Public versus Private Delivery of Municipal Solid Waste Services: The Case of Korean Local Governments

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ABSTRACT

This paper examines the effects of different institutional arrangements and characteristics on cost savings, efficiency gains, and productivity of providing municipal solid waste services. A cost function approach is employed, and South Korea local government data for ten years (2000 to 2009) is used for the research.

The empirical findings indicate that there is no effect of contracting-out on cost savings, efficiency and productivity gains in local solid waste disposal services in Korea. Solid waste service costs were not significantly lower under contracting-out than under direct public delivery. In addition, contrary to the arguments of proponents of privatization or contracting-out, efficiency and productivity gains under direct public delivery were higher than under contracting-out.

Keywords: municipal solid waste services; contracting-out; efficiency; productivity; substitutability

Presented at the Annual Conference of the Association for Public Policy Analysis and Management, May 25-27, 2013 in Shanghai, China.

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I. Introduction

Since the 1980s, diverse efforts have been made to enhance the efficiency of public services and to improve service quality from neo-liberalism and market mechanism in western society. In this context, new public management (NPM) provides theoretical basis and specific methodologies for innovations in public services (O'Toole and Meier, 2004). In other words, it has tried to improve quality of service or to provide public service efficiently by employing business management tools and introducing the value of competition into the public sector (Yoo et al., 2008). Privatization or contracting-out is part of these tendencies for government renovations. Especially, contracting-out has received high attention as an important tool to governmental reform because it has many virtues not only to enhance efficiency of service provision but also to save costs related to private service delivery (Ahn, 2005; Ferris and Graddy, 1986; Prager, 1994).

Along with growing interests about contracting-out, earlier studies analyzed about validity of introducing contracting-out in normative perspectives, or conducted qualitative researches through specific examples (Dehoog, 1984; Domberger and Jensen, 1997; Johnston and Romzek, 1999). Since the 2000s, there have been many empirical studies to evaluate efficiency and effectiveness of contracting-out using more specific and strict research methods (Bel and Miralles, 2002; Boardman and Hewitt, 2004; Duggan, 2002; Jang and Feiock, 2003; Romzek and Johnston, 2005; Monga, Metha, and Ranjan, 2009; O'Toole and Meier, 2004; Reeves and Barrow, 2000). Some studies have found positive effects of private delivery through contracting-out in solid waste services, such as reduced production costs, performance improvements, and efficiency gains, but other studies have shown opposite results. Specifically, they insisted that there were degradation of service quality and the increase in real costs, or more damages in public interests, and even the decrease of government reliability (Bae, 2003; Boardman and Hewitt, 2004; Choi et al., 2001; Duggan,

2002; Lee et al., 2003; O'Toole and Meier, 2004). Thus, as part of these academic trends, this paper attempts to examine the effects of private delivery on the efficiency and productivity of public service provision in Korea.

The purpose of this paper is to look at the effects of different institutional arrangements, such as direct public delivery and contracting-out to private company, on cost savings, productivity, economies of scale and factor substitutability in the delivery of solid waste disposal services. To do so, this paper employs a translog cost function approach and uses local government data in Korea covering ten years (from 2000 to 2009). It also employs yearly and regional dummies to control for variations across years and provinces. By utilizing the Korean case, this paper enhances the previous literatures on contracting-out and cost savings in solid waste disposal services. First, most studies for contracting-out primarily focused on U.S. or western countries data for empirical analysis, so only a few studies examined about developing countries, including Asian, Pacific, and African countries (Estache and Rossi, 2002; Jones and Mygind, 2000).

Second, this paper examines the differences in productivity between two types of institutional arrangements, that is, direct public delivery and contracting-out. For more detailed analysis to explain the relationship between contracting-out and cost savings in solid waste services, this research employs a hybrid cost function approach to measure total factor productivity (TFP) level, supply elasticity of cost, return to scale, price elasticity of input demand, and the Morishima elasticity of substitution. Third, costs for solid waste services in this paper include collection, incineration, reclamation, recycling, and disposal of commercial and industrial solid waste as well as residential solid waste. Although this approach makes it difficult to directly compare empirical findings in this research with those in other studies, it allows that we can have more comprehensive views about overall efficiency and productivity gains in solid waste services.

In section II, this paper discusses the different types of institutional arrangements and service characteristics in solid waste service provision and explains the actual local solid waste disposal systems in Korea. In Section III, we proposes an empirical model for parameter estimation, along with total factor productivity (TFP), supply elasticity of cost, return to scale, price elasticity of input demand and the Morishima elasticity of substitution. Section IV describes variables and data sources and presents descriptive statistics. Section V presents the empirical results, and Section VI summarizes important findings and discusses limitations of this study.

II. Literature Review

1. Different types of municipal solid waste service delivery[1]

Public domestic services are generally provided through three institutional arrangements, that is, direct public delivery, privatization, and contracting-out. According to Domberger and Jensen (1997), privatization means the transfer of ownership of physical assets from public to private sector, but privatization does not always promote competition in service provision. Contracting-out means the organizations that offer the lowest prices in the bidding process are chosen to provide particular services for the duration of the contract term. The distinction is that contracting out is "competition for the market as opposed to competition in it" (Domberger and Jensen, 1997). According to Vickers and Yarrow (1991), however, contracting out is also a kind of privatization. Contracting out allows the contractor to appropriate any financial surplus gained through service provision, meaning that the profit is transferred to the contractor. The transfer of the profit is central to ownership (Vickers and Yarrow, 1991).

Most public domestic services, including municipal solid waste services, have natural

[1] This section borrows from Bae (2010).

monopoly characteristics, implying that costs of service provision decrease when only one service provider provides those services entirely within a service region. But through an ex-ante competition that opens up competition to bidders, services can be provided with the lowest prices (Demsetz, 1968). Private contractors also may have stronger incentives to save on service provision costs and realize technical efficiency than public entities (Bel and Miralles, 2003). Therefore, contracting out may be able to provide public domestic services with natural monopoly characteristics at the lowest costs.

