Conditional panel data efficiency in the refuse collection service in Spain

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Introduction

The evaluation of the efficiency of public services has a long tradition in the public management sector (Narbón-Perpiñá and De Witte, 2018).

Global vs specific

- Specific services
- Overall municipality

Methodology

- Parametric vs Non-parametric
  - SFA
  - DEA, FDH, order-m

Determinants (Da Cruz and Marques, 2014)

- Natural conditions
- Customer
- Institutional
- Legacy conditions
- Market

Forms of provision

- Public vs private
- Cooperation
- Hybrids

Introduction

- Different efficiency levels for each management form (Pérez-López et al., 2016):
  - Lack of competition (Simões et al., 2010)
  - Contract managing and transaction costs (Bel and Fageda, 2006; Girth et al., 2012; Hefetz and Warner, 2012; Warner, 2012)
  - Municipal size and scale efficiency (Bosch and Solé-Ollé, 2005; Balaguer-Coll et al., 2007; Benito et al., 2010; Simões et al., 2013, Pérez-López et al., 2017)
  - Time effect (Máñez et al., 2016)

Introduction

Not all forms of management might be equally valid depending on the characteristics of the municipality in which the service is provided. For example, the effects of environmental variables, which are not directly controllable by the municipal government, might be influenced by the form of service management adopted.

Research question:
Which form of management is most appropriate to minimise the effects of environmental variables?

Introduction

Research question:
Which form of management is most appropriate to minimise the effects of environmental variables?

Specific service

- Refuse collection

Non-parametric approach

- Conditional panel data order-*m*

Non-controllable environmental variables

- Natural conditions
- Customer

Forms of provision

- Public vs private
- Single vs Cooperation

Background

PRIVATE VS PUBLIC PROVISION

- Competition in the service provision (Warner, 2012).
- Providing the same service in different municipalities may reduce cost (Donahue, 1989).
- Adaptation to certain socioeconomic environments due to their greater flexibility, not depending on neither political rules nor in the excessive bureaucracy or the red tape (Boyne, 2002, Alfiero et al., 2017).

H1: The long-term efficiency of public services managed by private companies will be less affected by environmental factors than public forms of management

Background

COOPERATION VS SINGLE PROVISION

- Small municipalities cooperate in the delivery of public services, sharing their resources and cost of the service (Boyne, 1996; Brown et al., 2012).
- Cost savings by increasing service provision to a greater population (Bel and Warner, 2015).
- Inter-municipal cooperation operates in local governments with different socioeconomic environments → Adaptation to heterogeneity

H2: The long-term efficiency of public services managed through inter-municipal cooperation will be less affected by environmental factors than the forms of individual management in municipalities of medium and small size

Background

COOPERATION WITH PRIVATE PRODUCTION

- More attractive to the private company and facilitate negotiations for the privatisation of the service in smaller municipalities (Kodryzski, 1994; Warner and Hefetz, 2003).
- Advantages of intermunicipal cooperation and private production: adaptation to diversity of environments.

H3: The long-term efficiency of public services managed through cooperation with private production will be less affected by environmental factors than any other form of management

Methodology

Order-*m* approach

Disadvantages of nonparametric approaches (DEA and FDH):

- Highly sensitive to outliers and extreme values, since DEA and FDH estimators envelop all data points (Daouia and Simar, 2007)
- Susceptible to measurement errors, because they assume the absence of statistical noise (De Witte and Marques, 2010)

The robust partial frontier approach: allowing the location of observations beyond the estimated efficiency frontier (Cazals et al., 2002)

