“Waste management policy and employment: the case of France”

AUTHORS	Younes Ben Zaied Nidhaleddine Ben Cheikh Pascal Nguyen Mohamed Badrane Mahjoub

ARTICLE INFO	Younes Ben Zaied, Nidhaleddine Ben Cheikh, Pascal Nguyen and Mohamed Badrane Mahjoub (2018). Waste management policy and employment: the case of France. *Environmental Economics*, *9*(1), 38-46. doi:10.21511/ee.09(1).2018.03
DOI	http://dx.doi.org/10.21511/ee.09(1).2018.03
RELEASED ON	Friday, 13 April 2018
RECEIVED ON	Tuesday, 06 March 2018
ACCEPTED ON	Friday, 06 April 2018

LICENSE	This work is licensed under a Creative Commons Attribution 4.0 International License

JOURNAL	"Environmental Economics"
ISSN PRINT	1998-6041
ISSN ONLINE	1998-605X
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
22	1	6

© The author(s) 2026. This publication is an open access article.

Younes Ben Zaied (France), Nidhaleddine Ben Cheikh (France), Pascal Nguyen (France), Mohamed Badrane Mahjoub (Tunisia)

Waste management policy and employment: the case of France

Abstract

This paper examines whether a causal relationship exists between waste tonnage and employment when the waste collection is entrusted to a private operator in France (i.e. waste management policy by delegation of service). The empirical investigation is based on weekly data for four waste streams for the period from January 2015 to June 2017. Using nonstationary time series techniques including cointegration, VECM (Vector Error Correction Model) and long-run causality test of Toda and Yamamoto (1995) within a bivariate framework, the results demonstrate potential causal negative relationship between waste tonnage and employment. For three waste streams (i.e. household waste, outdoor garbage waste and miscellaneous waste), the results suggest that waste management practices that aim at entrusting the collection and treatment to a private operator (i.e. waste management by delegation of service) are not economically beneficial to society, because this policy does not favor environmental jobs creation. The paper calls for the adoption of other waste management practices to preserve employment in the waste collection sector.

Keywords: waste tonnage, employment, VECM, long-run causality, jobs creation.
JEL Classification: C22, J88, Q53.

Introduction

Worldwide, the rapid increase in waste burdens along with a higher population growth rate and increased economic development has become a serious issue for policy makers. Sustainable development, initially introduced by the Brundtland report (1997) during the Earth Summit, is defined as economic development that strives to meet the needs of the current generation without compromising the ability to meet future generation's needs. Waste management is the basis for sustainable socioeconomic development, especially in European countries where the economic growth rate and human development index are relatively higher compared with developing countries. Therefore, adequate waste management policies are the only useful tool for green development, because they put forward a strategic pro-environmental behavior (D'Amato et al., 2016; Abbott et al., 2013; Berglund, 2006; Cerere et al., 2014). According to the World Bank report (2013), the solid waste tonnage was 3.5 million tons per day in 2010 and will increase to reach 10 million tons in 2100.

European countries have adopted several measures to reduce the amount of generated waste. Incentive taxes and prevention are the key policy options adopted to minimize waste production. The strategic policies that encourage recycling may have positive impacts on waste reduction and contribute significantly to changing people's preferences regarding a pro-environmental lifestyle (Bowles & Polania-Reyes, 2012). However, waste management policies should have a direct or indirect impact on economics through several channels and the direct impact of waste management policy on economics can be detected through its impact on employment. However, despite the waste collection sector offering the poorest quality jobs, waste transport, treatment, management practices could be beneficial for employment by the creation of environmental jobs. Due to the high labor intensity of waste collection (e.g., recycling and sorting), employment could be positively affected. In most cases, in waste management employment is unskilled and low-paying, but provides an initial route back into employment for the social excluded.

In France, the collectivity[1] must choose between two waste management practices. It can directly manage the waste collection and treatment by itself or entrust the process to a private operator through a public tender offer, called waste management by a delegation of service. Therefore, the private operator, a private company of waste collection and street cleaning services, collects and treats urban waste independently. The second practice should affect employment directly or indirectly because the private operator's goal is to earn the maximum profit through waste collection and treatment cost minimization.

© Younes Ben Zaied, Nidhaleddine Ben Cheikh, Pascal Nguyen, Mohamed Badrane Mahjoub, 2018.
Younes Ben Zaied, ESSEC Business School, France.
Nidhaleddine Ben Cheikh, Essca Business School, France.
Pascal Nguyen, Esdes Business School, France.
Mohamed Badrane Mahjoub, ISIMS, University of Sfax and Paris School of Economics, Tunisia.

