Asymmetric Cost Behavior in Local Public Enterprises:

Exploring the Public Interest and Striving for Efficiency

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Abstract

Asymmetric cost behavior, which was first identified in Germany in the 1920s, has attracted the attention of researchers over the last two decades. Cost management is essential not only for commercial enterprises (CEs) but also for public organizations. Therefore, in this research, I focus on local public enterprises (LPEs), one type of public organization in Japan, and clarify their cost behavior. Then, taking the perspective of institutional theory, I compare LPEs with CEs. Because LPEs are required to behave according to the restrictions of LPE law, they are more vulnerable to institutional pressure. Specifically, LPEs have two normative institutional constraints: (1) efficiency and (2) the public interest (i.e., the responsibility to support people's everyday lives). Therefore, LPEs must provide certain services even if they are unprofitable. To explore whether normative institutional pressure causes LPEs to be cost inefficient, I compare the cost behavior of these enterprises with that of CEs in five ways. I analyze (1) panel data covering 40 years, (2) the change over time, (3) the differences by industry type, (4) the relationship with population changes, and (5) the effect of political influence. I find that LPEs' cost management is not necessarily cost inefficient; however, their ability to adjust costs may be lost in the future due to the influence of institutional constraints. I therefore assert that LPE administrators must constantly struggle to balance the institutional constraints of the public interest and efficiency since these factors require long-term, stable management.

Keywords: local public enterprises, sticky costs, anti-sticky costs, asymmetric cost behavior, public interest, efficiency, institutional constraints

JEL codes: H83, M41

1 Introduction

After World War II, public enterprises (PEs) were created in both developed and developing countries to address market deficits and capital shortfalls, promote economic development, reduce mass unemployment and/or ensure national control over the overall direction of the economy (UN, 2008). Over the long term, PEs provided public services that were directly managed by governments. However, management inefficiencies, overstaffing, inflation and rising current account deficits in the 1980s exposed serious "government failures" and the limitations of PEs as major players in economic development (UN, 2008). Subsequently, new public management (NPM) led public organizations (including PEs) to change their behavior from reflecting administrative aspects to reflecting managerial aspects (Van Genugten 2008; Pérez-López et al. 2015). From the perspective of fiscal finance, the operations of public organizations switched from recognizing soft budget constraints to recognizing hard budget constraints (Bertero and Rondi 2000). Furthermore, in the 1990s, many public services provided by public sector organizations were outsourced or the organizations were privatized and became commercial enterprises (CEs) because of pressure to improve their efficiency and effectiveness (Hefetz and Warner 2007). Thus, public service costs in public sector organizations were initially reduced through outsourcing or privatization (Domberger and Jensen 1997; Domberger and Rimmer 1994; Hodge 2000), but the cost reduction effects gradually decreased over the long term (Bel and Costas 2006; Dijkgraaf and Gradus 2011). Therefore, in the 2000s, the responsibility for outsourced public services shifted again to corporatized PEs, which emphasize efficiency and have greater independence from the government than PEs that are directly managed by governments (Hefetz and Warner 2007; Grossi and Reichard 2008; Wollmann et al. 2010). Currently, various public services are provided by corporatized local public enterprises (LPEs) in every region of the world (Saussier and Klien 2013) (Table 1).

[Insert] Table 1. LPEs in selected countries

Recently, corporatized LPEs[1] have been found to be more efficient than LPEs directly managed by local governments (Voorn et al. 2017). Nevertheless, LPEs are generally considered to be more cost inefficient than CEs since the former face stronger institutional pressure (i.e., normative, coercive, and mimetic) than CEs (Frumkin and Galaskiewicz 2004). In particular, from the viewpoint of normative institutional constraints, LPE administrators are pressured by law to achieve efficiency[2] and serve the public interest[3]. However, it is very difficult for LPE administrators to do both simultaneously. If LPE administrators prioritize cost reductions due to the influence of efficiency pressures, the risk of

[1] Hereafter, in Section 1, "LPEs" refer to corporatized LPEs.

[2] The concept of efficiency is used differently in each study focusing on the public sector (Voorn et al. 2017). In this article, efficiency refers to cost efficiency.

[3] The concept of the public interest can be defined not only as a specific conceptualization of the term "public interest" but also with a variety of meanings from very specific to very broad definitions (Pesch 2005; Van Genugten 2008). Therefore, in this research, following De Bruijn et al. 2004, "public interest" is defined as both the importance of services (i.e., necessary and convenient for everyday lives) and the roles and responsibilities of governments.

declining public service quality increases. Conversely, pursuing the public interest can lead LPE administrators to manage their costs more inefficiently. Thus, LPE administrators must strike a balance between efficiency and the public interest under the pressure of these two normative institutional constraints (Kawarata 2005). By contrast, CE managers aim only to maximize profits; since they are subject to fewer institutional pressures than LPEs, they have greater flexibility in making management changes (Eldenburg et al. 2004; Balakrishnan et al. 2010; Holzhacker et al. 2015). However, to date, research on whether public services are more inefficiently performed by LPEs than CEs is lacking.

Therefore, my research question is whether LPEs manage their costs more inefficiently than CEs. In this research, I focus on LPEs in Japan and clarify their cost management. In addition, I compare my results with those for CEs based on the theoretical background of institutional theory. I choose Japanese LPEs for two reasons. First, the number of LPEs in Japan is very high compared to the number worldwide (Table 1). In Japan, the Local Public Enterprise Law was enacted in 1948, after World War II, and subsequently, many LPEs were established in each municipality. Therefore, it is possible to collect data from a large cross-sectional sample, making this empirical research more robust. Second, LPEs are consistently the main bodies providing public services and have been continuously engaged in this important role supporting civil life in Japan over the long term. Therefore, it is possible to collect consistent, long-term time series data. The accounting system for LPEs remained unchanged until 2014[4]. Therefore, in this research, I was able to collect fiscal data from 1974[5] to 2013 and verify the long-term changes in cost management alongside the global trends for each period, for example, the trends in NPM since the 1980s, outsourcing or privatizing into CEs since the 1990s, and the revival of LPEs since the 2000s.

Additionally, I discuss how LPEs' cost management should be sustainably controlled in the future not only in theory but also in practice. LPEs in Japan have encountered two main issues in recent years that have intensified the institutional constraints of achieving efficiency and serving the public interest: population changes and a deteriorating financial situation. According to Japan's population census, the country's population had reached its upper limit and entered a stage of decline (Figure 1). In Japan, the proportion of elderly people in the total population exceeded 14% in 1995, and Japan became an aging society. Furthermore, in 2007, this proportion exceeded 21%, representing a super-aging society. In conjunction with this shift, the population of youth and of those in the productive ages has continued to decline. Additionally, Japan's suburban population has decreased dramatically. The Japanese government reported that the percentage depopulated areas[6] of Japan has increased from 40.7% in 1972

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[4] LPEs in Japan adopted almost the same bookkeeping method as CEs beginning in 1966. After 2014, the accounting standards of LPEs have changed. Many of them are based mainly on changes in the balance sheet that this research does not pay attention to. On income statements (P/L) that I pay attention to in this study, the method of amortizing fixed assets when purchased with subsidies has been changed. Before 2013, the amortizing fixed assets were accounted for only in expenses; on the other hand, after 2014, the amortizing fixed assets were accounted for not only in expenses but also in revenue, as the long-term advances received.

[5] 1974 is the first year for which data collection was possible.

[6] The depopulated areas in Japan are defined in the Act on Special Measures for Promotion for Independence for Underpopulated Areas. There are many requirements for specifying depopulated

to 58.7% in 2015. The number of depopulated municipalities also increased from 32.3% in 1972 to 46.4% in 2015. LPEs must continue their businesses despite the institutional constraint of serving the public interest, even if the costs of idle capacity rise due to a declining number of users caused by population decreases. Conversely, the aging population, who need more public services (e.g., medical services, care services) at a low cost, will continue to increase in the future.

[Insert] Figure 1. Population changes in Japan

A final issue is the difficulty LPEs experience in repaying bonds (Figure 2 Panel A). LPEs issue bonds to finance new public service projects (including both maintenance and renovation projects) or to improve the quality or expand the quantity of public services. In examining LPEs' financial statements, although operating revenues and expenses may be in surplus, non-operating revenues and expenses often show deficits (Figure 2 Panel B and Panel C). This difference is due mainly to the repayment of bonds and interest payments. Since interest payments are a fixed cost, LPE administrators must reduce other variable costs. However, cost adjustment flexibility decreases with increases in LPE bonds. Namely, the repayment of LPE bonds requires LPE administrators to further enhance their organizations' efficiency.

[Insert] Figure 2. LPE bonds, operating and non-operating revenues and expenses

For LPEs to improve their efficiency, it is essential to consider further developing their cost management. Thus, clarifying LPEs' cost behavior and understanding its movement is important for improving LPEs' cost management (Murray 1975; Rainey et al. 1976). In research on cost behavior, German studies identified "Kostenremanenz" in the 1920s. Over the past 20 years, this phenomenon has again attracted the attention of empirical researchers in management accounting (Noreen and Soderstrom 1997) and is now known as "sticky costs (cost stickiness)" (Anderson et al. 2003). Sticky costs increase proportionally as activities increase, but when activities decrease, the costs do not decrease symmetrically. In subsequent studies, sticky costs were found to exist in each region, country and industry (Calleja et al. 2006; He et al. 2010; Subramaniam and Weidenmier 2016). Conversely, it has also been verified that a change in cost may exceed the change in activity (Weiss 2011). Subsequent empirical research showed that cost behavior includes not only sticky costs but also anti-sticky, i.e., asymmetric, costs when activity increases and decreases (Banker and Byzalov 2014). However, most previous studies have focused on CEs (Malik 2012; Günther et al. 2014), and only a few studies have focused on public sector organizations' cost behavior (Yasukata et al. 2011; Bradbury and Scott 2014; Cohen et al. 2014; Holzhacker et al. 2015). Therefore, the goal of this research is to examine LPEs' cost behavior, which has not yet been analyzed. In addition, I examine whether LPEs' cost behavior reflects high or low sticky costs when compared to CEs from the viewpoint of institutional theory through a

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areas: one is that the population declined more than 33%.

long-term empirical analysis.

Through this study, I contribute five findings to the cost behavior research. First, I find that LPEs' cost management is not necessarily inefficient compared to CEs from the perspective of cost behavior. Namely, I find that sticky costs exist in CEs' cost behavior, and conversely, anti-sticky costs are revealed in LPEs through a panel data analysis covering 40 years. In addition, I discovered that LPEs' cost behavior contrasts with that of CEs. However, these results also contrast with the expected conclusions in general. I believe that the lack of support for this expectation might be driven by accounting system (regulations on dividends and retained earnings) and management system (redundancies; e.g., preparation for disasters) differences between CEs and LPEs.

Second, I discovered that after a certain period of time has passed from LPEs' establishment, inefficient risks in LPEs' cost management are caused by institutional pressure to protect the public interest. Through a timeline (year by year) analysis over 40 years, I find that LPEs' cost behavior gradually shifted from anti-sticky costs to sticky costs. This result also contrasts with CEs' cost behavior, which did not drastically change. I discovered that the adjustment ability of management resources in LPEs was gradually lost over the long term. From the viewpoint of securing the public interest, obsolete equipment must be repaired or replaced to maintain the quality of public services, even if revenues decrease. I conjecture that cost-inefficient risk is affected by an increase in the costs of facilities and equipment.

Third, through an analysis by industry type, I find various characteristics of LPEs' cost behavior in each industry type, including high material resource industries and high human resource industries. The diversity of cost behavior in LPEs might be caused by the resource adjustment costs in various business environments and the various institutional restrictions, including the non-exclusion of public services and the influence of monopolies.

Fourth, I discovered that depopulation and structural changes in the population influence LPEs' cost behavior. Since population change is closely related to public service demand, the administrators of LPEs need to manage those costs that respond sensitively to population changes. I can show how public service providers should adjust their costs due to population changes, which suggests that the influence of population changes must be taken into consideration to preserve LPEs' cost adjustment ability.

Finally, I clarify how LPE administrators adjusted their costs based on changing activity levels over four years, which equals politicians' term in office, and verify the differences between LPEs and CEs. I find the cost behaviors' differences in both the speed of change and the direction of movement can be compared. Regarding the changing speed of cost behavior, LPE administrators try to adjust their costs so that they remain proportional over four years, as they aim to operate their services in a stable manner and attempt to balance the public interest and efficiency sustainably. Regarding the direction of movement, one might assume that LPE administrators are subject to institutional pressure from politicians, who respond to public opinion, and social demands, which require the enrichment of public services rather than excessive cost efficiency. I conjecture that LPE administrators intend to adjust their costs to balance their proportions during politicians' term in office.

In addition, by understanding the characteristics of LPEs' cost behaviors from an academic perspective, it will be possible to contribute to public administrators' ability to manage their future costs.

I also contribute to practical aspects of LPE cost management in the future sustainability plans called the Compact City and Intermunicipal Cooperation.

The article proceeds as follows. Section 2 discusses the characteristics of LPEs from the viewpoint of institutional theory, reviews the literature on public organization cost behavior and develops my research hypotheses. In Section 3, the research methodology is described, including the sample data, the variable measures, and the models. Section 4 presents and discusses the results. Finally, Section 5 summarizes the results and concludes with a discussion of the limitations of this study and suggestions for future research.

2 Background and Literature Review

2.1 Characteristics of LPEs

Since World War II, LPEs have been an important public service provider not only in developed countries throughout the world but also in developing countries (UN, 2008). LPEs are called various names within each country and region, such as “municipally owned enterprises”, “municipal corporations”, “local public companies”, “municipal corporatizations”, and “state-owned enterprises” (Collin et al. 2009; Saussier and Klien 2013; Voorn et al.2017).

A UN (2008) report defined public enterprises as follows: a “public enterprise can be considered an organization established by the government under public or private law, as a legal personality which is autonomous or semi-autonomous, that produces/provides goods and services on a full or partial self-financing basis, and in which the government or a public body/agency participates by way of having shares or representation in its decision-making structure”.

However, in the academic field, there is no definite and common definition of a public enterprise to date (Collin et al. 2009; Saussier and Klien 2013) because LPE regulations differ from country to country and LPEs’ service content differs from region to region. Thus, it can be stated that LPEs exist in an institutional twilight area, as they are both public administrators and private companies (Collin et al. 2009). Because of the existence of various forms and types of LPEs in each country and region, academics to date have not recognized common LPE issues. Based on a taxonomy, Saussier and Klien (2013) classified LPEs based on decision-making rights, organizational control, and property rights. They distinguished between directly managed LPEs and corporatized LPEs. Additionally, Voorn et al. (2017) described the unique features of directly managed LPEs and those of corporatized LPEs (Table 2).

[Insert] Table 2. Characteristics of directly managed LPEs and corporatized LPEs

Saussier and Klien (2013) explained that Japanese LPEs are part of the local public government and are not independent organizations. Therefore, they argued that Japanese LPEs are not suitable as subjects of empirical research because they are not financially and organically separate from local public governments. LPEs in Japan are certainly a type of public organization owned by local governments. However, I assert that the researchers’ argumentation is partly correct and partly wrong. According to their taxonomy, LPEs in Japan are classified into directly managed LPEs and corporatized

LPEs. The former are part of local public bodies, as these authors claim, but the latter are run independently. The services provided by corporatized LPEs are funded by user fees, and the entities must be profitable independently of local public bodies. Thus, corporatized LPEs have weaker regulations than directly managed LPEs and can be managed flexibly using their income from utilities. It is expected that the efficiency and effectiveness of the services provided by corporatized LPEs will be promoted over services provided by directly managed LPEs (Oshima 1971). Therefore, I argue that corporatized LPEs in Japan are suitable for empirical analysis because they are financially and organically separate from local public governments.

In Japan, legislation established LPEs in each municipality after World War II. The number of LPEs increased with the increase in population: there were 6,995 enterprises in 1974, 12,629 enterprises in 2002, when they reached a peak, and recently, after a decline due to privatization or amalgamation, there were 8,712 enterprises in 2013 (Figure 3). In addition, there are more directly managed LPEs than corporatized LPEs. However, the number of directly managed LPEs has decreased substantially since 2004 under the influence of privatization based on the institutional pressure of NPM. By contrast, the number of corporatized LPEs has not changed drastically for 40 years. I argue that corporatized LPEs are also appropriate for empirical analysis because the number of such organizations is larger than that in other countries, and data collection is possible over a longer period. For this reason, I focus on corporatized LPEs for this analysis.

[Insert] Figure 3. Trends in the number of LPEs in Japan

Corporatized LPEs (hereafter, LPEs) are governed by an administrator appointed by the mayor and approved by congress for a four-year term in office. Dismissal is restricted during this term. The administrator has decision rights regarding the management of an LPE. Therefore, the administrator is similar to the CEO of a CE. However, unlike CEOs, LPE administrators are not allowed to receive dividends from the organization's profits. Therefore, from the perspective of agency costs, there is little incentive for administrators to declare a high amount of dividends (Eldenburg and Krishnan 2003). However, if the administrator achieves a high level of performance (e.g., high evaluation of the service, cost reductions), the mayor can reappoint the administrator. Therefore, the administrators of LPEs may strive to achieve high performance with regard to serving the public interest and achieving efficiency. In other words, administrators may be indirectly influenced by politics (congress and the mayor). Additionally, LPEs' budget must be approved by both congress and the mayor, which means that LPE administrators are accountable to both parties. Therefore, the administrators of LPEs may face institutional pressure from stakeholders such as congress and the mayor.