Several studies have found that contracting-out leads to lower costs of solid waste disposal and improves productivity of services than direct provision by local governments (Batley, 1996; Domberger et al., 1986; Reeves and Barrow, 2000; Ryoo, 2009; Savas, 1977; Szymanski and Wilkins, 1993). On the other hand, recent evidences have suggested the opposite effects or have shown that there are no significant differences in cost savings between private contract-out and direct public delivery (Bae, 2009, 2010; Bel and Costas, 2006; Callan and Thomas, 2001; Dijkgraaf and Gradus, 2007; Yoo et al., 2008). There are several possible explanations for this. First, if a considerable threat of competition exists in providing municipal solid waste services, public managers are more concerned about cost savings, efficiency and productivity gains, which may improve performance under direct public provision and lead to no difference in cost between direct provision and private contract. For example, in areas where services were directly provided by public entities that were adjacent to areas where services became contracted out to private companies, economic performance improved considerably (Hodge, 1998). Second, private contracting itself may not be sufficient for performance improvements if there is no competition or weak competition (Djkgraaf and Gradus, 2007; Vickers and Yarrow, 1991). Or third, transaction costs arising from contracting out could be substantially large (Post et al., 2003).

2. Local solid waste disposal system in Korea

Local governments in Korea are mainly responsible for the provision of solid waste disposal services, whose services can be delivered by local government itself or private company under contract-out. Thus, the delivery of solid waste disposal services can be classified into the following three types: direct public delivery, contracting-out to private sector and mixed type of both public and private delivery. The collection and transportation of solid wastes are operated in various ways according to regional and seasonal characteristics, and along with these, an additional separating system of recyclable materials is operated at the same time. For instance, profitable solid wastes such as waste papers and scrap metals are primarily collected by the private sector, and unprofitable wastes like plastics are collected by local governments directly and then resold to private companies or transported to recycling facilities.

The total amounts of waste in Korea have increased constantly since the 2000s, but the amounts of solid waste are fixed compared to industrial waste or construction waste. The total amount of solid waste has remained at the level around 50,000 tons per day.

[Table 1] about here

Generally, the ways to dispose wastes are divided into the following three categories: reclamation, incineration and recycling. In Korea, reclamation was the major method to treat wastes until 1995, but the portion and importance of reclamation has been decreased over the last decade due to the environmental problems occurred in the process of transport and disposal of waste, residents' 'not in my backyard' (NIMBY) mentality, the implementation of volume-rate garbage disposal system, or the introduction of recycling policy (Park, 2009). The ratio of reclamation had gradually declined from 20.7% in 2001 to only 9.4% in 2010. Incineration has great importance in waste treatment policies and some developed countries

place emphasis on developing incineration technologies or investing in incineration facilities, because lands for reclamation can be reduced through incinerating waste, and it has advantage to utilize renewable energy by burning organic waste (Park, 2009). Especially, Korea must pay more attentions to developing technology for incineration since it has too many people for its limited land space and high level of energy consumption. However, due to lack of incineration technology, difficulty in securing installation charges, or negative perspectives about facility, there have been many troubles in the installation of incineration facilities and the process of incinerating systems, and the ratio of incineration is significantly low in Korea.

[Figure 1] about here

By the 2000s, national waste management programs and extended producer responsibility (EPR) were established, and waste management policy progressed toward the direction for minimizing wastes and to settle the recycling system for sustainable development. In this context, institutional strategies for the private sector to participate in waste disposal process have been considered in Korea (Ahn, 2010; Park, 2009). The ratio of recycling had steadily increased from 69.5% in 2001 to 83.4% in 2010, and we can find that waste disposal systems have been converted from reclamation and incineration to recycling method. Focusing on solid waste among many kinds of wastes, the ratio of reclamation has been decreased, the ratio of incineration has been gradually increased, and the ratio of recycling has been dramatically increased. In 1995, 72.3% of solid waste was disposed of through reclamation and only 23.7% was recycled. As results of the implementation of volume-rate garbage disposal system and the introduction of recycling policy, however, the ratio of reclamation has decreased to 17.9% and the ratio of recycling has greatly increased to 60.5% in 2010.

[Table 2] about here

III. Empirical Model of Solid Waste Service Costs[2]

Based on the hedonic cost function approach (Feigenbaum and Teeples, 1983; Schmit and Boisvert, 1996), the production function for solid waste service in local government *i* in year *t* can be derived as:

$$Q_{ij} = F(Y_{it}; Z_{it,1}, Z_{it,2}, Z_{it,3}, \cdots\cdots, Z_{it,m}) = F(L_{it}, K_{it}) \qquad [1]$$

where $Q_{it}(\cdot)$ is an index of output in local government *i* in year *t*, and Y_{it} is the total amount of solid waste collected, disposed of, and recycled in local jurisdiction *i* in year *t*. $Z_{it,1}$, $Z_{it,2}$, $Z_{it,3}$, ..., $Z_{it,m}$ represents institutional and service attributes of local government *i* in year *t* related to the total amount of solid waste disposal services (Y_{it}). Therefore, the output of solid waste disposal services in local jurisdiction *i* in year *t* (presented as Q_{it}) reflects the annual collection, recycling, and disposal of solid waste (measured in tons per year, Y_{it}) as well as associated institutional and service characteristics ($Z_{it,1}$, $Z_{it,2}$, $Z_{it,3}$,....., $Z_{it,m}$). L_{it} is labor input for all processes of solid waste disposal services, and K_{it} represents private capital input in local jurisdiction *i* in year *t*.

