Does Weight-based Pricing on Municipal Waste Contribute to Waste Reduction? Dynamic Panel Analysis in Flanders

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1. Introduction

Weight-based pricing (WBP) on municipal solid waste (MSW) is introduced in some European countries and regions. Although some pioneering studies examine the effect of WBP on MSW (De Jaeger, 2010; De Jaeger and Eyckmans, 2015; Dijkgraaf and Gradus, 2004; Linderhof et al., 2001), the controversy of its effectiveness is still ongoing. However, the existing literature does not consider the dynamic relationship between the dependent variables and unobserved individual heterogeneity among the municipalities. Therefore, this paper analyzes the effects of WBP on MSW in Flanders, Belgium, by applying the bias-corrected least-squares dummy variables (LSDVC) model to account for the dynamic relationship.

2. Methodology and Data

When we examine the effects of waste policies on waste generation and composition in detail, we should consider possible endogeneity in a wide sense (Sasao 2014). First is possible reverse causality, that is endogeneity in a narrow sense. If common characteristics exist across the municipalities that have introduced WBP, causal relationships may be misunderstood. Second is a fixed effects. If there are unobserved time-invariant municipalities characteristics or omitted variables, they may be correlated with the explanatory variables. Third is the presence of the lagged dependent variable resulting in autocorrelation.

We use a balanced panel dataset consisting of 307 (out of 308) Flemish municipalities and 11 years (from 2005 to 2015). Each municipality in Flanders either uses a classical price-per-bag (or price-per-container) or a WBP schedule. Considering the possible econometrical problems noted above, the model specification is as follows:

$$\ln(WASTE_t) = \alpha + \beta_1 \ln(WASTE_{t-1}) + \beta_2 \ln(DEMOG_t) + \beta_3 \ln(PRICE_t) + \beta_4 \ln\,(WBP_t) + \gamma_i + YEAR_t + \varepsilon_{it}$$

Where *WASTE* represents the generated amount of residual waste: all waste (in kg per capita) generated by households, excluding bulky waste and any selectively collected flows. The data on waste generation were provided by the Public Waste Agency of Flanders (OVAM). For the *DEMOG*, socio-demographic determinant, we consider the following four variables: average income (from

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the Studiedienst van de Vlaamse Regering, http://www4dar.vlaanderen.be/sites/svr (in Dutch)); population density (per square km); rate of older people; that of people younger than 5 years of age (from the Statistics Belgium, http://statbel.fgov.be/en). $PRICE$ represents the variable price for residual waste collection in each municipality. All prices are expressed as prices per kg of residual waste collected. The fee for the price-per-bag schedule is therefore transformed to a price-per-kg based on the conversion rate suggested by OVAM. Information on the pricing schedule for each municipality is collected via OVAM databases, municipal websites and provincial archives. We examine three types of WBP dummy variables: (1) continuous participation in WBP ("general participation effect" in De Jaeger and Eyckmans (2015)); (2) first year dummy "introduction effect" in addition to that, and (3) yearly WBP dummy variables to clarify the annual effects after introducing WBP. Furthermore, γ_i is the fixed effect of each municipality; $YEAR$ is the fixed effect of each year; and ε_{it} is the error term that includes all unobserved influences.

This study uses a standard (non-dynamic) fixed effects (FE) model, a Dynamic Ordinary Least Squares estimation (DOLS) and a dynamic Least Squares Dummy Variables estimation (LSDV) as benchmark, in addition to the LSDVC estimation. The DOLS estimator is biased upwards while the LSDV estimator is biased downwards (Bond, 2002). Kiviet (1995) removed the bias from the LSDV estimator, proving that the LSDVC was more efficient than various instrumental variable (IV) estimators including the general method of moments (GMM). Judson and Owen (1999) showed that the LSDVC estimator is the best choice for a balanced panel. However, it should be noted that the LSDVC estimator is only applicable in the presence of strict exogeneity between independent variables and the error term (Bun and Carree, 2005).

3. Results

First, we focus on the parameters of the lagged dependent variable, $\ln(WASTE_{t-1})$, to check the robustness of each estimation model. Because the order of the parameters by DOLS, LSDV, and LSDVC estimators is LSDV < LSDVC < DOLS for all the models, the estimation results by the LSDVC are more robust than LSDV and DOLS. The square root of the error variance estimate suggests that the model with first year dummy in addition to general participation in WBP is the most suitable model. The results show that introduction of the WBP decreases the amount of residual waste significantly (by 3 %), however, the remarkable decrease (24 or 25 %) is observed only in the first year after the introduction. The percentage is lower than that in the non-dynamic FE model for the (continuous) introduction of WBP and is higher for the first year effect. In addition, a 1 % increase of waste bag price decreases the amount of residual waste by 0.02 %. The percentage is lower than that in the non-dynamic FE model. This indicates that the estimation in non-dynamic models can overestimate the continuous effects of WBP.