LPEs are responsible for various public service businesses that complement the public services offered by local governments (Ooshima 1971; Kawarata 2005). More specifically, LPEs in Japan are businesses that act under the LPE law and municipal ordinances. Examples of businesses in which LPEs operate include residential water supply, industrial water supply, transportation (e.g., tramway, bus, and subway), electricity, gas power, hospitals, and other businesses that are run by local governments according to their own rules (Table 1). These businesses not only require a large amount of investment

that cannot be procured by the private sector but also will not necessarily be profitable for CEs. Therefore, LPEs provide essential, lifesaving activities that cannot be managed as CEs based on economic principles. For these reasons, administrators must attempt to recover the invested funds appropriately and make decisions that prevent losses (Yasukata et al. 2011). Additionally, they must be accountable to congress and the mayor in terms of securing profits and improving benefits for the public (Eldenburg and Krishnan 2008).

2.2 Institutional Constraints of LPEs

Institutions are social structures consisting of symbols, social actions and objectives, but institutions are formed not only through social structures but also through the activities in which norms and rules are produced. In its present form, the new institutionalism in organizational analysis provides a wide range of theoretical and methodological benefits (Scott 2001). Neo-institutional theorists, e.g., Meyer and Rowan (1977), noted that organizations engage in normative organizational behavior based on rules, laws, customs, traditions, and regulations with an emphasis on legitimacy, satisfactory behavior, structural decoupling, and symbols. They also explained that organizations pursue practices that may be of little relevance to maximizing efficiency and that organizations constantly seek ways to respond to pressure from external scrutiny and regulations rather than improving their performance. DiMaggio and Powell (1983) identified three forces that drive institutionalization: (1) coercive isomorphism, which stems from political influence and the need for legitimacy; (2) mimetic isomorphism, which results from standard responses to uncertainty; and (3) normative isomorphism, which is associated with professionalization. Among them, normative institutional pressure constrains both decision-making and organizational behavior (Balakrishnan et al. 2010; Holzhacker et al. 2015).

Public organizations promote mainly normative institutionalization in for-profit and nonprofit organizations since public organizations can establish rules, laws, and regulations and provide licenses and inspections. However, public organizations experience strong institutional pressure with regard to their role governing profit and non-profit organizations (Frumkin and Galaskiewicz 2004). Balakrishnan et al. (2010) also argued that the influences of institutional constraints are stronger for public organizations than for for-profit organizations. The authors showed that normative institutional constraints include political pressure, legal compatibility, the corporate governance system, and financial support. As evidence of normative institutional pressure that constrains both decision-making and organizational behavior, Wollmann (2000) explained that local German governments have changed their organizational structures based on the institutional pressure of NPM. One of the reasons for the strong influence of institutional constraints is that public organizations must respond to multidisciplinary evaluations at all times due to the existence of an unspecified number of stakeholders (Rainey 1997). Therefore, these organizations act to acquire legitimacy by observing institutional norms such as rules, laws, and regulations (Oliver 1991; Nee and Cao 2005), which makes them sensitive to normative institutional pressure (Frumkin and Galaskiewicz 2004).

For LPEs, there are two behavioral standards (codes of conduct) mandated by LPE law to stabilize public services and to continue the business over the long term: first, fulfilling public demands to satisfy the public interest, and second, pursuing appropriate profits by focusing on profitability and optimizing

costs by improving efficiency. LPEs must adopt a strict code of behavior and conduct their business while confronting these two normative pressures. In particular, from the perspective of the public interest, LPEs offer public services that are essential to citizens' lives. This system covers the provision of public goods and services in a comprehensive manner that complements the public services provided by local governments from the public interest perspective. In addition, the level of public service must always be kept constant since declining quality can threaten livelihoods. Thus, LPEs have a responsibility to support everyday lives and provide improved public benefits through their organizational behavior. Additionally, the evaluation of public services is conducted by all citizens, that is, an unspecified number of people. Because such evaluations are multifaceted, as Rainey (1997) noted, the administrators of LPEs must be concerned about serving the public interest. Thus, LPEs must provide public services even if they are unprofitable (Ooshima 1971; Kawarata 2005). As a result, institutional pressures also affect the cost-management decisions made by the administrators of government hospitals, which are a type of public organization (Balakrishnan et al. 2010). However, because the public interest must be balanced with efficiency, administrators cannot prioritize one over the other (Eldenburg et al. 2004). Conversely, with regard to efficiency, LPEs must provide services more economically, effectively, and efficiently than local municipalities (Kawarata 2005), which means that they must operate with limited assistance from the government. Moreover, raising public utility fees is not easy because it will be opposed by residents. Therefore, LPE administrators must manage their organizations to avoid service charge increases as much as possible. As a result, they may have anxiety due to the need for cost management and efficiency.

Because of these normative institutional constraints, LPEs' organizational behavior differs greatly from that of CEs. CEs act to maximize profits; because they are subject to fewer institutional pressures, they have greater flexibility when making changes (Eldenburg et al. 2004; Balakrishnan et al. 2010; Holzhacker et al. 2015). Therefore, institutional constraints more strongly affect the cost behavior of public organizations than that of for-profit organizations (Holzhacker et al. 2015). To confirm the characteristics of public organizations, research methods that compare these organizations with a control group, either for-profit or nonprofit organizations, are generally adopted (Sørensen 2007; Balakrishnan et al. 2010; Holzhacker et al. 2015). Therefore, I verify LPEs' cost behavior by comparing these organizations to CEs from the perspective of institutional constraints. Table 3 summarizes the differences in the institutional pressure experienced by LPEs and CEs according to Eldeburg et al. (2004) and Balakrishnan et al. (2010).

[Insert] Table 3. Organizational type and expected influence on cost behavior

In their governance systems, LPEs have fewer executives than CEs. Thus, LPEs usually have only one administrator and a few vice administrators. For this reason, the pressure from stakeholders is concentrated on the administrators; therefore, the administrators may focus on maintaining public service standards at a low cost in order to gain legitimacy. In terms of legal compliance, unlike CEs, which aim only to maximize profits, LPEs are required to pursue both the public interest and efficiency. Furthermore, in terms of political pressure, LPE administrators are accountable to residents, the local

parliament and the mayor with regard to public service quality and cost management. If LPE administrators prioritize cost reductions due to the influence of efficiency pressures, the risk of declining public service quality will increase. Conversely, pursuing the public interest can lead LPE administrators to manage their costs more inefficiently. Thus, LPE administrators must govern their organizations while considering both the public interest and efficiency, and they must behave in a manner that ensures business continuity (Kawarata 2005; Martinsons et al. 2007).

2.3 Cost Behavior of Public Sector Organizations

The concept of cost stickiness originated in the latter half of the 1920s. In Germany, Brasch (1927) termed this phenomenon "Kostenremanenz", and this notion was clarified through the direct observation of companies' cost information. Recently, "Kostenremanenz" has attracted the attention of empirical analysts; the German term has since been translated to "cost stickiness" ("sticky costs") by Anderson et al. (2003). Those authors examined 7,629 firms over 20 years, from 1979 to 1998, using annual Compustat data. In addition, they verified firms' cost behavior using models based on published financial data to determine the rate of change in net sales revenue (a proxy for the activity level as an explanatory variable) and the rate of change for selling, general and administrative expenses (a proxy for cost variables and the dependent variable). They found that the rate of change for costs when the activity level decreases is smaller than it is when the activity level increases (Figure 4).

[Insert] Figure 4. Image of sticky costs and anti-sticky costs

Figure 4 shows that cost and revenue change proportionately and linearly with respect to the normal t-1 phase of the slope from the t-1 to the t period, but sticky costs result in a slope that is less steep than the slope near the t-1 period. Thus, "Kostenremanenz" is empirically confirmed as "cost stickiness". With regard to additional evidence of cost stickiness, since Anderson et al. (2003), sticky costs have been verified through additional empirical research using those authors' model and have also been confirmed to exist in other scenarios, such as inter-industry and inter-country scenarios.

In a study focused on inter-industry scenarios, Subramaniam and Weidenmier (2016) examined cost behavior by industry using Compustat data from 1979 to 2000. They showed that cost stickiness is stronger in the manufacturing industry, which has more fixed assets, than in the merchandising, service and finance industries. However, He et al. (2010) examined the cost behavior of Japanese CEs by industry type from 1975 to 2000 using the PACAP database. They showed that the merchandising industry has stickier costs than the service and manufacturing industries. As described above, various cost behaviors have been confirmed for each industry for CEs. In addition, sticky costs were confirmed not only in industries with high material resources but also in industries with high human resources.

In studies focused on inter-country scenarios, Calleja et al. (2006) performed an analysis using financial data for US, UK, German, and French firms from 1988 to 2004. Their findings confirmed that German and French firms demonstrate stronger sticky costs than firms in the UK and US. The authors noted the possibility that differences in corporate governance and managerial oversight driven by the regulation laws in each country and the characteristics of each firm and each type of industry may also

affect sticky costs. Using Compustat data from 1988 to 2008, Banker et al. (2013) showed that the different worker protection regulations in 19 OECD countries affected labor adjustment costs. These studies suggested that as industries become more regulated by law, their cost adjustment flexibility decreases. LPEs that are highly subject to legal institutional restrictions may have a lower degree of freedom regarding cost management than CEs. In previous studies targeting CEs, the analysis period has mainly been set at approximately 20 years or less. Since public service providers are required to have stable management over the long term (longer than 20 years), it is necessary to further understand their long-term cost behavior.

Researchers have classified cost behavior for not only sticky costs but also anti-sticky costs (Weiss 2011). Figure 4 shows that anti-sticky costs also result in a slope that is initially steeper but that grows less steep as it approaches the t period. Thus, anti-stickiness results when the slope of costs for increasing activities is lower than the slope of costs for decreasing activities. Dalla Via and Perego (2014) confirmed the existence of anti-cost stickiness for small and medium-sized enterprises. At the same time, they noted that cost stickiness increases in large firms. Likewise, Sepasi and Hassani (2015), and Boshch and Blandon (2011) also showed that cost stickiness is higher in large enterprises when comparing large enterprises to small and medium-sized enterprises. These studies show that sticky costs increase when the adjustment costs (committed capacity costs) for capacity resources such as high-intensity assets or labor in large companies are high. That is, when the resource adjustment cost is high, it is difficult to adjust costs according to changes in the activity level (Banker et al. 2014a). Conversely, since the capacity resources of small and medium enterprises consists mainly of variable costs, anti-sticky costs emerge. Günther et al. (2014) organized and described the relationship between holding costs and adjustment costs based on the prior cost stickiness literature. The authors explained that the factors influencing cost stickiness can be classified into three relationship types: (1) high adjustment costs attributable to legal requirements or economic and psychological issues; (2) high holding costs attributable to opportunity costs; and (3) high holding costs attributable to social issues.

To date, most studies have focused only on CEs, and only a few empirical studies of cost behavior have focused on public organizations. Bradbury and Scott (2014) conducted an empirical analysis of the cost behavior of New Zealand's public municipalities from 2008 to 2012. In New Zealand, cost-management methods similar to those used by CEs have been introduced into public organizations since the 1980s as part of an NPM plan to improve the effectiveness and efficiency of administrative activities. With thirty years having passed since 1980, these authors examined whether cost management improved after 2008. However, the research showed that sticky costs continued to exist in New Zealand's local governments and that the efficiency of local government activities had not yet improved. Cohen et al. (2017) investigated the cost behavior of Greek local governments, which was a cause of the Greek fiscal crisis. These authors verified asymmetric cost behavior for different cost categories. Specifically, they focused on the difference between administrative costs and the costs of service provision by empirically describing the cost behavior. They found that the costs of service provision (a core competence of local governments) were sticky, and administrative costs were anti-sticky. These authors asserted that this asymmetric cost behavior was influenced by the decisions of local government administrators, who were pressured by politicians and stakeholders. Additionally, they argued that local

government administrators cannot decrease the cost of service provision in response to external pressures, even if revenues have decreased because of a fiscal crisis. Holzhacker et al. (2015) focused on the differences between the institutional pressures on government hospitals and those on for-profit and nonprofit hospitals and found differences in cost behaviors. Specifically, sticky costs were prevalent in government hospitals, which were subject to strong institutional pressures. The authors argued that one reason for their research results is that government hospitals need to take normative actions because of stakeholders' excessive pressure. The taxes, subsidies or donations from stakeholders such as local communities or citizens' groups force government hospitals to behave for the public interest. Yasukata et al. (2011) showed the existence of sticky costs in the Japanese National Hospital Organization, suggesting that sticky costs appeared within labor costs because the Japanese National Hospital Organization was strongly influenced by institutional pressures to not dismiss employees.

In analyses of these public organizations, there has been no focus to date on LPEs. LPEs have unique characteristics among public organizations because they are required to act not only in the public interest (similar to public organizations) but also in the interest of efficiency (similar to CEs). Therefore, it is academically interesting to investigate how LPEs' cost behavior has changed because such changes reflect the pressure to act in the interest of both the public and efficiency (Figure 5).

[Insert] Figure 5. The causal relationship between the institutional constraints on and the cost behavior of LPEs

2.4 Hypothesis Development

Based on the model developed by Anderson et al. (2003), asymmetric cost behavior, especially sticky costs, has been evaluated in empirical studies focused on CEs. Using the same method, the asymmetric cost behavior of local governments was confirmed by Bradbury and Scott (2014) and Cohen et al. (2017). Holzhacker et al. (2015) found that the degree of sticky costs was greater in public hospitals than in private hospitals because for-profit organizations have fewer institutional restrictions than do public organizations. Therefore, the latter can change their governance or cost structure to respond flexibly to increase their efficiency (Eldenburg et al. 2004; Eldenburg and Krishnan 2008; Balakrishnan et al. 2010; Holzhacker et al. 2015). Further, public organizations are more strongly influenced by institutional pressure than CEs (Frumkin and Galaskiewicz 2004). Therefore, it is theorized that sticky costs can be confirmed in LPEs, given that these organizations have characteristics similar to both public and private organizations. Additionally, LPEs are subject to the institutional restrictions that service levels must be maintained without generating profits. Therefore, sticky costs will be more prevalent in LPEs than in CEs. Thus, the first hypothesis is as follows:

Hypothesis H1: Sticky costs are more prevalent in local public enterprises than in commercial enterprises.

Günther et al. (2014) argued that asymmetric cost behavior is affected by adjustment costs, such as legal requirements. LPEs are legally required by LPE law both to work in the public interest and to

maximize efficiency. In addition, LPE administrators are influenced by various stakeholders against the background of the two normative institutional constraints. Therefore, they are required to maintain the public service level at a low, stable cost. In other words, pressures to prioritize efficiency will weaken the sticky costs of LPEs from the cost behavior perspective. Conversely, pressures to prioritize the public interest will boost LPEs' sticky costs because public service quality must be maintained, even if revenues decrease. To maintain their service level, LPEs must renew or replace aging facilities over the long term, and they must plan for these costs without increasing their service charges. When LPE administrators are subject to strong institutional constraints, they cannot make decisions quickly (Martinsons et al. 2007) and will put off these problems to the future. Sometimes, facilities can be repaired early in the business cycle, but after many years, it is often better to replace these facilities than to repair them. In these cases, the replacement or repair costs may drastically increase, and LPEs' resource adjustment ability will gradually be lost. Thus, it is believed that their cost behavior will change based on the influence of institutional constraints, especially the requirement to protect the public interest. Therefore, LPEs may take more time to balance their obligations due to the institutional constraints of both protecting the public interest and achieving efficiency. Thus, the next hypothesis is as follows:

Hypothesis H2: Institutional pressures are associated with the change in local public enterprises' cost behavior over time, in contrast to that of commercial enterprises.

Subramaniam and Weidenmier (2016) revealed that sticky costs are stronger in manufacturing industries with more fixed assets than in the commercial, service and finance industries. By contrast, He et al. (2010) showed that the commercial industry's sticky costs are higher than those of the service and manufacturing industries. As described above, various asymmetric cost behaviors have been confirmed for each type of industry for CEs, including cases with both high material resources (high fixed assets) and high human resources (high labor costs). Anderson et al. (2003) argued that sticky costs will increase when asset intensity and labor costs are high. LPEs' businesses include not only high asset-type industries, such as water supply and sewerage, but also high labor cost-type industries, such as transportation and hospitals. Moreover, due to institutional constraints, various asymmetric cost behaviors should appear in all businesses, as LPEs must balance serving the public interest and achieving efficiency rather than only aiming to maximize profits, which is the goal of CEs. I conjecture that sticky costs in LPEs will increase when these firms are pressured from the institutional constraint of serving the public interest; conversely, LPEs' sticky costs will decrease when they are pressured from the institutional constraint of achieving efficiency. Thus, the next hypothesis is as follows:

Hypothesis H3: Similar to that of commercial enterprises, local public enterprises' cost behavior is associated with the type of industry.

Banker et al. (2014b) found that sticky costs increase when demand uncertainty or the downside risk of demand increases. The demand for public services depends on population changes (Nakai 1988;

Nakano 2016). For this reason, the administrators of LPEs are required to predict changes in public service demand based on population changes (Nishioka et al. 2007). In Japan, the population structure has changed significantly since 1995. The population of youth and those of production age is decreasing; conversely, the elderly population is increasing. Furthermore, the economy and demand are experiencing a depression, and CEs are withdrawing from depopulated regions due to a lack of profitability. Even if public demand decreases due to the declining population, LPEs cannot stop providing services because of the institutional pressure to serve the public interest. In other words, from the perspective of the public interest, LPEs cannot reduce the quality of their public services. In addition, with the increase in elderly people, whose income is derived primarily from pensions, LPEs must maintain the same level of public services at low prices because of the institutional pressure to achieve efficiency. LPEs may experience increased sticky costs due to the downside risk of public demand and public demand uncertainty. By contrast, the market demand for CEs is affected not only by domestic trading but also by overseas trading, so they are less affected by population changes than LPEs. I theorize that LPEs' cost behavior will be more strongly influenced by population changes than that of CEs. Thus, the next hypothesis is as follows:

Hypothesis H4: Local public enterprises' sticky costs are strongly influenced by population changes since 1995 in relation to commercial enterprises.