Based on the duality theory, an indirect cost function can be derived from the production function in equation [2]:

$$TC_{ij} = TC_{it}(Q_{it}(Y_{it}; Z_{it,1}, Z_{it,2}, Z_{it,3}, \cdots\cdots, Z_{it,m}); P_{it,L}, P_{it,K}; H_{it,1}, H_{it,2}, H_{it,3}, \cdots\cdots, H_{it,n}) \qquad [2]$$

where total costs of solid waste disposal services in local government *i* in year *t* (TC_{it}) are the function of exogenously determined input prices ($P_{it,L}$, $P_{it,K}$), output (Q_{it}), and fixed factors ($H_{it,1}$, $H_{it,2}$, $H_{it,3}$,....., $H_{it,n}$). $P_{it,L}$ is the wages per solid waste employee and $P_{it,K}$ is the user

[2] This section borrows from Bae (2010).

cost of private capital per unit.

In this paper, we utilize a hybrid translog cost function to estimate the effects of different institutional arrangements on the costs of solid waste disposal services in Korean local governments. Translog function is comprised of the second-order Taylor expansion series, and thus it permits interaction terms and quadratic functional forms among explanatory variables (Bae, 2009, 2010; Caves, Christensen, and Tretheway, 1980; Simon and Blume, 1997). And this approach has been widely introduced to analyze the performance of public service provision in many previous studies (Ashton, 2000a, 2000b; Bae, 2009, 2010; Bhattacharyya, Parker, and Raffie, 1994; Bhattacharyya et al., 1995; Bruggink, 1982; Feigenbaum and Teeples, 1983; Lynk, 1993; Saal and Parker, 2000; Schmit and Boisvert, 1996; Teeples and Glyer, 1987). It has many advantages that can avoid the risk of bias problems in estimations as a result of model misspecification. In addition, it has flexible functional form that can approximate any true differentiable function without limited assumptions, such as separability, and accounts for the relationships among the input factors.

From equation [2], the following translog cost function can be derived for empirical analysis:

$$\begin{aligned}\ln TC_{ij} &= \alpha_0 + \alpha_y(\ln Y_{it}) + \frac{1}{2}\alpha_{yy}(\ln Y_{it})^2 + \beta_l(\ln P_{it,L}) + \frac{1}{2}\beta_{ll}(\ln P_{it,L})^2 + \beta_k(\ln P_{it,K}) \\ &+ \frac{1}{2}\beta_{kk}(\ln P_{it,K})^2 + \alpha_{yl}(\ln Y_{it})(\ln P_{it,L}) + \alpha_{yk}(\ln Y_{it})(\ln P_{it,K}) + \beta_{lk}(\ln P_{it,L})(\ln P_{it,K}) \\ &+ \sum \beta_m(\ln Z_{it,m}) + \sum \beta_n(\ln H_{it,n}) + \sum \beta_t(YEAR_t) + \sum \beta_s(PROVINCE_s) + \upsilon_{it}\end{aligned} \quad [3]$$

It is assumed that $\ln Q_{ij} = \ln Y_{it} + \ln g(Z_{it,1}, Z_{it,2}, Z_{it,3}, \cdots\cdots, Z_{it,m})$ and $\ln g(\cdot) = \sum \rho_l(\ln Z_{it,m})$ (Feigenbaum and Teeples, 1983; Schmit and Boisvert, 1996). And yearly and province dummy variables are employed to control technical developments and unexplained variations across years and provinces in Korea.

In the translog cost function in equation [3], there are two assumptions, the symmetry

requirement and the homogeneity of degree one, in order to ensure the production is convex and to satisfy the cost-minimization problem, which are as follows:

$$\sum \beta_i = 1; \text{ and } \sum \beta_{ij} = \sum \alpha_{yi} = 0 \quad \text{for} \quad i, j = L, K . \qquad [4]$$

By introducing Shephard's lemma, we can derive two demand functions in the shares of total solid waste costs from the translog cost function in equation [3]. Because the cost shares sum to unity, however, some other problems are occurred that error terms are correlated with the cost share equations and the covariance matrix is singular. In other words, any of the share equations can form a linear combination with the other. To avoid this singularity problem, it is necessary to eliminate one share equation. In this paper, the share equation of private capital is deleted.[3] The share equation of labor in local government *i* in year *t* based on Shephard's lemma is derived from equation [3], as follows:

$$S_{it,L} = \left(\frac{\partial \ln TC_{it}}{\partial \ln P_{it,L}}\right) = \beta_l + \beta_{ll} \ln P_{it,L} + \alpha_{yl} \ln Y_{it} + \beta_{lk} \ln P_{it,K} \qquad [5]$$

where $S_{it,L}$ is the cost share of labor. The translog cost function in equation [3] and the cost share equation of labor in equation [5] are estimated as a system by using Zellner's seemingly unrelated regression (SUR) method in order to increase efficiency of empirical analysis. This method draws the same empirical results as the equation-by-equation ordinary least squares (OLS) method (Cameron and Trivedi, 2005).

1. Total factor productivity(TFP) and efficiency gains

To compare the total factor productivity (TFP) levels between two institutional arrangements, direct public delivery and contracting-out, the translog cost function (presented in equation [3]) is estimated along with the labor cost share equation (presented in equation [5]). The average TFP level is measured by the average value of all residuals from the

[3] If either the share equation of private capital or the share of labor is deleted, there is no difference in empirical results.

estimated translog cost function, and the residual of each observation represents the logarithmic deviation from average productivity of all local governments (Bae, 2009, 2010; Lichtenberg and Siegel, 1987; Martin, McHugh, and Johnson, 1991). Therefore, the value of residual indicates the relative TFP level, compared with the average TFP level of all samples, and it also measures relative efficiency gain or loss compared to the predicted value of the estimated translog cost function. As cost function approach employed in this research, smaller value of residual represents better productivity. In other words, a negative (-) residual value represents productivity and efficiency gain, whereas a positive (+) value represents productivity and efficiency loss (Bae, 2009, 2010; Reeves and Barrow, 2000).

