Causal Effect of Introducing Outsourcing on the Usage of Japanese Public Libraries

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Abstract. For a long time, Japanese public libraries were managed by local governments. However, in 2003, other organizations, including private enterprises, superseded the management of libraries and introduced an outsourcing system called "designated administrator system." The suitability of this outsourcing system for libraries is now being debated, with many people arguing that it is unfit. To provide basic data for this discussion, we conducted a causal analysis on the introduction of outsourcing to public libraries in Japan. We performed a matching analysis, difference-in-differences (DD) analysis, and DD analysis with matching on library usage in terms of three factors, namely, the gate count, number of loans, and number of reference transactions. In the matching analysis, the average gate count per capita of all outsourcing libraries was higher than that of all direct management libraries. In the DD analysis with and without matching, the average gate count per capita and number of loans per capita of all the outsourcing libraries were higher than those of all the direct management libraries. These differences were statistically significant at a 0.01 significance level. The results indicate that the introduction of the designated administrator system increases the gate count per capita. Considering the difference in characteristics of the matching and DD analyses, the number of loans per capita may also be increasing with the introduction of the system.

Keywords: Outsourcing, Designated Administrator System, Japanese Public Libraries, Causal Effect, Matching, Difference-in-Differences Analysis

1 Introduction

Before 2003, Japanese public libraries were managed by the local governments; however, in 2003, other organizations, including private enterprises, superseded library management with the introduction of an outsourcing system named the "designated administrator system." Although the number of public libraries managed using this outsourcing system (henceforth, "outsourcing libraries") is increasing, whether local governments should employ this system for managing public libraries is under discussion. Many people argue the unsuitability of the system for public libraries. Few studies have examined the causal effect of introducing outsourcing to library management.

In this study, we used almost all Japanese public libraries for data and conducted three types of causal analyses: (1) matching analysis, (2) difference-in-differences (DD) analysis, and (3) DD analysis with matching. The matching and DD analyses have been frequently used in econometrics to detect causal effects of certain events. We analyzed the causal effects of introducing outsourcing on the usage of libraries in terms of the following factors: (i) gate count per capita, (ii) number of loans per capita, and (iii) number of reference transactions per capita. For the matching analysis, we analyzed the difference in the aforementioned three factors between outsourcing libraries and conventional libraries managed directly by local governments (henceforth, "direct management libraries") that were similar in (a) the number of holdings, (b) number of acquisition, (c) size of floors, (d) number of staffs, and (e) service population. The number of outsourcing and direct management libraries in the sample were approximately 400 and 3000, respectively (the numbers slightly differ depending on the investigation). These data were obtained from *Statistics on Libraries in Japan* (2015) [1], which is published by the Japan Library Association. For (2) the DD analysis, we compared changes in the aforementioned three factors of direct management and outsourcing libraries before and after the introduction of outsourcing. The data were obtained from *Statistics on Libraries in Japan* (2003–2015) [1]. For (3) the DD analysis with matching, we first analyzed direct management and outsourcing libraries that were similar in terms of the aforementioned (a) to (e). The libraries were then compared in terms of (i) to (iii).

2 Related Studies

In Japan, some librarians working in outsourcing libraries reported these changes observed after introducing the outsourcing system [2][3]. In addition, Maeda (2007) [4], the Japan Library Association (2007) [5], Koyama and Nagata (2008) [6] conducted questionnaire surveys to investigate the quality of outsourcing libraries and changes observed after introducing the outsourcing system. These reports and surveys ascertained that library services, including opening hours and days and library usage, were increased with the introduction of the outsourcing system. However, these studies included relatively small samples. Mouri and Ohba (2015) [7] conducted a comparative study, with a focus on the certified directors in outsourcing and direct management libraries.