This is an Open Access article, distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International license, which permits re-use, distribution, and reproduction, provided the materials aren't used for commercial purposes and the original work is properly cited.

[1] In France, the collectivity is a group of villages and suburbs of a big city that are grouped together to take unified public policy actions.

Waste management has been a major problem in ecological economics during the last three decades (i.e., 1980–2015) as documented in the literature (Beliën et al., 2014; Chongwoo & Lain, 1998; Silchenko et al., 2015; Burcea, 2014). The literature calls for additional empirical investigations to assess waste management policies and identify their economic impact. In addition, the literature demonstrates a discovery of unexplored areas of research and identifies trends that should be examined in future research to investigate the waste management economics nexus. In most cases, waste management papers have empirically investigated the role played by different policies and practices for solid, metal, and chemical waste, rather than household waste (Moss et al., 2013; Fizaine & Court, 2015). By contrast, the economic impact of waste management policy at the micro-level using daily or weekly data disaggregated by the waste stream was never investigated.

Basically, in the ecological economics literature, the nexus between employment and waste management policy was neglected because of data unavailability. In addition, detecting the impact of waste management policy on employment is difficult, especially at the macro level, because it is at the regional level and not a common policy. However, any optimal policy to change household or firm behavior with respect to waste management requires an appropriate specification of a suitable model and an appropriate methodology.

The impacts of waste management on employment were common in the literature. Most of those papers have analyzed the economic impact of waste management in the case of United States, whereas for the European case, empirical papers are inexistent. In this literature, the direct and indirect economic impacts of waste management on employment are discussed, including the impact of an increase in waste tonnage, for different waste streams, on the number of jobs created and sales of recyclable materials.

For the southern part of the United States, Roy F. Weston (1994, 1996) observed that recycling increased the net employment level and value-added in the studied areas. Precisely, Quigley (1988) concluded that the level of jobs created from waste collection and recycling is one job per 800 tons of materials recycled. Platt and Morris (1993) estimated that for every 15,000 tons of recovered materials, nine jobs would be directly created. However, with the same tonnage of recovered materials, two jobs would be created in incineration and only one job would be created in landfilling.

Sell et al. (1998) studied the impacts of waste developments in rural western US states to demonstrate that for the cases of Colorado, Nebraska, Oklahoma, Texas, and Utah, waste diversion operating and siting regions experienced larger gains in population, employment, and income, compared with the no development sites. To do that, they used data set for different years from 1984 to 1994. By contrast, Reamer (1991) explained that some barriers, like the under-valued public benefits of recycling and under-investment in research and development, prevented economic development from recycling.

This paper is a pioneer in using weekly per capita waste tonnage data for various waste streams to empirically investigate its impact on employment. The weekly data were collected by the private operator from January 2015 to June 2017 in the region of Paris, France. This company provided data describing four waste streams: miscellaneous waste, outdoor garbage waste, household waste, and packaging waste. In addition, the private operator also provided data that described the corresponding employment in weekly number of hours required in the collection of each waste stream.

Our study takes an innovative approach by implementing rigorous unit roots and multivariate cointegration tests to fully describe the random components and long-run patterns of the time series that characterize weekly per capita waste tonnage and employment. Next, we estimated a VECM (Vector Error Correction Model) to calculate the short-run impacts. Cointegration and error correction model techniques allow for the calculation and comparison of short- and long-run waste tonnage impact on employment. A short-run analysis of the relationship between waste tonnage and employment aims to quantify the impact without the private operator's long-run strategy to reduce waste collection costs. A long-run analysis of the relationship between waste tonnage and employment emphasizes the role of the waste management strategy adopted by the private operator and impact of per capita waste tonnage evolution, through time, on employment.

According to our review of the literature, we are the first to use time series techniques and weekly data for each waste stream to study the waste tonnage employment nexus. We use a rich weekly data set from the first week of January 2015 to the fourth week of May 2017. The data obtained from the private operator that manages waste collection include disaggregate time series for waste tonnage per capita in kilo and employment in number of hours by waste stream for the region of Paris,

France. The data includes four waste streams: miscellaneous waste, outdoor garbage waste, household waste and packaging waste.

In our methodology, the first step is to conduct the ADF, PP, and KPSS unit root tests. Next, we study the long-run causality and Johansen cointegration test before investigating the error correction models. When applied to the French data, we observe a long-run causality from the waste streams' tonnage to employment for outdoor garbage, household waste, and packaging waste. However, we did not observe evidence for the long-run causality between miscellaneous waste and employment. In estimating the long-run versus the short-run impacts of per capita waste tonnage on employment, we observe long-run negative impacts of waste tonnage on employment for miscellaneous waste, outdoor garbage, and household waste. However, for packaging waste, the impact cannot be detected, because the cointegration between waste tonnage and employment is rejected. The results we obtain suggest that waste management practices that aim at entrusting the collection and treatment to a private operator (i.e., management by delegation of service) are not economically beneficial to society because this policy does not favor environmental jobs creation.