As noted by Bradbury and Scott (2014) and Cohen et al. (2017), local government administrators are influenced by public opinion (demand for both low-cost and high-quality services) when they make cost management decisions. Public organizations, including LPEs, must respond to multidisciplinary evaluations at all times due to the existence of an unspecified number of stakeholders (Rainey 1997). In particular, LPE administrators are appointed by the mayor and approved by congress, who are, in turn, elected by citizens. Therefore, the administrators may be sensitive to not only public opinion but also political opinion (from mayors and local councils) if they wish to be reappointed for the next term, and they may strive to achieve a high level of performance with regard to protecting the public interest and achieving efficiency. As a result, LPE administrators may act to control and adjust their asymmetric cost behavior in the direction of symmetric cost behavior during the political term of mayors and local councils, which is 4 years in Japan. Thus, LPE administrators must aim for a long-term balance between protecting the public interest and achieving efficiency due to political pressure. Conversely, CEs' business managers may decide to control and adjust their costs with a focus on securing profits as quickly as possible, and they may not be as strongly affected by political pressure as LPEs. Thus because of institutional constraints, LPEs' long-term cost adjustments may be more controlled and move more slowly than those of CEs. As a result, it is hypothesized that the administrators of LPEs make decisions that result in asymmetric cost behavior that gradually transforms into a proportional relationship over the long term. The final hypothesis is as follows:

Hypothesis H5: Local public enterprise administrators make decisions that result in the long-term, proportional stabilization of cost behavior within a 4-year election period in

relation to commercial enterprises.

LPEs are characterized by serving the public interest and achieving efficiency. Thus, LPEs' cost behavior is presumed to change in the context of the tradeoff between the public interest and efficiency. Because of the need to run businesses in a stable manner, LPE administrators make deliberate decisions from a different perspective than that of CE managers.

3 Research Method and Sample Selection

3.1 Research Method

The analytical model of Anderson et al. (2003) is the basis of recent empirical studies of cost behavior; it was adopted in studies following Anderson et al. (2003) and recently used by Bradbury and Scott (2014), Cohen et al. (2017), and Holzhacker et al. (2015) to analyze the cost behavior of public organizations. Therefore, this study assumes that the model can also be applied to the analysis of LPEs' cost behavior. Thus, to verify hypotheses 1 to 3, I adopt model 1. To examine hypothesis 1, all the samples are analyzed through panel data analysis using model 1. Next, to verify hypothesis 2, the year-to-year changes in cost behavior are analyzed through OLS analysis using model 1. OLS analysis was adopted to clarify the cost behavior in prior studies (Anderson and Lanen 2007; Zanella et al. 2015). Thus, I intend to use not only panel data analysis but also OLS analysis to verify the existence of sticky costs. Finally, for hypothesis 3, the samples for each type of industry are analyzed through panel data analysis using model 1.

model 1

$$\ln\left(\frac{Cost_{i,t}}{Cost_{i,t-1}}\right) = \beta_0 + \beta_1 * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \beta_2 * Decrease\_Dummy_{i,t} * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \varepsilon_{i,t}$$

LPEs' operating expenses are substituted for Cost. Additionally, Revenue takes operating revenues as a proxy for the activity amount. Decrease Dummy is a dummy variable that takes the value of 1 when operating revenue decreases between the t period and the previous period and 0 otherwise. All the data are natural logarithms.

Using this model, it can be confirmed that when operating revenue increases by 1%, the cost changes by the value indicated by β1. Additionally, because of the Decrease Dummy, when operating revenue decreases by 1%, the cost decreases by β1 + β2, whereas β2 indicates the value of the sticky or anti-sticky costs. Therefore, when there is cost stickiness, β2 will be negative, and when cost stickiness is not present (anti-sticky costs), β2 will be positive.

To examine hypothesis 4, I clarify the influence of the total population change and the population structure on cost behavior. Therefore, I focus on population data from a report on population movement based on a basic resident registration system database[7]. In particular, it is necessary to clarify the

[7] Population data in each municipality is published as "Basic Resident Register Annual Population Report" by statistics bureau, ministry of internal affairs and communications in Japan.

influence of depopulation and the increasing ratio of the aging population on the cost behavior of LPEs. For this reason, I collect population data from 1995, which is the year Japan started to become an aging society. The population data were divided into three stages: 0-14 years old, 15-64 years old, and 65 years old and over. To evaluate hypothesis 4, I adopt the following model 2.

model 2

$$\ln\left(\frac{Cost_{i,t}}{Cost_{i,t-1}}\right) = \beta_0 + \beta_1 * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \beta_2 * Decrease\_Dummy_{i,t} * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \sum_{n=3}^{6} \beta_n \, Pop_{i,t,n} * Decrease\_Dummy_{i,t} * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \varepsilon_{i,t}$$

The total population represents the natural logarithms of the year-over-year comparison. The young population, the productive age population, and the elderly population are natural logarithms of each respective proportion of the total population.

Next, to examine hypothesis 5, it is necessary to confirm the relationship between operating revenues over 4 years and changes in operating expenses. I extend the model of Anderson et al. (2003) and verify the hypothesis using the following model 3.

model 3

$$\ln\left(\frac{Cost_{i,t}}{Cost_{i,t-1}}\right) = \beta_0 + \beta_1 * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \beta_2 * Decrease\_Dummy_{i,t} * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \beta_3 * \ln\left(\frac{Revenue_{i,t-1}}{Revenue_{i,t-2}}\right) + \beta_4 * Decrease\_Dummy_{i,t-1} * \ln\left(\frac{Revenue_{i,t-1}}{Revenue_{i,t-2}}\right) + \beta_5 * \ln\left(\frac{Revenue_{i,t-2}}{Revenue_{i,t-3}}\right) + \beta_6 * Decrease\_Dummy_{i,t-2} * \ln\left(\frac{Revenue_{i,t-2}}{Revenue_{i,t-3}}\right) + \beta_7 * \ln\left(\frac{Revenue_{i,t-3}}{Revenue_{i,t-4}}\right) + \beta_8 * Decrease\_Dummy_{i,t-3} * \ln\left(\frac{Revenue_{i,t-3}}{Revenue_{i,t-4}}\right) + \varepsilon_{i,t}$$

If asymmetric cost behavior terminates over time, the sticky costs value will gradually approach 0. If cost stickiness is confirmed by β2, it should change, $\beta 2 < \beta 4 < \beta 6$, with time, since LPE administrators are subject to institutional restrictions and will only gradually overcome the sticky costs. In particular, political pressure is strengthened by politicians' 4-year term. Additionally, local elections for congress and the mayor of each municipality in Japan are held almost simultaneously on the same day. Therefore, LPEs' cost behavior may be influenced by political pressure. The analysis begins at t=0, which is an election year, and elections are held in t=0, 4, 8, 12, etc.

3.2 Sample Selection and Descriptive Statistics

No empirical analysis of LPEs' cost behavior has been previously performed. This research is

therefore the first to examine LPEs' cost behavior. To obtain robust results, as much cross-sectional data as possible should be used. I collected non-consolidated fiscal accounting data on all LPE businesses from LPEs' yearbooks[8]. Thus, the sample population for this analysis is all local public enterprise businesses that are classified as corporatized LPEs. The data include 10 industry types (residential water supply, industrial water supply, sewage, transportation, electric power, gas power, hospitals, wholesale market, toll road, and car parking). In addition, observations must be made over a long period to confirm how cost behavior has changed in accordance with changes in Japan's social environment.

To verify LPEs' cost behavior, long-term cost data are necessary. Therefore, in this study, the analysis period is the 40 years from 1974 to 2013, which is a longer period than that analyzed by any previous empirical studies on cost stickiness. LPEs are legally obligated to release annual financial reports. The financial reporting method has not changed over the 40 years under study, making it possible to collect fiscal data over a very long period. The collected data represent 120,317 firm-years. To control for the effect of outliers, I removed (deleted) the largest and smallest 1 percent of observations (outliers). I used list-wise case deletion without winsorized data to delete the observations. That is, if there is even a single outlier in one sample, all the data from that sample are deleted (cleared). This approach is rather conservative as a statistical method, but since there are numerous samples, I contend that this approach is a valid statistical processing method to obtain robust analysis results. The final sample includes 115,929 firm-years. Therefore, the sample consists of unbalanced panel data.

Additionally, to create a comparison with LPEs over the same period, I collected data provided by Nikkei NEED-FinancialQUEST on CEs listed on the Tokyo Stock Exchange. LPEs' financial statements provide non-consolidated accounting data for various industry types, such as water supply and hospitals, so I also collected CE non-consolidated accounting data from the Annual Securities Reports for comparison. The collected data represent 85,705 firm-years. After excluding (deleting) outliers, the sample includes 84,343 firm-years. The descriptive statistics are calculated after the exclusion of outliers.

[Insert] Table 4. Descriptive statistics

4 Results

In panel data analysis, there is a process for choosing the optimal result from the model of pooled estimates, fixed effects, and random effects. I describe all the analysis results and explain the optimal results. First, in all panel data analyses, I used an F-test to determine whether a pooled model and a fixed/random effects model is more suitable. The result confirms that the fixed/random effects model is more suitable than the pooled model. In addition, I also conducted the Hausman test to confirm which model, the fixed effects or random effects model, is suitable. In addition, I confirmed the influence of

8 LPEs' yearbooks are edited annually by the ministry of internal affairs and communications in Japan. They include the annual financial statement of each LPE in each municipality. The financial statements include B/S, P/L, the detail information of expenses, etc.; these data are found in electronic databases after 1999.

serial correlation through the Durbin-Watson ratio. The influence of serial correlation is low in all the analyses.

To test hypothesis 1 using model 1, I analyzed panel data for 40 years. The results showed that LPEs' cost actions demonstrate asymmetric cost behavior (Table 5 Panel A). Namely, β2 was 0.0791 (fixed effects), and the positive value indicates anti-sticky costs. Conversely, the CE analysis resulted in a β2 value of -0.0978 (fixed effects), and the negative value indicates sticky costs (Table 5 Panel B). Thus, hypothesis 1 was *not* supported.

[Insert] Table 5. Cost behavior based on the panel data analysis using model 1

Under institutional constraints, it was predicted that sticky costs would increase because LPEs are subject to stronger institutional pressures than CEs. However, the analysis resulted in the opposite conclusion, which was not expected. In previous studies, no research showed that public organizations' cost behavior was anti-sticky (Yasukata et al. 2011; Bradbury and Scott 2014; Cohen et al. 2017; Holzhacker et al. 2015). Additionally, Banker and Byzalov (2014) argued that CEs' cost behavior generally indicated sticky costs on average. Clearly, this result is a new discovery that contrasts with previous studies.

This result signifies that LPE administrators actively manage their resource-adjustable costs when their operating revenue decreases and the pressure for low-cost economic efficiency increases. I believe that the lack of support for this hypothesis might be driven by the accounting (regulations on dividends and retained earnings) and management system (redundancies, i.e., preparation for disasters such as a standby isolated power unit and food stockpiled for emergencies) differences between CEs and LPEs. Namely, the anti-sticky costs are induced by resource-adjustable costs, which imply that there are redundant resources caused by LPEs' accounting and management systems.

Regarding the accounting system, I focus on the appropriation of retained earnings and the net income of LPEs. The retained earnings of CEs are often allocated to stakeholders, such as shareholders, managers, or workers. Unlike CEs, LPEs are subject to legal restrictions regarding how they can appropriate retained earnings. Namely, it is unnecessary for LPEs to distribute their final profits to stakeholders, such as shareholders, managers, and workers. Additionally, because they can receive preferential treatment regarding corporate tax and property tax, their retained earnings may often be generated. However, LPEs are required to operate with moderate profits and not to maximize their net income. Therefore, I conjecture that LPE administrators intend to ensure their management resource slack so that they can adjust quickly when operating revenue declines. Because the slack resources in LPEs are oriented toward preventing disasters, they are not necessary for normal operations. Therefore, there is a great deal of room for discretion; thus, it is easy to reduce these resources. In other words, LPE administrators may increase their management resources, thus increasing their operating expenses, in order to avoid significantly increasing their operating profits. In fact, as shown in Panel B of Figure 2, operating expenses and operating revenues show very similar, consistent movements over the long term. LPEs thus may accumulate excessive management resources rather than repaying their bonds. Because LPEs have little risk of bankruptcy, they may not make the effort to repay their debt; on the contrary, it

is possible that they intend to bear the cost of procuring excessive management resources accordingly. Therefore, they can use their profit for management resources instead of bond repayment.

Next regarding the management system, I focus on public sector management, especially the redundancy of management resources. Cyert and March (1963) argued that organizations use internal rules for different purposes to compensate for environmental changes. In public sector management, retaining slack management resources is explained as a necessary cost "redundancy" to prepare for disaster (Koike et al. 2015), such as retaining emergency equipment or facilities that can provide public services in a disaster such as an earthquake, typhoon, eruption, or flood. Therefore, LPEs are allowed to retain slack management resources as redundant management resources because LPE administrators can explain that it is necessary to secure slack resources for the public interest. That is, they earn legitimacy for their spending by retaining slack resources as redundant resources. LPE administrators can therefore adjust their costs for redundancy; in other words, they can increase the slack resources that are designated redundant resources when operating revenue is likely to exceed operating expenses; conversely, they can easily decrease the slack resources designated as redundant resources when their net income is in deficit and the disaster does not occur. I believe that when operating revenue is declining, it might actively reduce the holding costs of these slack resources, and therefore, I conjecture that anti-sticky costs appear in LPEs. Thus, I believe that LPE administrators may avoid sticky costs and obtain legitimacy for their spending by retaining redundant management resources and adhering to regulations for the disposal of net profits.

To verify hypothesis 2, I analyzed the cross-section of cost behavior using the data for each year separately and verified that the change was dynamic over time (Table 6). When the β2 coefficient was found to be not significant through the t-test of an OLS analysis, I used linear interpolation to show the movement of β2 and added the approximated curve (Figure 6). It is possible to confirm the tendency of the change in cost behavior through time based on the approximated curve[9]. Two characteristics—sticky costs and anti-sticky costs—were confirmed by the dynamic analysis. Panel A of Table 6 and Panel A of Figure 6 show that β2 changed from a positive to a negative value for LPEs' cost behavior, that the deviations of the β2 values were large and that the year-to-year change in β2 had a negative slope. Thus, the results robustly show that anti-sticky costs gradually weakened. Especially from 1975 to 2002, β2 had primarily positive values, indicating anti-sticky costs. However, the degree of anti-sticky costs gradually decreased, especially after 2004, when β2 was primarily negative, indicating sticky costs. In contrast, in the analysis of CEs, β2 was primarily negative in Panel B of Table 6 and Panel B of Figure 6. The average cost stickiness changed slightly with time but, in contrast to the results for the LPEs, there was no significant change in the value of β2 for CEs over time. Thus, institutional pressures were associated with the change in LPEs' cost behavior over time, in contrast to that of CEs; hypothesis 2 was partly supported for LPEs after around the year 2000.

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[9] This result was equivalent and consistent with the results using panel data analysis with the time trend dummy variable: $\ln\left(\frac{Cost_{i,t}}{Cost_{i,t-1}}\right) = \beta_0 + \beta_1 * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \beta_2 * Decrease\_Dummy_{i,t} * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) + \beta_3 * Timetrend + \beta_4 * Decrease\_Dummy_{i,t} * \ln\left(\frac{Revenue_{i,t}}{Revenue_{i,t-1}}\right) * Timetrend + \varepsilon_{i,t}$.

[Insert] Table 6. The results for individual years based on OLS analysis using model 1

[Insert] Figure 6. β2 value (sticky cost value) changes in each year

Considering the change in LPEs' long-term cost behavior, one can assume that the asymmetric cost behavior changed substantially after around the year 2000. LPEs gradually lost redundancy due to surplus profits and, simultaneously, the potential loss of cost adjustment flexibility. Additionally, LPEs and CEs had significantly different cost behavior characteristics. I hypothesized that these different cost behavior characteristics were caused by institutional constraints, especially those serving the "public interest". LPEs provide services in a constant and stable manner, and the quality of the public services must be maintained over the long term. For this purpose, LPEs must always maintain their facilities and equipment. For example, if the LPE is operating a water supply project, it will be necessary to constantly update the water pipeline and maintain the dam facility. However, in a long-term business, obsolete equipment must be repaired or replaced, even if revenues decrease. Moreover, it is difficult to increase utility fees. Since repair or replacement costs, as substantial fixed costs, increase with the passage of time[10], I suggest that increases in repair or replacement costs for large-scale facilities gradually lead LPEs to lose redundant management resources and cost adjustment flexibility. As a result, I assume that LPE administrators cannot gain gradual control over the efficiency of their services. In other words, LPE management is strongly affected by institutional pressure to protect the public interest. Therefore, I conjecture that this inefficiency risk is affected by an increase in reinvestment (replacement) costs for large-scale facilities or equipment.

Next, to verify hypothesis 3, I analyzed each industry type (Table 7) using model 1. I found significant results for all industries except for the toll road business. The results show that the presence of not only sticky costs but also anti-sticky costs was confirmed. Various cost behaviors appeared in LPEs for each industry. Based on these results, hypothesis 3 was partially supported. I found that similar to CEs, LPEs demonstrated diverse cost behaviors in each industry. In particular, considering the industry types with a high ratio of human resources[11], transportation businesses' cost behavior reflected anti-sticky costs (β2 was 0.0693 (fixed effects)), while hospital businesses' cost behavior reflected sticky costs (β2 was -0.1640 (fixed effects)). For the industry types with a high ratio of material resources[12], residential water supply, industrial water supply, and gas power businesses' cost behavior reflected anti-sticky costs (β2 was 0.2908 (fixed effects), 0.0565 (random effects), and 0.3996 (fixed effects)), while electricity and sewage businesses' cost behavior reflected sticky costs (β2 was -0.1473

10 Repair costs (including replacement costs) increased by a factor of 7.6 times from 1974 to 2013.
11 According to the LPEs' yearbook in 2013, labor cost ratios are as follows: residential water supply is 32.7%, industrial water supply is 39.6%, sewerage is 44.0%, transportation is 25.7%, electric power is 26.2%, gas power is 13.0%, and hospitals are 6.5%.
12 According to the LPEs' yearbook in 2013, depreciation cost ratios are as follows: residential water supply is 12.5%, industrial water supply is 11.9%, sewerage is 6.4%, transportation is 33.3%, electric power is 25.1%, gas power is 8.5%, and hospitals are 46.5%.