Mizunuma and Tsuji (2016, 2017a, 2017b, 2018) [8][9][10][11] comprehensively examined the differences between outsourcing and direct management libraries. Mizunuma and Tsuji (2016) [8] examined the reference services and reported that direct management libraries generally answer users' questions directly, whereas outsourcing libraries developed environments where users can find answers for themselves. Moreover, they reported that outsourcing libraries received more reference questions than direct management libraries. Mizunuma and Tsuji (2017a) [9] examined the changes in library usage in terms of the gate count, number of loans, and number of reference transactions, before and after introducing outsourcing. They asserted that in general, these factors exhibited an increase after the introduction of outsourcing. Mizunuma and Tsuji (2017b) [10] reported that (1) direct management libraries have more novels than outsourcing libraries, whereas outsourcing libraries have more

reference books than direct management libraries, and (2) the rates of borrowing books in outsourcing libraries were higher than those in direct management libraries. Mizunuma and Tsuji (2018) [11] stated that (1) the number of opening days and percentage of certified directors in outsourcing libraries were higher than those in direct management libraries, whereas (2) library usage, number of opening days, and number of certified directors increased after introducing an outsourcing system.

The aforementioned studies by Mizunuma and Tsuji, particularly [9], are similar to the proposed study. However, these studies did not conduct a strict causal analysis.

3 Method

As mentioned in Section 1, we conducted three types of causal analyses, namely the matching analysis, DD analysis, and DD analysis with matching. In the following subsections, we will explain the theoretical background of the conducted analyses and their implementation.

3.1 Theoretical Background

The following explanations are based on Angrist and Pischke (2009) [12], Hoshino and Tanaka (2016) [13], and Meyer (1995) [14], with some modification.

Angrist and Pischke (2009) first asked whether hospitals make people healthier. To discuss this problem precisely, they introduced some notations. First, a binary variable $T_i = \{0, 1\}$ was used to describe whether person i received any treatment (in this case, hospitalized). The outcome of interest—a measure of health status—was denoted using Y_i. The effect of hospital care on Y_i was in question. To address this concern, we considered the possible situations that might have occurred if they had not went to the hospital and vice versa. Therefore, for any individual, there were two potential health variables, namely Y_{1i} $(T_i = 1)$ and Y_{0i} $(T_i = 0)$, which indicate the health of person i when they were and were not hospitalized, respectively. $Y_{1i} - Y_{0i}$ was the causal effect of hospitalization on an individual[1]. However, because observing both the potential outcomes for the same person (Y_{1i} and Y_{0i}) is impossible, we must understand the effects of hospitalization by comparing the average health of people who were and were not hospitalized. The two unobservable events Y_{1i} for $T_i = 0$ and Y_{0i} for $T_i = 1$ were *counterfactual*.

The comparison of average health conditional on hospitalization status is formally associated with the average causal effect based on the following equation:

$$
\begin{aligned}
&\mathrm{E}[Y_i|T_i = 1] - \mathrm{E}[Y_i|T_i = 0] \\
&= \mathrm{E}[Y_{1i}|T_i = 1] - \mathrm{E}[Y_{0i}|T_i = 0] \\
&= \mathrm{E}[Y_{1i}|T_i = 1] - \mathrm{E}[Y_{0i}|T_i = 1] + \mathrm{E}[Y_{0i}|T_i = 1] - \mathrm{E}[Y_{0i}|T_i = 0] \\
&= \mathrm{E}[Y_{1i} - Y_{0i}|T_i = 1] + \mathrm{E}[Y_{0i}|T_i = 1] - \mathrm{E}[Y_{0i}|T_i = 0]
\end{aligned}
$$

Here, $\mathrm{E}[Y_i|T_i = 1] - \mathrm{E}[Y_i|T_i = 0]$ is the observed difference in the average health and

[1] In general, there is likely to be a distribution of both Y_{1i} and Y_{0i} in the population, therefore, the treatment effect can be different for different people.

thus can be calculated. $\mathrm{E}[Y_{1i} - Y_{0i}|T_i = 1]$ is the *average treatment effect on the treated* (ATET or ATT) and is the primary measure of causal inference. This term provided the average difference between the health of the hospitalized group (i.e., $\mathrm{E}[Y_{1i}|T_i = 1]$) and the potential outcomes if they had not been hospitalized (i.e., $\mathrm{E}[Y_{0i}|T_i = 1]$). Because the potential outcome term was *counterfactual*, the ATET could not be directly calculated. The final term $\mathrm{E}[Y_{0i}|T_i = 1] - \mathrm{E}[Y_{0i}|T_i = 0]$ is the *selection bias*, which is the difference in the average Y_{0i} between the hospitalized and non-hospitalized groups. Because the unwell people are more likely to seek treatment than the healthy people, the hospitalized people had worse Y_{0i}, and thus, the selection bias was negative in this example. A large selection bias (in the absolute value) could completely prevail over a positive ATET. Most studies on causal inference have aimed to yield a zero selection bias and thus obtain the ATET by using $\mathrm{E}[Y_i|T_i = 1] - \mathrm{E}[Y_i|T_i = 0]$ (which can be calculated using the acquired data).

