbors Election	1,428	0.166	0.282	0	1
Population (log)	1,428	12.96	0.707	11.37	15.28
Employment rate (log)	1,428	-0.948	0.269	-4.286	-0.300
Per capita tourism (log)	1,428	0.430	1.003	-3.970	3.501
Per capita GDP (log)	1,428	-3.775	0.364	-5.869	-0.004
Added value	1,428	23.03	0.743	21.21	25.41
Population density	1,428	258.6	361.2	28.88	2,653
Left-wing party	1,428	0.562	0.496	0	1
Regional election	1,428	0.196	0.397	0	1
Total urban waste per-capita	1,428	0.525	0.102	0.289	0.865
Term limit	1,428	0.287	0.453	0	1
High GDP	1,428	0.505	0.500	0	1
High female participation	1,428	0.526	0.500	0	1
Waste Framework Directive (WFD)	1,428	0.500	0.500	0	1

Table A3: Source of spatial dependence (first stage results of Table 3)

	No WFD		WFD		No WFD		WFD	
	No term-limit	Term-limit	No term-limit	Term-limit	Pre-electoral years	No pre-electoral years	Pre-electoral years	No pre-electoral years
Neighbors' waste recovery								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Neighbors 1 year before election	-0.02	0.06	0.01	0.10*	0.13**	-0.41***	-0.18**	0.08
	(0.08)	(0.06)	(0.04)	(0.05)	(0.06)	(0.15)	(0.07)	(0.06)
Neighbors 2 years before election	-0.00	0.02	-0.04	0.10	0.10*	-0.42***	-0.17***	-0.05
	(0.04)	(0.05)	(0.04)	(0.08)	(0.05)	(0.14)	(0.06)	(0.05)
Neighbors 3 years before election	0.03	-0.01	0.04	0.07	0.09*	-0.05	-0.03	0.07**
	(0.05)	(0.04)	(0.03)	(0.05)	(0.06)	(0.04)	(0.06)	(0.04)
Neighbors Election	0.04	-0.01	0.03	0.01	-0.05	-0.21**	-0.08	0.03
	(0.06)	(0.04)	(0.03)	(0.04)	(0.05)	(0.10)	(0.06)	(0.04)
Kleibergen-Paap F	0.501	0.610	6.462	2.765	1.637	2.778	3.324	2.345
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	457	251	558	138	299	288	306	282
R-squared	0.35	0.40	0.67	0.82	0.69	0.76	0.73	0.62
Number of Provinces	101	71	98	33	100	101	101	101

Notes: period 2001-2014. Neighbors' waste recovery is the average value across neighbors' of the (log) of per capita waste recovery. Provincial controls are: population, employment rate, per capita presence of tourism, per capita GDP, population density, value added, left-wing party, and regional election. Robust standard errors clustered at provincial level are shown in parenthesis. Significance at 10% level is represented by *, at the 5% level by **, and at 1% level by ***.

Table A4: Waste recovery and spatial interactions – Falsification tests (first stage results of Table B1)

Dependent Variable: Neighbors' waste recovery		
	(1)	(2)
Neighbors 1 year predicted before election	0.13***	
	(0.04)	
Neighbors 2 years predicted before election	0.09**	
	(0.04)	
Neighbors 3 years predicted before election	0.07**	
	(0.03)	
Neighbors predicted Election	0.10***	
	(0.03)	
Neighbors 1 year before election		0.00
		(0.03)
Neighbors 2 years before election		-0.04
		(0.02)
Neighbors 3 years before election		-0.04
		(0.03)
Neighbors Election		0.01
		(0.02)
Kleibergen-Paap F	4.231	1.608
Year Effects	Yes	Yes
Province Effects	Yes	Yes
Province Controls	Yes	Yes
Observations	1,428	1,326
Number of provinces	102	102

Notes: period 2001-2014. Neighbors' waste recovery is the average value across neighbors' of the (log) of per capita waste recovery. Provincial controls are: population, employemnt rate, per capita presence of tourism, per capita GDP, population density, value added, left-wing party, and regional election. Robust standard errors clustered at provincial level are shown in parenthesis. Significance at 10% level is represented by *, at the 5% level by **, and at 1% level by ***.