(random effects) and -0.2656 (fixed effects)).

[Insert] Table 7. Cost behavior of each industry based on the panel data analysis using model 1

The various cost behaviors suggest that there are factors other than the influence of the adjustment cost for human resources and material resources. It is possible that the non-exclusion of public services and the influence of monopolies also exert an influence on cost behaviors. Public services provide essential, lifesaving activities that cannot be managed based on CEs' economic principles. For example, it is impossible to cut off the electric power supply of people who do not pay their bills or to fail to provide medical services to those who cannot pay for them. Thus, these businesses would not be profitable for CEs. In LPE businesses with sticky costs, I conjecture that these non-exclusionary public services (welfare services for free) make LPEs' cost management less flexible from the perspective of institutional constraints, especially in terms of protecting the public interest. On the other hand, these LPEs' businesses are projects that require substantial investment and that cannot be procured by the private sector; therefore, the market share ratio of LPEs is generally high[13]. In these high market share business environments, it may be possible to manage their costs by accurately forecasting the necessary resources for the future without idle capacity costs. Therefore, I believe that the evidence of anti-sticky costs in the residential water supply business and the industrial water supply business originates from managing the supply based on the accurate prediction of demand.

Next, to verify hypothesis 4, I analyzed whether population changes impact LPEs' cost behavior. Table 8 shows the results of model 2. In Panel A of Table 8, β3 indicates the influence of the total population and is -0.3080 (fixed effects); β4 shows the influence of the youth population (0-14 years old) and is 0.5216 (fixed effects); β5 shows the influence of the productive age population and is not significant; and β6 indicates the effect of the elderly population and is -0.0901 (fixed effects). In particular, it should be noted that the changes in the total population (β3) and the elderly population (β6) may have had negative impacts on LPEs' cost behavior after 1995. Conversely, the youth population acted to strengthen the anti-sticky costs.

[Insert] Table 8. Population changes and cost behavior based on the panel data analysis using model 2

In contrast, population changes also impact CEs' cost behavior, as shown in Panel B of Table 8. The influence of the total population β3 is 2.4228 (fixed effects), the influence of the youth population β4 is -0.2005 (fixed effects), the influence of the productive age population β5 is 0.8441 (fixed effects), and the influence of the elderly population is 0.5842 (fixed effects). Thus, the results confirm that population changes affect cost management for not only LPEs but also CEs. Furthermore, population changes, except in the youth population, positively influence CEs' cost management. I argue that cost

[13] According to the LPEs' yearbook in 2013, the market share ratios are as follows: residential water supply is 99.5%, industrial water supply is 99.9%, sewerage is 91.3%, transportation (railway) is 13.4%, electric power is 1.0%, gas power is 2.3%, and hospitals are 12.3%.

management corresponding to population changes is important for both CEs and LPEs. In particular, since 1995, LPEs have had to consider that changes in the total population and the elderly population affect cost management. Thus, Hypothesis 4 was almost supported.

Next, using model 3, I verified that LPEs' long-term cost management was performed over 4-year periods, verifying hypothesis 5. Thus, LPE administrators decide to control costs under normative institutional constraints from the local parliament and mayor. The results of the analysis are shown in Table 9, and the changes in the asymmetry of LPEs' and CEs' cost behaviors over 4 years are shown in Figure 7. In the analysis of model 3, the β2 value is the rate of change from t-1 to t, which indicates whether the asymmetric cost behavior involved sticky costs or anti-sticky costs. Additionally, the β4, β6, and β8 values represented the annual change in asymmetric cost behavior for t-1/t-2, t-2/t-3, and t-3/t-4, respectively. The result of the analysis of LPEs in Panel A of Table 9 shows that β2 was 0.1157 (fixed effects), and the positive value indicates that anti-sticky costs were observed over the short term. However, the asymmetric cost behavior values (β4, β6, and β8) gradually approached zero through each period and were 0.0226, -0.0179, and -0.0158 (fixed effects), respectively, and the change from a positive value to a negative value occurred over 4 years. It can be theorized that the anti-sticky value gradually shifted in the direction of the value of sticky costs within 4 years. Thus, the administrators of LPEs managed their costs to approximate a proportional relationship throughout the four years, with the goal of stable operations. Therefore, hypothesis 5 was supported.

[Insert] Table 9. Cost behavior over 4 years based on the panel data analysis using model 3

[Insert] Figure 7. β2, β4, β6, and β8 value (sticky cost value) change in each 4-year period

The analysis of CEs in Panel B of Table 9 contrasts with the analysis of LPEs. β2 was -0.0685 (fixed effects), and the negative value indicates sticky costs. Additionally, the value changed in the subsequent period. The three asymmetric cost behavior values (β4, β6, and β8) were 0.0505, 0.0244, and -0.0070 (fixed effects), respectively, and the change from a negative value to a positive value occurred over 4 years. Therefore, CE managers returned costs to a proportional relationship to secure profits as quickly as possible.

LPEs balance the public interest and efficiency, and this process requires sustainable management. Therefore, with a focus on the four-year change in cost behavior, it was theorized that administrators decide to maintain their costs after anti-sticky costs are observed. Additionally, they decide to improve services in the public interest instead of pursuing excessive efficiency, which may be due to institutional pressure stemming from the election of a local parliament and mayor.

5 Conclusions

This study verified the long-term cost behavior of Japanese LPEs by comparing these firms with CEs. We found five primary results. First, it was generally believed that LPEs are less efficient than private enterprises (CEs), but when examining the cost behavior change, the results revealed that LPEs are not necessarily inefficient with regard to cost stickiness. A panel data analysis covering 40 years

showed contrasting results. The results indicated that sticky costs were confirmed for CEs, whereas anti-sticky costs were present among LPEs. I believe that the lack of support for this expectation might be driven by differences between CEs' and LPEs' accounting and management systems. In terms of the difference in accounting systems, the regulations on dividends and retained earnings mark a difference in accounting systems. LPEs are also subject to legal restrictions regarding how they can appropriate retained earnings, though they may often be generated since they can receive preferential treatment regarding corporate tax and property tax. Furthermore, LPE administrators are not allowed to receive dividends from the organization's profits. Therefore, it is possible that LPE administrators intend to ensure that they have slack management resources because LPEs are required to operate with moderate profits and not to maximize their net income. In terms of the difference in management systems, securing slack resources is different in CEs and LPEs. LPEs earn legitimacy for their spending by retaining slack resources as facilities for disasters (i.e., redundancies) because they must serve the public interest. For this reason, I believe that it is possible that profits may be allocated to the expenses of redundancies if the LPE administrator predicts an increase in profits. I also suggest that compared to CEs, LPEs have more redundancies that allow them to adjust their management resources. Based on the results of the analysis, I argue that choosing LPEs as public service providers over outsourcing and privatization was a successful decision in terms of cost management, and it was not a mistake since LPEs can manage their costs by maintaining the flexibility of cost adjustment.

Second, the cross-sectional analysis for each year shows that the timeline transition of cost behavior is different between LPEs and CEs. Namely, LPEs' anti-sticky costs have shifted to sticky costs even though CEs' cost behavior remained unchanged. Therefore, the fluctuation of LPEs' cost behavior suggests that LPE administrators gradually lost the flexibility to adjust costs around the year 2000. In other words, LPEs are gradually losing redundancy due to surplus profits. I suppose that this trend has occurred because LPEs have experienced strong institutional pressure to protect the public interest from the viewpoint of maintaining public service quality. Namely I conjecture that this inefficiency risk is affected by increases in repair and replacement costs. Obsolete equipment must be repaired or replaced in order to maintain public service quality, even when revenues decrease. Since repair and replacement costs, as fixed costs, increase with the passage of time, I suggest that increases in these costs gradually lead LPEs to lose cost adjustment flexibility. Therefore, LPEs' business must be continually managed to reduce their costs by maintaining their ability to adjust management resources. In other words, LPE administrators must carry out cost management that is always conscious of taking measures to maintain the ability to adjust management resources. For this reason, LPE administrators should always be careful to maintain a balance between efficiency and the public interest. These findings are confirmed by clarifying the change in long-term cost behavior over 40 years. Regarding the cost behavior of public sector organizations, I argue that it is necessary to verify their cost management based on long-term empirical analysis because of the premise that public organizations must operate stably over the long term.

Third, in the analysis by industry, LPEs' cost behavior showed not only anti-sticky costs but also sticky costs. LPEs' anti-sticky costs differ from findings in previous studies to date. Therefore, it is possible that the panel data analysis results of the 40 years are influenced and distorted by the type of

industry. In addition, the results of this analysis indicate a conclusion that differs from previous studies: anti-sticky costs are stronger in projects with high resource adjustment costs, such as high-intensity assets. In other words, for projects with substantial physical assets, such as the residential water supply, industrial water supply and gas businesses, the presence of anti-sticky costs was confirmed. Especially in industries with high fixed assets, market monopoly rates are also high[14]. These industries' administrators may be able to adjust their management resources according to accurate future demand forecasts. Therefore, anti-sticky costs appear in these industries despite high fixed assets. Conversely, in LPE businesses with sticky costs, I conjecture that these non-exclusionary public services (welfare services for free) make LPEs' cost management less flexible from the perspective of institutional constraints, especially in terms of protecting the public interest. I suggest that the influence of monopolies and the non-exclusionary nature of public services also influence cost behaviors. For those industries in which anti-sticky costs appeared, further detailed research that focuses on the characteristics of each of these industries is needed. Furthermore, it is also important to clarify how administrators can maintain cost adjustment abilities over the long term.

Fourth, I clarified the relationship between population changes and LPEs' cost behavior. Population changes drive changes in the demand for public services. In Japan, the increasing number of elderly people and the decreasing population are major demographic issues. In order for LPEs to maintain stable cost management in the future, LPE administrators must engage in cost management in response to population changes. This analysis confirmed that the population changes, the increasing elderly population, and the decreasing total population have had a negative influence on LPEs' cost behavior, suggesting that the impact of population changes must be taken into account when considering management needs. Forecasting future population changes will provide accurate demand forecasts for management. A declining population and an increasing number of elderly people are a problem not only in Japan but also across developed countries. I believe that determining how to reduce surplus capacity costs based on population changes has become an important issue for LPEs throughout the world.

Fifth, I verified that asymmetric cost behaviors were resolved over subsequent periods in the 4-year time frame because of institutional pressure from politicians. Clearly, both LPE administrators and CE managers acted to resolve asymmetric cost behaviors. However, there were differences in the speed of change and the direction of movement. In CEs, business managers promptly adjusted their costs to acquire cost management flexibility when sticky costs were present. In contrast, when anti-sticky costs were present in LPEs, administrators managed their costs subtly and slowly, and cost behaviors gradually shifted toward a proportional relationship over four years. Because LPEs must supply their services stably and sustainably, one might assume that LPE administrators should avoid responding promptly and suddenly controlling their costs and instead attempt to balance the public interest and cost efficiency. Regarding the direction of movement of cost behaviors over four years, LPE administrators chose to improve services in the public interest instead of pursuing efficiency. The examination of the four-year change in cost behaviors shows that the LPE administrators decided to maintain their costs after anti-sticky costs were observed. One might assume that LPE administrators are subject to

[14] Refer to footnote 13.

institutional pressure from the politicians who insist on responding to public opinion and social demands that require the enrichment of public services rather than excessive cost efficiency. Conversely, CE managers may aim to adjust their costs promptly to be able to manage them flexibly. Thus, from a decision-making perspective, I believe LPE administrators must aim for a long-term balance between protecting the public interest and achieving efficiency due to institutional pressure from politicians. In contrast, CEs' business managers may decide to control and adjust their costs with a focus on securing profits as quickly as possible.

Management accounting research can provide information about cost behavior and propose effective cost management strategies not only in theory but also in practice. In public organizations, including LPEs, it is important to understand how cost behavior will change in the future. Currently, Japan's national and local governments are promoting two plans to resolve the two main issues of population changes and a deteriorating financial situation. The first plan is called the Compact City Plan. It intends to concentrate urban functions, such as public service systems, in central urban areas, thus improving the efficiency of cost management in depopulated areas. Examples include district development plans to increase the public transportation network of central urban areas and a renewed maintenance plan to construct a single building that houses many types of public services together. The second plan is the Intermunicipal Cooperation Plan, in which public services will be combined through amalgamation or joint ventures to improve efficiency with economies of scale. By reaching agreements with different public organizations, separately managed entities can be consolidated into one organization. For example, in the water supply business, several LPEs can jointly develop large dams and provide water services for a wide area that spans multiple municipalities.

Although the expectations for the Compact City Plan and the Intermunicipal Cooperation Plan are high, the effects and benefits of these policies, such as improved public services and reduced costs, have not been adequately explained. In addition, because the Compact City Plan and the Intermunicipal Cooperation Plan have not been studied sufficiently in either an academic or a real-world context, we do not know whether they will improve efficiency. Therefore, it is extremely important to understand the future cost behavior of public organizations to determine whether the Compact City or Intermunicipal Cooperation Plans will provide the effective management of public organizations in the context of a declining population and depopulated areas. Having reached these five conclusions, my research explored how public organization administrators have made long-term cost management decisions.

In the future, research should examine the factors influencing LPEs' asymmetric cost behavior, as noted by Günther et al. (2014), including both internal and external factors. Especially for industries in which sticky costs have been confirmed, we need to determine how to maintain cost flexibility over the long term. In contrast, in industries with anti-sticky costs, we must learn how to maintain cost adjustment flexibility. It is conceivable that LPEs may be subject not only to institutional constraints, such as achieving efficiency and protecting the public interest, but also to the non-exclusionary nature of public services and the influence of monopolies. There is a continuing need for detailed investigations of and research on public organizations' asymmetric cost behavior, especially that of LPEs.

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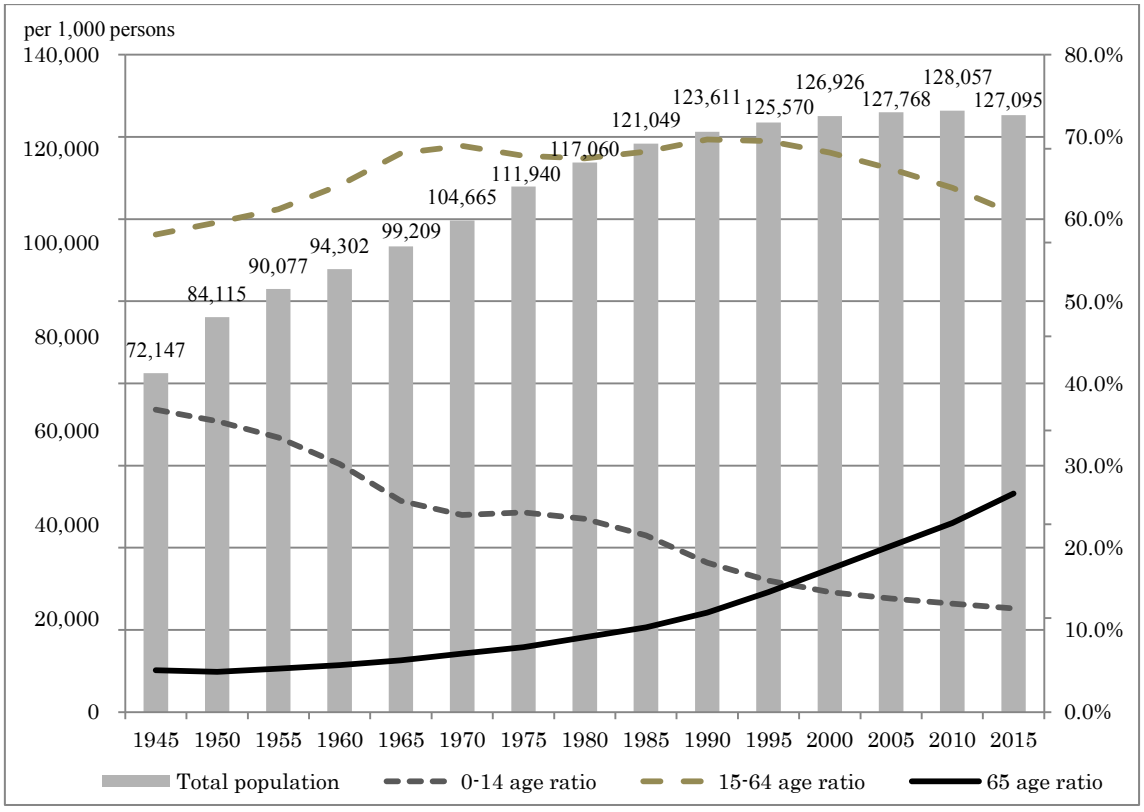
Appendix

Variable	Definition
Cost	Operating expenses
Revenue	Operating revenues
Pop _Total	The natural logarithm of total population deflated by the previous year's total population
Pop_Youth	The natural logarithm of the youth population (aged 0-14) deflated by the total population
Pop_Middle	The natural logarithm of the middle-aged population (aged 15-64) deflated by the total population
Pop_Elder	The natural logarithm of the elderly population (aged 65 and over) deflated by the total population

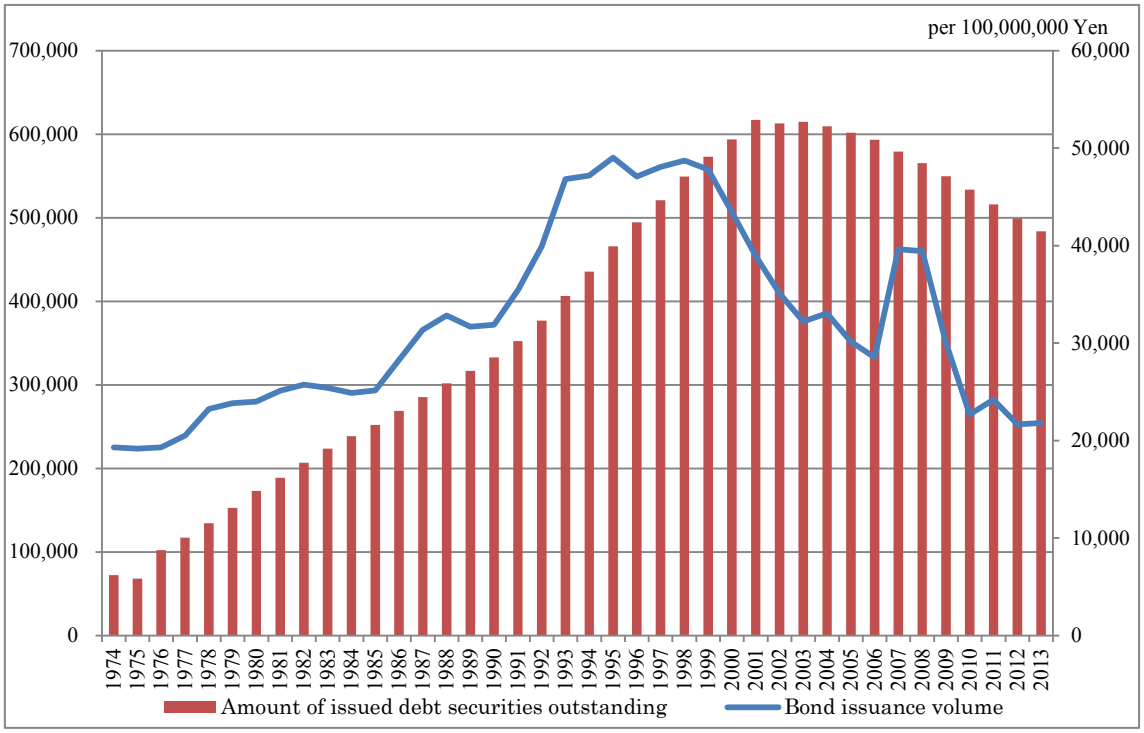
Figure 1. Population changes in Japan



Created based on Japan's population census for the year 2015.

