Sustainable budgeting and financial balance: Which lever will you pull?

Giovanna D'Inverno[a,b,*], Francesco Vidoli[c], Kristof De Witte[b,d]

[a] *Dep. of Economics and Management, University of Pisa, Via Ridolfi 10, 56124 Pisa, Italy*
[b] *Faculty of Economics and Business, KU Leuven, Naamsestraat 69, 3000 Leuven, Belgium*
[c] *Faculty of Economics, University of Urbino 'Carlo Bo', Via Saffi 42, 61029 Urbino, Italy*
[d] *UNU-Merit, Maastricht University, Boschstraat 24, 6211 AX Maastricht, The Netherlands*

Abstract

During the past few decades, countries have experienced a remarkable increase in local expenditure levels to address rising local needs. However, the limited availability of financial resources, exacerbated first by the 2008 financial crisis and then by Covid-19 crisis, has called for budget restrictions usually imposed by higher levels of government. In this paper, we evaluate the impact of a balance budget rule enforcement, exploring its effect on the local government cost efficiency and, in particular, considering the complex trade-off between efficiency and equity. Specifically, our identification strategy considers the exogenous introduction of a new budget balance rule that requires local governments to respect both an annual and a longer-term equilibrium criterion. The difference-in-differences analysis builds on a rich panel dataset covering all the public functions. We find that, on average, the budget rule enforcement exerted a positive effect on local government efficiency.

Keywords: OR in government, Local government performance, Balanced budget rules, Cost efficiency, Difference-in-Differences

JEL classification: C54, D24, H61, H71, H72

1. Introduction

Local governments have been increasingly designated as the most suitable government level to provide better tailored services and to address citizens' needs (Ben-Bassat *et al.*, 2016; D'Inverno & De Witte, 2020). However, to preserve the long-term fiscal sustainability of local public finances, higher levels of government have progressively enforced budget balance rules on local administrations (Asatryan *et al.*, 2018). The way local governments respond to a budget balance rule enforcement is not neutral with respect to efficiency and equity, nor does it bring equitable results to citizens (Bellofatto & Besfamille, 2021). As a response, local governments might increase the taxation level, reduce the service provision or decrease the public spending. Any of these responses represents a potential lever a local government can pull, with different degrees of rigidity and leading

*Corresponding author (giovanna.dinverno@unipi.it).
Email addresses: giovanna.dinverno@unipi.it (Giovanna D'Inverno), francesco.vidoli@uniurb.it (Francesco Vidoli), kristof.dewitte@kuleuven.be (Kristof De Witte)

to different overall results (Azevedo *et al.*, 2021). The present paper investigates whether the enforcement of a fiscal rule does affect the local government cost efficiency level, and ultimately the public finance sustainability, and through which available policy options.

The existing literature has mostly focused on the causal effect of budget balance rule enforcement (or relaxation) on debt, taxes, expenditure, the expenditure composition, or corruption (*e.g.*, Luechinger & Schaltegger, 2013; Grembi *et al.*, 2016; Asatryan *et al.*, 2018; Venturini, 2020, Daniele & Giommoni, 2021 and the review by Borge & Hopland, 2020).[1] Bergman *et al.* (2016) find that fiscal rules and government efficiency are substitutes in promoting sustainable public finances. However, despite the focus on the causal impact of fiscal rules enforcement, earlier literature neglected two aspects needed to provide an exhaustive causal impact assessment, as well as to take into account the collective well-being at the local level: efficiency and equity. Efficiency in local governments is defined as the ability to provide higher public services using a given set of resources (Narbón-Perpiñá & De Witte, 2018a). Equity can be defined as the right balance between offered services (historical output) and potential demand (standard output) (Vidoli & Fusco, 2018). This trade-off between efficient spending and service level aiming at social equity allows each citizen to have his/her needs met by the local government, regardless of the territory he/she is in. Ignoring these two interconnected aspects in the impact evaluation implicitly implies that local governments manage public resources at their best without any waste and that there are no disparities across local governments in terms of provided services.

Accordingly, a second strand of literature explores the impact of fiscal rules, and specifically the effect of accrual accounting, encompassing an efficiency perspective at municipal level (Lampe *et al.*, 2015; Dorn *et al.*, 2019). Under the pressure to improve the municipal financial sustainability, an increasing number of papers have investigated the role of fiscal and financial variables as determinants of local government efficiency, such as tax revenue, transfers and grants, financial liabilities and debt (Milán-García *et al.*, 2022). Local governments might raise the public debt not to overly cut the expenses or not to increase too much local taxes. In this regard, the relationship between efficiency and debt has been explored, making for example clear distinction between commercial and non-commercial borrowing (Prior *et al.*, 2019). In this context, the role of balance budget rules and debt containment policy restrictions on efficiency becomes ambiguous (and therefore worth to be explored). It might be costly in the short run, with a loss in utility for the citizens due to spending cut and tax increase, and beneficial in the long run with steady state benefits of a lower stock of debt (Alesina & Passalacqua, 2016). Overall, these studies do not make a clear distinction between the concept of actual/historical expenditure levels and standard expenditure needs/costs. Evaluating only the expenditure levels of the local authority is not at all equivalent to evaluating the costs, as the former concerns only the monetary aspect

[1] Recent papers focusing on fiscal rules on local governments within a single country are Schaltegger & Feld (2009) and Burret & Feld (2018) for Switzerland, Argimón & Cos (2012) for Spain, Ben-Bassat *et al.* (2016) for Israel, Grembi *et al.* (2016) and Bonfatti & Forni (2019) for Italy, Köppl-Turyna & Pitlik (2018) for Austria, Christofzik & Kessing (2018) for Germany and Borge & Hopland (2020) for Norway. Beyond the country level, Foremny *et al.* (2017) analyze 17 OECD countries, while Bergman *et al.* (2016) study 27 EU countries.

of the current expenditure with the same exogenous conditions. Conversely, the evaluation of costs takes into account the local territorial and socio-demographic characteristics, which in turn affect the demand and supply of services and ultimately address the equity aspect (Porcelli *et al.*, 2016; Vidoli & Fusco, 2018; Porcelli & Vidoli, 2020). As the demand and supply of local public good are simultaneously determined in terms of cost, there are endogeneity issues that arise and pose a challenge from a methodological perspective.[2]

The present paper bridges the two identified gaps in the earlier literature. In particular, we consider the complex trade-off between efficiency - evaluated from the expenditure side - and equity - evaluated from the side of the produced output or the offered service - and we distinguish between actual/historical expenditure levels and standard expenditure needs/costs. This is because, in a spending review perspective, municipalities would be led to achieve greater efficiency only on the side of lower expenditure, but (and here the trade-off between expenditure and offered service arises) to the detriment of the provided service. Our identification strategy exploits the exogenous introduction of a new budget balance rule in the Flemish Region of Belgium from 2014 onwards, known as the "policy and management cycle" (*beleids- en beheerscyclus – BBC*). Compared to the previous, much weaker, audit system, where only a balanced planned budget was needed with no binding constraints, this new audit rule requires local governments to respect two equilibrium criteria: the annual and the long-term structural equilibrium (Wayenberg *et al.*, 2017; Coppens *et al.*, 2018; Vanneste & Goeminne, 2020). We use a difference-in-differences approach to assess the impact of the rule enforcement comparing two groups of municipalities: one displaying over time a very poor structural underperformance and, for this reason, being the main policy target (*i.e.*, the treatment group) and the other one showing consistently a good performance (*i.e.*, the control group). As outcome variable, local government cost efficiency is measured by an endogenous stochastic frontier approach in which we combine both the demand (*i.e.*, local citizens' needs) and the supply side (*i.e.*, actual provided services) of local services. We argue that combining the demand and supply side is crucial as resources might be used in an efficient way, but not necessarily an optimal way if the supply does not meet the demand.

We contribute to the existing literature in three ways. First, we provide causal evidence of a budget balance rule enforcement on local government's cost efficiency and on the consequences triggered by the introduction of such fiscal rules, with critical policy implications both for policy makers at different government levels and for citizens. Second, we provide a comprehensive picture of the complex relationship between the fiscal instruments at hand of the local governments, namely the revenue and expenditure-side measures together with the fiscal rules, and their different levels of rigidity. We identify the policy options available for local governments to comply with higher-level government restrictions and their fiscal reaction in terms of efficiency and equity. Finally, we contribute to the emerging literature dealing with endogeneity in the efficiency methods (D'Inverno *et al.*, 2020; Mergoni & De Witte, 2021) and we show how to tackle it in the empirical application. In particular, we emphasise the different nuances underlying the concept of expendi-

[2] For the economic framework see, for example, Vidoli & Fusco (2018); Porcelli & Vidoli (2020), while for the methodological approach Karakaplan & Kutlu (2017a,b); Kutlu *et al.* (2020).

ture levels and costs when it comes to evaluate local government finances and its efficiency.

We consider three hypotheses concerning the relationship between local government cost efficiency and different fiscal instruments at hand of the local governments. First, in the short term it is difficult for local governments to reduce expenditures. Consequently, we hypothesise that local government efficiency is unlikely to be affected by expenditure-side measures. Similarly, the actual output provision cannot be drastically reduced in the short run in relation to the observed local needs. Second, as in the short run tax revenues might represent the most flexible levers available to policy makers (Reuter, 2020), we hypothesise that local government efficiency is most likely influenced through the revenue-side channel. The literature has not reached a consensus about the sign of the relationship between tax revenues and local government efficiency. On the one hand, the fiscal illusion effect makes local governments perceive that they have sufficient income to meet any expense and therefore less pressured to operate efficiently (Bosch *et al.*, 2012; Prior *et al.*, 2019). On the other hand, higher taxes increase local accountability as voters require greater attention in public spending management and accordingly efficiency (Benito *et al.*, 2010; Jia *et al.*, 2020). However, not all tax revenue types have the same impact on local government efficiency: the local property tax triggers different mechanisms compared to the local income tax. Property taxes depend on values assessed periodically. They are not strongly affected by cyclical changes in income and hence they do not pressure local governments to use resources efficiently (Oates & Schwab, 2004). On the contrary, income tax makes citizens face the choice between work and leisure. To this extent, local governments are expected to meet voters' demands for tighter control of public spending and to increase cost efficiency (Oates & Schwab, 2004; Prior *et al.*, 2019). Third, we hypothesise that more efficient municipalities need less effort to recover their under-performance compared to municipalities with lower level of efficiency. These research hypotheses will be tested in the section 4, where we devote specific attention to the heterogeneous behaviour of local governments in the face of a uniform policy.