2. Supply elasticity of cost and economies of scale

Through the supply elasticity of cost and the return to scale (RTS), we can analyze whether solid waste disposal systems have realized economies of scale. The return to scale is calculated as the inverse of the supply elasticity of cost. The supply elasticity of cost with respect to the total amount of solid waste disposals in local government *i* in year *t* (Y_{it}) can be derived from the equation [6], as follows:

$$\frac{\partial \ln TC_{it}}{\partial \ln Y_{it}} = \alpha_y + \alpha_{yy} \ln Y_{it} + \alpha_{yl} \ln P_{it,L} + \alpha_{yk} \ln P_{it,K} \qquad [6]$$

From equation [6], the return to scale (RTS) of each local government in year *t* can be calculated through the reciprocal of supply elasticity of cost:

$RTS_{it} = (\frac{\partial \ln TC_{it}}{\partial \ln Y_{it}})^{-1} = \frac{\partial \ln Y_{it}}{\partial \ln TC_{it}}$. $RTS_{it} > 1$ means that the average costs could be further saved by expanding the magnitude and size of municipality *i*'s solid waste disposal system. On the other hand, $RTS_{it} < 1$ implies that the size and magnitude of waste treatment system should be reduced to saving average costs and to improving efficiency. $RTS_{it} = 1$ denotes a

constant return to scale and no existence of either economies of scale or diseconomies of scale.

3. Price elasticity of input demand and elasticity of substitution

Own-price and cross-price elasticities of input factor and the Morishima elasticities of substitution can be calculated by using parameters from the translog cost function in equation [3]. Own- and cross-price elasticities of input demand are written as:

$$\varepsilon_{ii} = \frac{\partial I}{\partial P_i} \cdot \frac{P_i}{I} = S_i + \frac{\beta_{ii}}{S_i} - 1$$

$$\varepsilon_{ij} = \frac{\partial I}{\partial P_j} \cdot \frac{P_j}{I} = S_j + \frac{\beta_{ij}}{S_i} \quad (i \neq j) \text{ for } i, j = \text{L or K} \qquad [7]$$

where ε_{ii} indicates a percent change in the demand for input *i* in response to a percent change (increase or decrease) in its own price, and ε_{ij} represents a percent change in the demand for input *i* in response to a percent change in input *j*. $\varepsilon_{ij} > 0$ implies that labor and capital have a substitution relationship, and $\varepsilon_{ij} < 0$ implies the complementary relationship between input factors.

The Morishima elasticity of substitution can be expressed from simple equation composed by own-price and cross-price elasticities as follow:

$$\theta_{ij} = \varepsilon_{ij} - \varepsilon_{ii} \quad \text{for } i, j = \text{L or K} \qquad [8]$$

where θ_{ij} measures a percent change in the factor ratio of input *i* to input *j* when the price of input *j* increases by 1%, under the assumption that the price of input *i* is held constant (Nguyen and Streitwieser, 1999). $\theta_{ij} > 0$ implies that labor and capital are Morishima substitutes, and $\theta_{ij} < 0$ implies that they are Morishima complements.

IV. Data, Variables and Descriptive Results

1. Data and variables

This paper analyzes the effects of institutional arrangements in the delivery of local solid waste disposal services in Korea. It utilizes Korea's local government data covering 156 local solid waste disposal systems for ten years from 2000 to 2009.[4] All data for the empirical analysis were obtained from the Korean Ministry of Environment and Statistics Korea (KOSTAT). In addition, all continuous variables measured in KRW are adjusted at a constant 2009 KRW using GDP deflators.

Total costs of solid waste disposal services cover all kinds of costs occurred in collecting and treating solid waste and managing waste disposal process within a year. The total costs are calculated from the summation of labor expenditure, facility installment cost, equipment fund, vehicle operation cost, management cost, and contracting-out fee. Wages per employee (P_L) are obtained from labor expenditures divided by the number of employees in solid waste disposal system. User costs of private capital per unit (P_K) are derived from following equation: $P_K = \frac{S_K \times TC}{K}$, where S_K is the cost share of private capital, TC is the total costs of solid waste disposal services, and K is the stock of the private capital. Capital stock in local government i in year t (K_{it}) can be obtained by utilizing the perpetual inventory method. The formula for calculating K_{it} is as follows: $K_{it} = I_{it} + (1-d)K_{it-1}$. In this equation, I_{it} is the capital expenditure in local government i in year t, d is the depreciation rate of private capital, and K_{it-1} is the capital stock in local government i in year t-1. This paper applies depreciation rate of 0.059 in calculating the private capital stock (Nadiri and Prucha, 1993). Cost share of labor is obtained from labor expenditures divided by total solid waste

[4] Among the 164 local governments in Korea, we do not include the waste disposal systems in seven metropolitan governments – Seoul, Busan, Daegu, Incheon, Gwangju, Daejeon, and Ulsan – and Jeju Province, because these waste disposal systems are especially large in terms of size and magnitude of waste disposal systems, compared with the other 156 local systems.

disposal expenditures, and cost share of private capital is obtained by subtracting cost share of labor from unity.