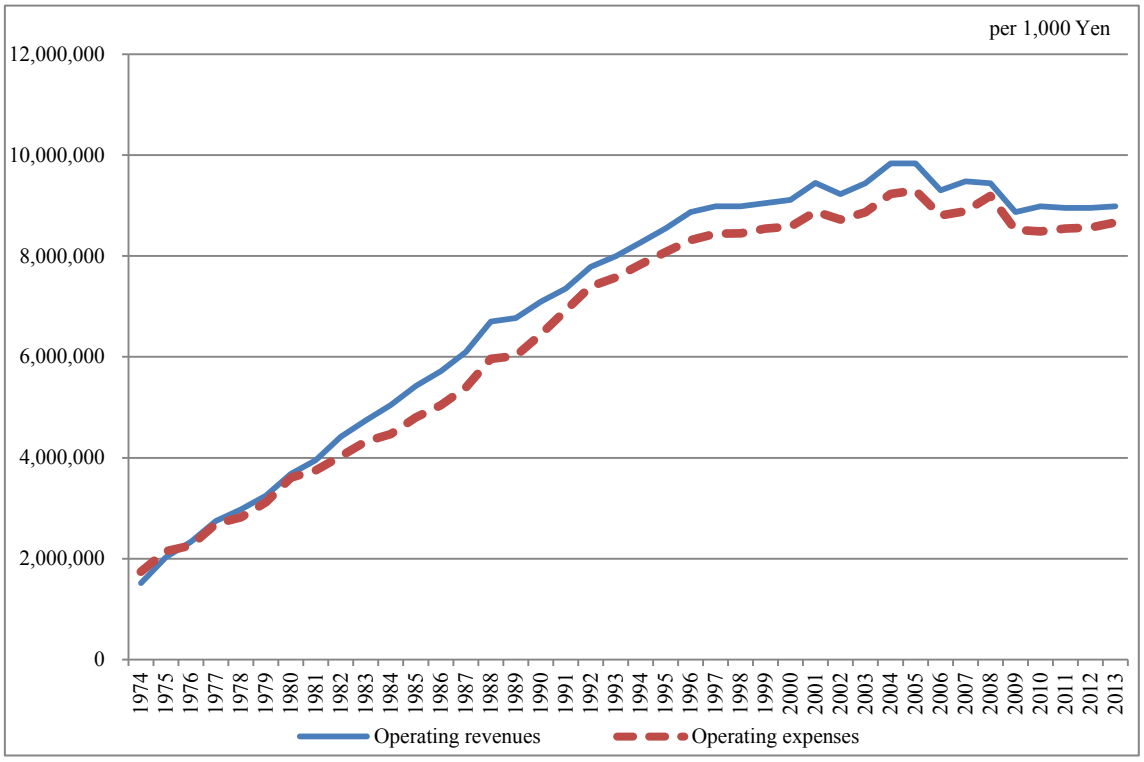
Figure 2. LPE bonds, operating and non-operating revenues and expenses

Panel A: LPEs' bonds



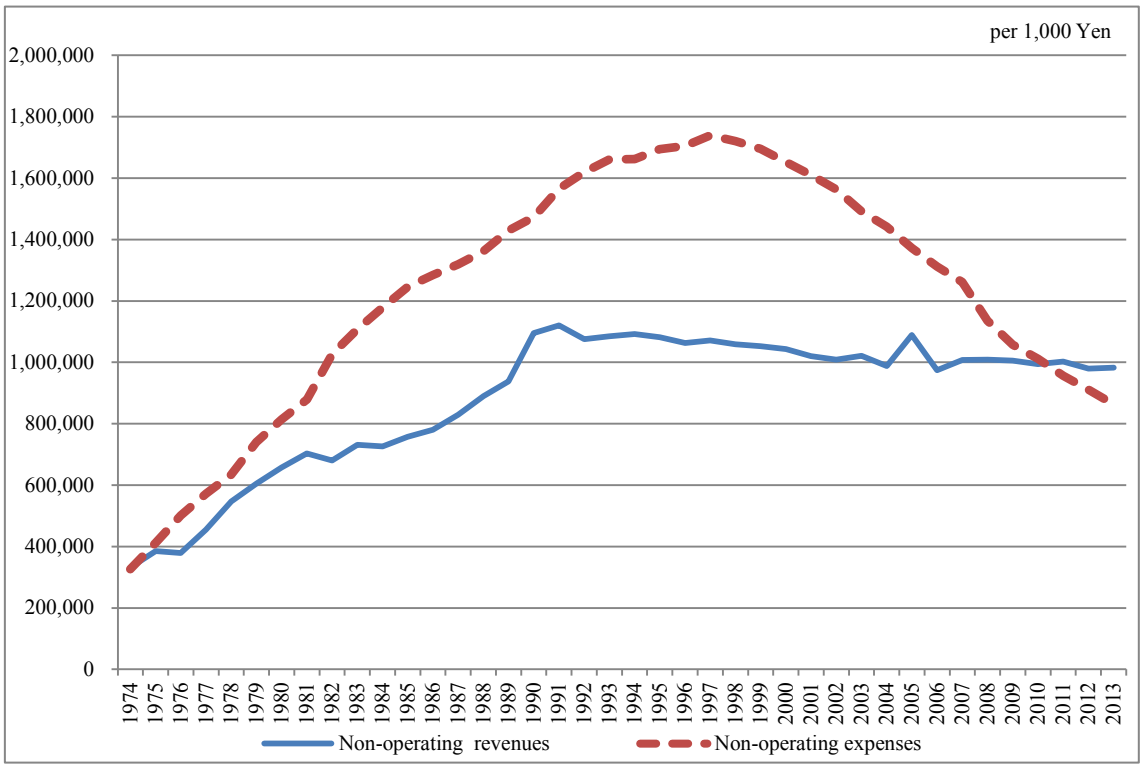
Created with reference to LPEs' yearbooks

Panel B: LPEs' operating revenues and expenses



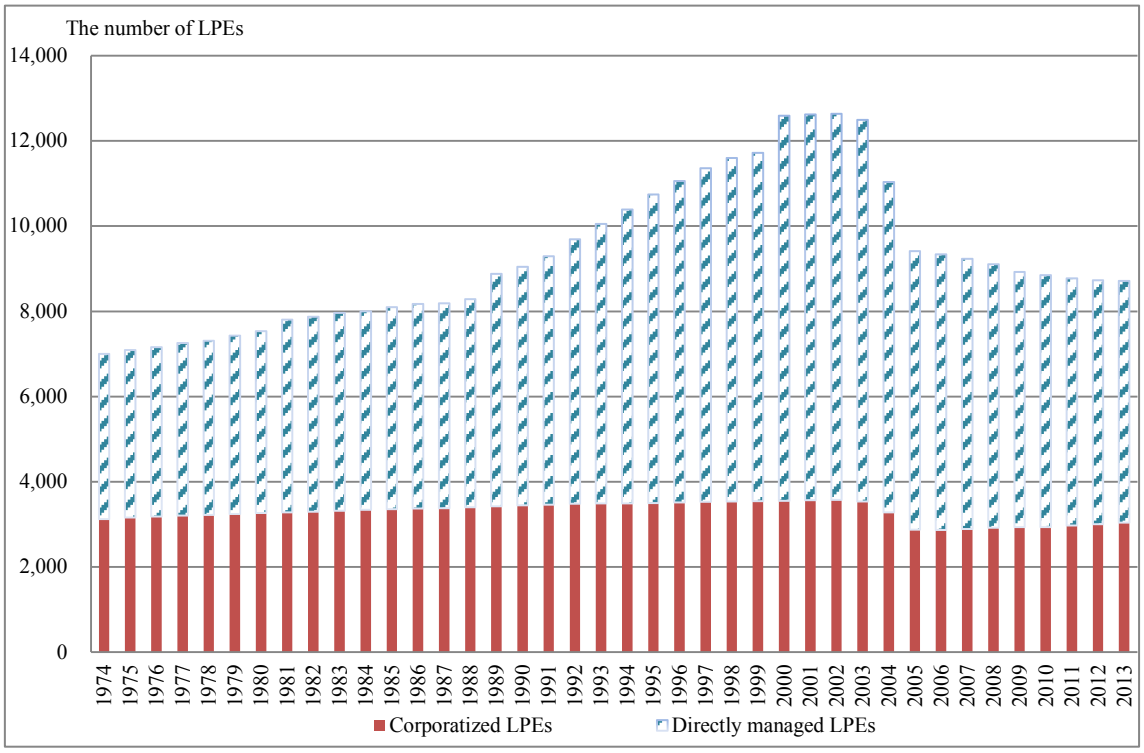
Created with reference to LPEs' yearbooks

Panel C: LPEs' non-operating revenues and expenses



Created with reference to LPEs' yearbooks

Figure 3. Trends in the number of LPEs in Japan



Created with reference to LPEs' yearbooks

Figure 4. Image of sticky costs and anti-sticky costs

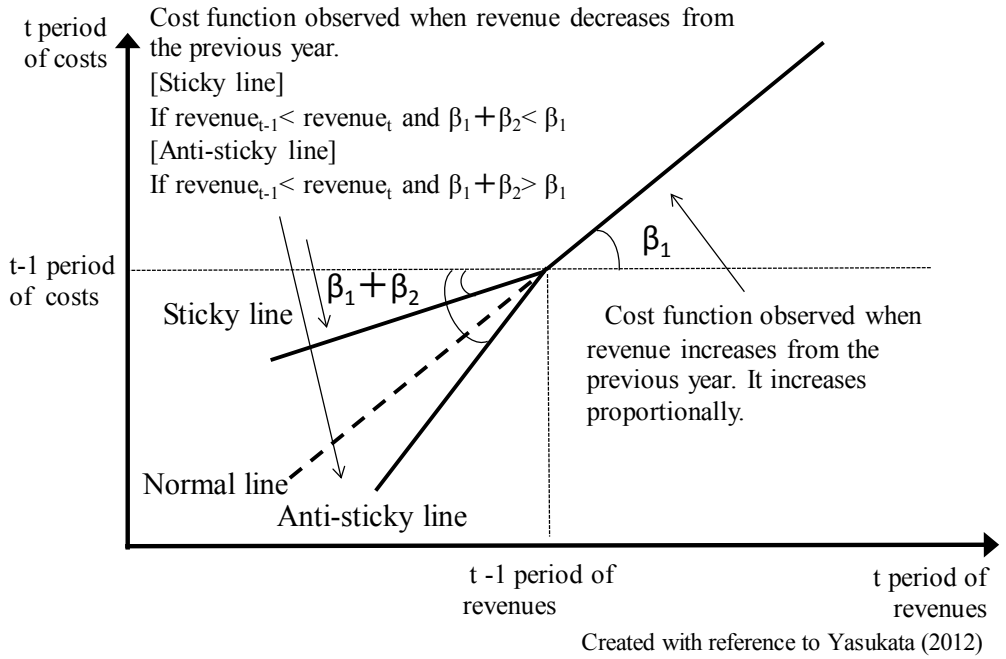


Figure 5. The causal relationship between the institutional constraints on and the cost behavior of LPEs

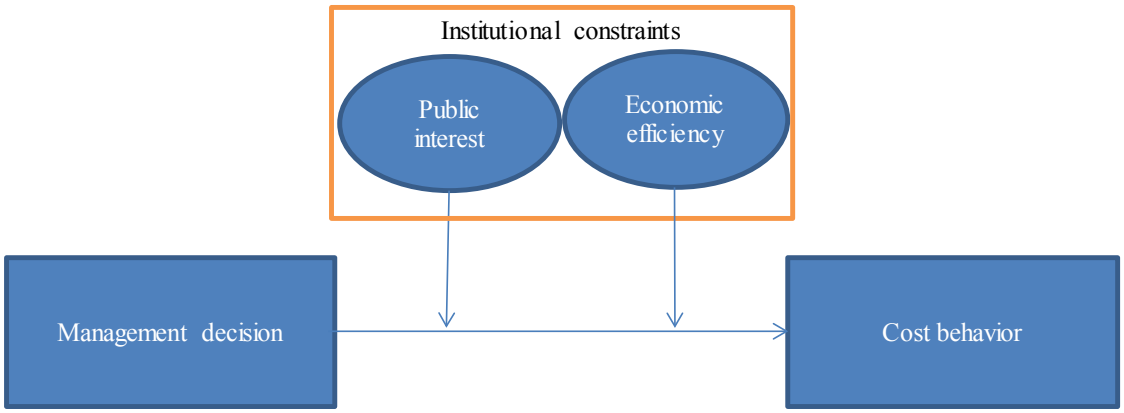
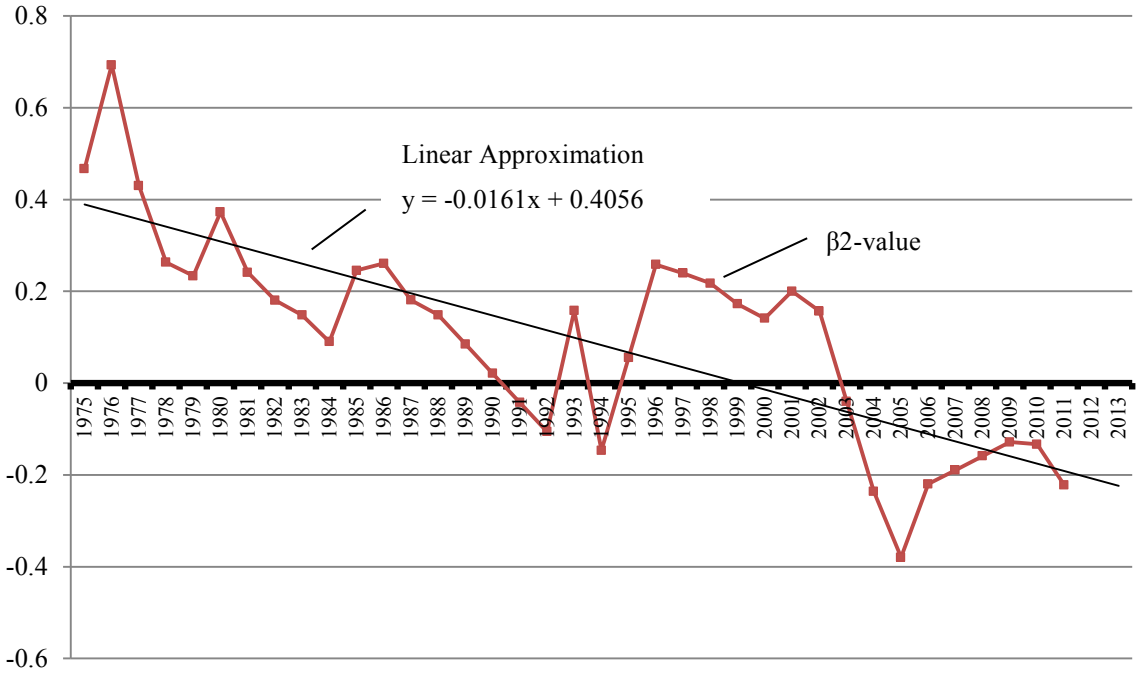
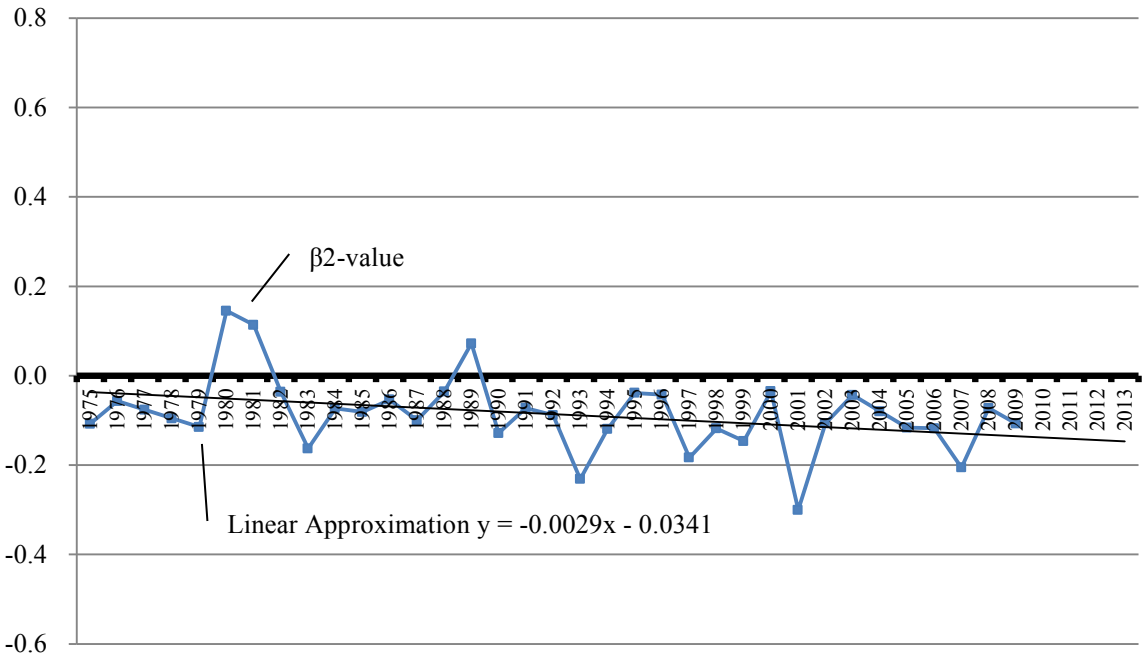


Figure 6. β2 value (sticky cost value) changes in each year[15]

Panel A: LPEs



Panel B: CEs



[15] The results in 2012 and 2013 in Panel A and between 2010 and 2013 in Panel B were not significant, so the interpolation method could not be adopted.