Methodology

Environmental factors

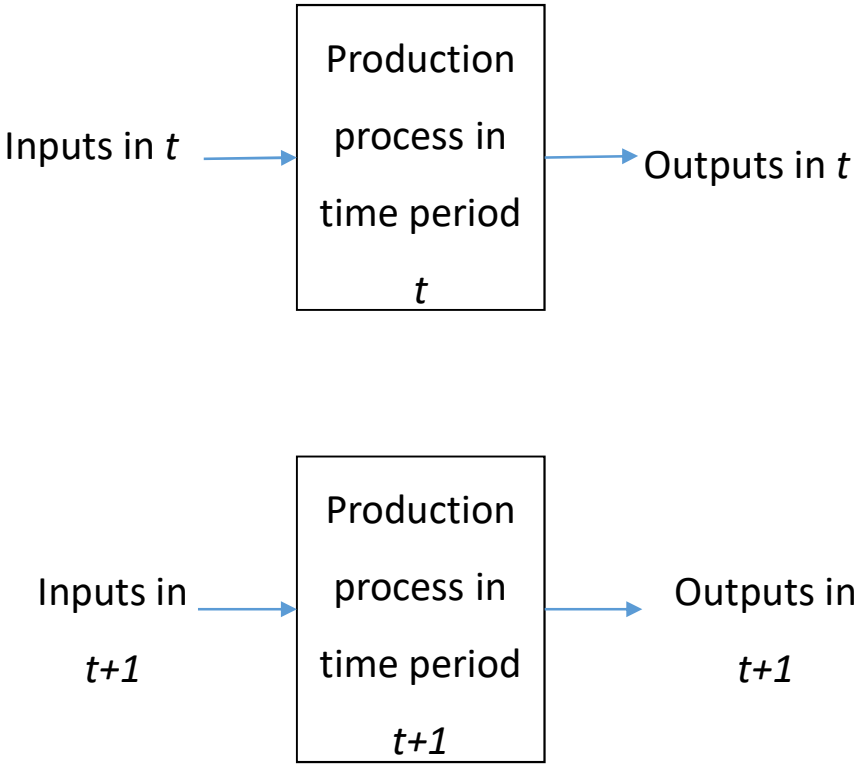
The inclusion of exogenous variables in the efficiency analysis is diverse, and it has been undertaken from two different approaches (Arcelus et al., 2013; Cordero and Salinas, 2017):

- **Two-stage analysis:** the efficiency is estimated in a first stage and then is regressed on the exogenous variables→ Only possible when there exists separability between the inputs, outputs and environmental variables (Simar and Wilson, 2007).
- **Conditional frontier:** the exogenous variables are included in the efficiency estimation (Daraio and Simar 2005, 2007a, 2007b).

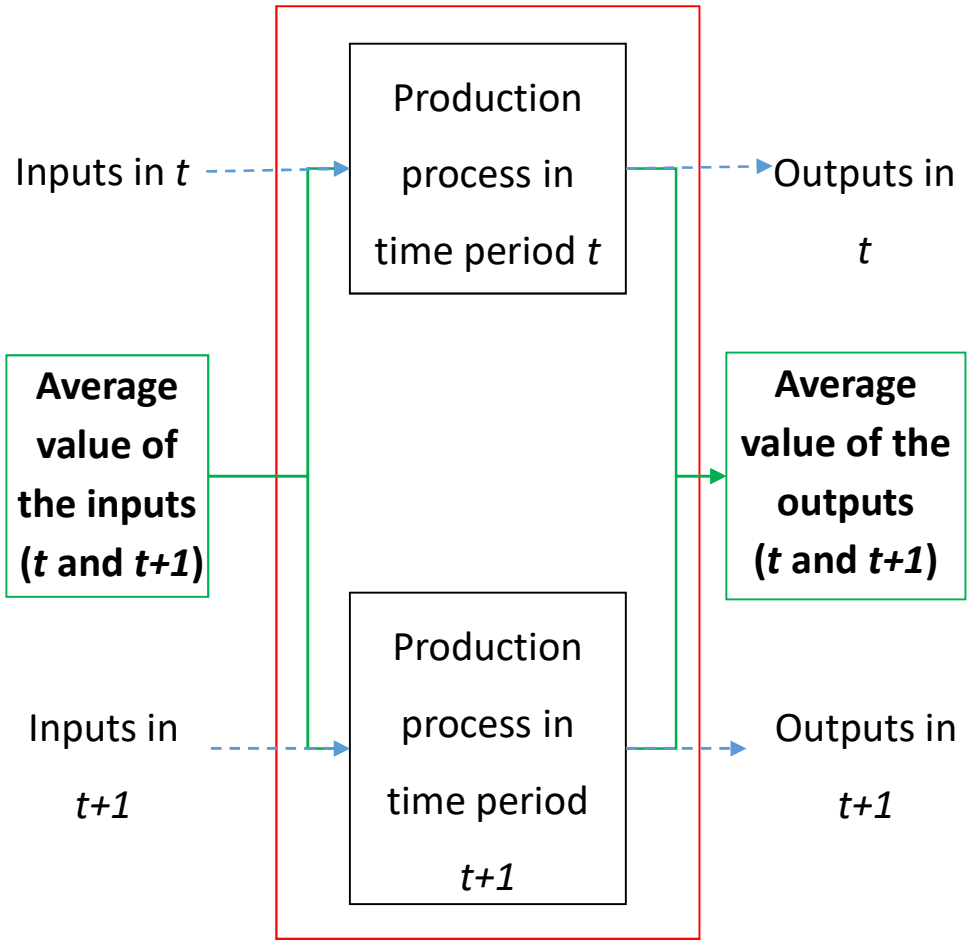
Methodology

Contemporaneous analysis and long-run panel data analysis (Pérez-López et al., 2018)