The total amounts of municipal solid waste collected, disposed of, and recycled (Y_{it}) are employed to represent the demands of local residents for solid waste services. Also, several variables are introduced to represent institutional and service characteristics associated with local solid waste disposal services, including institutional arrangements of service delivery. The first variable concerns which provider more collects, manages, and delivers the residential solid waste between local government and private contractor. It is coded as "0" if the local governments directly collect and dispose of residential solid waste, but coded as "1" if any other private contractor delivers solid waste services under contracting-out. Second, local tax share per residents is employed to reflect the level of economical or financial condition of local governments. It is obtained from total amounts of local tax divided by the number of local residents. Third, fiscal independency is introduced to account for the fiscal capacity of local governments. It will be more efficient in solid waste disposal service when fiscal independency of municipality is high, because the more local government has fiscal capacity, the better efficient and effective services can be provided. Thus, all other things being equal, along with an increase in fiscal independency, the costs of solid waste services are likely to decrease as well. Fourth, population density is calculated as the number of residents per km^2 in each municipality. All other things being constant, the costs of solid waste service will increase in accordance with the high level of population density.

In addition, this paper introduces nine yearly dummy variables to control for technological advances in solid waste disposal services as well as for unexplained variables, like national economic fluctuations or market conditions. The year 2000 is used as the base year for these yearly dummies. And seven province dummies are employed for the empirical

estimation in order to control for relatively constant characteristics and unexplained variations of each province in Korea. South Korea comprises eight provinces: Gangwon, Gyeonggi, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Kyungbuk, and Kyungnam, and in each province, local governments have similar cultures, traditions, geographical locations, level of developments and industrial structures. Gyeonggi province is used as the base for other seven province dummies.

2. Descriptive results

Table 3 shows the descriptive results on the variables employed for analyzing municipal solid waste services in Korea. The costs of government-leading solid waste services are lower than those of private-leading through contracting-out. Solid waste services under the government-leading system are relatively labor intensive, on the other hand, solid waste services under the private-leading system are nearly capital intensive. The average wages per employee in the private-leading system were much higher than the government-leading and average amounts of local solid waste disposed by private sector was also higher than direct public delivery. However, there seems to be little difference in the user costs of capital per unit between government- and private-leads: the user cost of capital was 0.5972 for government-leading, while it is 0.6025 for private-leading.

The average amount of local tax per resident was about ₩246,030, but the amount of local tax per resident was much higher in local governments under private contractors (₩370,510) than under public delivery (₩226,040). Population density was higher under private-leading service delivery than under government-leading. Fiscal independency is slightly different between government- and private-leads on the basis of average percentage of fiscal independency.

[Table 3] about here

V. Empirical Results

1. Parameter estimates and total factor productivity level

Table 4 reports the empirical results for solid waste services in Korea. To improve efficiency of empirical estimation, four types of translog cost functions were estimated, along with their cost share equations of labor, using Zellner's SUR estimation method.[5] As shown in Table 4, Model 1 and 3 were estimated with nine yearly dummies and eight province dummies, but Model 2 and 4 were estimated without them. All the first-order and second-order coefficients of input prices and total amounts of solid waste disposal are statistically significant and also have expected signs, except for the first-order coefficients of total amounts of solid waste disposal. So, the estimated elasticities based on these coefficients are robust and reliable. The adjusted R^2 values for the cost functions are 0.5529 to 0.6238, while the adjusted R^2 values for the cost share equations of labor are 0.1267 to 0.2440.

[Table 4] about here

As mentioned above, several variables are introduced to account for institutional attributes or economical characteristics associated with local solid waste disposal services. Local tax per resident, employed to represent economical or financial condition of local governments, has no effect on cost savings in all models. Fiscal independency is positively related to solid waste service costs in Models 1 and 3 which contain province and yearly dummies for fixed-effects on empirical estimations. It means that when the local governments have more capacity or independency in terms of fiscal aspects, they may have fewer incentives to save costs of delivering public services and programs. Thus, they can

[5] The cost share equation of private capital was omitted to avoid the problem of singularity.

utilize more money to provide those services in local governments with high level of fiscal independency. In Models 2 and 4, however, fiscal independency has no effect on cost savings, and as expected, population density significantly contributes to an increase in solid waste service costs.

The main purpose of this study is to examine the cost savings and productivity gains in solid waste service between two institutional arrangements, direct public delivery versus contracting-out to private companies. To achieve this purpose, we conducted analysis in two ways. First, in the empirical estimation, we introduced a dummy variable on the implementation of contracting-out in solid waste services, as shown in Models 3 and 4. Second, we measured the relative TFP levels between two types of arrangements, using coefficients estimated in Model 1 of Table 4. According to the results of Models 3 and 4, institutional arrangements in the delivery of local solid waste disposal services have no significant effects on the costs of solid waste services. In other words, solid waste service costs were not lower under contracting-out than under public delivery. This result corresponds with recent evidence that there are no significant differences in cost savings between public delivery and private contracting-out (previous studies???).

On the other hand, Table 5 reports the average value of the residuals obtained from the estimated translog cost function in Model 1 of Table 4, which represents the relative TFP level for each group. The relative TFP level means the relative distance from the average productivity of all solid waste disposal systems. Since we utilize a cost function approach, a smaller residual value means better productivity, and a negative residual value implies efficiency gains.

[Table 5] about here

According to the results on TFP levels in Table 5, for all sample, local solid waste

services failed to achieve efficiency and productivity gains (average residual value of all sample was 0.008). However, direct public delivery in solid waste services achieved efficiency and productivity gains (average -0.0385) compared to the contracting-out systems (average 0.0291). In addition, a mean-difference test was conducted to examine whether these gains are significantly different between the two institutional arrangements. According to the result of mean-difference test, there is significant difference between them.

Additionally, Table 6 shows the frequency and percentage of efficiency gains in the two institutional arrangements. Under direct public delivery, about 53.5% of solid waste disposal systems achieved efficiency gains, while only about 49.8% of solid waste disposal systems did under contracting-out. These findings support previous studies that public sector could achieve more efficiency and productivity than private sector in the delivery of public services.