Figure 7. β2, β4, β6, and β8 value (sticky cost value) change in each 4-year period

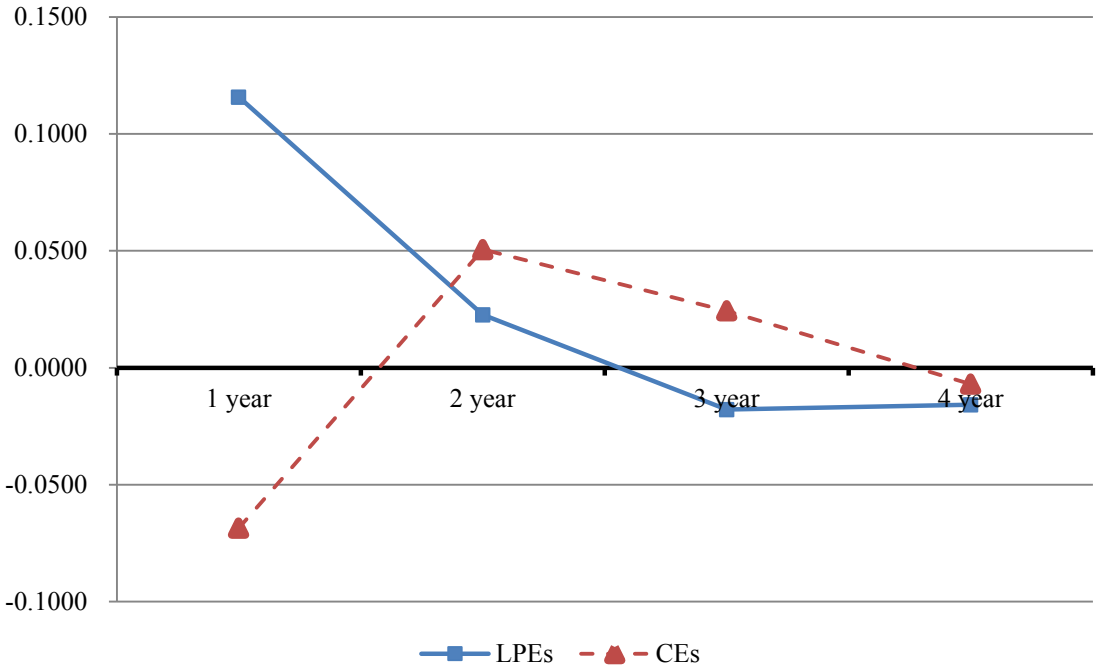


Table 1. LPEs in selected countries

Country	Number of municipalities	Number of LPEs*	Sectors of activities**
Austria	2,359	149	Electricity, gas, heating, public transport, water, sewerage, waste, telecommunications, public equipement, cemeteries, public areas, health
Belgium	589	243	Electricity, gas, communication networks, funding, economic development, water, waste, health, social care
Czech Republic	6,258	339	Public transport, electricity, gas, heating, water, waste
Denmark	275	224	Economic development, electricity, gas, heating, water, waste, public transport, leisure, computing, housing
Estonia	247	224	Electricity, gas, water, housing, public transport, heating, health, social services, trade, waste
Finland	448	944	Economic development, energy, water, sewerage, waste, public transport, ports, telecommunications
France	36,565	1,198	Tourism, planning, housing, public transport, economic development, water, sewerage, waste, environment, leisure, culture, telecommunications, parking spaces
Germany	13,854	3,500	Energy, economic development, water, waste, public transport, public equipment, housing, banks, telecommunications
Greece	900	1,116	Water, sewerage, culture, tourism, training, careers
Italy	8,101	963	Regions: economic development, planning, public equipment, public transport, Provinces: commercial events, tourism municipalities: energy, water, waste, pharmacies, cemeteries
Japan	1,727	9,379	Residential water, industrial water, transport, electricity, gas, hospitals, and other businesses that are run by each local government according to its own rules
Latvia	547	669	Health, heating, waste, real estate operations, sport, public transport, pharmacies, water, social care, radio & TV, auditing, training, tourism, electricity
New Zealand	85	257	-
Poland	2,489	2,415	Water, construction, waste, real estate operations, electricity, gas, heating, public transport, trade, leisure, culture, sport
Portugal	4,037	76	Energy, public transport, tourism, environment, planning, commercial and industrial infrastructures, health, education, food industry
Slovakia	2,920	239	Waste, water, sewerage, heating, public spaces, health, public transport, public lighting, sport, housing, cemeteries, local television, tourism
Slovenia	193	60	Water, waste, road, cemeteries, public transport, public spaces, electricity, heating
South Korea	232	306	-
Spain	8,106	770	Municipalities and provinces: public transport, water, real estate, planning, economic development, cemeteries
Sweden	290	1,750	Energy, water, waste, public transport, housing, tourism, economic development
United Kingdom	326	185	Economic development, tourism,public equipment, health, social care

Created with reference to Saussier and Klien (2013)

* LPEs include not only corporatized LPEs but also directly managed LPEs.

** Sources: Dexia Crediop (2004)

Table 2. Characteristics of directly managed LPEs and corporatized LPEs

	Directly managed LPEs	Corporatized LPEs
Decision rights	Local government	LPE management
Legal status	Local government	Corporation
Governed under	Public municipal law	Public municipal law and municipal ordinances
Organisation form	Multi-purpose	Single-purpose
Governed by	Local bureaucracy	Appointed executive board
Funded through	Taxes	User fees
Cooperative flexibility	Medium	High

Created with reference to Saussier and Klien (2013) and Voorn et al. (2017)

Table 3. Organizational type and expected influence on cost behavior

Institutional Pressures		LPEs	CEs
Governance system	Important constituencies	Rural community members / residents / service user	Shareholders
	Board composition	Officer or publicly elected figure	Business people
	Board size	Small	Large
Legal compliance		Public interests and efficiency	Profit maximization
Political pressure		Maximum pressure	Minimal pressure
Financial performance	Access to capital	Fees, donations, bonds and limited tax support	Net sales, debt and equity financing
	Emphasis on economic returns	Soft budget constraints	Rewards for efficiency
	Charity service*	Lack of cost only for indigent residents	Preference for profits over charity for indigent people

Created with reference to Eldenburg et al. (2004), Balakrishnan et al. (2010)

* No compensation service for needy persons

Table 4. Descriptive statistics

Panel A: LPEs

(Scale: 1,000 Yen)

		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	Sample Size
Total	Cost *	1,946,197	7,320,193	382	148,701	441,239	1,512,568	295,467,927	115,929
	Revenue **	2,083,008	9,354,756	75	170,870	477,245	1,547,037	355,330,535	
	Ln $cost_t$ / $cost_{t-1}$	0.04101	0.09656	-0.48719	-0.00904	0.02957	0.08073	0.57912	
	Ln $revenue_t$ / $revenue_{t-1}$	0.04341	0.10744	-0.56932	-0.00933	0.02114	0.07433	0.66314	
Residential water supply	Cost *	1,065,668	6,774,393	2,160	107,613	221,621	603,446	295,467,927	64,675
	Revenue **	1,300,173	8,365,265	294	130,266	272,108	735,249	355,330,535	
	Ln $cost_t$ / $cost_{t-1}$	0.04577	0.10358	-0.48290	-0.01010	0.03116	0.08902	0.57874	
	Ln $revenue_t$ / $revenue_{t-1}$	0.04900	0.11070	-0.56601	-0.00895	0.02035	0.07403	0.66286	
Industrial water supply	Cost *	476,548	889,671	1,677	62,770	214,673	463,819	8,042,787	7,296
	Revenue **	611,846	1,125,119	708	67,160	265,268	615,598	11,326,896	
	Ln $cost_t$ / $cost_{t-1}$	0.01980	0.11230	-0.48719	-0.03042	0.01117	0.06390	0.56784	
	Ln $revenue_t$ / $revenue_{t-1}$	0.02361	0.10851	-0.56583	-0.00629	0.00177	0.03059	0.64851	
Sewerage	Cost*	5,322,071	18,203,066	1,086	201,342	682,454	2,744,434	225,035,329	4,525
	Revenue**	7,300,351	28,571,454	75	101,462	555,047	3,217,774	344,008,013	
	Ln $cost_t$ / $cost_{t-1}$	0.03273	0.08959	-0.47635	-0.00871	0.01830	0.05856	0.57912	
	Ln $revenue_t$ / $revenue_{t-1}$	0.04654	0.10907	-0.55551	-0.00635	0.02001	0.07392	0.66314	
Transportation	Cost *	8,925,017	19,250,696	382	348,485	1,779,477	6,132,778	149,541,551	2,677
	Revenue **	8,705,197	21,195,366	1,741	306,571	1,570,819	5,174,318	163,824,708	
	Ln $cost_t$ / $cost_{t-1}$	0.01174	0.08491	-0.48158	-0.02899	0.01153	0.04929	0.57121	
	Ln $revenue_t$ / $revenue_{t-1}$	0.01463	0.09550	-0.53314	-0.02770	0.00457	0.04682	0.65543	
Electric power	Cost *	1,685,005	1,401,034	7,198	715,088	1,359,032	2,324,393	7,926,889	1,261
	Revenue **	2,265,455	1,792,677	13,700	948,625	1,911,831	3,179,656	9,605,919	
	Ln $cost_t$ / $cost_{t-1}$	0.03174	0.07822	-0.40621	-0.01232	0.02570	0.06965	0.45241	
	Ln $revenue_t$ / $revenue_{t-1}$	0.02399	0.07932	-0.37420	-0.01410	0.00869	0.04683	0.62548	
Gas power	Cost *	1,263,644	3,293,313	27,840	198,447	447,234	954,152	40,287,262	2,274
	Revenue **	1,377,663	3,505,486	27,253	215,862	487,177	1,064,206	40,270,247	
	Ln $cost_t$ / $cost_{t-1}$	0.04504	0.09517	-0.36607	-0.01443	0.02992	0.09005	0.56286	
	Ln $revenue_t$ / $revenue_{t-1}$	0.04829	0.09993	-0.28446	-0.01263	0.02464	0.08038	0.58733	
Hospitals	Cost *	3,090,634	3,621,221	28,828	726,049	1,687,856	4,030,324	31,602,391	32,066
	Revenue **	2,790,521	3,360,561	700	621,644	1,463,985	3,637,399	32,298,365	
	Ln $cost_t$ / $cost_{t-1}$	0.04084	0.07661	-0.47925	-0.00031	0.03384	0.07567	0.57704	
	Ln $revenue_t$ / $revenue_{t-1}$	0.04011	0.10112	-0.56932	-0.00902	0.03386	0.08350	0.65367	
Wholesale market	Cost *	1,900,347	3,679,698	42,733	235,815	496,231	1,091,269	16,949,597	516
	Revenue **	1,718,437	3,206,354	58,783	188,243	477,556	1,372,835	14,497,486	
	Ln $cost_t$ / $cost_{t-1}$	0.01971	0.07123	-0.41089	-0.01870	0.01412	0.05088	0.43474	
	Ln $revenue_t$ / $revenue_{t-1}$	0.01658	0.06003	-0.42070	-0.01496	0.00482	0.03430	0.51378	
Toll road	Cost *	497,635	481,220	22,252	195,702	290,347	642,219	2,372,781	270
	Revenue **	692,079	884,575	22,778	186,634	342,516	826,008	4,569,640	
	Ln $cost_t$ / $cost_{t-1}$	0.02885	0.13502	-0.39079	-0.03376	0.02208	0.08266	0.53742	
	Ln $revenue_t$ / $revenue_{t-1}$	0.02526	0.15362	-0.56601	-0.03861	0.02085	0.07889	0.62754	
Car parking	Cost *	82,441	68,813	2,222	38,621	74,155	108,933	372,239	369
	Revenue **	127,903	112,924	4,366	51,008	98,883	174,920	563,130	
	Ln $cost_t$ / $cost_{t-1}$	0.00743	0.13908	-0.44680	-0.05085	0.00225	0.05782	0.57128	
	Ln $revenue_t$ / $revenue_{t-1}$	0.00069	0.12528	-0.53474	-0.04949	0.00000	0.05577	0.66278	

* Operating expenses, ** Operating revenues

Panel B: CEs

(Scale: 1,000,000 Yen)

		Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	Sample Size
Total	Cost *	125,774	648,568	2	9,127	23,643	68,737	21,359,227	84,343
	Revenue **	131,521	659,166	3	9,817	24,978	72,599	21,403,613	
	Ln $cost_t$ / $cost_{t-1}$	0.03958	0.14110	-0.73556	-0.02781	0.03373	-0.03163	0.81494	
	Ln $revenue_t$ / $revenue_{t-1}$	0.03871	0.15540	-0.77351	0.10157	0.03435	0.10635	0.85349	
Agriculture and fishery	Cost *	94,881	152,120	2	4,295	17,998	138,252	602,390	426
	Revenue **	96,747	153,914	3	4,419	20,480	140,481	612,888	
	Ln $cost_t$ / $cost_{t-1}$	0.03889	0.16101	-0.58739	-0.03284	0.02816	0.08908	0.73166	
	Ln $revenue_t$ / $revenue_{t-1}$	0.03931	0.18943	-0.70995	-0.03497	0.02480	0.09267	0.81866	
Mining	Cost *	60,597	22,065	261	52,866	67,054	74,242	101,943	82
	Revenue **	62,770	22,779	180	55,544	68,566	76,659	104,996	
	Ln $cost_t$ / $cost_{t-1}$	0.03611	0.17392	-0.64688	-0.05549	0.02399	0.10066	0.58887	
	Ln $revenue_t$ / $revenue_{t-1}$	0.03559	0.19552	-0.64940	-0.06487	0.02476	0.09957	0.65909	
Petroleum	Cost *	57,586	53,898	2,769	10,215	55,354	72,511	218,544	65
	Revenue **	76,792	94,113	4,638	15,943	60,555	84,634	452,228	
	Ln $cost_t$ / $cost_{t-1}$	0.04612	0.20656	-0.35237	-0.05296	0.02296	0.13136	0.80511	
	Ln $revenue_t$ / $revenue_{t-1}$	0.03331	0.23462	-0.66545	-0.08351	0.03760	0.14985	0.75472	
Construction	Cost *	132,019	237,300	174	21,094	47,333	132,397	2,015,551	5,272
	Revenue **	136,941	246,680	212	21,748	49,045	135,420	2,168,285	
	Ln $cost_t$ / $cost_{t-1}$	0.02690	0.13266	-0.67110	-0.04520	0.02896	0.10185	0.68698	
	Ln $revenue_t$ / $revenue_{t-1}$	0.02572	0.13736	-0.74256	-0.04859	0.02892	0.10341	0.75482	
Foods	Cost *	72,220	212,318	27	5,542	16,471	56,063	3,464,264	6,679
	Revenue **	75,446	220,709	22	6,162	17,553	59,375	3,480,490	
	Ln $cost_t$ / $cost_{t-1}$	0.06045	0.15442	-0.72516	-0.01157	0.03919	0.11229	0.81494	
	Ln $revenue_t$ / $revenue_{t-1}$	0.06093	0.16605	-0.76474	-0.01254	0.03795	0.11462	0.85105	
Tectiles, pulp and paper	Cost *	43,365	100,497	16	3,610	10,185	31,938	1,045,802	6,287
	Revenue **	45,521	105,242	7	3,923	10,908	33,395	1,100,228	
	Ln $cost_t$ / $cost_{t-1}$	0.05120	0.17111	-0.71247	-0.03426	0.03310	0.11877	0.79249	
	Ln $revenue_t$ / $revenue_{t-1}$	0.05190	0.18957	-0.77349	-0.03882	0.03393	0.12721	0.84832	
Chemicals	Cost *	60,838	122,718	41	7,817	19,003	54,036	1,563,564	10,279
	Revenue **	66,040	131,944	10	8,578	20,478	58,024	1,602,062	
	Ln $cost_t$ / $cost_{t-1}$	0.04384	0.12206	-0.70580	-0.01651	0.03451	0.09264	0.80315	
	Ln $revenue_t$ / $revenue_{t-1}$	0.04249	0.13302	-0.73760	-0.01987	0.03496	0.09632	0.85053	
Resources and materials	Cost *	100,727	294,103	158	9,626	22,143	70,419	3,678,713	8,040
	Revenue **	105,601	306,000	236	10,254	23,420	73,837	3,753,397	
	Ln $cost_t$ / $cost_{t-1}$	0.02205	0.13031	-0.72685	-0.04353	0.02438	0.08901	0.78846	
	Ln $revenue_t$ / $revenue_{t-1}$	0.02044	0.14584	-0.77351	-0.05065	0.02428	0.09562	0.82038	
Machinery and electric machinery	Cost *	97,397	374,006	10	8,861	19,449	49,936	4,862,221	14,947
	Revenue **	101,324	382,156	21	9,415	20,626	52,640	4,994,719	
	Ln $cost_t$ / $cost_{t-1}$	0.03525	0.15359	-0.73094	-0.04333	0.03814	0.11601	0.80750	
	Ln $revenue_t$ / $revenue_{t-1}$	0.03442	0.18155	-0.77308	-0.05260	0.04087	0.12769	0.85349	
Automobiles and transportation equipment	Cost *	136,215	531,671	23	11,284	26,030	63,670	10,970,663	11,402
	Revenue **	141,568	554,663	6	12,113	27,180	66,138	12,079,264	
	Ln $cost_t$ / $cost_{t-1}$	0.03515	0.13022	-0.73524	-0.02943	0.03336	0.09610	0.81312	
	Ln $revenue_t$ / $revenue_{t-1}$	0.03423	0.14288	-0.76523	-0.03243	0.03415	0.09974	0.84630	
Financial	Cost *	363,828	1,715,798	75	18,530	59,053	147,589	21,359,227	8,920
	Revenue **	369,269	1,720,356	51	20,414	61,312	152,949	21,403,613	
	Ln $cost_t$ / $cost_{t-1}$	0.04457	0.15367	-0.73556	-0.02835	0.03425	0.11203	0.81210	
	Ln $revenue_t$ / $revenue_{t-1}$	0.04371	0.16007	-0.75328	-0.03005	0.03524	0.11322	0.83715	
Broadcasting, software, commercial etc.	Cost *	118,766	383,299	101	9,540	24,001	63,343	6,034,976	11,944
	Revenue **	132,210	435,412	94	10,141	25,172	67,917	6,371,287	
	Ln $cost_t$ / $cost_{t-1}$	0.04143	0.12023	-0.71695	-0.01427	0.03405	0.09108	0.80006	
	Ln $revenue_t$ / $revenue_{t-1}$	0.04007	0.12611	-0.73672	-0.01583	0.03397	0.09146	0.83182	