Our main empirical findings show that poorly performing municipalities started recovering their inefficiency after the balance budget rule enforcement. Specifically, this applies to those local authorities that have chosen to pull the "revenue-side lever", raising income tax as the preferred policy option.

The remainder of the paper is organized as follows. Section 2 introduces the Flemish institutional setting and the new "policy and management cycle" budget balance rule. Section 3 describes the data and specifically how to measure local government cost efficiency. Section 4 and 5 present, respectively, the empirical strategy and the main results. Section 6 discusses the findings and concludes.

2. Institutional framework

2.1. Local competences and public budgeting in Flanders

Local governments in Flanders (the Dutch-speaking region of Belgium) are granted a high degree of autonomy in their policy decisions, both in terms of public provision and fiscal policies. As in most European countries, they have responsibilities in general administration, culture, care services, educational services, housing, road maintenance and local mobility, public safety and environment (CEMR, 2016). Intergovernmental grants and tax revenues constitute the two main sources of revenues to support service provision in those areas (Geys & Revelli, 2011). Tax revenues amount to approximately 40% of total revenues, and constitute mainly of local income taxes (as surcharge taxes on the federal tax on labour income) and local property taxes (as surcharge taxes on the regional tax on immovable property), which together constitute 80% of local fiscal revenues (see also De Witte *et al.*, 2018).

2.2. The 'policy and management cycle' rule

Despite the extensive choice of available tax instruments and the high discretion in policy making granted by the Belgian constitution, the municipal power over local finances has been remarkably reduced throughout successive rounds of state reform and, in particular, the regionalisation of the Municipal and the Provincial Law in 2002 (Wayenberg *et al.*, 2017; Coppens *et al.*, 2018). Before these measures, Flemish municipalities were under a very weak balance budget system compared to other countries and only a balanced planned budget was needed with no binding constraints (Fredriksen, 2013). Starting from 2014, the Flemish Region has introduced a new budget balance rule, known as the "policy and management cycle" (*beleids- en beheerscyclus – BBC*), to improve the efficiency and effectiveness within the boards. Compared with the previous system, this new budget balance rule requires all Flemish local governments to respect two equilibrium criteria: *(i)* the annual and *(ii)* the long-term (six-years) structural equilibrium (see also Wayenberg *et al.*, 2017; Coppens *et al.*, 2018; Vanneste & Goeminne, 2020).

To this extent, this reform offers a good test bed to shed lights on the impact of a financial balance rule enforcement on municipal performance and to identify the local policy measures triggered by its introduction.

3. Data

3.1. Selected variables

The empirical application builds on a rich panel dataset covering all 307 municipalities of the Flemish Region of Belgium over the period 2006–2016. The main data sources come from *Statistics Flanders*, *Statbel*, *Flanders.be* and the *Federal Police*.

The data cover several aspects to measure exhaustively the local government performance along with its socio-economic characteristics and fiscal variables, as listed in Table 1. First, we have information on the total local expenditures, which are allocated to provide local public services[3]. Second, we observe public service

[3]A clarification is in order: the concept of cost used in this paper is related to the budget data available for the individual municipalities in Flanders. In the present case, this is cash basis, *i.e.* includes only those costs for which there has been a financial manifestation, and not accrual basis, which requires transactions to be recorded in the tax period to which they relate regardless of when the payments occur. This has advantages and disadvantages. While more correct from an accounting point of view, the use of the accrual principle would have been infeasible in our analysis because of the non-availability of data on depreciation (different between functions) and in general on the capital stock. However, as also acknowledged by the Reuter (2020), the use of a cash basis makes our analysis robust for governments engaging in creative accounting.

provision from both the demand and the supply side of local services. Combining the demand and supply side is important as a local government might use its resources in an efficient way - looking merely for efficiency - but if the supply does not meet the demand, territorial imbalances might arise across local authorities in terms of equity. Citizens' local needs (*i.e.* the demand side) and the actual provided services (*i.e.* the supply side) are detailed for each municipal area as listed in the municipal balance sheet and commonly acknowledged across countries (CEMR, 2016; OECD/UCLG, 2016; Narbón-Perpiñá & De Witte, 2018a). By law (i.e., Gemeentedecreet) Flemish municipalities have to provide specific services and deliver specific outputs. This law is the basis for our selection of services and outputs. For the administration, the number of births, the number of deaths and the net migration rate are usually deemed representative of the local needs tackled in the registry and immigration offices by the administrative staff, proxy of the related service provision. School-age children represent the local demand for the education provision met by the number of childcare places made available by the municipality. Social care services target the most vulnerable individuals or in need of extra support. The family deprivation index is taken as measure of the needed assistance addressed by the provision of housing rental services. The demand for early childhood support represented by the number of children under 2.5 years is tackled by the number of available childcare places for toddles. Similarly, the residential aged care can be seen as the response to the need of assistance by the elderly population above 80 years. As support to the culture, the number of library borrowers are considered as the local demand met by the number of items stored in public libraries. The increment of population together with urban sprawl (measured by the urbanicity index) can be seen as the local demand of housing services proxied with the number of building permits for residential properties. The utilization density captures the intensity of the land use that generates the need for environmental and waste management services, proxied by the amount of residual waste. For the mobility function, the number of car passengers are deemed representative of the local demand for road management service provision, measured by the length of paved roads. The number of crimes sizes the need for the local police intervention, quantified by the police personnel. These functions cover all together more than 90% of the total municipal expenditures. Third, we include data on fiscal variables, such as local property and income taxes, and on other relevant contextual variables.

Table 1 lists all the variables considered in our empirical analysis, along with their definition and descriptive statistics. The choice of the proposed variables follows the data availability, their relevance for the Flemish institutional setting and is in line with the main literature on local government efficiency evaluation, public finance and sustainable balance budgeting (see for all the review by Narbón-Perpiñá & De Witte, 2018a,b and a more recent one by Milán-García *et al.*, 2022, along with Asatryan *et al.*, 2018; De Witte *et al.*, 2018; Dorn *et al.*, 2019; Venturini, 2020, among others). In this regard, it is worth mentioning that for the present empirical analysis the selected variables are the most suitable ones for the Flemish context, its local competences set by law and provide a specification richer than in other papers for two main reasons. First, a number of potential variables have been chosen for each municipal function following the extensive existing literature and complemented with additional variables available in the Flemish data sources. The variables have been identified to represent each municipal function required by law and the associated services. In this regard, an effort has been made to identify separately the actual local provision from the local demand, whereas in the existing literature this difference is quite blurred and often overlooked. Second, for some potentially alternative variables data were available only for few years or few municipalities, weakening the data coverage in terms of sample units and time span.

Table 1: List of variables and their descriptive statistics

Variables	Mean	St. Dev.	Min	Max
Total (operating) expenditure *	1,013 €	279 €	501 €	2,872 €
Local needs				
Births ***	10.091	1.660	4.328	17.857
Deaths ***	9.239	1.774	4.010	16.957
Net migration **	0.461	0.563	-3.912	5.714
Children in kindergarten (2.5 to 5) **	3.740	0.443	1.894	5.714
Children in primary school (6 to 11) **	6.513	0.695	3.689	9.013
Family deprivation index	0.059	0.049	0.000	0.389
Children in day care (0 to 2.5) **	2.589	0.344	1.096	4.147
Elderly aged 80 years or older **	5.047	1.064	2.019	9.859
Library borrowers ***	201.882	117.381	0.000	1,376.929
Increment of population	0.558	0.598	-4.514	6.122
Urbanicity index *	0.064	0.021	0.022	0.251
Utilization density	23.544	8.663	4.729	57.579
Car passengers *	0.521	0.229	0.368	3.797
Thefts, physical and property crimes ***	33.249	15.851	8.827	118.945
Actual local provision				
Administrative staff ***	5.046	3.559	0.000	18.000
Childcare places for school-aged children (2.5-12) ***	6.388	5.277	0.000	36.849
Housing social rental offices ***	1.023	0.883	0.000	5.477
Childcare places for toddlers (0-2.5) ***	12.618	3.607	2.493	25.395
Residential aged care ***	12.924	6.603	0.000	48.468
Number of items in public libraries *	3.541	1.822	0.000	20.114
Building permits for residential properties *	0.003	0.002	0.000	0.024
Residual waste *	0.127	0.054	0.000	0.365
Paved roads *	0.013	0.010	0.003	0.110
Police personnel *	0.011	0.018	0.002	0.285
Other economic and fiscal variables				
Taxable income *	17,414 €	2,328 €	10,999 €	27,858 €
Total inhabitants	20,555	33,455	945	517,042
Residential sales prices	193,278 €	41,581 €	89,694 €	375,765 €
Revenue on income tax *	275 €	72 €	0 €	618 €
Revenue on property tax *	279 €	120 €	110 €	1,295 €

Notes: * = per capita; ** = per capita x 100; *** = per capita x 1000

Panel for 307 Flemish municipalities over 2006–2016. Net migration is the difference between the number of immigrants and emigrants as a share of the total population (De Witte *et al.*, 2018). Utilization density is the ratio between the sum of inhabitants and number of jobs over the built-up area: the more people and jobs located in a built-up area, the better the land utilization (Jaeger & Schwick, 2014). Urbanicity index is the build-up area over the total surface as a measure of urban sprawl. Building permits for residential properties is the number of building permits for residential properties (apartments and one-family residence) (De Witte *et al.*, 2018). Thefts, physical and property crimes is the sum of the three types. Residual waste is the waste collected at municipal level. Police personnel is the sum of actual operational and civilian personnel.

3.2. Measuring local government cost efficiency

To investigate the effects of the budget rule reform on efficiency and to verify what levers local governments have pulled over the years to react to it, it is first necessary to define and measure the local government cost efficiency.[4] Concerning the local government performance evaluation, we are interested in the relationship between the local expenditures and the outputs (namely, the actual local service provision, often improperly proxied by its determinants). A local government is efficient when it is using few resources to provide higher levels of service provision. On the contrary, it is inefficient when it is using more resources than other local governments to deliver the same or even lower levels of service provision.

To measure efficiency, previous studies have mostly used either non-parametric or parametric techniques, generally known as "frontier methods", such as Data Envelopment Analysis or Stochastic Frontier approaches (see for example the reviews in Galariotis *et al.*, 2016; Narbón-Perpiñá & De Witte, 2018a and a more recent one in Milán-García *et al.*, 2022). The efficient units constitute the 'best practice frontier' and the inefficiency is measured as the distance from this frontier. However, earlier efficiency literature mainly focused on the relationship between expenditure and local needs proxied by its supply and demand determinants (see Appendix A), but overlooked how the actual service provision meets the local needs and thus neglecting the output misalignment between different territories.