The remainder of the paper is organized as follows. Section 1 describes the weekly data set we use in our empirical analysis, the different waste streams, and the empirical model. Section 2 develops the methodology we use to test and estimate the long-run and short-run models, Last section presents and discusses the results of our empirical analysis, outlines the recommendations addressed to collectivities in terms of waste management practice, and evaluates the economic impacts.

1. Context, data set description, and the model

France's current waste management policy was adopted in 2007. This waste management strategy was implemented through a new legislative framework with specific targets for waste management at the national level. Its main objectives are to reduce the production of household waste and similar waste per capita by 7%, reduce the waste sent to a landfill or incinered by 15%, implement economic incentive tools to reduce waste production, and increase the recycling rate from 24% to 35%. However, in practice, the collectivity must choose between two waste management practices. It can manage the waste collection and treatment by itself or entrust the process to a private operator. Indeed, the second practice can affect economics through several channels like employment.

To address this issue, the objective of this paper is to investigate the long-run impact of waste production (Y_t) on employment (E_t) using weekly French data collected by the private operator in the region of Paris. This company provides weekly data, from January 2015 to May 2017, describing per capita waste production for each waste stream and employment in number of hours for each waste stream. The wastes are classified in four streams: miscellaneous waste, outdoor garbage waste, household waste, and packaging waste.

Due to possible endogeneity between the variables, a bivariate VECM model is estimated in the form

$$\Delta E_t = \alpha_0 + \lambda T + \sum_{i=1}^{K} \beta_i \Delta \mathrm{E}_{t-i} + \sum_{i=1}^{K} \gamma_i \Delta \mathrm{Y}_{t-i} + \sum_{j=1}^{r} \Psi_j \mathrm{ECM}_{t-1} + \mathcal{E}_i \,,$$

where K denotes the number of lags and r the number of linearly independent cointegrating vectors. The cointegration is examined within Johansen's (1991) approach where a maximum of two cointegrating vectors is found. Y and E denote the per capita waste tonnage and employment and ECM is the lagged cointegration error used to control short-run adjustment. The VECM is estimated in five steps. First, we test for unit root at level and first difference using the ADF, PP, and KPSS tests. Second, we select the optimal lag (K) using the AIC. Third, we perform the Toda and Yamamoto (1995) causality test within a bivariate framework to check the causal relationship between per capita waste stream (Y) and employment (E). Fourth, the Johansen (1991) cointegration test is applied with trend to test for long-run relationships. Finally, we estimate the VECM using the optimal lag length and cointegration rank, determined previously.

Miscellaneous waste is defined as hazardous waste that includes adhesives, used cooking oil and grease, epoxies, mortars and uncured cement, swimming pool and photo chemicals, glues, nail polish and chemicals, smoke detectors and fire extinguishers. This type of waste is hazardous and should never be thrown in the trash or recycling bin. Outdoor garbage waste is defined as all construction and furniture waste thrown into the outdoor garbage bin. Household and packaging waste are residential waste and include food scraps, newspapers and magazines, bottles, cans, clothing, compost, food packaging, yard trimmings and plant debris.

The private operator that manages waste collection in Paris provided an original weekly data set. This

database describes the weekly per capita waste tonnage collected for each of the four waste streams and the weekly number of hours required for the collection of each corresponding waste stream. Using this desegregated database, we investigate the impact of waste tonnage on employment in France when waste management is entrusted to a private operator or privatized. A description of the variables and basic descriptive statistics for each waste stream are presented in Table 1.

Table 1. Description of the variables and basic descriptive statistics, January 11, 2015-May 24, 2017