Random assignment of T_i to the sample population (so-called RCT (Randomized Controlled Trial)) solves the selection problem. Because random assignment makes T_i independent of potential outcomes, it makes selection bias zero (i.e. $\mathrm{E}[Y_{0i}|T_i = 1] - \mathrm{E}[Y_{0i}|T_i = 0] = \mathrm{E}[Y_{0i}|T_i = 0] - \mathrm{E}[Y_{0i}|T_i = 0] = 0$). However, the RCT is difficult to perform. In the hospitalization example, some unwell people are forced to not be hospitalized in order to implement RCT.

Matching. First, consider the causal effect of an on-the-job training (OJT) on employee wages in a company. Do employees have higher wages after the OJT because of elements, such as improved skills and knowledge? Because of the selection bias, we cannot compare the wages of employees who did and did not receive the OJT. For example, employees with less years of service in the company may receive the OJT, whereas those who already have high wages may be reluctant.

Here, X_{1i} and X_{2i} represent employee i's (1) years of service in the company and (2) the wage before the OJT, respectively. Furthermore, we assumed the following:

$$\{Y_{1i}, Y_{0i}\} \perp T_i | X_{1i}, X_{2i}$$

That is, treatment T was randomly assigned in the set of employees with identical X_1 and X_2. The RCT was performed for the set of employees with identical X_1 and X_2. This approach is termed *conditional independence assumption* (CIA). With the CIA,

$$\mathrm{E}[Y_{0i}|T_i = 1, X_{1i}, X_{2i}] = \mathrm{E}[Y_{0i}|T_i = 0, X_{1i}, X_{2i}]$$

which indicates that conditional on covariates X_1 and X_2, the selection bias disappears. Therefore,

$$\begin{aligned}
&\mathrm{E}[Y_i|T_i = 1, X_{1i}, X_{2i}] - \mathrm{E}[Y_i|T_i = 0, X_{1i}, X_{2i}] \\
&= \mathrm{E}[Y_{1i}|T_i = 1, X_{1i}, X_{2i}] - \mathrm{E}[Y_{0i}|T_i = 0, X_{1i}, X_{2i}] \\
&= \mathrm{E}[Y_{1i} - Y_{0i}|T_i = 1, X_{1i}, X_{2i}] + \mathrm{E}[Y_{0i}|T_i = 1, X_{1i}, X_{2i}] - \mathrm{E}[Y_{0i}|T_i = 0, X_{1i}, X_{2i}] \\
&= \mathrm{E}[Y_{1i} - Y_{0i}|T_i = 1, X_{1i}, X_{2i}]
\end{aligned}$$

Here, using the law of iterated expectations,

$$\mathrm{E}\{\mathrm{E}[Y_i|T_i = 1, X_{1i}, X_{2i}]|T_i = 1\} = \mathrm{E}[Y_i|T_i = 1]$$

and

$$\mathrm{E}\{\mathrm{E}[Y_{1i} - Y_{0i}|T_i = 1, X_{1i}, X_{2i}]|T_i = 1\} = \mathrm{E}[Y_{1i} - Y_{0i}|T_i = 1] \quad (=\mathrm{ATET})$$

Therefore,

$$\begin{aligned}
&\mathrm{ATET} \\
&= \mathrm{E}\{\mathrm{E}[Y_{1i} - Y_{0i}|T_i = 1, X_{1i}, X_{2i}]|T_i = 1\} \\
&= \mathrm{E}\{\mathrm{E}[Y_i|T_i = 1, X_{1i}, X_{2i}] - \mathrm{E}[Y_i|T_i = 0, X_{1i}, X_{2i}]|T_i = 1\} \\
&= \mathrm{E}\{Y_i - \mathrm{E}[Y_i|T_i = 0, X_{1i}, X_{2i}]|T_i = 1\}
\end{aligned}$$