Moving beyond the traditional definition of expenditure efficiency we construct a more comprehensive measure of the local government cost efficiency explicitly including the output produced in order to jointly assess the equity issues as well. To do so, we use a stochastic frontier approach to estimate the structural model of demand and supply of local public good. Specifically, we estimate the following stochastic endogenous frontier model, as proposed by Karakaplan & Kutlu (2017a,b) and Kutlu *et al.* (2020):

$$\begin{cases} y_i = \boldsymbol{x}'_{yi}\boldsymbol{\beta} + v_i + u_i, \qquad i = 1, \dots, n \\ \boldsymbol{x}_i = \boldsymbol{Z}_i\boldsymbol{\delta} + \epsilon_i \\ \text{with} \\ \begin{bmatrix} \widetilde{\epsilon}_i \\ v_i \end{bmatrix} \equiv \begin{bmatrix} \Omega^{-1/2}\epsilon_i \\ v_i \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} I & \sigma_v\rho \\ \sigma_v\rho' & \sigma_v^2 \end{bmatrix} \right) \end{cases} \tag{1}$$

where $y_i \in \mathbb{R}_+$ is the cost of the i^{th} local government, $\boldsymbol{x}_{yi}$ explains the cost variability and it is composed by an endogenous part (*i.e.*, the actual level of services provided in different municipal areas, $\boldsymbol{x}_i$) and an exogenous part (*i.e.*, supply variables representing morphological and socio-economic characteristics influencing the expenditure level). $\boldsymbol{x}_i$ is conditional on $\boldsymbol{Z}_i$, the vector of all exogenous instrumental variables (*i.e.*, the observed local needs). The instrumental variables are used to solve the endogeneity issue that arises if the optimal output quantity is simultaneously determined with the unitary price. The instruments satisfy the common assumptions such as the relevance assumption, the exclusion assumption and the exchangeability assumption. v_i is the symmetric two-sided error represent-

[4]Please note that, thereafter, we will use interchangeably 'efficiency' and 'performance' where these terms are to be understood as synonyms of 'cost efficiency'.

ing random effects and $u_i > 0$ is the one-sided error term representing inefficiency.[5]

3.3. Local government cost efficiency estimates

To obtain the cost efficiency estimates from Model (1), we rely on the 2006-2016 panel dataset covering all 307 municipalities of the Flemish Region of Belgium. The dependent variable is the operating expenditure, while the municipal output covariates are detailed in Table 2, as introduced in Section 3.1. They distinguish between local service provision (endogenous) and local needs (exogenous). We explicitly take into account the multiplicity of offered services and the correlation between them, which is usually neglected in analyses focusing on a single function. In particular, we include the main municipal areas as listed in the Flemish balance sheets (representing together more than 90% of the total expenditure). For each function, we include one or more outputs and their corresponding instrumental variables. As control variables, we also include the level of taxable income, the number of inhabitants (economy of scale) and the residential sales price as an overall proxy for input prices. Two clarifications have to be given regarding prices of labour and capital within the chosen stochastic cost frontier model: *(i)* the first one concerns the price of local labour, which has not been included in the model both because of the impossibility of obtaining this data for all municipalities and because this variable is essentially constant among Municipalities because it is defined at the national level; *(ii)* then, capital, and its price, was as obvious highly variable within the different functions: we, therefore, introduce the price of capital relative to residential sales, which is thus a proxy for the greater or lesser cost of public offices.

Applying Model (1) on this dataset, we observe that Flemish municipalities show on average 89.65% of efficiency. This indicates that there is room for improvements in the cost efficiency.[6]

4. Empirical framework

To explore the effects of budget rule enforcement on local government efficiency, we proceed in three consequent empirical steps while testing the earlier introduced hypotheses. First, we assess the impact of the new budget rules policy on the municipal efficiency. Then, we explore if local authorities responded in a homogeneous or in a differentiated way to this policy. Finally, we investigate what tools/levers municipalities that responded positively to the policy used to react to it.

4.1. Does the reform have an impact on local government efficiency?

In a first step, the response of municipalities to the policy is analyzed in a counterfactual setting using a difference-in-differences approach (Athey & Imbens, 2017; Wang *et al.*, 2021). Clearly, the BBC policy was targeting the inefficient municipalities. Since the BBC policy affected all Flemish municipalities at the same

[5]The two-sided residual term is usually assumed to be normally distributed: $v \sim N(0, \sigma_v^2)$ while u is distributed as a half-normal and is always positive: $u \sim N^+(0, \sigma_u^2)$. The standard SFA model also assumes that v and u are each identically independently distributed (*iid*) and the covariates in the model. Please note that in Karakaplan & Kutlu (2017a)'s original model even the term u can be related to specific covariates; we, therefore, report a simplified version.

[6]In Appendix B, we show how the model provides a superior fitting to the theoretical model.

Table 2: Municipal output (local needs and provision) by municipal function

Municipal function	Local needs variables (*Exogenous* municipal output)	Local provision variables (*Endogenous* municipal output)
Administration	Births, Deaths, Net migration	Administrative staff
Education	Children in kindergarten (2.5 to 5)	Childcare places for school-aged
	Children in primary school (6 to 11)	children (2.5 - 12)
Care services	Family deprivation index	Housing social rental offices
	Children in day care (0 to 2.5)	Childcare places for toddlers (0-2.5)
	Elderly aged 80 years or older	Residential aged care
Culture	Library borrowers	Number of items in public libraries
Housing	Increment of population	Building permits for residential
	Urbanicity index	properties
Environment	Utilization density	Residual waste
Mobility	Car passengers	Paved roads
Local police	Thefts, physical and property crimes	Police personnel

time and "*all [municipalities] in the groups were randomly assigned, regardless of their adherence with the entry criteria, regardless of the treatment they actually received, and regardless of subsequent withdrawal from treatment or deviation from the protocol*" (Fisher *et al.*, 1990), an Intention-To-Treat (ITT, Gupta, 2011) setting has been chosen, comparing the dynamics of efficient municipalities as untreated and inefficient municipalities as treated. More formally, the ITT effect of the exogenous introduction of the BBC policy on eff_{it} (as defined in section 3.2) can be estimated for municipality i in time t as:

$$eff_{it} = \alpha_0 + \alpha_1 D_i + \alpha_2 P_t + \alpha_3 D_i * P_t + X'_{it}\alpha_4 + \mu_i + \theta_t + \epsilon_{it} \qquad (2)$$

where α_3 is the parameter of interest, measuring the ITT (*i.e.*, the effect of the *BBC* policy in the post-treatment years for the treated/inefficient group), D_i is a dummy variable equal to 1 if the municipality belongs to the target group of inefficient municipalities, P_t is a dummy equal to 1 after 2013 (*i.e.*, the last year before the *BBC* policy takes effect), X denote a set of control variables, and μ and θ represent the fixed effects at time and municipality level. In this setting, the control group consists of municipalities that show a high and stable level of efficiency, *i.e.* municipalities that performed better than their peer group before the treatment, while the treated group consists of municipalities that are inefficient. The main idea is that, without the implementation of the BBC policy, those municipalities would have continued in their inefficient trend.

At this stage, the key issue is how to non-arbitrarily split the municipalities into a cluster, acting as a control group, and other homogeneous trend groups, acting as treatment groups, since each municipality exhibits both its own level of efficiency and its own trend over time. We rely on functional data clustering as a methodological approach, since it allows, in a fully non-parametric way, to segment groups with trends that have a similar level and shape (for a more exhaustive description, please see Appendix C). Differently from PSM (propensity score matching) or CEM (coarsened exact matching) methods, data are not preprocessed *ex ante* as well as it is not required to choose a level of balance and there is no pruning of observations that have no close matches (Iacus *et al.*, 2009). To this extent, functional data clustering is useful to fully exploit within and between variation in the available sample and detect clusters similar in shape and in trend. With this technique, the efficiency trend for each municipality is considered as a single functional curve, associated with an average curve that constitutes the best representation in terms of both level and shape. From an empirical point of view, therefore, the proposed technique will make it possible to identify the membership of each individual municipality, in terms of trend, to a precise cluster (in the application example presented in section 5, we detect 5 clusters) and accordingly, using this classification, to choose one cluster as reference (or control) and the other ones as treatment in order to estimate equation (2).

4.2. Does the reform have a heterogeneous impact across inefficient local governments?

In a second step, we explore whether there is heterogeneity among inefficient municipalities. This is a key issue that transcends the specific case in question: believing that a single policy has uniform effects on the territory, in fact, is both a strong hypothesis at the theoretical level, but also leads to biased results in the likely case in which omitted variables, different behaviors and response times lead municipalities to respond in different ways.

In other words, focusing only on inefficient municipalities, the question arises as to whether all inefficient municipalities have uniformly reacted to the fiscal recovery policy, or if different paths occurred. This question is particularly important in situations where the policy is not designed specifically for each local government, but instead - as in this case - is the same for all municipalities.

From an empirical point of view, two new distinct groups are identified (again by functional clustering) showing two clusters, with the year 2014 as baseline. In the first group, municipalities - although inefficient - improved their efficiency since the introduction of the policy (we label this group "*increasing*"). In the second group, municipalities maintained or worsened their inefficiency over time (we label this group "*decreasing*"). This further subdivision makes it possible to identify with improved precision the municipalities of interest both in absolute terms (belonging to the cluster of step 1) and in relative terms. The latter measures the response to the policy (belonging to the cluster of step 2) allowing the estimation of the model in equation (3):

$$\begin{aligned} \mathit{eff}_{it} =& \alpha_0 + \alpha_{1A} D_i^I + \alpha_{1B} D_i^D + \alpha_2 P_t + \alpha_{3A} D_i^I * P_t + \alpha_{3B} D_i^D * P_t + \\ & X_{it}' \alpha_4 + \mu_i + \theta_t + \epsilon_{it} \end{aligned} \tag{3}$$

where superscript D stands for "*decreasing*" and I stands for "*increasing*".

4.3. What are the levers pulled by the municipalities recovering their inefficiency?

In a third step, we address the key research question: what fiscal levers and what behaviors characterize municipalities that - despite being inefficient - have been able to reverse the trend? What are the fiscal levers that these municipalities have used in the short term? And whether policies that are not designed for individual local governments, and are not linked to the auditing of the service levels, but only to the public spending control, can be sufficient to guarantee a fair distribution of the fiscal effort?