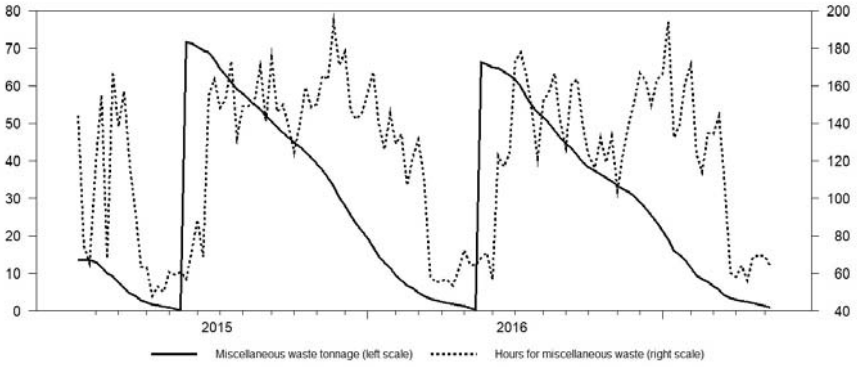
Variable	Description	Mean	Max.	Min.
Miscellaneous waste				
Y	Weekly miscellaneous waste tonnage per capita in kg	28.01	71.6	0.35
E	The number of hours required each week for the collection of miscellaneous waste	121.6	194.2	47.9
Outdoor garbage waste				
Y	Weekly per capita tonnage of outdoor garbage waste expressed in kg	10.2	22.8	0.26
E	The number of hours required for the collection of outdoor garbage waste each week	56.4	85.7	10.3
Household waste				
Y	Weekly per capita tonnage of household waste expressed in kg	114.1	247.5	4.9
E	The number of hours required for the collection of household waste	556.9	624.6	377.4
Packaging waste				
Y	Weekly per capita tonnage of packaging waste expressed in kg	19.5	42.8	0.92
E	The number of hours required each week for the collection of packaging waste	180.7	228.3	60.17

Note: All series are observed with weekly frequency. The private operator (i.e., the company that manages waste collection) defines the four waste streams and provides weekly data for each stream.

Household waste represents the most relevant stream in terms of tonnage and employment. On average, this type of waste represents more than five times the tonnage of the other waste streams and more than six times the number of hours required for the collection of outdoor garbage waste. However, packaging waste, which can be used as a measure of household recycling behaviors, notably deviates from the average of the other waste streams (e.g., miscellaneous or outdoor garbage).

Indeed, the results from any study aiming to identify the factors influencing household recycling behavior could improve proenvironment policies and decisions with the goal of increasing sustainable and green development.

As we investigate the time series' properties of the weekly waste streams' tonnage and employment, we must observe the time graph of each couple of variables. In Figure 1, each waste stream tonnage and employment are represented by a line graph.