[Table 6] about here

2. Supply elasticity of cost and economies of scale

Table 7 shows the supply elasticity of cost and RTS in solid waste services for each group. As previously mentioned, supply elasticities of cost were calculated from equation [6] and RTS is derived from the inverse of the supply elasticities of cost, where coefficients were obtained from the estimated translog cost function in Model 1 of Table 4 and from the sample means of variables from Table 3. According to Table 7, on the basis of all samples, the supply elasticity of cost with respect to the total amounts of solid waste disposal is about 0.7520. In other words, the average costs of solid waste services increased by 7.52%, along with 10% increase in the total amount of solid waste disposal. So, it means that the average costs can be further saved and economy of scale can be realized through increasing the size and magnitude of solid waste disposal systems.

[Table 7] about here

Moreover, we also calculated the supply elasticities of cost and RTSs in the two institutional arrangements. The supply elasticity of cost is lower (0.7032) and RTS is higher (1.4221) under direct public delivery compared to contracting-out systems (0.7742 and 1.2916). This may implies that the size and magnitude of solid disposal system under direct public delivery need to be further increased to save average costs than under private contract-out in the delivery of local public services.

3. Price elasticity of input demand and the Morishima elasticity of substitution

Table 8 reports the price elasticity of input demand and the Morishima elasticity of substitution in solid waste services for each group. As shown in Table 8, since there are two inputs, in absolute values, the own-price elasticity of labor is identical to the cross-price elasticity of labor with respect to capital, and the own-price elasticity of capital is identical to the cross-price elasticity of capital with respect to labor. For the same reason, the two Morishima elasticities of substitution are identical to each other (Bae, 2010).

[Table 8] about here

According to Table 8, all own-price elasticities of input demand have negative signs which are theoretically correct. In the whole sample, along with a 10% increase in wages per solid waste worker, the demand for employees decreased by about 4.88%. Along with a 10% increase in user cost of private capital, the demand for capital stock decreased by about 3.16%. But there are some differences in own-price elasticities between two institutional arrangements. The own-price elasticity of labor is -0.4519 under direct public delivery, while it is -0.5025 under contracting-out. This means that when the price of labor is high, solid

waste services under contracting-out are likely to use less labors than under direct public delivery. The own-price elasticity of capital is -0.3579 under direct public delivery, while it is -0.2965 under contracting-out. That is, in response to high price of capital, solid waste services under direct public delivery are likely to use less capital than under contracting-out.

In the whole sample, the cross-price elasticity of capital with respect to labor is 0.3159, which means that a 10% increase in wages per worker resulted in an increase in the demand for private capital by 3.16%. The cross-price elasticity of labor with respect to capital is 0.4875, implying that a 10% increase in user cost of capital led to an increase in the demand for labor by 4.88%. These cross-price elasticities are positive but not large and less than unity, implying that labor and capital in solid waste services are weak substitutes. And there are little differences in cross-price elasticities between the two institutional arrangements. The cross-price elasticity of capital with respect to labor is 0.3579 under direct public delivery, whereas it is 0.2965 under contracting-out. It means that in response to an increase of wage per employee, public delivery systems in solid waste services are likely to use more capital than under the contracting-out. The cross-price elasticity of labor with respect to capital is 0.4519 under direct public delivery, whereas it is 0.5025 in the latter. In response to an increase in user cost of private capital, contracting-out systems in solid waste services are likely to use more labor than under the public delivery systems.

All Morishima elasticities of substitution are positive and close to unity, so it means that labor and capital are Morishima substitutes. In the whole sample, the Morishima elasticity of substitution is 0.8034, implying that a 10% increase in wages per employee (or user cost of capital) led to an increase in the ratio of capital to employees (or the ratio of employees to capital) by 8.03%. But the results show that the Morishima elasticities of substitutions are not so different between direct public delivery and contracting-out.

VI. Conclusions

Privatization or contracting-out has received a lot of attention in many countries that can lower service costs and improve the quality of services by removing bureaucratic waste and realizing economies of scale. This western style of governmental renovation and institutional change in public service delivery was universally applied to other countries as well. Focusing on solid waste services, contracting-out system is gaining more significance in both developed and developing countries. Especially in Korea, local governments provide solid waste disposal services through direct public delivery or some parts of solid waste have been collected, treated, and disposed by private contractors. Thus, this paper examined the effects of contracting-out on cost savings, efficiency and productivity gains of solid waste disposal services in Korea. This examination of the Korean experiment of contracting-out can advance the existing literatures on the efficiency and effectiveness of public versus private service delivery. For the empirical estimation, we used the cross-sectional time-series data covering the ten years from 2000 to 2009 in Korean local governments.

The empirical findings indicate that there is no effect of contracting-out on cost savings, efficiency and productivity gains in local solid waste disposal services in Korea. Solid waste service costs were not significantly lower under contracting-out than under direct public delivery. In addition, contrary to the arguments of proponents of privatization or contracting-out, efficiency and productivity gains under direct public delivery were higher than under contracting-out. In other words, local governments employing public delivery of solid waste disposal services realize more efficiency gains than those employing private contractors, and they also achieve higher productivity levels under public delivery than under contracting-out. These findings may have possible explanations that, in Korea, local governments place a high value on efficiency and productivity because they are faced with competition from external producers and pressures from high level of government. If so, local

governments try to improve their internal operation and management systems for better service delivery (Bae, 2010; Hodge, 1998). Local solid waste services under both direct public delivery and contracting-out need to further reduce the average costs of services and realize economies of scale by increasing the size and magnitude of their delivery systems. During the last three decades, the Korean central government has made continuous efforts to privatize public enterprises, and to contract out public services to private companies. However, the empirical results of this paper suggest that these efforts may not help reduce solid waste service costs, and rather can decrease efficiency of service.