To answer these questions, we study the characteristics and fiscal choices of the inefficient but increasing municipalities, by comparing them in a logistic model to the inefficient but decreasing municipalities. More specifically – defining the dichotomous variable y equal to 0 if an inefficient municipality is worsening its performance, and 1 if it is improving it – the ratio between the probability of belonging to the reference group versus that of the comparison group can be related to continuous or categorical covariates $\boldsymbol{x}$ according to:

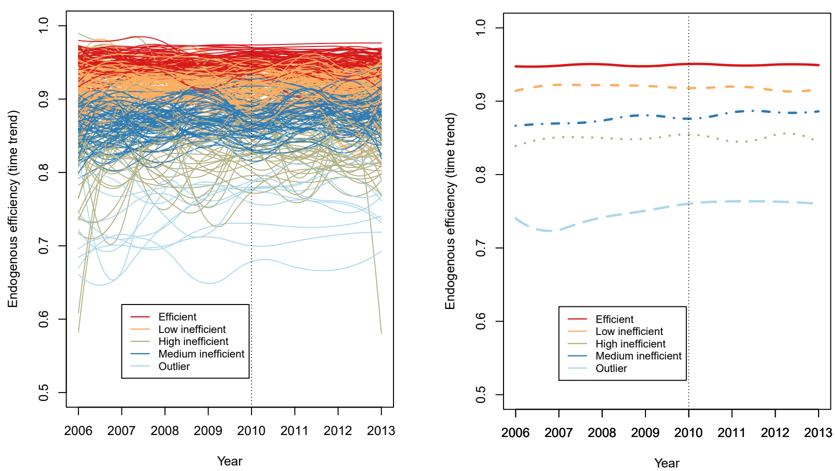
$$E(y|x) = \frac{e^{\boldsymbol{x\beta}}}{1 + e^{\boldsymbol{x\beta}}} = S(\beta\boldsymbol{x}) \tag{4}$$

where the link function S is a sigmoid function. The estimates will provide the odds ratio of covariates $\boldsymbol{x}$ on the probability of belonging to the increasing group given the decreasing group. For a more exhaustive discussion, please see Hosmer Jr *et al.* (2013).

5. Results

5.1. Does the reform have an impact on local government efficiency?

Panel estimation of cost efficiency – estimated from equation (2) according to the specification in the Table 2 – allows us to assess, for each municipality, the distance to the cost frontier and especially its variation over time. In functional terms, the cost efficiency of a municipality can be interpreted as a single curve and its trend can be compared to other ones. This is presented in Figures 1a and 1b. The left figure shows the individual trajectories for the period before the policy began (2006-2013) – *i.e.* the individual smoothed trends (or in functional term the 'basis') representing the evolution over time of the efficiency of each individual municipality. The right panel presents the estimated average curves, that is the average smoothed trend per cluster over time based on individual trends.



(a) Smoothed trend basis.
Individual smoothed trends representing the efficiency evolution over time of each municipality

(b) Functional clusters.
Estimated average curves per cluster over time based on individual trends

Figure 1: Smoothed trend basis and functional clusters, before the policy was implemented (2006-2013), for all 307 Flemish municipalities.

Five clusters of curves are identified. We highlight the curve of efficient units (stable over time, in red; representing the reference line), three clusters of inefficient municipalities differentiated by level (also stable and with a parallel trend with respect to the reference cluster) and a final residual cluster of municipalities with high variations over time that can be considered as outlier municipalities.

We are interested to examine whether, starting in the year 2014, differences in the trends between efficient and inefficient units emerge. Doing so, we aim to verify if - on average - the fiscal control policy impacts the local government cost inefficiencies. The estimates from the ITT framework are presented in Table 3. They show a positive and significant effect (parameter of $P*D$) for local authorities belonging to the inefficient clusters. In other words, a discrete improvement in cost efficiency can be noted for inefficient municipalities, which is not the case for the already efficient municipalities.

Table 3: Intention-To-Treat: Effect of policy on absolute cost efficiency levels

	*Dependent variable: Cost efficiency * 100*
	Estimate
D	-6.458^{***}
P	-0.701
$P * D$	1.091^{**}
Total area (sq. km / 1000)	0.205^{***}
Built area (sq. km / 1000)	-1.525^{***}
Inhabitants / 1000	0.045^{***}
Constant	94.873^{***}
Observations	3,031
R^2	0.233
Adjusted R^2	0.232
Residual Std. Error	0.047 (df = 3024)
F Statistic	153.175^{***} (df = 6; 3024)
Note:	*p<0.1; **p<0.05; ***p<0.01

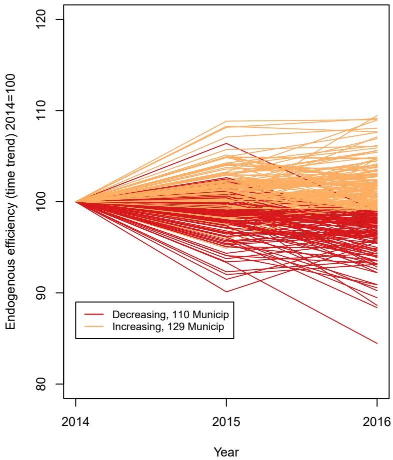
The estimate related to $P * D$ measures the effect on cost efficiency of the BBC policy in the post-treatment years for the municipalities deemed inefficient in the pre-treatment years. The positive and significant coefficient denotes that on average these municipalities have recovered part of their cost inefficiency with respect to the other group of municipalities.

However, this finding holds for the average municipality, and ignores the heterogeneity in behavior from the year of treatment. Therefore, in the next step, and still using the proposed functional data framework, individual trajectories (now in a relative sense, *i.e.* with base year equal to 2014) have been analyzed only for the absolute inefficient municipalities.

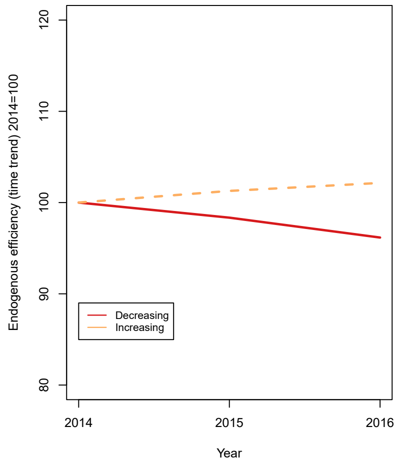
5.2. Does the reform have a heterogeneous impact across inefficient local governments?

We verify heterogeneous behavior among inefficient units regardless of the absolute starting level of inefficiency. To do so, we test if these units have recovered the cost inefficiency gap since 2014, or whether their inefficiency has grown even since the policy began.

For the inefficient municipalities of the step 1, figures 2a and 2b present the relative trends highlighting two clusters that - in the short term[7] - have had different behaviors. As outlined in section 4.2, these clusters have been named respectively "decreasing" (110 municipalities belong to this cluster) and "increasing" (129 municipalities belong to this cluster) efficiency.



(a) Smoothed trend basis.
Individual smoothed trends representing the efficiency evolution over time of each individual municipality



(b) Functional clusters.
Estimated average curves per cluster over time based on individual trends

Figure 2: Smooth trend basis and functional clusters, after the policy was implemented (2014-2016), for the 239 municipalities deemed inefficient in the pre-treatment period.

This second differentiation allows us to comparing the trend of the inefficient municipalities (split between "decreasing" and "increasing") and the efficient municipalities, as a trend differential from 2014 according to the model proposed in equation (3). Table 4 shows how the effect in efficiency catch-up is more outspoken and significant for the "increasing" municipalities, regardless of the absolute level of inefficiency, while it is no longer statistically significant for the other ones. Following the way the "decreasing" and "increasing" groups have been designed, the positive impact of the budget balance rule enforcement on the local government efficiency comes only from those municipalities who gained efficiency over the post treatment period. This evidence is mechanical but, nevertheless, informative. At this point, the municipalities that - with respect to the reference efficient cluster - responded positively to the policy have been clearly identified and their used policy options can be investigated.

[7]This is clearly a limitation of the analysis, which for reasons of data availability does not allow us to verify the effect of the policy even in the medium and long term.

Table 4: Intention-To-Treat: Effect of policy on absolute and relative levels of cost efficiency

	*Dependent variable: Cost efficiency * 100*
	Estimate
D_decreasing	−6.628***
D_increasing	−6.312***
P	−0.702
*P * D_decreasing*	0.943
*P * D_increasing*	1.216**
Total area (sq. km / 1000)	0.213***
Built area (sq. km / 1000)	−1.495***
Inhabitants / 1000	0.045***
Constant	94.814***
Observations	3,031
R^2	0.234
Adjusted R^2	0.232
Residual Std. Error	0.047 (df = 3022)
F Statistic	115.420*** (df = 8; 3022)

Note: *p<0.1; **p<0.05; ***p<0.01

The estimate related to *P*D_decreasing* and *P*D_increasing* measures the effect on cost efficiency of the BBC policy in the post-treatment years for the municipalities deemed inefficient in the pre-treatment years, distinguishing between a group showing a decreasing trend in efficiency (110 municipalities) and a group with an increasing one (129 municipalities). The positive and significant coefficient for *P * D_increasing* denotes that municipalities that have recovered part of their cost inefficiency with respect to the reference efficient municipalities outweigh the municipalities with a decreasing trend.

5.3. What are the levers pulled by the municipalities recovering their inefficiency?

It is now possible to answer our key question, namely, what are the characteristics of the municipalities who have responded positively to the policy and what are the fiscal levers that they have used as opposed to local authorities that have not recovered efficiency. In other words, what are the characteristics that differentiate the group of municipalities that - while inefficient - have nonetheless improved their performance from those on which the policy has had no effect, at least in the short term?

Table 5 reports results in terms of robust relative risk ratio (RRR), showing how the "risk" of falling in the comparison group (municipalities that have improved their performance) compared to the risk of falling in the reference group (municipalities that have worsened their performance) changes with the variable in analysis. It is possible to verify which levers the municipalities have modified in order to recover efficiency within a set of managerial levers that can be modified in the short-medium term. The results show that recovering cost efficiency can be done by producing less output, focusing on efficiencies of scale (making agreements with or merging with neighboring municipalities; see D'Inverno *et al.*, 2020), reducing administrative or operational expenditure or by increasing the local tax rate.