Table A5: Alternative dependent variable and additional control (first stage results of Table B3)

Dependent Variable: Neighbors' waste recovery	Share of waste recovery	Share of waste recovery	Per-capita waste recovery (log)	Per-capita waste recovery (log)
	(1)	(2)	(3)	(4)
Neighbors 1 year before election	0.00	0.00	0.04	0.06
	(0.01)	(0.01)	(0.04)	(0.04)
Neighbors 2 years before election	0.00	0.00	-0.00	0.00
	(0.01)	(0.01)	(0.03)	(0.03)
Neighbors 3 years before election	0.01	0.01	0.04**	0.03
	(0.00)	(0.00)	(0.02)	(0.02)
Neighbors Election	-0.01	-0.01	0.05*	0.07**
	(0.00)	(0.00)	(0.03)	(0.03)
Total waste per capita			-0.21	0.29
			(0.73)	(0.51)
Kleibergen-Paap F	1.863	1.927	4.102	4.610
Year Effects	103	103	Yes	Yes
Province Effects	Yes	Yes	Yes	Yes
Province controls	No	Yes	No	Yes
Observations	1,442	1,442	1,428	1,428
Number of Provinces	0.75	0.75	102	102

Notes: period 2001-2014. In columns (1) an (2) neighbors' waste recovery is the average value across neighbors' of the share of waste recovery. In columns (3) an (4) neighbors' waste recovery is the average value across neighbors' of the (log) of the per-capita waste recovery. Provincial controls are: population, employemnt rate, per capita presence of tourism, per capita GDP, population density, value added, left-wing party, and regional election. Robust standard errors clustered at provincial level are shown in parenthesis. Significance at 10% level is represented by *, at the 5% level by **, and at 1% level by ***.

Table A6: Heterogeneity results (first stage results of Table C1)

Dependent Variable: Neighbors' waste recovery	Left-wing party		High female participation		High GDP	
	Yes	No	Yes	No	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)
Neighbors 1 year before election	0.02	0.08	0.12	0.09	-0.02	0.10**
	(0.03)	(0.05)	(0.09)	(0.07)	(0.02)	(0.05)
Neighbors 2 years before election	0.01	0.03	-0.02	0.08	-0.02	0.04
	(0.03)	(0.05)	(0.05)	(0.06)	(0.02)	(0.04)
Neighbors 3 years before election	0.03	0.04	0.06*	0.04	0.04*	0.03
	(0.03)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)
Neighbors Election	-0.05*	0.09***	-0.02	0.09**	-0.02	0.10***
	(0.03)	(0.03)	(0.04)	(0.04)	(0.02)	(0.03)
Kleibergen-Paap F	1.723	3.400	4.554	1.473	2.173	3.353
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Province Effects	Yes	Yes	Yes	Yes	Yes	Yes
Province controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	802	626	699	719	714	714
Number of Provinces	77	71	61	62	102	102

Notes: period 2001-2014. Neighbors' waste recovery is the average value across neighbors' of the (log) of per capita waste recovery. Provincial controls are: population, employemnt rate, per capita presence of tourism, per capita GDP, population density, value added, left-wing party, and regional election. Robust standard errors clustered at provincial level are shown in parenthesis. Significance at 10% level is represented by *, at the 5% level by **, and at 1% level by ***.

Appendix B: Robustness tests

In this section, we perform a set of robustness checks intended to address possible issues related to the validity of the instruments, which could bias the baseline estimates. First, we use a different definition of the political budget cycle as an external instrument. After controlling for province and year fixed effects, we test for the potential presence of remaining sources of bias by performing balancing regressions. Finally, we conduct a battery of falsification tests, including the use of a different dependent variable.

Alternative measures of the political budget cycle as instrumental variables

Council resignations and/or dismissals among provinces might create concerns about identification, as the resignation/dismissal could be endogenous to local area circumstances. To account for this, and in the spirit of the test conducted by Repetto (2018), we construct an artificial political cycle for all provinces by using "predicted" years relative to the election, regardless of commissioner status. More precisely, we fix the election cycle timing to that at the beginning of the study period, and we assume that each province votes again every 5 years. That is, if a province is in its pre-electoral year in 2002, it is automatically assumed to vote again in 2008 and thus be in its pre-electoral year in 2007. We repeat the same procedure according to the specific year of the term that provinces are in during 2001. Using these theoretical schedules, we build the predicted pre-electoral year dummy variable and then construct averages for this dummy across neighbors to instrument the per capita waste recovery of neighboring municipalities. Column 1 of Table B1 reports the second stage results (Column 1 of Table A4 reports the first stage results) of this analysis and shows that the coefficient is statistically significant and very similar to, although slightly larger in magnitude than, those obtained in the baseline specification, thus suggesting that endogenous resignation is not a serious concern.