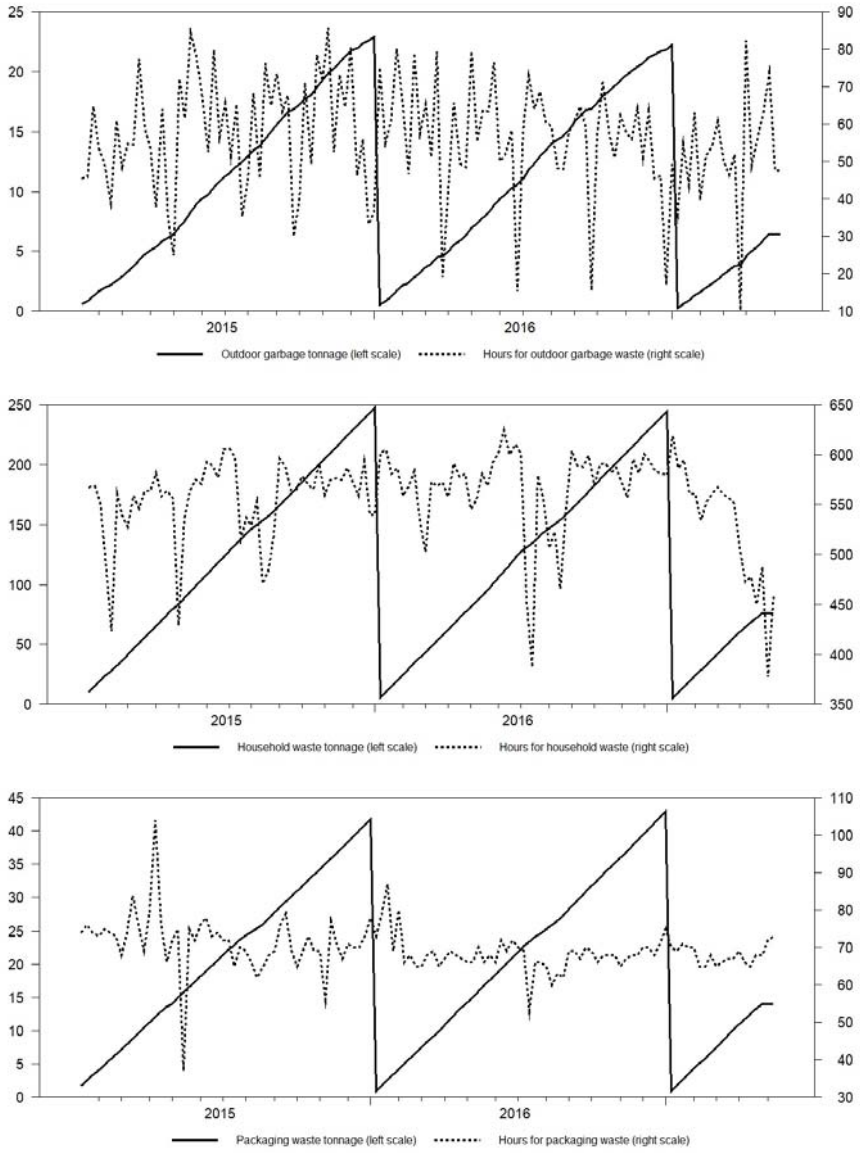


Fig. 1. Per capita weekly waste tonnage and employment

From Figure 1, we can clearly observe the long-run dependence between employment and waste tonnage. Notably, for miscellaneous waste and outdoor garbage waste, the continuous (per capita waste tonnage) and discontinuous (employment) lines exhibit the same co-movement properties, as we can observe the presence in the same period of peak or acute decline. However, the peak represents the seasonal effects, caused by social events (Thanksgiving, National Day, music festivals, and summertime wedding celebrations), which increase the consumption of goods and, consequently, waste tonnage.

These figures suggest that most of these variables (i.e., waste tonnage and employment) are nonstationary and must be analyzed through time series techniques. To move beyond these preliminary observations, we must analyze the nonstationary properties of the weekly time series for all the waste streams. We began our empirical investigation by determining the order of integration of all the variables. If the variables are integrated in the same order for each waste stream, then we can test for long-run equilibrium between both nonstationary variables that are integrated in the same order. The existence of a long-run relationship allows for the estimation and comparison of per capita waste tonnage impact on employment.

2. Empirical methodology and results

The empirical analysis is based on a collectivity in the southern region of Paris, France. The time dimension of the dataset covers the period from January 2015 to May 2017 (i.e., weekly data). The private operator that manages waste collection provides weekly data for the four waste streams. The data describe the weekly per capita waste production and corresponding time in number of

hours spent in the collection of each waste stream. The main focus of our empirical investigation is the identification of the impact of waste management by a private operator on employment.

2.1. Unit root tests. We use nonstationary time series techniques, because the data exhibit a unit root (integrated of order 1). The next step of the empirical analysis tests for the long-run equilibrium system between per capita waste tonnage and employment. We use the multivariate approach of Johansen (1991) to test for long-run relationship between waste production and employment.

The null hypothesis of the ADF and PP unit root tests is that the variables have a unit root. For the KPSS test, the null hypothesis is the opposite. The results of the three unit root tests are reported in Table 2. The results clearly indicate that all the waste streams' per capita waste tonnage and employment are nonstationary and integrated of order one. The presence of unit root is because of the presence of seasonality and a stochastic component that is not stationary over time.

Table 2. Unit root tests

	ADF	PP	KPSS
Miscellaneous waste			
Y	-2.41	-2.32	0.14
E	-3.15	-3 .64	0 .11
ΔY	-3.43	-3.56	0.43
ΔE	-4.21	-4.87	0.31
Outdoor garbage waste			
Y	-2.49	-2.5	0.17
E	-2.34	-10.7	0.38
ΔY	-3.34	-4.01	0.23
Household waste			
Y	-2.5	-2.66	0.16
E	-2.8	-5.62	0.15
ΔY	-4.12	-3.87	0.26
ΔE	-3.96	-7.32	0.39
Packaging waste			
Y	-2.61	-2.69	0.16
E	-2.3	-2.4	0.36
ΔY	-3.79	-2.92	0.37
ΔE	-3.53	-4.01	0.41

Both waste tonnage per capita and employment demonstrate the same order of integration: they become stationary after one difference transformation. Consequently, we test for long-run equilibrium among the nonstationary variables using the Johansen (1991) cointegration test.

2.2. Cointegration test and estimation. We apply the multivariate approach developed by Johansen (1991) to test for cointegration. The results are reported in Table 3 and demonstrate that the null hypothesis of the absence of cointegration is clearly rejected for the three waste streams. The Akaike Information Criterion selected a model with five lags. The cointegration test is performed with five lags and with time trend. As the results indicate, two cointegration relationships are identified for miscellaneous waste, outdoor garbage waste, and household waste. However, there is no evidence of cointegration between per capita waste tonnage and employment for the case of packaging waste. The absence of a long-run relationship between waste production and employment for the packaging waste stream can be attributed to the absence of a sufficient data set: data are available only for 53 weeks between July 2016 and May 2017.