* Operating expenses, ** Operating revenues

Table 5. Cost behavior based on the panel data analysis using model 1

Panel A: LPEs

	Predicted sign	Pooled		Fixed effects		Random effects	
β_0		0.0200	***	0.0207	***	0.0200	***
		67.38		68.24		67.20	
β_1	+	0.5077	***	0.4952	***	0.5077	***
		195.84		183.96		195.33	
β_2	−	***0.0677***	***	***0.0791***	***	***0.0677***	***
		9.74		***10.69***		***9.71***	
Adj.R^2		0.3389		0.3355		0.3389	
N		115,929		115,929		115,929	
DW		2.1138		2.1819		2.1138	
H-Test		Statistic		(Degree of freedom)		P-value	
		393.42		(2)		0	

Panel B: CEs

	Predicted sign	Pooled		Fixed effects		Random effects	
β_0		0.0023	***	0.0026	***	0.0028	***
		8.49		9.23		7.44	
β_1	+	0.8704	***	0.8647	***	0.8682	***
		463.94		413.83		448.82	
β_2	−	***-0.1008***	***	***-0.0978***	***	***-0.1045***	***
		-28.85		***-24.92***		***-28.74***	
Adj.R^2		0.8379		0.8467		0.8337	
N		84,343		84,343		84,343	
DW		1.6487		1.8114		1.6913	
H-Test		Statistic		(Degree of freedom)		P-value	
		20.48		(2)		0	

For β_0, β_1, and β2, upper data indicate coefficient estimates;
lower data indicate t-statistics, *significant at the 10% level,
**significant at the 5% level, ***significant at the 1% level,
Adj.R^2=Adjusted R^2, N=Number of Observations,
DW=Durbin-Watson ratio, H-Test=HausmanTest,
β2 indicates the value of the sticky or anti-sticky costs.

Table 6. The results for individual years based on OLS analysis using model 1

Panel A: LPEs

Year	β_0	β_1	β_2	Adj.R^2	N	F-statistic	Prob(F-statistic)
1975	0.0834 ***	0.2884 ***	0.4668 ***	0.2751	2,656	504.75	0
1976	0.0864 ***	0.2572 ***	0.6934 ***	0.2730	2,723	512.00	0
1977	0.0860 ***	0.3476 ***	0.4302 ***	0.2701	2,802	519.33	0
1978	0.0528 ***	0.3991 ***	0.2634 ***	0.2763	2,858	546.30	0
1979	0.0667 ***	0.4025 ***	0.2336 ***	0.2648	2,886	520.66	0
1980	0.0916 ***	0.3922 ***	0.3728 ***	0.3513	2,890	783.28	0
1981	0.0476 ***	0.3327 ***	0.2413 ***	0.2548	2,934	502.45	0
1982	0.0255 ***	0.3887 ***	0.1806 ***	0.2594	2,962	519.64	0
1983	0.0246 ***	0.4699 ***	0.1482 ***	0.2988	2,991	637.99	0
1984	0.0297 ***	0.4181 ***	0.0902 *	0.2515	3,028	509.42	0
1985	0.0317 ***	0.4139 ***	0.2455 ***	0.2602	3,050	537.21	0
1986	0.0197 ***	0.4338 ***	0.2608 ***	0.2680	3,075	563.78	0
1987	0.0143 ***	0.5593 ***	0.1810 ***	0.3488	3,080	825.59	0
1988	0.0242 ***	0.5104 ***	0.1485 ***	0.2868	3,110	626.03	0
1989	0.0243 ***	0.5686 ***	0.0430	0.3046	3,119	683.80	0
1990	0.0384 ***	0.5471 ***	-0.0170	0.2625	3,130	557.86	0
1991	0.0400 ***	0.5447 ***	0.0765	0.2582	3,137	546.72	0
1992	0.0306 ***	0.5313 ***	-0.1058 **	0.2550	3,163	542.28	0
1993	0.0280 ***	0.5212 ***	0.1578 ***	0.2928	3,179	658.97	0
1994	0.0231 ***	0.4643 ***	-0.1466 ***	0.1953	3,180	386.74	0
1995	0.0132 ***	0.5559 ***	0.0230	0.2637	3,200	573.78	0
1996	0.0130 ***	0.4663 ***	0.2584 ***	0.2767	3,204	613.60	0
1997	0.0156 ***	0.4735 ***	0.2397 ***	0.2874	3,218	649.59	0
1998	0.0105 ***	0.4898 ***	0.2175 ***	0.2764	3,219	615.49	0
1999	0.0091 ***	0.5487 ***	0.1725 ***	0.2742	3,230	610.90	0
2000	0.0049 ***	0.5338 ***	0.1411 ***	0.2718	3,218	601.34	0
2001	0.0114 ***	0.4594 ***	0.2003 ***	0.2171	3,224	447.96	0
2002	-0.0038 **	0.4173 ***	0.1568 ***	0.2193	3,232	454.84	0
2003	-0.0032 **	0.5785 ***	-0.0134	0.2736	3,198	602.98	0
2004	-0.0028 *	0.6758 ***	-0.2361 ***	0.3058	2,821	622.12	0
2005	-0.0025	0.8186 ***	-0.3796 ***	0.4385	2,454	958.94	0
2006	0.0017	0.5754 ***	-0.2197 ***	0.1988	2,725	338.93	0
2007	0.0032 **	0.4978 ***	0.0439	0.2448	2,708	439.79	0
2008	0.0033 **	0.4470 ***	-0.0240	0.2427	2,710	435.20	0
2009	-0.0040 ***	0.5068 ***	-0.1284 ***	0.2081	2,698	355.35	0
2010	-0.0040 ***	0.4387 ***	-0.1333 ***	0.1414	2,723	225.06	0
2011	0.0052 ***	0.5021 ***	-0.2221 ***	0.1472	2,687	232.87	0
2012	0.0061 ***	0.3067 ***	0.0309	0.1048	2,740	161.25	0
2013	0.0085 ***	0.3630 ***	-0.0593	0.0799	2,767	121.07	0

*significant at the 10% level, **significant at the 5% level, ***significant at the 1% level, Adj.R^2=Adjusted R^2, N=Number of Observations

Panel B: CEs

Year	β_0	β_1	β_2	Adj.R^2	N	F-statistic	Prob(F-statistic)
1975	0.0298 ***	0.8926 ***	-0.1076 ***	0.9298	1,053	6,966.39	0
1976	0.0168 ***	0.8543 ***	-0.0567 **	0.9092	1,065	5,330.40	0
1977	0.0123 ***	0.8500 ***	-0.0206	0.9236	1,090	6,579.05	0
1978	0.0119 ***	0.9113 ***	0.0097	0.9332	1,149	8,025.62	0
1979	-0.0017	0.9397 ***	-0.1150 ***	0.9321	1,367	9,374.25	0
1980	0.0069 ***	0.9050 ***	0.1452 ***	0.9241	1,385	8,428.48	0
1981	0.0137 ***	0.8879 ***	0.1137 ***	0.9383	1,406	10,678.92	0
1982	0.0096 ***	0.9295 ***	-0.0363 *	0.9400	1,436	11,249.80	0
1983	0.0059 ***	0.9583 ***	-0.1630 ***	0.9342	1,479	10,497.84	0
1984	0.0033 ***	0.9371 ***	-0.0730 ***	0.9509	1,525	14,756.17	0
1985	0.0024 **	0.9439 ***	-0.0812 ***	0.9506	1,575	15,138.00	0
1986	0.0065 ***	0.9357 ***	-0.0535 ***	0.9432	1,621	13,444.14	0
1987	0.0014	0.9704 ***	-0.0997 ***	0.9364	1,673	12,319.27	0
1988	-0.0027 **	0.9274 ***	-0.0356 *	0.9156	1,720	9,322.80	0
1989	0.0035 ***	0.8948 ***	0.0722 ***	0.9404	1,759	13,874.49	0
1990	0.0040 ***	0.9445 ***	-0.1287 ***	0.9125	1,837	9,573.52	0
1991	0.0073 ***	0.9377 ***	-0.0722 ***	0.9292	1,916	12,558.01	0
1992	0.0062 ***	0.9458 ***	-0.0883 ***	0.9367	1,981	14,654.93	0
1993	0.0007	0.9829 ***	-0.2312 ***	0.9381	2,053	15,552.19	0
1994	-0.0014	0.9539 ***	-0.1195 ***	0.9304	2,107	14,068.74	0
1995	-0.0025 ***	0.9156 ***	-0.0387 ***	0.9294	2,150	14,142.35	0
1996	0.0009	0.9173 ***	-0.0425 **	0.9256	2,214	13,765.34	0
1997	-0.0018 *	0.9506 ***	-0.1833 ***	0.9018	2,320	10,654.80	0
1998	0.0023 ***	0.9527 ***	-0.1180 ***	0.9396	2,398	18,638.26	0
1999	-0.0095 ***	0.9371 ***	-0.1462 ***	0.9215	2,487	14,597.35	0
2000	-0.0055 ***	0.9057 ***	-0.0351 **	0.8997	2,554	11,446.83	0
2001	-0.0052 ***	0.9058 ***	-0.3004 ***	0.8385	2,637	6,845.25	0
2002	0.0021	0.8670 ***	-0.1067 ***	0.8690	2,730	9,054.03	0
2003	-0.0057	0.8663 ***	-0.0434 **	0.8287	2,869	6,938.02	0
2004	-0.0005	0.8287 ***	0.0063	0.8195	2,929	6,647.12	0
2005	0.0023	0.8583 ***	-0.1164 ***	0.8104	2,963	6,331.68	0
2006	0.0044 ***	0.8663 ***	-0.1177 ***	0.8128	2,974	6,456.73	0
2007	0.0056 ***	0.8797 ***	-0.2054 ***	0.7544	3,007	4,617.78	0
2008	0.0120 ***	0.7870 ***	-0.0728 ***	0.6937	3,054	3,457.98	0
2009	0.0061 ***	0.8248 ***	-0.1069 ***	0.7444	3,098	4,511.85	0
2010	-0.0211 ***	0.7556 ***	-0.0237	0.7156	3,112	3,914.58	0
2011	-0.0009	0.7059 ***	-0.0111	0.6902	3,183	3,545.08	0
2012	0.0064 ***	0.6528 ***	0.0077	0.6426	3,206	2,881.67	0
2013	0.0012	0.7256 ***	-0.0174	0.6940	3,261	3,698.40	0

*significant at the 10% level, **significant at the 5% level, ***significant at the 1% level, Adj.R^2=Adjusted R^2, N=Number of Observations

Table 7. Cost behavior of each industry based on the panel data analysis using model 1

Panel A: LPEs

	Residential water supply		
	Pooled	Fixed	Random
β_0	0.0254 ***	0.0261 ***	0.0254 ***
	59.17	59.80	58.85
β_1	0.4820 ***	0.4719 ***	0.4820 ***
	137.78	131.64	137.03
β_2	***0.2748*** ***	***0.2908*** ***	***0.2748*** ***
	23.82	***24.29***	***23.69***
Adj.R^2	0.3189	0.3115	0.3189
N	64,675	64,675	64,675
DW	2.2075	2.2369	2.2075
H-test	245.02	(2)	0.00

	Industrial water supply		
	Pooled	Fixed	Random
β_0	0.0135 ***	0.0135 ***	0.0135 ***
	9.40	9.21	9.36
β_1	0.3111 ***	0.3101 ***	0.3111 ***
	22.33	21.44	22.23
β_2	***0.0565*** *	***0.0500***	***0.0565*** *
	1.83	***1.56***	***1.83***
Adj.R^2	0.1004	0.0927	0.1004
N	7,296	7,296	7,296
DW	2.1257	2.1746	2.1257
H-test	1.80	(2)	0.41

	Sewage		
	Pooled	Fixed	Random
β_0	0.0098 ***	0.0107 ***	0.0100 ***
	6.71	7.24	6.05
β_1	0.4224 ***	0.4059 ***	0.4179 ***
	33.71	31.17	33.18
β_2	***-0.2731*** ***	***-0.2656*** ***	***-0.2713*** ***
	-7.63	***-7.27***	***-7.58***
Adj.R^2	0.2180	0.2304	0.2120
N	4,525	4,525	4,525
DW	1.8467	1.9222	1.8679
H-test	16.18	(2)	0.00

	Transportation		
	Pooled	Fixed	Random
β_0	0.0065 ***	0.0073 ***	0.0065 ***
	3.54	3.94	3.54
β_1	0.4322 ***	0.4159 ***	0.4322 ***
	20.75	19.27	20.72
β_2	***0.0428***	***0.0693*** *	***0.0428***
	1.07	***1.66***	***1.07***
Adj.R^2	0.2563	0.2545	0.2563
N	2,677	2,677	2,677
DW	2.0214	2.0660	2.0214
H-test	8.62	(2)	0.01

	Electric power		
	Pooled	Fixed	Random
β_0	0.0165 ***	0.0168 ***	0.0165 ***
	6.76	6.79	6.70
β_1	0.5541 ***	0.5476 ***	0.5541 ***
	19.24	18.55	19.06
β_2	***-0.1473*** *	***-0.1326***	***-0.1473*** *
	-1.83	***-1.60***	***-1.81***
Adj.R^2	0.2829	0.2695	0.2829
N	1,261	1,261	1,261
DW	2.4386	2.4553	2.4386
H-test	1.64	(2)	0.44

	Gas power		
	Pooled	Fixed	Random
β_0	0.0170 ***	0.0174 ***	0.0170 ***
	9.50	9.61	9.42
β_1	0.6776 ***	0.6705 ***	0.6776 ***
	45.03	43.62	44.67
β_2	***0.3908*** ***	***0.3996*** ***	***0.3908*** ***
	6.56	***6.56***	***6.50***
Adj.R^2	0.5958	0.5892	0.5958
N	2,274	2,274	2,274
DW	2.3302	2.3448	2.3302
H-test	8.68	(2)	0.01

	Hospitals		
	Pooled	Fixed	Random
β_0	0.0127 ***	0.0128 ***	0.0127 ***
	33.69	33.33	33.66
β_1	0.6315 ***	0.6279 ***	0.6315 ***
	170.84	166.43	170.71
β_2	***-0.1581*** ***	***-0.1640*** ***	***-0.1581*** ***
	-20.34	***-20.38***	***-20.33***
Adj.R^2	0.5960	0.5954	0.5960
N	32,066	32,066	32,066
DW	1.9019	1.9436	1.9019
H-test	109.05	(2)	0.00

	Wholesale market		
	Pooled	Fixed	Random
β_0	0.0134 ***	0.0135 ***	0.0134 ***
	3.87	3.88	3.85
β_1	0.5407 ***	0.5297 ***	0.5407 ***
	9.49	9.14	9.45
β_2	***0.2506*** *	***0.2464*** *	***0.2506*** *
	1.85	***1.80***	***1.85***
Adj.R^2	0.2622	0.2556	0.2622
N	516	516	516
DW	2.0174	2.0448	2.0174
H-test	1.74	(2)	0.42

	Toll road		
	Pooled	Fixed	Random
β_0	0.0131	0.0138	0.0131
	1.33	1.37	1.31
β_1	0.4400 ***	0.4316 ***	0.4400 ***
	6.18	5.90	6.12
β_2	***-0.1208***	***-0.1073***	***-0.1208***
	-0.92	***-0.79***	***-0.91***
Adj.R^2	0.1951	0.1781	0.1951
N	270	270	270
DW	1.7790	1.7883	1.7790
H-test	0.42	(2)	0.81

	Car parking		
	Pooled	Fixed	Random
β_0	-0.0197 **	-0.0215 **	-0.0197 **
	-2.27	-2.44	-2.26
β_1	0.7101 ***	0.7247 ***	0.7101 ***
	8.28	8.28	8.25
β_2	***-0.6605*** ***	***-0.7056*** ***	***-0.6605*** ***
	-4.75	***-4.94***	***-4.74***
Adj.R^2	0.1690	0.1646	0.1690
N	369	369	369
DW	2.2295	2.2731	2.2295
H-test	2.10	(2)	0.35

Upper data indicate coefficient estimates; lower data indicate t-statistics, *: significant at the 10% level, **: significant at the 5% level, ***: significant at the 1% level, Adj.R^2=Adjusted R^2, N=Number of Observations, DW=Durbin-Watson ratio, H-Test:Hausman Test, β2 indicates the value of the sticky or anti-sticky costs.