Falsification test

We conduct a timing falsification test by replacing the dependent variable with a one-year lag. Along these lines, since the political cycle of neighboring provinces at time t impacts per capita waste recovery, which affects the waste recovery behavior of a given province at time t, it is very unlikely that the waste recovery decisions of neighboring provinces in year t shape a given

province's own waste recovery attitude at time t-1. The results are shown in Table B1. As seen in Column 2, the coefficient of neighbors' waste recovery at time t does not have any impact on the level of a given province's own waste recovery decisions at time t-1. Column 2 of Table A4 reports the first stage results.

Table B1: Waste recovery and spatial interactions – Falsification tests (second stage)

Dependent Variable:	Per-capita waste recovery (log)	Per-capita waste recovery $(log)_{t-1}$
	(1)	(2)
Neighbors' waste recovery	0.85***	0.93
	(0.25)	(0.63)
1 year predicted before election	0.00	
	(0.02)	
2 years predicted before election	-0.01	
	(0.02)	
3 years predicted before election	0.02	
	(0.02)	
1 year predicted Election	0.02	
	(0.02)	
1 year before election		-0.04**
		(0.02)
2 years before election		-0.02
		(0.02)
3 years before election		-0.00
		(0.02)
Election		-0.03
		(0.02)
Kleibergen-Paap F	4.231	1.608
Hansen Test (p-value)	0.731	0.796
Year Effects	Yes	Yes
Province Effects	Yes	Yes
Province Controls	Yes	Yes
Observations	1,428	1,326
R-squared	0.81	0.78
Number of Provinces	102	102

Notes: period 2001-2014. Neighbors' waste recovery is the average value across neighbors' of the (log) of per capita waste recovery. The corresponding first stage is reported in Table A4 of the Online Appendix. Provincial controls are: population, employment rate, per capita presence of tourism, per capita GDP, population density, value added, left-wing party, and regional election. Robust standard errors clustered at provincial level are shown in parenthesis. Significance at 10% level is represented by *, at the 5% level by **, and at 1% level by ***.

Balancing test

Demographic, institutional and socio-economic variables might be poorly measured proxies for the confounders. In this respect, as recently shown by Pei et al. (2018), a more suitable test consists of including provincial controls as dependent variables on the left-hand side of the regression equation. Table B2 shows the results of these balancing regressions for various provincial characteristics, and none of these regressions yields significant effects. These results help to rule out the possibility that a correlation between the neighbouring waste-recovery attitude variable and other time-varying characteristics of provinces are driving the results.

Table B2: Balancing regressions (second stage)

Dependent variable	Population	Employment	Tourism	GDP	Density	Value Added	Center-left	Regional election
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Neighbors' waste recovery	0.02	-0.38	-0.01	0.02	-26.09	-0.03	0.26	-0.11
	(0.02)	(0.36)	(0.18)	(0.04)	(22.86)	(0.03)	(0.51)	(0.12)
Kleibergen-Paap F	4.504	4.302	5.311	4.599	4.618	4.774	-	-
Hansen Test (p-value)	0.186	0.498	0.274	0.121	0.817	0.456	-	-
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,442	1,442	1,442	1,442	1,442	1,442	1,442	1,442
R-squared	0.99	-0.34	0.56	0.97	0.64	0.96	-	-
Number of Provinces	102	102	102	102	102	102	103	103

Notes: period 2001-2014. Neighbors' waste recovery is the average value across neighbors' of the (log) of per capita waste recovery. The variable neighbors' waste recovery is instrumented by using the following variables: neighbours' 1 year before election, neighbours' 2 years before election, neighbours' 3 years before election, and neighbours' election. Provincial control variables are: 1 year before election, 2 years before elections, 3 years before elections, election, population, employment rate, per capita presence of tourism, per capita GDP, population density, value added, left-wing party, and regional election, excluding each time the dependent variable. Robust standard errors clustered at the provincial level are shown in parentheses. Significance at 10% level is represented by *, at the 5% level by **, and at 1% level by ***.