Values equal to or very close to 1 show that there is no statistically significant difference between the two groups. Similar findings are observed for most of the outputs (from Childcare places to Police staff), for scale factors (the number of inhabitants) and for level of operative expenditure. In other terms, municipalities

Table 5: Logistic regression exploring different levers pulled by municipalities recovering their inefficiency after the policy was implemented (2014-2016) – Relative Risk Ratios.

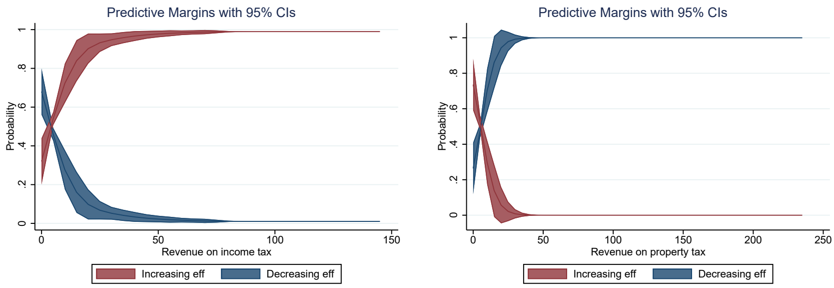
	Fiscal revenue (1)		Service provision (2)		Scale economies (3)		Expenditure (4)		Absolute cluster (5)	
Decreasing relative efficiency	(base outcome)									
Increasing relative efficiency:										
Revenue on income tax	1.072	***	1.166	***	1.257	***	1.239	**	1.267	***
Revenue on property tax	0.824	***	0.848	***	0.869	***	0.821	***	0.814	***
Childcare places (0-2.5 year)			0.999		0.999		0.999		0.999	
Social housing offices			0.988	*	0.991		0.990		0.989	*
Library items			1.000		1.000		1.000		1.000	
Residual waste			1.000		1.000		1.000		1.000	
Paved roads			0.996	***	0.996	***	0.996	***	0.996	***
Police staff			0.999		0.999		0.999		0.999	
Building permits			1.008	***	1.009	***	1.009	***	1.010	***
Inhabitants					1.000		1.000		1.000	
Inhabitants (square)					1.000		1.000		1.000	
Operating expenditure							1.001		1.001	**
Abs Efficient funct. cluster									baseline	
Low ineff. functional cluster									2.495	**
Medium ineff. functional cluster									1.885	
High ineff. functional cluster									1.408	
Constant	2.271	***	3.945	***	3.118	***	1.657		0.432	

Note: *$p<0.1$; ** $p<0.05$; *** $p<0.01$.

The table reports the results in terms of robust Relative Risk Ratio (RRR), that is the "risk" of falling in the comparison group (municipalities that have improved their performance) compared to the risk of falling in the referent group (municipalities that have worsened their performance) as different levers are pulled: increasing fiscal revenues (column 1), cutting on service provision (column 2), exploiting economies of scale (column 3) or cutting on expenditure (column 4). Values equal to or very close to 1 show that there is no difference in response between the two groups. Municipalities that responded positively to the BBC policy using a certain lever display RRR greater than 1. Column (5) includes the starting level of inefficiency: the lower the initial absolute inefficiency level, the easier the efficiency gap recovery.

that responded positively to the policy did it not by "shifting" the levers of the service provision or acting on the returns to scale side. However, municipalities seem to have focused on the fiscal side: as could be expected in the short term, we remark a positive influence of income tax. Citizens decide how much to work, according to their preferences. To this extent, "*the income tax appears to be stickier and harder to manoeuvre than all other tax instruments*" (Geys & Revelli, 2011). Instead, for property tax, politicians can decide to raise or decrease the property tax and there is not much citizens can do about it and this would worsen the level of efficiency. This in line with the second generation fiscal decentralization evidence: local governments with greater tax autonomy display larger accountability levels to the citizens (Jia *et al.*, 2020). Following the same logic, we observe a significantly positive, but small, response related to the building permits variable, used by many municipalities as an immediate way to "*strategically recover fiscal revenue*" (De Witte *et al.*, 2018) and, therefore, recover indirectly underperformance. Conversely, we observe a relatively small negative but significant response associated with the paved roads and social housing variables, as outputs that can be quickly compressed in the short term to preserve resources and retrieve efficiency.

Finally, the estimates regarding the absolute level of inefficiency confirm how it is easier to recover efficiency, in a relative sense, if local authority started from a lower level of absolute inefficiency since the municipality is already close to the cost frontier. In addition, Figures 3a and 3b show the different predicted probabilities between the "decreasing and increasing efficiency" groups as a response to income and property taxes change.



(a) Revenue on income tax

(b) Revenue on property tax

Figure 3: Predicted probabilities by increasing vs decreasing efficiency, logit model. Focus on income and property taxes, as potentially useful levers to recover cost efficiency after the policy was implemented (2014-2016).

6. Conclusion

This paper explored the causal impact of a budget balance rule enforcement on local government's cost efficiency. We investigate the exogenous introduction of the 'policy and management cycle' rule in the Flemish region of Belgium from 2014 onwards using a difference-in-differences approach. To measure the local government cost efficiency, we use a stochastic frontier approach that combines the demand and supply side of public service provision. Relying on a rich dataset covering all the public functions for the Flemish municipalities over the period 2006-2016, the analysis uncovers that, on average, poorly performing municipalities have managed to recover inefficiency over time and this applies mostly for those local authorities that have raised the income taxation level.

Our empirical results suggest that the only effective lever to comply with balance budget rule without harming the municipal cost efficiency is by increasing income tax revenues in the short term. On the contrary, increasing property tax might even be more harmful. This evidence is relevant beyond the Flemish case for two reasons. First, policies promoting fiscal sustainability might not be sufficient to guarantee a fair distribution of the fiscal effort and citizens are the ones ultimately bearing the consequences. Second, municipalities are expected to be struggling with recovering revenues in the next years as a consequence of the Covid-19 crisis. Higher forms of government should take this into account and maybe re-think the current budgeting rules so to prevent more severe mismanagement of the resources and not to further shrink the local economy (CEMR, 2020). Perhaps, time has finally come to "*change the direction*" of sub-national policies by emphasizing the importance of fiscal incentives for producing local economic prosperity instead of imposing one-size-fits-all restrictions. Second generation fiscal federalism, in fact, has long since extended traditional approaches by "*showing how non-linear transfer systems can produce both equalization and high marginal fiscal incentives to produce local economic growth*" (Weingast, 2009).

Our findings shed light on the effectiveness of regulatory and policy changes. Many countries and supra-national organisations are struggling with compliance with fiscal rules (Reuter, 2020). Our results show the effectiveness of coming from a weak balance budget system, to a strict financial balance rule enforcement.

Its introduction triggered different fiscal instruments such as more attention to income tax revenues, and less focus on property tax revenues. Moreover, our findings show that the regulatory changes might also have a differential impact on municipalities, with the underlying inefficiency of municipalities as one of the drivers of this heterogeneity. These elements make our findings policy relevant as policy makers are constantly looking for effective regularly enforcement and their impact.

The lack of longer post-intervention time series availability represents a limitation of the present study and prevents us from a medium/long-term assessment of the policy effects as well as of the individual municipalities' behaviour. As scope for future research, the time span should be increased and longer-term effects explored. Additionally, comparative studies with other countries should be considered so to check whether behaviour remains stable and comparable, under different legislative and administrative conditions.

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Appendices

Appendix A. Cost efficiency measures

The measure of efficiency of local authorities is usually carried out in the public economic literature by analysing the function of public expenditure, *i.e.* comparing current expenditure with the determinants of local supply and demand without considering the intimate link that exists between the standard level of local expenditure and the standard level of local services (see, *e.g,.* Studies, 1981, Reschovsky, 2006, Reschovsky, 2007, Blochliger *et al.*, 2007, Blochliger & Charbit, 2008, Dafflon & Mischler, 2007).

This approach ignores a fundamental part of the problem, *i.e.* the output or the supplied level of service. More formally (Ladd, 1994; Schneider, 2002), the efficient cost for each service depends on three basic dimensions: the optimal quantity of service, the prices for the inputs used in the production process (primarily labour costs) and the contextual variables related to the supply (*i.e.* the external factors that, all things being equal, can favour or hinder the supply of local public goods - *e.g.* the morphological characteristics of the territory or the surface area). The unitary local public service supply y can be expressed in terms of unitary cost as:

$$y = s(g, p, A) \tag{A.1}$$

where g are the endogenous outputs, p the input price vector and A the structural - *i.e.* exogenous - supply variables that represent morphological and socio-economic constraints changing the unitary service costs. The unitary demand of local public service (g), instead, can be expressed as:

$$g = d(Q, R, y) \tag{A.2}$$

where Q are demographic and socio-economic contextual variables, R is the average income[8] and y represents the unitary cost of local public service.

Given these premises, there are essentially two paths that can be taken to empirically evaluate the performance of local authorities. *(i)* The first approach involves the estimation of the cost by using a structural model of demand and supply of local public good (equation A.4), in which the method of instrumental variables is used to solve the endogeneity since their optimal quantity is determined simultaneously[9] in terms of expenditures. *(ii)* The second approach (equation A.3) involves the estimation of expenditure needs using the reduced form of the structural model of demand and supply of public services. These alternatives are clearly not at all equivalent: if, in fact, with the first approach expenditures and output and, therefore, costs are jointly evaluated, in the second approach only the expenditure part is taken into account.

Earlier literature typically followed the simplest approach, in which the expenditure function (A.3) is obtained by substituting equation (A.2) into (A.1):

$$y = f(Q, R, p, A, g_s) \tag{A.3}$$

In this formulation, outputs are replaced with environmental variables related to the local socio-economic context (*i.e.* demographic structure, population density, etc.) that affects local spending needs. In the expenditure framework, the explanatory variables are all exogenous (bringing consistent estimates) and the estimates have a high degree of reliability. The main disadvantage, however, is linked to the inability to directly assess the relationship between the output and the spending term.