PANEL A. Contemporaneous analysis

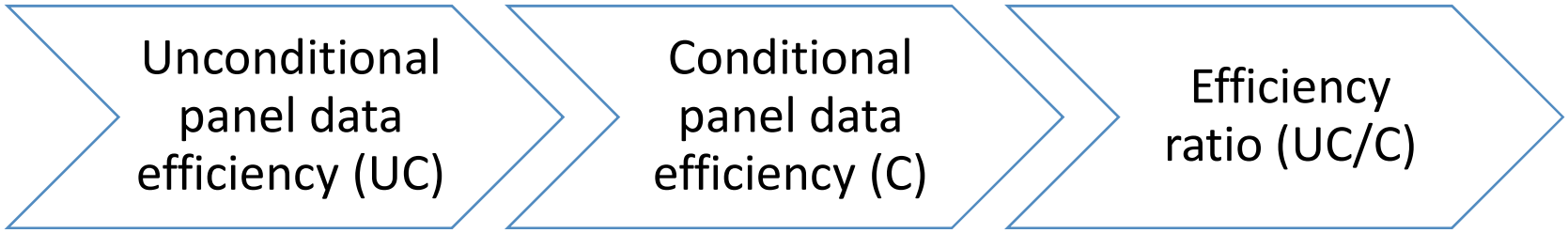


PANEL B. Long-run panel data analysis

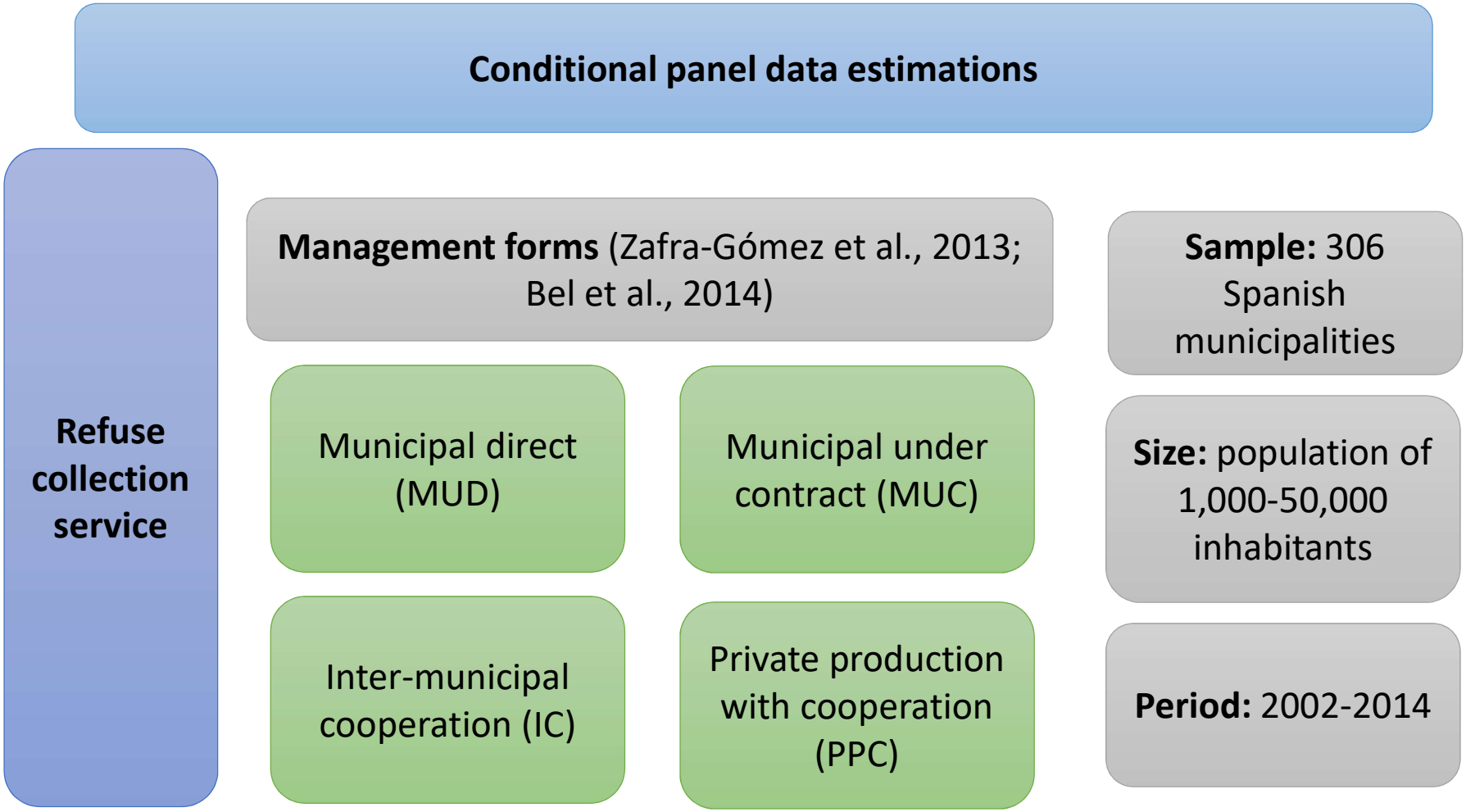


Methodology

We apply the **conditional order-*m* frontier considering a panel data structure** (Cazals et al., 2002; Daraio and Simar, 2005, 2007a, 2007b, Surroca et al., 2016)



Data and variables



Data and variables

Service delivery forms for the refuse collection service

Category	Concept
Municipal direct (MUD)	The service is managed by the municipality itself or through a public agency or public enterprise controlled by the municipality.
Municipal under contract (MUC)	Management is contracted out to a single private company.
Inter-municipal cooperation (IC)	Joint management by several municipalities, through a public entity created for this specific purpose (consortium or association) or through the transfer of management to a supra-local public entity (regional council).
Private production with cooperation (PPC)	Joint management among two or more municipalities, contracted out to a private company.

Source: The authors, based on Zafra-Gómez et al. (2013), Bel et al. (2014) and Plata-Díaz et al. (2014).

Data and variables

Refuse collection service: input and outputs

Variable	Definition	Source
Total Cost	The total cost of the waste collection service is composed of the capital and the operational costs of the service	Virtual Office of Local Government Financial Coordination of the Ministry of Public Administration and Treasury
MSW tonnes	Annual production of waste, in tonnes/year.	Survey of Local Infrastructure and Equipment (EIEL), from the Ministry of Public Administration's website