	Agriculture and fishery			Mining			Petroleum			Construction		
	Pooled	Fixed	Random	Pooled	Fixed	Random	Pooled	Fixed	Random	Pooled	Fixed	Random
β_0	0.0080	0.0059	0.0084	0.0059	0.0058	0.0059	-0.0109	0.0049	-0.0109	0.0011 *	0.0012 **	0.0011 *
	1.69	1.11	1.37	0.52	0.47	0.52	-0.46	0.21	-0.49	1.87	2.02	1.85
β_1	0.7606 ***	0.7735 ***	0.7539 ***	0.8134 ***	0.8132 ***	0.8134 ***	0.8512 ***	0.7625 ***	0.8512 ***	0.9576 ***	0.9563 ***	0.9576 ***
	28.42	22.42	27.05	12.79	11.42	12.64	7.28	6.51	7.72	-3.68	196.60	205.95
β_2	***-0.0244***	***-0.0613***	***-0.0202***	***-0.0254***	***-0.0289***	***-0.0254***	***-0.4249*** **	***-0.2344***	***-0.4249*** **	***-0.0306*** ***	***-0.0283*** ***	***-0.0308*** ***
	-0.47	***-0.90***	***-0.37***	***-0.21***	***-0.21***	***-0.21***	***-2.07***	***-1.11***	***-2.20***	***-3.68***	***-3.18***	***-3.67***
Adj.R^2	0.7818	0.7885	0.7751	0.8112	0.8068	0.8112	0.5767	0.6237	0.5767	0.9557	0.9559	0.9556
N	426	426	426	82	82	82	65	65	65	5,272	5,272	5,272
DW	1.9859	2.1566	2.0054	1.6398	1.6473	1.6398	2.1331	2.3279	2.1331	2.0352	2.1086	2.0396
H-test	1.10	(2)	0.58	0.19	(2)	0.91	9.74	(2)	0.01	0.90	(2)	0.64

	Foods			Tectiles, pulp and paper			Chemicals			Resources and materials		
	Pooled	Fixed	Random	Pooled	Fixed	Random	Pooled	Fixed	Random	Pooled	Fixed	Random
β_0	0.0030 **	0.0041 ***	0.0040 ***	0.0032 **	0.0075 ***	0.0080 ***	0.0017 **	0.0030 ***	0.0030 ***	0.0023 ***	0.0021 ***	0.0021 *
	2.54	3.23	2.64	2.20	4.84	3.93	2.12	3.54	2.48	2.99	2.65	1.81
β_1	0.8671 ***	0.8520 ***	0.8624 ***	0.8277 ***	0.7865 ***	0.8091 ***	0.8627 ***	0.8503 ***	0.8573 ***	0.8546 ***	0.8592 ***	0.8574 ***
	123.78	102.46	117.60	104.93	83.75	97.56	135.15	121.25	130.29	138.10	136.03	138.79
β_2	***-0.1764*** ***	***-0.1697*** ***	***-0.1771*** ***	***-0.1247*** ***	***-0.0721*** ***	***-0.1092*** ***	***-0.2071*** ***	***-0.1780*** ***	***-0.2038*** ***	***-0.0535*** ***	***-0.0574*** ***	***-0.0610*** ***
	-11.41	***-9.37***	***-10.98***	***-7.75***	***-3.92***	***-6.56***	***-16.13***	***-12.44***	***-15.37***	***-5.08***	***-5.22***	***-5.71***
Adj.R^2	0.7747	0.7851	0.7627	0.7578	0.7796	0.7376	0.7481	0.7667	0.7406	0.8620	0.8728	0.8638
N	6,679	6,679	6,679	6,287	6,287	6,287	10,279	10,279	10,279	8,040	8,040	8,040
DW	1.5778	1.7382	1.6197	1.4800	1.7361	1.5495	1.5055	1.6892	1.5648	1.6629	1.8629	1.7186
H-test	14.22	(2)	0.00	26.63	(2)	0.00	35.10	(2)	0.00	108.33	(2)	0.00

	Machinery and electric machinery			Automobiles and transportation equipment			Financial			Broadcasting, software, commercial etc.		
	Pooled	Fixed	Random	Pooled	Fixed	Random	Pooled	Fixed	Random	Pooled	Fixed	Random
β_0	0.0036 ***	0.0034 ***	0.0032 ***	0.0025 ***	0.0021 ***	0.0025 ***	-0.0009	-0.0008	-0.0008	0.0010 **	0.0010 *	0.0010 **
	5.94	5.41	4.27	4.27	3.44	3.22	-0.97	-0.76	-0.75	1.98	1.75	1.98
β_1	0.8280 ***	0.8267 ***	0.8283 ***	0.8849 ***	0.8861 ***	0.8835 ***	0.9211 ***	0.9179 ***	0.9207 ***	0.9363 ***	0.9331 ***	0.9363 ***
	219.89	200.41	215.04	197.99	182.17	193.04	143.12	127.14	140.29	218.09	198.05	218.04
β_2	***-0.0638*** ***	***-0.0676*** ***	***-0.0688*** ***	***-0.0695*** ***	***-0.0797*** ***	***-0.0739*** ***	***-0.1518*** ***	***-0.1515*** ***	***-0.1547*** ***	***-0.1186*** ***	***-0.1265*** ***	***-0.1186*** ***
	-9.76	***-9.31***	***-10.18***	***-8.53***	***-8.82***	***-8.78***	***-12.42***	***-10.89***	***-12.37***	***-14.27***	***-13.64***	***-14.27***
Adj.R^2	0.8920	0.8961	0.8913	0.8829	0.8885	0.8806	0.8112	0.8143	0.8080	0.8793	0.8792	0.8793
N	14,947	14,947	14,947	11,402	11,402	11,402	8,920	8,920	8,920	11,944	11,944	11,944
DW	1.7204	1.8500	1.7463	1.6846	1.8344	1.7211	1.7796	1.8728	1.7943	1.9776	2.0349	1.9776
H-test	6.44	(2)	0.04	3.12	(2)	0.21	1.54	(2)	0.46	53.60	(2)	0.00

Upper data indicate coefficient estimates; lower data indicate t-statistics, *: significant at the 10% level, **: significant at the 5% level, ***: significant at the 1% level,
Adj.R^2=Adjusted R^2, N=Number of Observations, DW=Durbin-Watson ratio, H-Test:Hausman Test, β2 indicates the value of the sticky or anti-sticky costs.

Table 8. Population changes and cost behavior based on the panel data analysis using model 2

Panel A: LPEs

The effect of total population change			
	Pooled	Fixed effects	Random effects
β_0	0.0041 ***	0.0041 ***	0.0041 ***
	11.38	10.66	11.30
β_1	0.5321 ***	0.5227 ***	0.5321 ***
	96.27	84.53	95.56
β_2	-0.0347 ***	-0.0401 ***	-0.0347 ***
	-3.57	-3.60	-3.54
β_3	***-0.4190*** ***	***-0.3080*** **	***-0.4190*** ***
	-3.10	***-2.17***	***-3.08***
β_4			
β_5			
β_6			
Adj.R^2	0.2458	0.2346	0.2458
N	55,976	55,976	55,976
DW	2.1775	2.3250	2.1775
H-Test	Statistic	(Degree of freedom)	P-value
	56.96	(3)	0

The effect of youth (0-14 years) population change			
	Pooled	Fixed effects	Random effects
β_0	0.0041 ***	0.0041 ***	0.0041 ***
	11.38	10.80	11.30
β_1	0.5321 ***	0.5212 ***	0.5321 ***
	96.33	84.34	95.66
β_2	0.6357 ***	0.9987 ***	0.6357 ***
	7.44	9.89	7.39
β_3			
β_4	***0.3372*** ***	***0.5216*** ***	***0.3372*** ***
	7.91	***10.36***	***7.85***
β_5			
β_6			
Adj.R^2	0.2465	0.2361	0.2465
N	55,976	55,976	55,976
DW	2.1745	2.3227	2.1745
H-Test	Statistic	(Degree of freedom)	P-value
	102.74	(3)	0

The effect of middle-aged (15-64 years) population change			
	Pooled	Fixed effects	Random effects
β_0	0.0041 ***	0.0041 ***	0.0041 ***
	11.33	10.60	11.25
β_1	0.5322 ***	0.5227 ***	0.5322 ***
	96.29	84.53	95.58
β_2	-0.0329	-0.0861 *	-0.0329
	-0.76	-1.67	-0.76
β_3			
β_4			
β_5	***0.0053***	***-0.0954***	***0.0053***
	0.06	***-0.90***	***0.06***
β_6			
Adj.R^2	0.2457	0.2345	0.2457
N	55,976	55,976	55,976
DW	2.1768	2.3245	2.1768
H-Test	Statistic	(Degree of freedom)	P-value
	57.83	(3)	0

The effect of elderly (65+ years) population change			
	Pooled	Fixed effects	Random effects
β_0	0.0042 ***	0.0041 ***	0.0041 ***
	11.41	10.72	11.33
β_1	0.5320 ***	0.5224 ***	0.5322 ***
	96.25	84.47	95.54
β_2	-0.1367 ***	-0.1721 ***	-0.1367 ***
	-3.48	-3.70	-3.45
β_3			
β_4			
β_5			
β_6	***-0.0695*** ***	***-0.0901*** ***	***-0.0695*** ***
	-2.66	***-2.91***	***-2.64***
Adj.R^2	0.2458	0.2346	0.2458
N	55,976	55,976	55,976
DW	2.1768	2.3246	2.1768
H-Test	Statistic	(Degree of freedom)	P-value
	56.72	(3)	0

From β_0 to β_6, upper data indicate coefficient estimates; lower data indicate t-statistics, *significant at the 10% level,

**significant at the 5% level, ***significant at the 1% level, Adj.R^2=Adjusted R^2, N=Number of Observations,

DW=Durbin-Watson ratio, H-Test=HausmanTest, β_3 means Pop_total, β_4 means Pop_youth, β_5 means Pop_middle and β_6 means Pop_elder

Panel B: CEs

The effect of total population change			
	Pooled	Fixed effects	Random effects
β_0	0.0004	0.0021 ***	0.0010 **
	0.94	5.01	2.08
β_1	0.8338 ***	0.8049 ***	0.8265 ***
	312.88	253.81	297.84
β_2	0.4892 ***	-0.0567 ***	-0.0839 ***
	11.81	-10.10	-10.10
β_3	***1.3489***	***2.4228*** ***	***1.3283***
	14.01	***2.71***	***2.71***
β_4			
β_5			
β_6			
Adj.R^2	0.7964	0.8075	0.7872
N	53,146	53,146	53,146
DW	1.6478	1.8569	1.7017
H-Test	Statistic	(Degree of freedom)	P-value
	248.89	(3)	0

The effect of youth (0-14 years) population change			
	Pooled	Fixed effects	Random effects
β_0	0.0004	0.0023 ***	0.0013 ***
	1.07	5.58	2.81
β_1	0.8336 ***	0.8047 ***	0.8256 ***
	312.80	254.01	298.87
β_2	-0.5776 ***	-0.3699 ***	-0.5211 ***
	-16.99	-10.66	-15.51
β_3			
β_4	***-0.3122*** ***	***-0.2005*** ***	***-0.2791*** ***
	-14.56	***-9.21***	***-13.18***
β_5			
β_6			
Adj.R^2	0.7964	0.8078	0.7884
N	53,146	53,146	53,146
DW	1.6478	1.8523	1.6941
H-Test	Statistic	(Degree of freedom)	P-value
	397.68	(3)	0

The effect of middle-aged (15-64 years) population change			
	Pooled	Fixed effects	Random effects
β_0	0.0004	0.0023 ***	0.0013 ***
	0.94	5.49	2.71
β_1	0.8338 ***	0.8048 ***	0.8258 ***
	312.88	254.03	298.97
β_2	0.4892 ***	0.3057 ***	0.4299 ***
	11.81	7.28	10.51
β_3			
β_4			
β_5	***1.3489*** ***	***0.8441*** ***	***1.1996*** ***
	14.01	***8.65***	***12.63***
β_6			
Adj.R^2	0.7964	0.8077	0.7883
N	53,146	53,146	53,146
DW	1.6478	1.8525	1.6941
H-Test	Statistic	(Degree of freedom)	P-value
	401.70	(3)	0

The effect of elderly (65+ years) population change			
	Pooled	Fixed effects	Random effects
β_0	0.0004	0.0023 ***	0.0013 ***
	1.11	5.59	2.71
β_1	0.8336 ***	0.8047 ***	0.8258 ***
	312.78	254.02	298.97
β_2	1.6929 ***	1.1022 ***	0.4299 ***
	14.06	9.02	10.51
β_3			
β_4			
β_5			
β_6	***0.8986*** ***	***0.5842*** ***	***1.1996*** ***
	14.79	***8.65***	***12.63***
Adj.R^2	0.7964	0.8077	0.7883
N	53,146	53,146	53,146
DW	1.6478	1.8525	1.6941
H-Test	Statistic	(Degree of freedom)	P-value
	393.74	(3)	0

From β_0 to β_6, upper data indicate coefficient estimates; lower data indicate t-statistics, *significant at the 10% level,

**significant at the 5% level, ***significant at the 1% level, Adj.R^2=Adjusted R^2, N=Number of Observations,

DW=Durbin-Watson ratio, H-Test=HausmanTest, β_3 means Pop_total, β_4 means Pop_youth, β_5 means Pop_middle and β_6 means Pop_elder

Table 9. Cost behavior over 4 years based on the panel data analysis using model 3

	Panel A: LPEs			Panel B: CEs		
	Pooled	Fixed effects	Random effects	Pooled	Fixed effects	Random effects
β_0	0.0113 ***	0.0122 ***	0.0113 ***	0.0010 ***	0.0015 ***	0.0011 ***
	31.30	30.76	31.10	4.03	4.45	3.78
β_1	0.4764 ***	0.4693 ***	0.4764 ***	0.8748 ***	0.8760 ***	0.8744 ***
	141.08	135.29	140.16	442.75	428.33	444.22
β_2	***0.0972*** ***	***0.1157*** ***	***0.0972*** ***	***-0.0719*** ***	***-0.0685*** ***	***-0.0714*** ***
(t/t-1)	***12.26***	***13.89***	***12.18***	***-21.40***	***-19.31***	***-21.22***
β_3	0.0586 ***	0.0550 ***	0.0586 ***	0.0352 ***	0.0346 ***	0.0349 ***
	18.74	17.18	18.62	18.09	17.41	18.07
β_4	***0.0137*** *	***0.0226*** ***	***0.0137*** *	***0.0470*** ***	***0.0505*** ***	***0.0474*** ***
(t-1/t-2)	***1.74***	***2.76***	***1.73***	***13.72***	***14.23***	***13.90***
β_5	0.0710 ***	0.0690 ***	0.0710 ***	0.0229 ***	0.0213 ***	0.0226 ***
	24.95	23.75	24.78	12.25	11.15	12.18
β_6	***-0.0226*** ***	***-0.0179*** **	***-0.0226*** ***	***0.0216*** ***	***0.0244*** ***	***0.0217*** ***
(t-2/t-3)	***-2.94***	***-2.23***	***-2.92***	***6.44***	***7.02***	***6.50***
β_7	0.0460 ***	0.0456 ***	0.0460 ***	0.0224 ***	0.0217 ***	0.0221 ***
	18.13	17.58	18.01	13.52	12.45	13.40
β_8	***-0.0156*** **	***-0.0158*** **	***-0.0156*** **	***-0.0075*** **	***-0.0070*** **	***-0.0076*** **
(t-3/t-4)	***-2.15***	***-2.09***	***-2.13***	***-2.40***	***-2.12***	***-2.44***
Adj.R^2	0.3194	0.3104	0.3194	0.8926	0.8956	0.8904
N	100,923	100,923	100,923	72,814	72,814	72,814
DW	2.1958	2.2610	2.1958	1.9671	2.1173	1.9863
H-Test	Statistic (Degree of freedom) P-value			Statistic (Degree of freedom) P-value		
	138.30 (8) 0			285.45 (8) 0		

From β_0 to β_8, upper data indicate coefficient estimates; lower data indicate t-statistics,
*significant at the 10% level, **significant at the 5% level, ***significant at the 1% level

Adj.R^2=Adjusted R^2, N=Number of Observations, DW=Durbin-Watson ratio, H-Test=HausmanTest,
β2 value is the rate of change from t-1 to t, β4, β6, and β8 values represented the annual change in asymmetric cost behavior for t-1/t-2, t-2/t-3, and t-3/t-4, respectively.