Evaluating the expenditure of the local authority is not equivalent to evaluating the cost: if, in fact, the evaluation of the expenditure concerns only the monetary aspect being equal the exogenous conditions, the cost evaluation implies the inclusion, in the evaluation setting, of the provided level of the service and accordingly of the public service equity and is, therefore, much more informative (Vidoli & Fusco, 2018; Porcelli & Vidoli, 2020). In this setting, the cost function (A.4) is obtained by the simultaneous estimation of the equation (A.2) and (A.1):

$$\begin{cases} y = s(g, p, A) \\ g = d(Q, R, y) \end{cases} \tag{A.4}$$

[8]Please note the variable R in the demand function; in empirical results, in fact, high-income Authorities demand higher spending. R is used in the regression model to sterilize the income effects on the standard needs with the aim to identify needs that result from income elastic demand for the public service.

[9]In particular, simultaneity can be defined (Wooldridge, 2002) as the joint determination of one or more explanatory variables with the dependent variable, typically through an equilibrium mechanism. In other words, simultaneity includes endogeneity by its very nature.

The cost approach is empirically more complex - with respect to the expenditure one - to implement both on linear least squares regression models and especially in frontier models as interest shifts to the minimum cost and efficiency estimations.

Parametric stochastic frontier models, introduced by Aigner *et al.* (1977) and Meeusen & van den Broeck (1977), specify a single output in terms of a response function and a composite error term. The compound error consists of a two-sided error representing random effects and a one-sided term representing technical inefficiency. Since their introduction, several related papers have been published in the relevant literature; see Kumbhakar & Lovell (2000), Greene (2008) and Kumbhakar *et al.* (2020) for overviews of developments in this area.

The stochastic production/cost frontier model (SFA) can be written, in general terms, as:

$$y_i = f(\boldsymbol{x}_i; \boldsymbol{\beta}) + v_i - s u_i, \qquad i = 1, \ldots, n \tag{A.5}$$

where $y_i \in R_+$ is the output of unit i, $\boldsymbol{x}_i \in R_+^p$ is the vector of inputs, $f(\cdot)$ defines a production/cost (frontier) relationship between inputs $\boldsymbol{X}$ and the output Y, v_i is the symmetric two-sided error representing random effects, s is equal to 1 for production functions and -1 for cost functions and $u_i > 0$ the one-sided error term which represents inefficiency. Given these premises, technical/cost efficiency is defined as $TE_i = \exp(-u_i)$ (typically y_i is log-output). In applications, the two-sided error term is usually[10] assumed to be normally distributed: $v \sim N(0, \sigma_v^2)$ while u is distributed half-normally on the non-negative part of the real number line: $u \sim N^+(0, \sigma_u^2)$; moreover, following common practice, it is assumed that v and u are each identically independently distributed (*iid*).

This econometric setting is usually solved by traditional maximum likelihood estimation for stochastic frontier models, but "*if the model has endogeneity problem, then the traditional maximum likelihood estimation for stochastic frontier models gives inconsistent parameter estimates*" (Karakaplan & Kutlu, 2017a). In other words, the traditional estimation methods of the joint distribution of the dependent variable and the endogenous variables fall for the composite nature of the error term as the sum of a Normal and a Half-Normal part.

Given these premises, several authors (Greene, 2008; Amsler *et al.*, 2016; Griffiths & Hajargasht, 2016; Amsler *et al.*, 2017; Karakaplan & Kutlu, 2017a,b) have recently focused on proposing methods for estimating stochastic frontiers in the presence of endogeneity. In this paper, the Karakaplan & Kutlu (2017a) model has been chosen because of the feasibility of instrumenting the endogenous variables and the inefficiency part in a single stage.

$$\begin{cases} y_i = \boldsymbol{x}'_{yi}\boldsymbol{\beta} + v_i - s u_i, \qquad i = 1, \ldots, n \\ \boldsymbol{x}_i = \boldsymbol{Z}_i \boldsymbol{\delta} + \epsilon_i \\ \text{with} \\ u_i = h(\boldsymbol{x}'_{ui}\boldsymbol{\phi_u}) u_i^* \\ \begin{bmatrix} \tilde{\epsilon}_i \\ v_i \end{bmatrix} \equiv \begin{bmatrix} \Omega^{-1/2}\epsilon_i \\ v_i \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} I & \sigma_v \rho \\ \sigma_v \rho & \sigma_v^2 \end{bmatrix} \right) \end{cases} \tag{A.6}$$

[10]Several distributions can be assumed for the one-sided error term; *e.g.*, half-normal, truncated normal, gamma, exponential, etc.

where $y_i \in \mathbb{R}_+$ is the output of unit i, $\boldsymbol{x}_i \in \mathbb{R}^p_+$ is the vector of inputs, v_i is the symmetric two-sided error representing random effects and $u_i > 0$ is the one-sided error term which represents technical inefficiency[11]. The covariates are split into three groups: $\boldsymbol{x}_{yi}$, the exogenous and endogenous variables explaining y; $\boldsymbol{x}_i$, the endogenous variables; and $\boldsymbol{x}_{ui}$, the exogenous and endogenous variables explaining u. In addition to this, the endogeneity of $\boldsymbol{x}_i$ is corrected using $\boldsymbol{Z}_i$, the vector of all exogenous instrumental variables.

Note that introducing time - in our application - as additional year dummies has been chosen for numerical feasibility; this can be done avoiding the problem of incidental parameters (Greene, 2004) if the number of time periods is not too small – as in our application – so that as the number of units increases the estimate of fixed effects is not random.

Appendix B. Comparison between cost and expenditure efficiency estimation

Table B.1, Table B.2 and Table B.3, respectively, account for the expenditure baseline model estimated on the mean values (OLS), for the expenditure standard SFA and for the cost endogenous SFA models results. Two main considerations emerge. First, the available data allow to estimate a complete specification, inclusive of the demand factors for all the main functions allowing for a very effective adherence to the underlying theoretical framework that links total expenditure to individual determinants (demand factors for the models in Tables B.1 and B.2 and outputs – with their instrumental variables – for Table B.3) for each function provided by the municipality. Second, the efficiency results estimated with the classical SFA model with demand factors and with the endogenous model on instrumented outputs (Figure B.1) are quite different, justifying the use of a more complex, but more theoretically correct, estimation model.

[11] The two-sided residual term is usually assumed to be normally distributed: $v \sim N(0, \sigma_v^2)$ while u is distributed as a half-normal and is always positive: $u \sim N^+(0, \sigma_u^2)$. The classical model also assumes that v and u are each identically independently distributed (iid) and the covariates in the model. As usual $s = 1$ for production functions and $s = -1$ for cost functions.

Table B.1: Expenditure baseline model - OLS regression

Covariates	Expenditure function (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Taxable income (log, per capita)	0.466	0.335	0.341	0.451	0.399	0.394	0.397	0.520
	[0.001]***	[0.023]**	[0.020]**	[0.000]***	[0.001]***	[0.001]***	[0.001]***	[0.000]***
Residential sales prices (log)	0.200	0.259	0.305	0.279	0.287	0.274	0.271	0.163
	[0.004]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.001]***
Inhabitants	-0.180	-0.202	-0.264	-0.323	-0.247	-0.217	-0.213	-0.297
	[0.385]	[0.348]	[0.206]	[0.058]*	[0.115]	[0.177]	[0.209]	[0.072]*
Inhabitants (square)	0.0170	0.0179	0.0202	0.0210	0.0176	0.0156	0.0154	0.0172
	[0.111]	[0.097]*	[0.054]*	[0.015]**	[0.028]**	[0.060]*	[0.080]*	[0.049]**
Deaths (log, per capita)		0.242	0.209	0.0500	0.0314	0.0252	0.0270	-0.0000174
		[0.000]***	[0.001]***	[0.284]	[0.487]	[0.582]	[0.558]	[1.000]
Births (log, per capita)		0.0670	0.167	0.0901	0.0721	0.0618	0.0639	0.0535
		[0.458]	[0.006]***	[0.034]**	[0.095]*	[0.143]	[0.131]	[0.179]
Net migration (log, per capita)		28.98	21.20	-25.98	8.000	9.141	8.632	-11.48
		[0.394]	[0.498]	[0.398]	[0.855]	[0.830]	[0.840]	[0.681]
Children in kindergarten (2.5 to 5) (log, per capita)			-0.0144	-0.0237	-0.0282	-0.0292	-0.0287	0.00254
			[0.493]	[0.200]	[0.119]	[0.107]	[0.114]	[0.879]
Children in primary school (6 to 11) (log, per capita)			-0.0511	-0.0337	-0.0372	-0.0365	-0.0366	-0.0265
			[0.008]***	[0.043]**	[0.025]**	[0.028]**	[0.025]**	[0.068]*
Family deprivation index				1.709	1.572	1.527	1.536	0.918
				[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
Children in day care (0 to 2.5) (log, per capita)				0.00993	0.0163	0.00638	0.00769	0.0158
				[0.617]	[0.416]	[0.735]	[0.686]	[0.383]
Elderly aged 80 years or older (log, per capita)				0.0259	0.0408	0.0357	0.0366	0.0391
				[0.062]*	[0.001]***	[0.006]***	[0.006]***	[0.001]***
Library borrowers (log, per capita)					0.00465	0.00537	0.00544	-0.00248
					[0.794]	[0.741]	[0.742]	[0.777]
Utilization density (log, per capita)						0.0585	0.0534	-0.0298
						[0.104]	[0.184]	[0.428]
Urbanicity index (%)							0.0150	-0.175
							[0.886]	[0.081]*
Car passengers (log, per capita)							0.0271	0.0390
							[0.626]	[0.329]
Crimes (log, per capita)								0.294
								[0.000]***
Dummy years, 2006 to 2016	yes	yes	yes	yes	yes	yes	yes	yes
N	3376	3376	3376	3376	3233	3233	3233	3233
AIC	-1186.742	-1375.497	-1469.236	-1931.333	-1930.022	-1964.064	-1963.217	-2753.095
BIC	-1100.999	-1271.381	-1352.872	-1796.595	-1789.16	-1817.077	-1803.981	-2587.735

Note: The dependent variable is the expenditure. OLS regression to estimate the relationship between expenditure and local output. Column (1) explains expenditure with basic local determinants. Column (2) adds local demand factors for administration. Column (3) adds local demand factors for education. Column (4) adds local demand factors for social services. Column (5) adds local demand factors for culture. Column (6) adds local demand factors for environment. Column (7) adds local demand factors for local mobility. Column (8) adds local demand factors for local police.