MSW tonnes * quality	Annual production of waste, in tonnes/year, corrected by the index of service quality, which is an internal measure indicating the adequacy/inadequacy of the service provided, in terms of the availability and cleanness of the containers, and of the periodicity of the waste collection performed.	
Containers	Number of containers available on public streets in the municipalities.	

Data and variables

Refuse collection service: environmental variables

Variable	Definition	Source
Population size	Total population for each local government (logarithm).	National Institute of Statistics
Population density	Number of inhabitants of each municipality divided by its extension (squared kilometers).	
Altitude	The height of the municipality above sea level	
Urban agglomeration	Number of population centres within the municipal area	
Tourist activity	Index of tourism-oriented activities.	Spanish Economic and Social Yearbook: La Caixa
Industrial activity	Index of industrial-oriented activities.	
Commercial activity	Index of commercial-oriented activities.	

Results

Panel data conditional efficiency by management form

	N	mean	p50	min	max	sd
MUD	56	0.6117169	0.6269287	0.2211366	0.9030533	0.1923723
MUC	108	0.4427363	0.4261568	0.1002076	0.8558541	0.2188207
IC	107	0.6037226	0.5953881	0.192636	1	0.2114647
PPC	35	0.6599805	0.7259037	0.3649756	0.9162404	0.1752245
Total	306	0.5548017	0.5689942	0.1002076	1	0.2226795

Panel data unconditional efficiency by management form

	N	mean	p50	min	max	sd
MUD	56	0.1556911	0.1469825	0.0520987	0.3684572	0.0754984
MUC	108	0.0857054	0.0746953	0.0276452	0.2253988	0.0453279
IC	107	0.1799163	0.1557901	0.0445049	1	0.1242675
PPC	35	0.1325236	0.1217797	0.0590555	0.3036283	0.0575667
Total	306	0.1368113	0.1170958	0.0276452	1	0.0955468