Shares analysis

A final issue concern regards the use of level, that is our dependent variable is given by the amount of recycled waste, in per capita terms. However, such an amount depends on how much waste was produced by residents. The point here is that both the amount of recycled waste and

total waste produced are two key elements of the analysis that should be controlled for simultaneously.

Hence, to tackle this concern, we have replicated our baseline estimates by using the quota of the recycled waste over the total amount of waste produced, as the dependent variable. The results of this analysis are reported in Table B3, Col. 1 and 2 and, reassuringly, are very similar to those of Table 2. Moreover, to strength our evidence, we have complemented this set of robustness test by keeping the per-capita waste recovery as the dependent variable, while controlling for the per capita total amount of waste. Also in this case, results of this analysis, shown in Table B3, Col. 3 and 4, lead to similar conclusion as those depicted in Table 2.

Table B3: Alternative dependent variable and additional controls (second stage)

Dependent variable:	Share of waste recovery	Share of waste recovery	Per-capita waste recovery (log)	Per-capita waste recovery (log)
	(1)	(2)	(3)	(4)
Neighbors' waste recovery	0.98*	1.07*	0.83**	0.76**
	(0.55)	(0.56)	(0.37)	(0.37)
Total waste per capita			0.86	1.22***
			(0.66)	(0.47)
Kleibergen-Paap F	1.863	1.927	4.102	4.610
Hansen Test (p-value)	0.549	0.554	0.856	0.890
Year Effects	Yes	Yes	Yes	Yes
Province Effects	Yes	Yes	Yes	Yes
Province controls	No	Yes	No	Yes
Observations	1,442	1,442	1,428	1,428
R-squared	0.75	0.75	0.80	0.81
Number of Provinces	103	103	102	102

Notes: period 2001-2014. In columns (1) and (2) neighbors' waste recovery is the average value across neighbors' of the share of waste recovery. In columns (3) and (4) neighbors' waste recovery is the average value across neighbors' of the (log) of per capita waste recovery. The variable neighbors' waste recovery is instrumented by using the following variables: neighbours' 1 year before election, neighbours' 2 years before election, neighbours' 3 years before election, and neighbours' election. Provincial controls are: 1 year before election, 2 years before elections, 3 years before elections, election, population, employment rate, per capita presence of tourism, per capita GDP, population density, value added, left-wing party, and regional election. The corresponding first stage is reported in Table A5 of the Online Appendix. Robust standard errors clustered at provincial level are shown in parenthesis. Significance at 10% level is represented by *, at the 5% level by **, and at 1% level by ***.

All this evidence seems to reinforce the existence of a positive relationship between waste recovery at the provincial level and the waste recovery of neighbouring provinces.

Appendix C: Heterogeneity analysis

Partisan affiliation

Partisan politics influence on the way that provinces provide their services and their expenditures (see e.g. Tellier, 2006), also in relation to waste collection policies (Plata-Diaz et al., 2014). Therefore, we gathered information on the parties supporting the president of the province and we build a dummy variable, *left-wing party*, that equals one if the president of the province is supported by a left-wing coalition, and zero otherwise. We use the split-sample idea to divide the sample in two according to the political affiliation dummy variable. A comparison of Columns 1 and 2 of Table C1 suggests that provinces guided by left-wing majorities seem to be affected by spatial interactions, as the coefficient for neighbors' waste recovery is positive (1.03) and statistically significant at the 1% level, while that accounting for the other coalitions turns out to be indistinguishable from zero. Intriguingly, these findings suggest that the need to mimic neighboring policies emerges only in the case of councils governed by left-wing majorities, as these parties might be more sensible to certain policies, such as waste recovery (Bivand and Szymanski, 2000).

Female representation

The need to mimic neighbors' behavior might ultimately also depend on the gender composition of the provincial council, as it has been recently shown by the review of the literature conducted by Hessami and da Fonseca (2020) on the extent to which female representation affects policy decisions and outcomes across different countries and tiers of government. Hence, we collect data on the share of female representation in the provincial council along the entire period of observation and we group provinces into those for which the female representation is below the median (low female representation) and those for which it is above the median (high female representation), and we estimate Eq. (1) and Eq. (2) on these samples. The results of this analysis are reported in Table C1 and indicate that strategic

interactions seem to be stronger in provinces with a higher level of female representation. The spatial coefficient for municipalities characterized by high female representation is positive (0.74) and statistically significant at the 1% level (col. 3), while that of low-female representation turns out to be not statistically significant (col. 4). What these findings indicate is that woman might have a different perception of waste collection polices if compared to man, as also reflected in the 2020 Global Forum on Environment, section dedicated to "Gender-specific consumption patterns, behavioral insights, and circular economy" (OECD, 2020).