Table B.2: Expenditure SFA model

	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Taxable income (log, per capita)	0.57622	0.03316	17.38	0	0.51122	0.64122
Residential sales prices (log)	0.13918	0.01913	7.28	0	0.10169	0.17666
Inhabitants	-0.38094	0.04516	-8.44	0	-0.46945	-0.29243
Inhabitants (square)	0.02103	0.00232	9.07	0	0.01649	0.02558
Children in kindergarten (2.5 to 5) (log, per capita)	0.00008	0.01223	0.01	0.995	-0.02389	0.02406
Children in primary school (6 to 11) (log, per capita)	-0.02280	0.00607	-3.76	0	-0.03470	-0.01091
Family deprivation index	0.88000	0.07183	12.25	0	0.73921	1.02078
Children in day care (0 to 2.5) (log, per capita)	0.02038	0.01465	1.39	0.164	-0.00832	0.04909
Elderly aged 80 years or older (log, per capita)	0.03972	0.00442	8.98	0	0.03105	0.04838
Library borrowers (log, per capita)	-0.00251	0.00414	-0.61	0.544	-0.01061	0.00560
Increment of population	0.00651	0.00491	1.33	0.185	-0.00312	0.01613
Utilization density (log, per capita)	-0.03295	0.01137	-2.9	0.004	-0.05524	-0.01066
Urbanicity index (%)	-0.18643	0.02706	-6.89	0	-0.23947	-0.13339
Car passengers (log, per capita)	0.03304	0.01559	2.12	0.034	0.00248	0.06361
Deaths (log, per capita)	0.00186	0.01985	0.09	0.925	-0.03705	0.04078
Births (log, per capita)	0.07188	0.02391	3.01	0.003	0.02501	0.11875
Net migration (log, per capita)	-23.79842	16.55202	-1.44	0.15	-56.23979	8.64295
Crimes (log, per capita)	0.29076	0.01068	27.22	0	0.26983	0.31170
Dummy years, 2006 to 2016	yes					
σ_v	0.10971	0.00408			0.10199	0.11801
σ_u	0.17873	0.00795			0.16381	0.19501
σ^2	0.04398	0.00218			0.03971	0.04825
λ	1.62915	0.01151			1.60660	1.65170

Note: The dependent variable is the expenditure. Expenditure Stochastic Frontier Analysis (SFA) to estimate the relationship between expenditure and local output, while accounting for municipal underperformance. Full specification, including basic local determinants, local demand factors for administration, education, social services, culture, housing, environment, local mobility and local police.

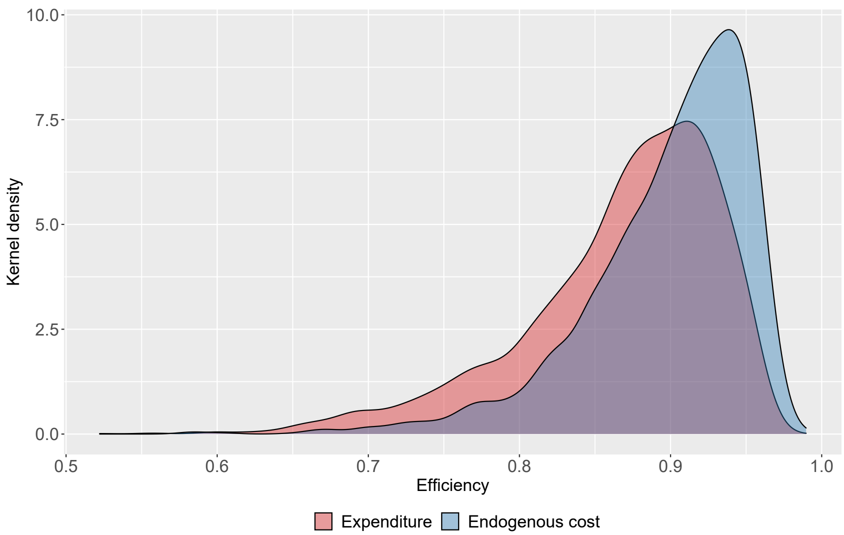

Figure B.1: Expenditure and endogenous cost efficiency kernel distributions

Table B.3: Endogenous cost SFA model

	Coef.	Std.Err.	P-value
Taxable income (log, per capita)	0.25237	0.18912	0.18206
Inhabitants	-0.06563	1.16116	0.95493
Inhabitants (square)	0.01742	0.04738	0.71311
Residential sales prices (log)	-0.06107	0.09906	0.53756
Administrative staff (log, per capita)	0.47384	0.20985	0.02395
Childcare places for school-aged children (2.5 - 12) (log, per capita)	-0.02658	0.156	0.86469
Housing social rental offices (log, per capita)	-0.28605	0.20901	0.17112
Childcare places for toddlers (0-2.5) (log, per capita)	-0.21016	0.19199	0.27367
Residential aged care (log, per capita)	0.04607	0.07751	0.55221
Number of items in public libraries (log, per capita)	-0.01362	0.16943	0.93593
Building permits for residential properties (log, per capita)	0.00424	0.14506	0.97666
Residual waste (log, per capita)	0.70684	0.38056	0.06326
Paved roads (log, per capita)	0.08832	0.13525	0.51375
Police personnel (log, per capita)	0.2348	0.31595	0.45737
Dummy year	yes		
Average efficiency = 89.65225			
Median efficiency = 90.95941			

Local provision (Endogenous variables):	Local needs (Instrumental variables):
Administrative staff (log, per capita)	Deaths (log, per capita)
Childcare places for school-aged children (2.5 - 12) (log, per capita)	Births (log, per capita)
Housing social rental offices (log, per capita)	Children in kindergarten (2.5 to 5) (log, per capita)
Childcare places for toddlers (0-2.5) (log, per capita)	Children in primary school (6 to 11) (log, per capita)
Residential aged care (log, per capita)	Children in day care (0 to 2.5) (log, per capita)
Number of items in public libraries (log, per capita)	Elderly aged 80 years or older (log, per capita)
Building permits for residential properties (log, per capita)	Library borrowers (log, per capita)
Residual waste (log, per capita)	Increment of population
Paved roads (log, per capita)	Utilization density (log, per capita)
Police personnel (log, per capita)	Urbanicity index (%)
	Car passengers (log, per capita)
	Crimes (log, per capita)
	Family deprivation index

Note: The dependent variable is the expenditure. Endogenous cost Stochastic Frontier Analysis (SFA) to estimate the relationship between expenditure and local output, while accounting for municipal underperformance and local provision instrumented by local needs. Full specification, including basic local determinants, local provision and need for administration, education, social services, culture, housing, environment, local mobility and local police.

Appendix C. Functional data clustering

Functional data analysis (FDA, Ramsay & Silverman, 2005) extends the classical multivariate methods when data are natively or can be considered as functions or curves.
A key issue in the functional data approach is that observations are assumed to belong to a space of infinite dimensions, whereas in practical applications only sampled curves are observed at a finite time-points. In fact, usually discrete observations X_{ij} of each sampled path $X_i(t)$ in a finite set of nodes $t_{ij} : j = 1, ..., m_i$ are available. For these reasons, the first step in an FDA-type analysis is often to reconstruct the functional form of the data from the discrete observations using nonparametric smoothing methods of functions.

In recent years, such an approach has been extended to classical statistical estimation methods such as factor analysis, regression models and clustering techniques either through non-parametric methods which generally consist of defining specific distances or dissimilarities for functional data and then applying clustering algorithms such as hierarchical clustering or k-means or through model-based algorithms (Bouveyron & Jacques, 2011; Bouveyron *et al.*, 2015).
In the application proposed in this paper (Figure 1a, 1b, 2a and 2b), the funFEM algorithm (Bouveyron & Jacques, 2015) has been used to cluster the distinct efficiency trends modeling them as curves within a common and discriminative functional subspace.

References

Aigner, D., Lovell, C. A. K., & Schmidt, P. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, **6**, 21–37.

Alesina, A., & Passalacqua, A. 2016. The political economy of government debt. *Handbook of macroeconomics*, **2**, 2599–2651.

Amsler, C., Prokhorov, A., & Schmidt, P. 2016. Endogeneity in stochastic frontier models. *Journal of Econometrics*, **190**(2), 280 – 288.

Amsler, C., Prokhorov, A., & Schmidt, P. 2017. Endogenous environmental variables in stochastic frontier models. *Journal of Econometrics*, **199**(2), 131 – 140.

Argimón, I., & Cos, P. H. d. 2012. Fiscal rules and federalism as determinants of budget performance: An empirical investigation for the spanish case. *Public finance review*, **40**(1), 30–65.

Asatryan, Z., Castellón, C., & Stratmann, T. 2018. Balanced budget rules and fiscal outcomes: Evidence from historical constitutions. *Journal of Public Economics*, **167**, 105–119.

Athey, S., & Imbens, G. W. 2017. The state of applied econometrics: Causality and policy evaluation. *Journal of economic perspectives*, **31**(2), 3–32.

Azevedo, A., Pereira, P. J., & Rodrigues, A. 2021. Optimal timing and capacity choice with taxes and subsidies under uncertainty. *Omega*, **102**, 102312.

Bellofatto, A. A., & Besfamille, M. 2021. Tax decentralization notwithstanding regional disparities. *Journal of Urban Economics*, **123**, 103346.

Ben-Bassat, A., Dahan, M., & Klor, E. F. 2016. Is centralization a solution to the soft budget constraint problem? *European Journal of Political Economy*, **45**, 57–75.

Benito, B., Bastida, F., & García, J. A. 2010. Explaining differences in efficiency: an application to spanish municipalities. *Applied economics*, **42**(4), 515–528.

Bergman, U. M., Hutchison, M. M., & Jensen, S. E. H. 2016. Promoting sustainable public finances in the European Union: The role of fiscal rules and government efficiency. *European Journal of Political Economy*, **44**, 1–19.

Blochliger, H., Merk, O., Charbit, C., & Mizell, L. 2007. *Fiscal equalization in OECD countries*. Tech. rept. OECD network on fiscal relations across levels of government, Working paper , n. 4.

Blochliger, H., & Charbit, C. 2008. Fiscal equalisation. *OECD Journal: Economic Studies*, **1**, 1–22.

Bonfatti, A., & Forni, L. 2019. Fiscal rules to tame the political budget cycle: Evidence from italian municipalities. *European Journal of Political Economy*, **60**, 101800.

Borge, L.-E., & Hopland, A. O. 2020. Less fiscal oversight, more adjustment. *European Journal of Political Economy*, **63**, 101893.

Bosch, N., Espasa, M., & Mora, T. 2012. Citizen control and the efficiency of local public services. *Environment and planning c: Government and policy*, **30**(2), 248–266.