This paper has several limitations. First, we analyzed effects on cost savings of different institutional arrangements for solid waste service delivery, but we could not deal with the effects on the quality of services, due to the unavailability of data. Private contractors may lead to low quality of services because they have strong incentives to reduce their costs rather than improve service quality. Thus, further researches should be done to examine the effects of contracting-out on quality or equity issues of solid waste services. Second, this paper included only three control variables for empirical estimation. Although we introduced province and yearly dummy variables in order to control unexplained conditions and variations, we have to find out socio-economic characteristics which might influence on the delivery of solid waste services.

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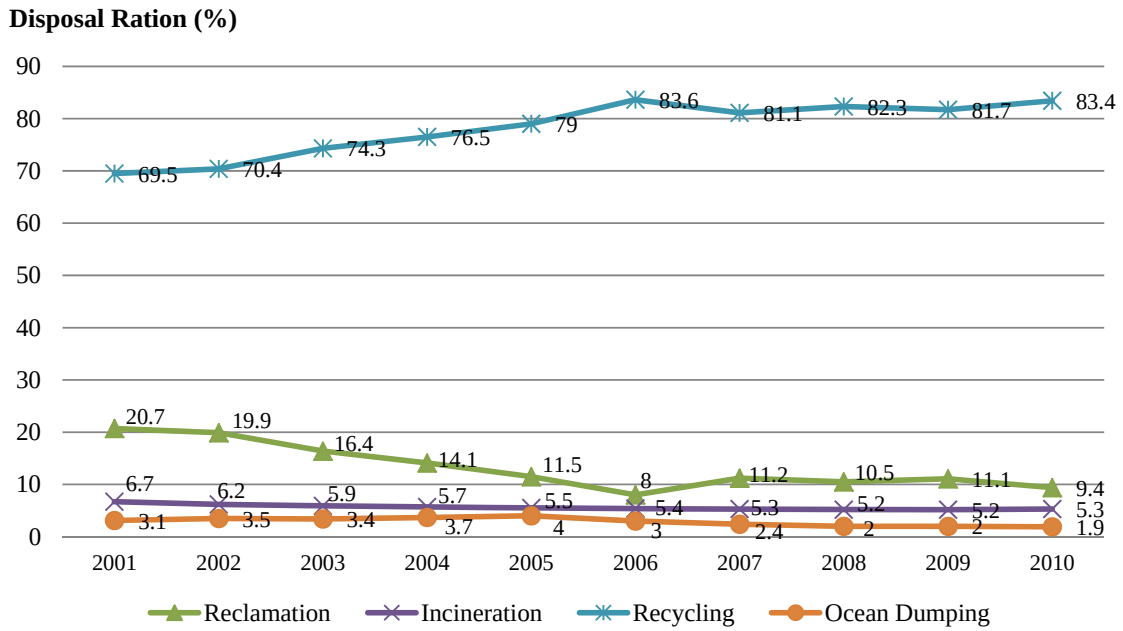
Table 1. Amounts of Waste in Korea

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total	Amount (tons/day)	252,927	269,548	295,047	303,514	295,723	318,928	337,158	359,296	357,861	365,154
	year-on-year(%)	11.6	6.6	9.5	2.9	-2.6	7.8	5.7	6.6	-0.4	2
Solid Waste	Amount (tons/day)	48,499	49,902	50,736	50,007	48,398	48,844	50,346	52,072	50,906	49,159
	year-on-year(%)	4.4	2.9	1.7	-1.4	-3.2	0.9	3.1	3.4	-2.2	-3.4
Industrial Waste	Amount (tons/day)	95,908	99,505	98,891	105,018	112,419	101,099	114,807	130,777	123,604	137,875
	year-on-year(%)	-5.5	3.8	-0.6	6.2	7	-1.1	13.5	13.9	-5.5	11.5
Construction Waste	Amount (tons/day)	108,520	120,141	145,420	148,489	134,906	168,985	172,005	176,447	183,351	178,120
	year-on-year(%)	37.8	10.7	21	2.1	-9.1	25.3	1.8	2.6	3.9	-2.9

Note: Specified wastes are excluded from the total amount of industrial wastes.

Figure 1. Annual Changes in Waste Disposal System



Note: Specified wastes are excluded from the total amount of industrial wastes.

Table 2. Different Types of Treatments in Each Waste (2010)

		Total	Reclamation	Incineration	Recycling	Ocean Dumping
Total	Amount(tons/day)	365,154	34,306	19,511	304,381	6,956
	Ratio(%)	100%	9.4%	5.3%	83.4%	1.9%
Solid Waste	Amount(tons/day)	49,159	8,797	10,609	29,753	0
	Ratio(%)	1	17.9%	21.6%	60.5%	0.0%
Industrial Waste	Amount(tons/day)	137,875	23,309	7,983	99,627	6,956
	Ratio(%)	1	16.9%	5.8%	72.3%	5.0%
Construction Waste	Amount(tons/day)	178,120	2,200	919	175,001	0
	Ratio(%)	100%	1.2%	0.5%	98.2%	0.0%

Note: Specified wastes are excluded from the total amount of industrial wastes.

Table 3. Descriptive Results(??)