Table 3. Johansen (1991) cointegration test

Rank	Eigenvalue	Trace stat	5% critical value
Miscellaneous waste			
0	0.16	35.15	15.49
At most 1	0.11	13.9	3.84
Outdoor garbage waste			
0	0.25	40.5	15.49
At most 1	0.05	6.13	3.84
Household waste			
0	0.09	18.8	15.49
At most 1	0.06	7.6	3.84
Packaging waste			
0	0.1	5.5	15.49
At most 1	0.01	0.82	3.84

Next, as both per capita waste tonnage and employment are endogenous, we must identify the causality direction within the long-run relationships. To do that, we apply the approach of Toda and Yamamoto (1995), which aims at performing a long-run causality test within a bivariate framework to check the causal relationship between per capita waste stream (Y) and employment (E). Whereas the Granger causality test requires us to estimate a VAR model with the optimal lag length p and to test the zero restriction for these lags, the Toda and Yamamoto (1995) test comprises an estimation of a VAR (Vector Auto Regressive) process with $p + d$ lags, where d is the integration degree of the series. The results of this test are presented in Table 4 for all waste streams. We accept the null of non-long-run causality only for packaging waste streams; thus, confirming the absence of no cointegration for this type of waste. However, for the miscellaneous, outdoor garbage, and household wastes, the long-run causality goes from per capita waste tonnage to employment. Consequently, the long-run coefficient of employment is normalized to one when estimating the long-run impact of waste tonnage on employment.

The estimated long-run coefficient is presented in Table 5 with its standard errors. For packaging waste, the long-run causality is rejected for two directions, confirming the absence of cointegration for this waste stream. From these results, we can clearly see the long-run negative dependence between weekly waste and employment and per capita waste tonnage for all the waste streams. The negative impact of waste tonnage on employment is the result of the privatization of waste collection and treatment processes. The delegation of waste service by the government to a private operator is an inefficient waste management policy.

Table 4. Long-run causality test

	Waste tonnage to employment	Employment to waste tonnage
Miscellaneous waste	7.47* (0.007)	15.06* (0.001)
Outdoor garbage waste	8.37* (0.004)	1.11 (0.29)
Household waste	9.16* (0.003)	1.97 (0.16)
Packaging waste	2.49 (0.12)	0.86 (0.35)

Note: (*) indicates the presence of long-run causality at 1% significance level. p-values are in parentheses.

For the collection of miscellaneous waste, an increase of per capita waste tonnage by 1 kg will reduce the weekly corresponding employment by more than half an hour (-0.55 hours). Thus, for the collection of miscellaneous waste, the private operator tends to reduce the number of its unskilled workers to increase the productivity of the remaining one and minimize the waste collection cost. Furthermore, we also observe a long-run negative impact of per capita waste tonnage on employment for the case of outdoor garbage waste. Indeed, an increase of weekly per capita outdoor garbage waste by 1 kg leads to a reduction of weekly corresponding employment by 0.26 hours. However, for household waste, the most relevant in terms of quantity compared with the other waste streams, a 1 kg increase in its weekly per capita tonnage reduces its employment by 0.23 hours.

Waste employment is extremely crucial for many people. As unskilled workers can satisfy it, this type of employment is usually very useful, especially for socially excluded people, because it provides an initial route back into employment for them. We observe empirically that a waste management policy that aims at entrusting waste collection to a private operator is not in favor of employment. It has a negative impact on economics through waste employment destruction.

An error correction model is considered in the next subsection to analyze the short-run impact of waste tonnage on employment and estimate the lagged cointegration error to measure the adjustments' measure within the equilibrium system.

Table 5. Cointegrating equations

Variables	Coefficient	Standard Errors
Miscellaneous waste		
E_t	1	-
Y_t	-0.55**	0.29
Outdoor garbage waste		
E_t	1	
Y_t	-0.26***	0.17
Household waste		
E_t	1	
Y_t	-0 .23**	0.13
Packaging waste		
E_t	-	-
Y_t	-	-

Note: (**) indicates significance at 1%, 5%, and 10% levels, respectively.

2.3. Error correction model. The estimated error correction model (Table 6) is weakly significant. Despite the statistical significance of the lagged cointegration error, the short-run coefficients that measure the short-run impact of per capita waste tonnage on employment are weakly significant. The lagged values of the residuals from the cointegrating relation are statistically significant for only two of the four waste streams. These results validate the cointegration of miscellaneous waste and household waste. The negative estimation of the lagged values implies that adjustments will cause the system to gradually converge toward the equilibrium. For the case of miscellaneous waste, two weeks (i.e., 1/0.5) are required for employment to return to its initial equilibrium level following a shock that impacts per capita waste tonnage. However, for household waste, only one week (i.e., 1/0.9) is required for employment to return to its initial equilibrium level following a shock on its corresponding per capita waste tonnage.