In strict matching, $\mathrm{E}[Y_i|T_i = 0, X_{1i}, X_{2i}]$ is calculated as the mean of Y_j of employee j, who belongs to the control group and satisfies equations $X_{1j} = X_{1i}$ and $X_{2j} = X_{2i}$, with employee i from the treatment group. However, with the increasing number (N) of covariates X, finding such employee j in the control group (i.e., employee j with $X_{1j} = X_{1i}$, $X_{2j} = X_{2i}$, ..., $X_{Nj} = X_{Ni}$) is increasingly difficult. We can use the standardized Euclidean distance between (X_{1j}, X_{2j}, ..., X_{Nj}) and (X_{1i}, X_{2i}, ..., X_{Ni}) and adopt employee j with the shortest distance from employee i. However, an excessively large number of covariates N results in the curse of dimensionality. Therefore, propensity score matching is generally employed. In propensity score matching, $\mathrm{E}[Y_i|T_i = 0, X_{1i}, X_{2i}]$ is calculated as $\mathrm{E}[Y_i|T_i = 0, p(X_{1i}, X_{2i})]$, where $p(X_i)$ is $P(T_i = 1|X_i)$, which indicates the probability that employee i with covariate X_i is from the treatment group. Propensity score matching is supported by the following propensity score theorem.

Suppose the CIA holds for Y_{1i} *and* Y_{0i}. *Then* $\{Y_{1i}, Y_{0i}\} \perp T_i|p(X_i)$.

DD Analysis. Let us begin with the following equation:

$$Y_{it}^j = \alpha + \beta^j d_t + \gamma d^j + A d_t^j + \varepsilon_{it}^j$$

In the aforementioned equation, Y_{it}^j is the outcome of interest for unit i $(= 1, \ldots, N_t)$ of group j $(= 0,\ 1)$ in period t $(= 0,\ 1)$. $d_t = 1$ for $t = 1$ and $d_t = 0$ otherwise, whereas $d^j = 1$ for $j = 1$ and $d^j = 0$ otherwise. d_t^j is a dummy variable representing people in the treatment group after receiving the treatment. β^1 and β^0 summarize the ways that group $j = 0$ and group $j = 1$ are influenced by time, respectively. A time-invariant difference may be observed in the overall means between groups $j = 0$ and $j = 1$, which is represented by γ. A and ε_{it}^j are the true causal effect of the treatment on the treatment group outcome (i.e., ATET) and an error term, respectively.

The key identifying assumption is that A is 0 in the absence of the treatment (i.e., $\mathrm{E}[\varepsilon_{it}^j|d_t^j] = 0$). In this case,

$$\begin{aligned}
\bar{Y}_1^1 &= \alpha + \beta^1 + \gamma + A \\
\bar{Y}_0^1 &= \alpha + \gamma
\end{aligned}$$

$$\bar{Y}_1^0 = \alpha + \beta^0$$
$$\bar{Y}_0^0 = \alpha$$

where the bar, subscript, and superscript indicate the average over i, time period, and group, respectively. The DD of the aforementioned four factors (i.e., $\bar{Y}_1^1$, $\bar{Y}_0^1$, $\bar{Y}_1^0$, and $\bar{Y}_0^0$) can be represented as follows:

$$(\bar{Y}_1^1 - \bar{Y}_0^1) - (\bar{Y}_1^0 - \bar{Y}_0^0) = A + \beta^1 - \beta^0$$

This approach assumes that if β^1 and β^0 are identical, the ATET A can be obtained as follows: $(\bar{Y}_1^1 - \bar{Y}_0^1) - (\bar{Y}_1^0 - \bar{Y}_0^0)$. This is called *parallel trend assumption*.