Bouveyron, C., & Jacques, J. 2011. Model-based clustering of time series in group-specific functional subspaces. *Advances in data analysis and classification*, **5**(4), 281–300.

Bouveyron, C., & Jacques, J. 2015. *funfem: an r package for functional data clustering*. Tech. rept. Quatrième Rencontres R, Grenoble, France.

Bouveyron, C., Côme, E., Jacques, J., *et al.* 2015. The discriminative functional mixture model for a comparative analysis of bike sharing systems. *The annals of applied statistics*, **9**(4), 1726–1760.

Burret, H. T., & Feld, L. P. 2018. (un-) intended effects of fiscal rules. *European Journal of Political Economy*, **52**, 166–191.

CEMR. 2016. *Local and Regional Government in Europe. Structure and Competences*. Tech. rept.

CEMR. 2020. *COVID-19's impact on local and regional finances*. Tech. rept.

Christofzik, D. I., & Kessing, S. G. 2018. Does fiscal oversight matter? *Journal of Urban Economics*, **105**(March), 70–87.

Coppens, B., Stinglhamber, P., Van Meensel, L., & Van Parys, S. 2018. Local Government Finances in Belgium. *Economic review*, 33–61.

Dafflon, B., & Mischler, P. 2007. Measuring local government expenditure needs. The Copenhagen Workshop 2007.

Daniele, G., & Giommoni, T. 2021. Corruption under austerity.

De Witte, K., Geys, B., & Schönhage, N. L. 2018. Strategic public policy around population thresholds. *Journal of Urban Economics*, **106**, 46–58.

D'Inverno, G., Moesen, W., & De Witte, K. 2020. Local government size and service level provision. evidence from conditional non-parametric analysis. *Socio-economic planning sciences*, 100917.

Dorn, F., Gaebler, S., & Roesel, F. 2019. Ineffective fiscal rules? The effect of public sector accounting standards on budgets, efficiency, and accountability. *Public Choice*, 1–26.

D'Inverno, G., & De Witte, K. 2020. Service level provision in municipalities: A flexible directional distance composite indicator. *European journal of operational research*.

D'Inverno, G., Smet, M., & De Witte, K. 2020. Impact evaluation in a multi-input multi-output setting: Evidence on the effect of additional resources for schools. *European journal of operational research*.

Fisher, L., Dixon, D., Herson, J., Frankowski, R., Hearron, M., & Peace, K. 1990. Intention to treat in clinical trials. *Pages 331–350 of:* Peace, K. (ed), *Statistical issues in drug research and development*. New York: Marcel Dekker.

Foremny, D., Sacchi, A., & Salotti, S. 2017. Decentralization and the duration of fiscal consolidation: Shifting the burden across layers of government. *Public choice*, **171**(3-4), 359–387.

Fredriksen, K. 2013. *Fiscal consolidation across government levels-part 2. fiscal rules for sub-central governments, update of the institutional indicator*. Tech. rept. OECD.

Galariotis, E., Guyot, A., Doumpos, M., & Zopounidis, C. 2016. A novel multi-attribute benchmarking approach for assessing the financial performance of local governments: Empirical evidence from france. *European journal of operational research*, **248**(1), 301–317.

Geys, B., & Revelli, F. 2011. Economic and political foundations of local tax structures: an empirical investigation of the tax mix of flemish municipalities. *Environment and planning c: Government and policy*, **29**(3), 410–427.

Greene, W. 2008. The econometric approach to efficiency analysis. *In: The measurement of productive efficiency and productivity change* H. O. Fried and C. A. K. Lovell and S. S. Schmidt, eds. Oxford University Press.

Greene, W. 2004. The behaviour of the maximum likelihood estimator of limited dependent variable models in the presence of fixed effects. *The econometrics journal*, **7**(1), 98–119.

Grembi, V., Nannicini, T., & Troiano, U. 2016. Do fiscal rules matter? *American economic journal: Applied economics*, 1–30.

Griffiths, W. E., & Hajargasht, G. 2016. Some models for stochastic frontiers with endogeneity. *Journal of Econometrics*, **190**(2), 341 – 348.

Gupta, S. 2011. Intention-to-treat concept: A review. *Perspect clin res.*, **2**(3), 109–112.

Hosmer Jr, D. W., Lemeshow, S., & Sturdivant, R. X. 2013. *Applied logistic regression*. Vol. 398. John Wiley & Sons.

Iacus, S., King, G., & Porro, G. 2009. Cem: Software for coarsened exact matching. *Journal of statistical software*, **30**, 1–27.

Jaeger, J. A., & Schwick, C. 2014. Improving the measurement of urban sprawl: Weighted urban proliferation (wup) and its application to switzerland. *Ecological indicators*, **38**, 294–308.

Jia, J., Ding, S., & Liu, Y. 2020. Decentralization, incentives, and local tax enforcement. *Journal of Urban Economics*, **115**, 103225.

Karakaplan, M., & Kutlu, L. 2017a. Endogeneity in panel stochastic frontier models: an application to the japanese cotton spinning industry. *Applied economics*, **49:59**, 5935–5939.

Karakaplan, M., & Kutlu, L. 2017b. Handling endogeneity in stochastic frontier analysis. *Economics bulletin*, **37**, 889–891.

Köppl-Turyna, M., & Pitlik, H. 2018. Do equalization payments affect subnational borrowing? evidence from regression discontinuity. *European Journal of Political Economy*, **53**, 84–108.

Kumbhakar, S. C., & Lovell, C. A. K. 2000. *Stochastic frontier analysis*. Cambridge University Press, Cambridge.

Kumbhakar, S. C., Parmeter, C. F., & Zelenyuk, V. 2020. Stochastic frontier analysis: Foundations and advances i. *Pages 1–39 of:* Ray, S. C., Chambers, R., & Kumbhakar, S. (eds), *Handbook of production economics*. Singapore: Springer Singapore.

Kutlu, L., Tran, K. C., & Tsionas, M. G. 2020. A spatial stochastic frontier model with endogenous frontier and environmental variables. *European journal of operational research*, **286**(1), 389 – 399.

Ladd, H. 1994. Measuring disparities in the fiscal condition of local governments. *In:* Anderson, J. (ed), *Fiscal equalisation for state and local government finance*. Westport, CT: Praeger.

Lampe, H. W., Hilgers, D., & Ihl, C. 2015. Does accrual accounting improve municipalities' efficiency? Evidence from Germany. *Applied economics*, **47**(41), 4349–4363.

Luechinger, S., & Schaltegger, C. A. 2013. Fiscal rules, budget deficits and budget projections. *International tax and public finance*, **20**(5), 785–807.

Meeusen, W., & van den Broeck, J. 1977. Efficiency estimation from cobb-douglas production functions with composed error. *International economic review*, **18**, 435 – 444.

Mergoni, A., & De Witte, K. 2021. Policy evaluation and efficiency: a systematic literature review. *International transactions in operational research*, **In press**.

Milán-García, J., Rueda-López, N., & De Pablo-Valenciano, J. 2022. Local government efficiency: reviewing determinants and setting new trends. *International transactions in operational research*, **29**(5), 2871–2898.

Narbón-Perpiñá, I., & De Witte, K. 2018a. Local governments' efficiency: A systematic literature review-—Part I. *International Transactions in Operational Research*, **25**(2), 431–468.

Narbón-Perpiñá, I., & De Witte, K. 2018b. Local governments' efficiency: A systematic literature review—-Part II. *International Transactions in Operational Research*, **25**(4), 1107–1136.

Oates, W. E., & Schwab, R. M. 2004. What should local governments tax: income or property? *City taxes, city spending*, 7–29.

OECD/UCLG. 2016. *Subnational Governments around the world: Structure and finance.*

Porcelli, F., & Vidoli, F. 2020. A comprehensive model for the evaluation of standard expenditure needs and standard level of local services. *Local government studies*, **46**(5), 734–762.

Porcelli, F., Vidoli, F., Dispotico, R., & Ballanti, D. 2016. Public sector economics and the need for reforms. MIT Press.

Prior, D., Martín-Pinillos-Castellanos, I., Pérez-López, G., & Zafra-Gómez, J. L. 2019. Condición financiera y eficiencia en los gobiernos locales de las islas canarias en tiempos de crisis financiera: Cost efficiency and financial situation of local governments in the canary isles during the recession. *Revista de contabilidad - spanish accounting review*, **22**(2), 129–144.

Ramsay, J., & Silverman, B. 2005. *Functional data analysis.* Springer Series in Statistics.Springer, New York.

Reschovsky, A. 2006. Local governance in industrial countries. Public Sector Governance and Accountability Series. The World Bank.

Reschovsky, A. 2007. Intergovernmental fiscal transfers: principles and practice. R. Boadway and A. Shah.

Reuter, W. 2020. Benefits and drawbacks of an “expenditure rule”, as well as of a ”golden rule”, in the eu fiscal framework. *European parliament - economic governance support unit (egov)*, 1–47.

Schaltegger, C. A., & Feld, L. P. 2009. Are fiscal adjustments less successful in decentralized governments? *European Journal of Political Economy*, **25**(1), 115–123.

Schneider, M. 2002. Local fiscal equalisation based on fiscal capacity: The case of austria. *Fiscal studies*, **23**(1), 105–133.

Studies, O. U. M. (ed). 1981. *Measuring local government expenditure needs: The copenhagen workshop*. OECD.

Vanneste, S., & Goeminne, S. 2020. The role of the past in public policy: empirical evidence of the long-term effect of past policy and politics on the local budget balance. *Economics of governance*, **21**(1), 75–99.

Venturini, F. 2020. The unintended composition effect of the subnational government fiscal rules: The case of Italian municipalities. *European Journal of Political Economy*, **63**(March), 101874.

Vidoli, F., & Fusco, E. 2018. Level of services, spatial dependence and allocative efficiency in local governments. *Local government studies*, **44**(6), 848–873.

Wang, Z., Zhao, W., Deng, N., Zhang, B., & Wang, B. 2021. Mixed data-driven decision-making in demand response management: An empirical evidence from dynamic time-warping based nonparametric-matching did. *Omega*, **100**, 102233.

Wayenberg, E., Reuchamps, M., Kravagna, M., & Fallon, C. 2017. Local planning in Belgium:. *Policy analysis in belgium*, 107–128.

Weingast, B. R. 2009. Second generation fiscal federalism: The implications of fiscal incentives. *Journal of urban economics*, **65**(3), 279–293.

Wooldridge, J. 2002. *Introductory econometrics: A modern approach*. Southwestern.