The level of employment in waste management, measured in number of hours, varies significantly between different waste streams. Household waste appears to be labor intensive compared with the other waste streams, which can explain why the long-run impact of household waste tonnage on employment is less critical in absolute value compared with the other waste streams.

Environmental policies have direct and indirect impacts on employment. For the case of waste management, these policies could be more labor intensive than others for air or water. However, there is usually a tradeoff between strategies to reach the fixed environmental goals and reduce the impact on employment when it is negative. Without

using disaggregated data, certain macro-level studies recognize that waste management policies may have both net positive and negative impact on employment (WRc, 1999; Waste Watch, 1999).

Table 6. Estimation of the VECM

Waste streams	Miscellaneous waste	Outdoor garbage waste	Household waste
ECM_{-1}	-0.5* (0.21)	1.2 (0.8)	-0.9* (0.25)
ΔY_{t-1}	-0.34 (0.3)	0.02 (0.5)	-0.15 (0.12)
ΔY_{t-2}	0.29 (0.31)	0.35 (0.52)	-0.16** (0.12)
ΔY_{t-3}	0.58* (0.31)	-0.51 (0.52)	-0.09 (0.12)
ΔY_{t-4}	0.57* (0.31)	0.27 (0.52)	-0.06 (0.12)
ΔY_{t-5}	0.47 (0.31)	0.23 (0.52)	-0.04 (0.12)
ΔY_{t-6}	0.33 (0.29)	-0.4 (0.51)	-0.12 (0.11)
ΔY_{t-7}	0.35 (0.29)	-0.26 (0 .51)	-0.03 (0.11)
ΔY_{t-8}	0.11 (0.29)	-0.34 (0.51)	-0.04 (0.11)
ΔY_{t-9}	-0.3 (0.28)	0.34 (0.5)	-0.17** (0.11)
ΔE_{t-1}	-0.12 (0.13)	0.06 (0.33)	0.08 (0.18)
ΔE_{t-2}	0.02 (0.11)	0.24 (0.3)	0.01 (0.17)
ΔE_{t-3}	0.07 (0.11)	0.22 (0.28)	0.13 (0.16)
ΔE_{t-4}	0.18** (0 .1)	0.15 (0.26)	0.16 (0.15)
ΔE_{t-5}	0.06 (0.11)	-0 .14 (0.23)	0.18 (0.14)
ΔE_{t-6}	0.04 (0.12)	-0.07 (0.2)	0.15 (0.13)
ΔE_{t-7}	-0.18 (0 .12)	0.04 (0.18)	0.007 (0.12)
ΔE_{t-8}	-0.09 (0.12)	-0.13 (0.15)	-0.04 (0.11)
ΔE_{t-9}	-0.016 (0.12)	-0.03 (0.11)	-0.004 (0.1)

Note: Standard errors are in parentheses; * and ** indicate the 1% and 5 % significance levels, respectively.

The relationship between employment and waste management policies is complex and multiple impacts can be observed from empirical studies. The results may differ with respect to the nature of the data-the context and weight of waste stream tonnage within all waste tonnage. Evidently, waste management policies could be in favor of waste management services demand, but it does not necessarily result in the creation of additional jobs. Indeed, labor can be, in most cases, substituted by technology and constrained by productivity.

For the case of France, this paper is a pioneer in its use of weekly data for each waste stream with its corresponding employment to model the waste-employment nexus using nonstationary time series techniques. The net effect of waste tonnage on employment, when the delegation of service is adopted as waste management policy, is, consequently, estimated in the number of hours for each waste streams.

Conclusion and policy implications

The consideration of employment effects when evaluating policies is essential. The adoption of delegation of service as a waste management policy negatively affects employment. However, to understand how employment effects can be better taken into account when evaluating a waste management policy, recognizing that impacts may arise at different level is also essential.

In this paper, we have disaggregated the waste tonnage by waste streams. Fortunately, a novel and rich weekly database was by the waste collector in per capita waste tonnage and its corresponding employment in number of hours for each of the four waste streams. The waste collector company provides data describing four waste streams: miscellaneous waste, outdoor garbage waste, household waste, and packaging waste, for the region in Paris, France. Using nonstationary time series methods, we modeled the relationship between waste tonnage and employment when the collectivity choose the delegation of service as a waste management policy. The long- versus short-run impact analysis we have developed in this paper reveals that the delegation of service could be harmful to employment.