MUD: Municipal Direct; MUC: Municipal Under Contract; IC: Intermunicipal Cooperation; PPC: Private Production with cooperation

Results

Li test: conditional and unconditional efficiency by managment form

Null hypothesis (H_0): C=UC	10% significance	5% significance	1% significance
Municipal Direct	H_0 rejected	H_0 rejected	H_0 rejected
Municipal under contract	H_0 rejected	H_0 rejected	H_0 rejected
Intermunicipal Cooperation	H_0 rejected	H_0 rejected	H_0 rejected
Private production with cooperation	H_0 rejected	H_0 rejected	H_0 rejected

C= Conditional efficiency *UC= Unconditional efficiency*

Results

Panel data efficiency ratio by management form

	N	mean	p50	min	max	sd
MUD	56	0.2801349	0.2020642	0.1225993	0.9683605	0.18059
MUC	108	0.2269246	0.169507	0.1206495	0.9544021	0.16492
IC	107	0.3197558	0.2231839	0.1287848	1	0.2113533
PPC	35	0.2089762	0.1760878	0.0990175	0.6313192	0.1086621
Total	306	0.2670701	0.189376	0.0990175	1	0.1850051

Results

Li test: efficiency ratio by management form

Study hypothesis	Null hypothesis (H_0)	10% significance	5% significance	1% significance
H_1	Efficiency ratio (MUD) = Efficiency ratio (MUC)	H_0 rejected	H_0 rejected	H_0 rejected
H_2	Efficiency ratio (IC) = Efficiency ratio (MUC)	H_0 rejected	H_0 rejected	H_0 rejected
	Efficiency ratio (MUD) = Efficiency ratio (IC)	H_0 no rejected	H_0 no rejected	H_0 no rejected
H_3	Efficiency ratio (MUD) = Efficiency ratio (PPC)	H_0 no rejected	H_0 no rejected	H_0 no rejected
	Efficiency ratio (IC) = Efficiency ratio (PPC)	H_0 rejected	H_0 no rejected	H_0 no rejected
	Efficiency ratio (MUC) = Efficiency ratio (PPC)	H_0 rejected	H_0 rejected	H_0 no rejected

MUD: Municipal Direct; MUC: Municipal Under Contract; IC: Intermunicipal Cooperation; PPC: Private Production with cooperation

Results

H1: Not accepted

Private production (MUC) less affected by environment than public (MUD)

- Li test: H_0 rejected → Distribution of efficiency ratio of MUC differs from MUD
- Mean efficiency ratio MUD (28%) > Mean efficiency ratio MUC (22%) → MUD is less affected by environmental factors

Results

H1: Not accepted

Private production (MUC) less affected by environment than public (MUD)

H2:

Joint production (IC) less affected than single (MUD and MUC)

Partially accepted

- Li test: H_0 rejected when IC is compared with MUC → We cannot accept this hypothesis when IC is compared with MUD
- Mean efficiency ratio IC (31%) > Mean efficiency ratio MUC (22%) → IC is less affected by environmental factors

Results

H1: Not accepted

Private production (MUC) less affected by environment than public (MUD)

H2:

Joint production (IC) less affected than single (MUD and MUC)

Partially accepted

H3:

Private production with cooperation (PPC) less affected than the rest of management forms (MUD, MUC and IC)

Results

- Li test: H_0 rejected when PPC is compared with MUC → We cannot accept this hypothesis when PPC is compared with MUD and IC.
- Mean efficiency ratio PPC (20%) < Mean efficiency ratio MUC (22%) → MUC is less affected by environmental factors

H3: **Not accepted**

Private production with cooperation (PPC) less affected than the rest of management forms (MUD, MUC and IC)

Summary and conclusions

Contribution:

- To estimate the conditional order-*m* frontier using panel data evaluation → More conclusive results in time-series analyses of efficiency.
- To detect whether different management forms of the waste collection service moderate the effects of environmental variables, which are not directly controllable by the municipality. → So, public managers could take into account these factors in the decision of the service provisions.

Summary and conclusions

Contribution:

- From the policy standpoint:
  - Efficiency estimation depends on environmental factors.
  - Differences between management forms arise when private production is compared with other management forms.
    - Private production is more affected by the environment than municipal direct and inter-municipal cooperation.
    - Private production is less affected by the environment than PPC.

Summary and conclusions

Next steps:

There are different results for each management form.

How do the environmental factors affect to the efficiency?

Perform an analysis of the effect of the environmental factors through non-parametric regression

Thank you very much!

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