3.2 Implementation

We conducted the matching analysis, DD analysis, and DD analysis with matching. In this study, *treatment* T mentioned in the previous subsection is the introduction of the designated administrator system (outsourcing). *Outcomes* (Y in the previous subsection) are library usage in terms of the following factors: (i) gate count per capita, (ii) number of loans per capita, and (iii) number of reference transactions per capita.

For the matching analysis, the sample included 3,253 public libraries listed in the *Statistics on Libraries in Japan* (2015). For the DD analysis, 3,811 public libraries listed in the *Statistics on Libraries in Japan* (2005–2015) were included in the sample because the 2005 edition includes the data on the first outsourcing library. We classified the libraries as outsourcing and direct management libraries based on *The Report on Public Libraries Managed by the Designated Administrator System* [15].

Matching. As discussed in Section 1, we compared (i) gate count per capita, (ii) number of loans per capita, and (iii) number of reference transactions per capita of outsourcing and direct management libraries. These were matched in terms of (a) the number of holdings, (b) number of acquisition, (c) size of the floors, (d) number of staffs, and (e) service population. In matching, the statistical computing software *R* [16] was used. First, *glm*—a generalized linear model function—was used for calculating propensity scores. Then, *match* function in the *Matching* package was used [17].

Table 1 shows the numbers of sample libraries. In Table 1, *OutSrc* and *DirectM* represent the outsourcing and direct management libraries, respectively. The sample libraries were classified based on their serving municipalities, that is, prefectures, ordinance-designated cities, Tokyo special wards, other cities, and towns and villages. Furthermore, the libraries were divided into two types, namely main libraries and annexes. The results of the analysis were obtained for each type and for all libraries combined. These data were obtained from *Statistics on Libraries in Japan* (2015) [1] published by the Japan Library Association.

Table 1. The number of sample libraries for matching

	N	
	OutSrc	DirectM
All Libraries	431	2,822
Prefectures	4	56
Main Libraries	4	43
Annexes	0	13
Ordinance-designated Cities	55	226
Main Libraries	1	19
Annexes	54	207
Tokyo Special Wards	99	124
Main Libraries	3	20
Annexes	96	104
Other Cities	216	1,865
Main Libraries	94	667
Annexes	122	1,198
Towns and Villages	57	551
Main Libraries	52	462
Annexes	5	89

DD Analysis. Let M be the year when a certain outsourcing library introduced the designated administrator system. The difference in the gate count per capita is defined as (A) the difference between the mean of the gate count per capita in M + 2 and in M + 1 and the mean of the gate count per capita in M − 1 and in M − 2. For example, for a certain outsourcing library with M = 2010, its gate count in 2008, 2009, 2011, and 2012 were 0.85, 0.95, 1.02, and 1.07, respectively. The difference of the gate count per capita for the library was calculated as follows: (1.02 + 1.07)/2 − (0.85 + 0.95)/2 = 0.15. The difference in the number of loans per capita and in reference transactions per capita were defined similarly. As mentioned in Section 1, we obtained such data from the *Statistics on Libraries in Japan* (2003–2015). Therefore, M varied from 2005 to 2013. Table 2 presents the number of outsourcing libraries for this analysis. The sample size of the libraries differs based on the type of library usage because of the missing data in the aforementioned *Statistics on Libraries in Japan*, which resulted in the exclusion of some of the libraries from the sample.

For the direct management libraries, the difference in the gate count per capita is defined similarly. For example, in the year M, the difference in the gate count per capita is defined as (B) the difference between the mean of the gate count per capita in M + 2 and in M + 1 and the mean of the gate count per capita in M − 1 and in M − 2. Contrary to outsourcing libraries, in direct management libraries, M has no particular meaning (e.g., a year when the designated administrator system was introduced). Table 2 shows the number of direct management libraries used for this analysis. The number of samples was higher than 10,000 because of numerous duplicates. For example, a library that was mentioned in the *Statistics on Libraries in Japan* from 2005 to 2015 appeared seven times in the data (M = 2007, 2008, ..., 2013).

In the DD analysis, we examined the statistical difference between (A) for outsourcing libraries and (B) for direct management libraries by using the Welch's t test.