Variables	**All Samples** Mean (Standard Deviation)	**Government-Lead** Mean (Standard Deviation)	**Private-Lead** Mean (Standard Deviation)	**Mixed-Contracting** Mean (Standard Deviation)
Costs for solid waste services (1,000 KRWs)	9,430,920 (17,100,000)	8,348,520 (17,900,000)	11,500,000 (11,700,000)	13,600,000 (12,700,000)
Total labor spending (1,000 KRWs)	3,010,605 (13,300,000)	2,876,121 (15,000,000)	2,208,105 (1,970,380)	3,648,350 (3,913,844)
Total capital spending (1,000 KRWs)	6,420,316 (9,100,645)	5,492,413 (8,410,259)	9,279,167 (11,600,000)	9,939,494 (10,600,000)
Labor cost share	0.3933 (0.2534)	0.4073 (0.2547)	0.2769 (0.2351)	0.3480 (0.2422)
Capital cost share	0.6067 (0.2534)	0.5927 (0.2547)	0.7231 (0.2351)	0.6520 (0.2422)
User cost of capital	0.5915 (0.2255)	0.5972 (0.2342)	0.6025 (0.1478)	0.5673 (0.1926)
Wages per employee (1,000 KRWs)	168,968.8 (1,803,909)	124,095.7 (1,169,528)	203,481 (685,969.1)	347,753.8 (3,344,040)
Amounts of solid waste disposal (tons)	56,275 (68,653)	45,516 (57,672)	77,829 (57,660)	97,826 (91,035)
Dummy for contracting-out implementation	0.69 (0.46)	0.60 (0.49)	1.00 (0.00)	1.00 (0.00)
Local tax share (local tax per resident, 1,000 KRWs)	246.03 (118.15)	226.04 (95.55)	370.51 (170.87)	314.80 (156.08)
Population density	800.90 (2,013.33)	597.16 (1,519.68)	1,038.32 (2,921.36)	1,604.83 (3,152.76)
Fiscal independency (%)	26.15 (16.65)	23.87 (15.43)	33.23 (17.18)	34.67 (18.40)
N	1239	975	24	240

Table 4. Empirical Results: Translog Cost Function

Variables	**Model 1** Estimate (Standard Error)	**Model 2** Estimate (Standard Error)	**Model 3** Estimate (Standard Error)	**Model 4** Estimate (Standard Error)
lnY	0.4753	-0.0138	0.4460	-0.0044
	(0.2955)	(0.3317)	(0.2973)	(0.3326)
$\ln P_L$	0.4331	0.8523	0.4337	0.8516
	(0.0657)***	(0.0700)***	(0.0657)***	(0.0700)***
$\ln P_K$	0.5669	0.1477	0.5663	0.1484
	(0.0657)***	(0.0700)**	(0.0657)***	(0.0700)**
$1/2(\ln Y)^2$	0.0788	0.1367	0.0813	0.1360
	(0.0278)***	(0.0310)***	(0.0280)***	(0.0311)***
$1/2(\ln P_L)^2$	0.0469	0.0144	0.0469	0.0145
	(0.0032)***	(0.0032)***	(0.0032)***	(0.0032)***
$1/2(\ln P_K)^2$	0.0469	0.0144	0.0469	0.0145
	(0.0032)***	(0.0032)***	(0.0032)***	(0.0032)***
$(\ln Y)(\ln P_L)$	-0.0512	-0.0604	-0.0512	-0.0604
	(0.0050)***	(0.0055)***	(0.0050)***	(0.0055)***
$(\ln Y)(\ln P_K)$	0.0512	0.0604	0.0512	0.0604
	(0.0050)***	(0.0055)***	(0.0050)***	(0.0055)***
$(\ln P_L)(\ln P_K)$	-0.0469	-0.0144	-0.0469	-0.0145
	(0.0032)***	(0.0032)***	(0.0032)***	(0.0032)***
Contracting-out Implementation			0.0303	-0.0153
			(0.0354)	(0.0403)
ln(local tax share)	-0.0631	-0.0665	-0.0679	-0.0617
	(0.0653)	(0.0519)	(0.0656)	(0.0535)
ln(population density)	0.0317	0.0521	0.0306	0.0532
	(0.0211)	(0.0227)**	(0.0212)	(0.0230)**
Fiscal independency	0.0042	-0.0002	0.0041	-0.0003
	(0.0025)*	(0.0021)	(0.0025)*	(0.0021)
Constant	4.9463	5.7260	5.1236	5.6539
	(1.6271)***	(1.8294)***	(1.6396)***	(1.8399)***
Province dummies	Yes	No	Yes	No
Yearly dummies	Yes	No	Yes	No
N	1239	1239	1239	1239
DV: lnTC				
adj. R^2	0.6238	0.5530	0.6237	0.5529
χ^2	18608.41	14368.3	8922.28	14369.49
$p > \chi^2$	0.000	0.000	0.000	0.000
DV: labor cost share				

adj. R^2	0.2440	0.1267	0.2439	0.1271
χ^2	347.34	147.24	346.68	147.45
$p > \chi^2$	0.000	0.000	0.000	0.000

Note: *, **, *** significant at the 10%, 5%, and 1% levels, respectively.

Table 5. Test Results on TFP Levels

	All Sample	**Public Delivery**	**Contract Out**	**Mean-Difference Test**
Mean (t-statistic)	0.0080	-0.0385	0.0291	-1.7294
Standard Deviation (p-value)	0.6381	0.6567	0.6287	0.0840
N(df)	1239	387	852	1237

Table 6. Efficiency Gains

	All Sample		**Public Delivery**		**Contract Out**	
	N	%	N	%	N	%
Efficiency Gains	631	50.93	207	53.49	424	49.77
Efficiency Loss	608	49.07	180	46.51	428	50.23
Total	1239	100.00	387	100.00	852	100.00

Table 7. Supply Elasticities of Cost and Return to Scale

	All Sample	**Public Delivery**	**Contract Out**
Supply Elasticity of Cost	0.7520	0.7032	0.7742
Return to Scale	1.3297	1.4221	1.2916

Note: Elasticities and returns to scale (RTSs) calculated from sample means.

Table 8. Elasticities of Substitution

	All Sample		Public Delivery		Contract Out	
	Price	**Morishima**	**Price**	**Morishima**	**Price**	**Morishima**
Labor, Labor	-0.4875		-0.4519		-0.5025	
Capital, Capital	-0.3159		-0.3579		-0.2965	
Capital, Labor	0.3159	0.8034	0.3579	0.8098	0.2965	0.7990
Labor, Capital	0.4875	0.8034	0.4519	0.8098	0.5025	0.7990

Note: Elasticities calculated from sample means.