Income

Finally, we use the median value to the GDP per capita to divide provinces into those with low (below the median) and high (above the median) values of GDP. We then estimate Equations (1) and (2) for these subsamples. We posit that households might have an incentive to sort themselves in response to changes in the provision of an efficient waste collection system, as high-income households are more incline to recycling, or to pay attention to the recycling services provided in the area they live (Valenzuela-Levi, 2019). Hence, in provinces characterized by a higher level of GDP the need to mimic their neighboring should be more marked as compared to provinces characterized by a low level of GDP. The results of this analysis are reported in Table C1, columns 11 and 12, and support the prediction that strategic interactions are weaker with low levels of GDP. Indeed, in column 11, which presents the results for the sample of provinces with a low level of GDP, the coefficient associated with neighbours' waste recovery is positive (0.57) but not statistically significant. On the contrary, in the group of provinces whose level of GDP is high (column 6) the coefficient of neighbors' waste recovery is positive (0.98) and statistically significant at the 5% level.

Table C1: Heterogeneity results – Second stage results

Dependent variable: per-capita waste recovery (log)	Left-wing party		High female participation		High GDP	
	Yes	No	Yes	No	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)
Neighbors' waste recovery	1.03***	0.79	0.72***	0.85	0.97***	0.52
	(0.40)	(0.49)	(0.15)	(0.62)	(0.31)	(0.51)
Kleibergen-Paap F	1.723	3.400	4.554	1.473	2.173	3.353
Hansen Test (p-value)	0.513	0.720	0.291	0.248	0.806	0.712
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Province Effects	Yes	Yes	Yes	Yes	Yes	Yes
Province controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	802	626	742	670	719	699
R-squared	0.83	0.75	0.83	0.79	0.83	0.81
Number of Provinces	77	71	72	72	62	61

Notes: period 2001-2014. Neighbors' waste recovery is the average value across neighbors' of the (log) of per capita waste recovery. The variable neighbors' waste recovery is instrumented by using the following variables: neighbours' 1 year before election, neighbours' 2 years before election, neighbours' 3 years before election, and neighbours' election. Provincial controls are: 1 year before election, 2 years before elections, 3 years before elections, election, population, employment rate, per capita presence of tourism, per capita GDP, population density, value added, left-wing party, and regional election. The corresponding first stage is reported in Table A6 of the Online Appendix. Robust standard errors clustered at provincial level are shown in parenthesis. Significance at 10% level is represented by *, at the 5% level by **, and at 1% level by ***.

References

Bivand, R., Szymanski, S. (2000), Modelling the spatial impact of the introduction of Compulsory Competitive Tendering, *Regional Science and Urban Economics*, 30, 2, 203-219.

Hessami, Z., da Fonseca, M.L. (2020), Female political representation and substantive effects on policies: A literature review, *European Journal of Political Economy*, 63, 101896.

OECD (2020), *Gender-specific consumption patterns, behavioural insights, and circular economy*. Session 5, 2020 Global Forum on Environment, Paris 5-6 March, Available here: https://www.oecd.org/env/GFE-Gender-Issues-Note-Session-5.pdf.

Pei, Z., Pischke, J. S., Schwandt, H. (2018), Poorly measured confounders are more useful on the left than on the right, *Journal of Business & Economic Statistics*, 37, 205–216.

Plata-Díaz, A. M., J. L. Zafra-Gómez, G. Pérez-López, and A. M. López-Hernández. (2014), Alternative Management Structures For Municipal Waste Collection Services: The Influence Of Economic And Political Factors, *Waste Management*, 34, 11, 1967-1976.

Repetto, L. (2018), Political budget cycles with informed voters: evidence from Italy, *The Economic Journal*, 128, 3320-3353.

Tellier, G. (2006), Public Expenditures in Canadian Provinces: An Empirical Study of Politico-Economic Interactions, *Public Choice*, 126, 367–385.

Valenzuela-Levi, N. (2019), Do the rich recycle more? Understanding the link between income inequality and separate waste collection within metropolitan areas, *Journal of Cleaner Production*, 213, 440-450.