Table 2. The number of sample libraries for the DD analysis with and without matching

	N					
	Gate Count		Loans		Reference Transactions	
	OutSrc	DirectM	OutSrc	DirectM	OutSrc	DirectM
All Libraries	236	12,609	256	17,853	178	12,262
Prefectures	3	482	3	468	3	497
Main Libraries	3	358	3	365	3	375
Annexes	0	124	0	103	0	122
Ordinance-designated Cities	25	1,007	23	1,371	27	1,541
Main Libraries	1	107	1	106	1	127
Annexes	24	900	22	1,265	26	1,414
Tokyo Special Wards	63	496	69	881	42	698
Main Libraries	1	112	1	147	1	116
Annexes	62	384	68	734	41	582
Other Cities	114	7,616	125	11,152	91	7,491
Main Libraries	59	3,581	73	4,770	43	3,606
Annexes	55	4,035	52	6,382	48	3,885
Towns and Villages	31	3,008	36	3,981	15	2,035
Main Libraries	28	2,648	33	3,533	14	1,834
Annexes	3	360	3	448	1	201

DD Analysis with Matching. In the DD analysis, the similarity between outsourcing and direct management libraries was not considered. In the DD analysis with matching, we first found the direct management libraries that were similar to each outsourcing library and then calculated the difference between (A) and (B) mentioned in the previous subsection. As mentioned in matching subsection, *glm* was again used for calculating propensity scores and then *match* function was used to find similar libraries. The number of sample libraries are the same as those in Table 2.

4 Results and Discussion

Table 3 presents the results of the straightforward comparison of outsourcing libraries and direct management libraries (i.e., without using causal analysis). In Table 3, the left-most column represents the types of municipalities of the libraries and the top row represents library usage. The "**" and "*" in column "S" indicate that differences between the left-hand outsourcing and direct management libraries were statistically significant at 0.01 and 0.05 levels, respectively. For example, the average gate count per capita for all outsourcing and direct management libraries were 1.3557 and 0.9172, respectively, and their difference was statistically significant at a 0.05 level.

The straightforward comparison of the gate count per capita of all the outsourcing and direct management libraries did not exhibit statistical difference at a 0.01 level. By contrast, the gate count and number of loans of libraries in the "Other Cities" category exhibited statistical differences at a 0.01 level.

Table 3. Results of straightforward comparison between outsourcing and direct management libraries

	Gate Count			Loans			Reference Transactions		
	OutSrc	DirectM	S	OutSrc	DirectM	S	OutSrc	DirectM	S
All Libraries	1.3557	0.9172	*	2.2095	2.1063		0.0161	0.0155	
Prefectures	0.5092	0.1706		0.3850	0.1880		0.0282	0.0085	
Main Libraries	0.5092	0.2070		0.3850	0.2333		0.0282	0.0102	
Annexes	—	0.0501		—	0.0379		—	0.0030	
Ordinance-designated Cities	0.2028	0.1817		0.2728	0.3454		0.0054	0.0054	
Main Libraries	0.4141	0.5482		0.4078	1.2999		0.0744	0.0228	
Annexes	0.1989	0.1481		0.2702	0.2577		0.0041	0.0038	
Tokyo Special Wards	0.7029	0.6512		0.8932	1.0155		0.0085	0.0128	
Main Libraries	4.5794	1.6683		3.1428	2.5604		0.0697	0.0353	
Annexes	0.5817	0.4556		0.8229	0.7184		0.0066	0.0084	
Other Cities	1.2219	0.7227	**	2.3240	1.7782	**	0.0173	0.0144	
Main Libraries	2.0919	1.5744	*	4.0880	3.7334		0.0292	0.0287	
Annexes	0.5516	0.2485	**	0.9649	0.6897	*	0.0081	0.0065	
Towns and Villages	4.1681	2.0130	*	6.0585	4.3793	*	0.0343	0.0246	
Main Libraries	4.4969	2.3212	*	6.4898	5.0220	*	0.0360	0.0278	
Annexes	0.7485	0.4131		1.5734	1.0432		0.0159	0.0081	

4.1 Matching

Table 4 shows the matching results. In Table 4, the left-most column and top row represent the types of libraries and library usage, respectively. The "**" and "*" in column "S" indicate that the left-hand ATETs were statistically significant at 0.01 and 0.05 levels, respectively. Table 4 shows that the average gate count per capita of all the outsourcing libraries was 1.3557, which was higher than that for all the direct management libraries by 0.4647. The difference was statistically significant at a 0.01 level, which was inconsistent with the results obtained through the straightforward comparison. "Other Cities" libraries exhibited a statistical significance at a 0.01 level in terms of the gate count, which was inconsistent with the results obtained through the straightforward comparison.