For all the waste streams, the impact of waste tonnage evolution on employment was negative. A higher impact was estimated for the miscellaneous waste, where a 1 kg increase in per capita waste tonnage may reduce weekly employment by 0.55 hours. Moreover, for the case of outdoor garbage waste, a 1 kg increase in waste tonnage per capita decreases employment by 0.29 hours. Thus, we conclude there is a negative net effect of this waste management policy on employment. Even if it appears that the delegation of service is efficient and suitable compared with other waste management policy, such as the “régie”, its adoption is not beneficial for society. The delegation reduces jobs in the waste collection and treatment sectors and increases the unemployment rate. Finally, this paper is the first to apply an empirical analysis to detect the net direct effect of waste management policy on employment. This paper calls for the adoption of a more suitable policy to reach community environmental and social goals.

References

1. Abbott, A., Nandeibam, S., & O'Shea, L. (2011). Explaining the variation in recycling rates across the UK. *Ecological Economics, 70,* 2214-2223.
2. Abbott, A., Nandeibam, S., & O'Shea, L. (2013). Recycling: social norms and warm-glow revisited. *Ecological Economics, 90,* 10-18.
3. Beliën, J., De Boeck, L. & Van Ackere, J. (2011). Municipal Solid Waste Collection Problems: A Literature Review. *HUB RESEARCH PAPERS, 2011/34*.
4. Berglund, C. (2006). The assessment of households' recycling costs: the role of personal motives. *Ecological Economics, 56,* 560-569.
5. Bowles, S., & Polania-Reyes, S. (2012). Economic Incentives and Social Preferences: Substitutes or Complements? *Journal of Economic Literature, 50*(2), 368-425.
6. Burcea, S. G. (2014). *Formalizing The Romanian Informal Waste Sector: How Interested are Informal Recyclers?* Proceedings of the 15th International Academic Conference, Rome. Retrieved from http://iises.net/proceedings/international-academic-conference-rome/table-of-content/detail?article=formalizing-the-romanian-informal-waste-sector-how-interested-are-informal-recyclers--0
7. Chongwoo, C., & Fraiser, I. (1998). The Economics Of Household Waste Management: A Review. The Australian *Journal of Agricultural and Resource Economics, 42*(3), 269-302.
8. Cerere, G., Mancinelli, S., & Mazzanti, M. (2014). Waste prevention and social preferences: the role of intrinsic and extrinsic motivations. *Ecological Economics, 107,* 163-176.
9. D'Amato, A., Mancinelli, S., & Zoli, M. (2016). Complementarity vs substitutability in waste management behaviours. *Ecological Economics, 123,* 84-94.
10. Dickey, D., & Fuller, W. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association, 74,* 427-431.
11. Fizaine, F., & Court, V. (2015). Renewable electricity producing technologies and metal depletion: A sensitivity analysis using the EROI. *Ecological Economics, 110,* 106-118.
12. Johansen, S. (1991). Estimation and Hypothesis Testing of Co-integration Vectors in Gaussian Vector Autoregressive Models. *Econometrica, 59,* 1551-1580.
13. Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. (1992). Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Roo. *Journal of Economics, 54,* 159-178.
14. Moss, R. L., Tzimas, E., Kara, H., Willis, P., & Kooroshy, J. (2013). The potential risks from metals bottlenecks to the deployment of Strategic Energy Technologies. *Energy Policy, 35,* 556-564.
15. Platt, Brenda A., & Morris, David (1993). *The Economic Benefits of Recycling*. Washington, D.C. Institute for Local Self-Reliance. January.
16. Quigley, John (1988, March). Employment Impact of Recycling. *Biocycle*.
17. Reamer, Andrew D. (1991). Creating Jobs from Trash. *Commentary,* 20-29.
18. Roy F., & Weston, Inc. (1996). *Economic Benefits of Recycling in the Southern States*. Prepared for the Southern States Energy Board. Norcross, Georgia. August.
19. Roy F., & Weston, Inc. (1994). *Value Added to Recyclable Materials in the Northeast*. Prepared for the Northeast Recycling Council, Council of State Governments. Wilmington, Massachusetts. May 8.
20. Sell, Randall S., Leistritz, F. L., Murdock, S. H., Spies, S., White, S., Krannich, R. S., Wrigley, K., & Wulfhorst, J. D. (1998). Economic and Fiscal Impacts of Waste and Non-waste Development in Rural United States. *Impact Assessment and Project Appraisal, 16*(1), 3-13.
21. Silchenko, K., Del Gobbo, R., Castellano, N., Franceschetti, B. M., Tosi, V., & La Verghetta, M. (2015). *Sorting Through Waste Management Literature: A Text Mining Approach to a Literature Review*. Management International Conference, Slovenia.
22. Toda, H. Y., & Yamamoto, H. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics, 66,* 225-250.