Table 4 shows that almost all the ATETs are positive, which indicates that outsourcing libraries exhibited higher usage in terms of all factors than direct management libraries; however, the differences were not statistically significant.

Table 4. Matching results

	Gate Count			Loans			Reference Transactions		
	OurSrc	ATET	S	OurSrc	ATET	S	OurSrc	ATET	S
All Libraries	1.3557	0.4647	**	2.2095	0.2440		0.0161	0.0010	
Prefectures	0.5092	0.2407		0.3850	0.1237		0.0282	0.0173	
Main Libraries	0.5092	0.2513		0.3850	0.1664		0.0282	0.0181	
Annexes	—	—		—	—		—	—	
Ordinance-designated Cities	0.2028	0.0399		0.2728	−0.0660		0.0054	0.0020	
Main Libraries	0.4141	—		0.4078	—		0.0744	—	
Annexes	0.1989	0.0447		0.2702	0.0219		0.0041	0.0010	
Tokyo Special Wards	0.7029	0.1742		0.8932	0.0434		0.0085	0.0037	
Main Libraries	4.5794	2.7431		3.1428	1.3758		0.0697	0.0520	
Annexes	0.5817	0.1195		0.8229	−0.0007		0.0066	0.0012	
Other Cities	1.2219	0.3288	**	2.3240	0.3499	*	0.0173	0.0024	
Main Libraries	2.0919	0.4251		4.0880	0.2762		0.0292	0.0014	
Annexes	0.5516	0.1767	*	0.9649	0.0098		0.0081	−0.0017	
Towns and Villages	4.1681	1.4083		6.0585	0.7562		0.0343	0.0065	
Main Libraries	4.4969	1.8844		6.4898	0.9769		0.0360	0.0083	
Annexes	0.7485	0.5620	**	1.5734	−0.7419		0.0159	0.0062	

4.2 DD Analysis

Before performing the DD analysis, we examined the validity of the parallel trend assumption (mentioned in subsection 3.1) for the data. Figs. 1, 2, and 3 show the trend of usage of the three libraries.

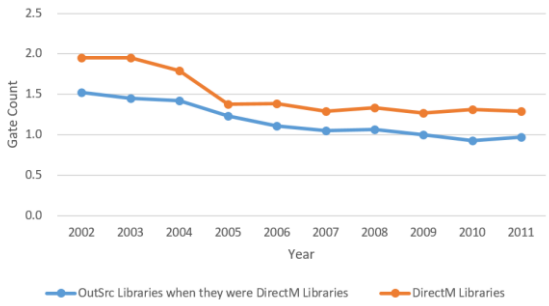

Fig. 1. Trend of gate count per capita for outsourcing and direct management libraries

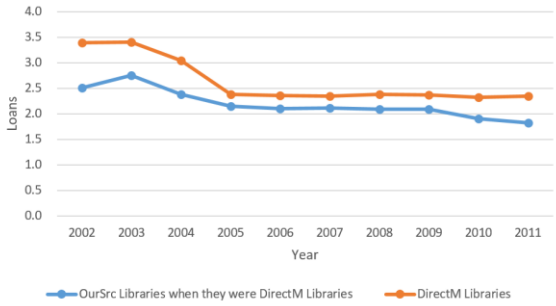

Fig. 2. Trend of the number of loans per capita of outsourcing and direct management libraries

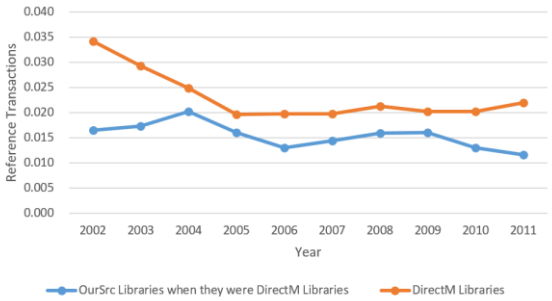

Fig. 3. Trend of the number of reference transactions per capita of outsourcing and direct management libraries

These figures indicate parallel trends. Furthermore, we conducted a regression analysis by setting (1) the year as an explanatory variable and (2) the difference in the library usage of outsourcing and direct management libraries as an explained variable. For all library usage in terms of the three factors, a hypothesis of zero regression coefficients was not rejected. These results indicate that the parallel trend assumption was valid for the data. Figs. 1–3 show that curves of "OutSrc Libraries when they were DirectM Libraries" were consistently lower than those of "DirectM Libraries." It means that usage of libraries which introduced outsourcing were relatively lower before the introduction. We will discuss this point later.

Table 5 shows the results of the DD analysis. In Table 5, for example, the average gate count per capita of all libraries that introduced outsourcing increased 0.2261 after the introduction. This is (A) mentioned in subsection 3.2. By contrast, the average gate count per capita for all the direct management libraries increased −0.0343 (or decreased 0.0343). This is (B) mentioned in subsection 3.2. The "DD" is the difference between (A) and (B), and for all libraries, this difference reached 0.2603. This difference between (A) and (B) was statistically significant at 0.01 level, which is shown in the "S" column.

Furthermore, significant differences were observed in the gate count per capita, with a 0.01 significance level for libraries in the ordinance-designated cities and other cities. Moreover, significant differences were observed in the number of loans, at a 0.01 significance level for all libraries, including those in ordinance-designated cities, Tokyo special wards, and other cities.

The following observations were made: (1) Tables 4 and 5 revealed significant differences in different types of library usage in different libraries. More significant differences were observed in the DD analysis than in matching. (2) Although the DD analysis revealed the difference in the *chronological changes* of the two investigation targets, the matching analysis indicated the difference in the *current status* of the targets. (3) Furthermore, we found that the curves of "OutSrc Libraries when they were DirectM Libraries" (Figs. 1–3) were consistently lower than those of "DirectM Libraries." The aforementioned observations indicated that (i) outsourcing is generally introduced to the libraries with relatively low usage, and (ii) outsourcing increases the usage significantly than the direct management libraries; (iii) however, the amounts of usage have not reached the level where significant differences (from direct management libraries) were observed. However, let us emphasize again that matching showed that

the usage of outsourcing libraries was higher than direct management libraries in terms almost all factors, although this increase was not statistically significant.

Table 5. Results of DD analysis

	Gate Count				Loans				Reference Transactions			
	Differences		DD	S	Differences		DD	S	Differences		DD	S
	OutSrc	DirectM	(ATET)		OutSrc	DirectM	(ATET)		OutSrc	DirectM	(ATET)	
All Libraries	0.2261	−0.0343	0.2603	**	0.1679	−0.0044	0.1723	**	0.0041	0.0008	0.0033	
Prefectures	0.3753	−0.0024	0.3777		0.2368	0.0012	0.2356		0.0170	0.0004	0.0167	
Main Libraries	0.3753	−0.0038	0.3791		0.2368	0.0010	0.2358		0.0170	0.0005	0.0165	
Annexes	—	0.0016	—		—	0.0020	—		—	−0.0001	—	
Ordinance-designated Cities	0.0208	−0.0087	0.0295	**	0.0421	−0.0055	0.0477	**	0.0005	0.0004	0.0001	
Main Libraries	−0.0060	−0.0195	0.0135		0.0442	0.0335	0.0107		0.0059	0.0012	0.0047	
Annexes	0.0219	−0.0075	0.0293	**	0.0421	−0.0088	0.0509	**	0.0003	0.0003	0.0000	
Tokyo Special Wards	0.2772	−0.0268	0.3040		0.1389	0.0141	0.1248	**	0.0048	−0.0029	0.0077	
Main Libraries	13.8551	−0.0343	13.8894		2.5164	0.0445	2.4719		0.2240	−0.0002	0.2242	
Annexes	0.0582	−0.0246	0.0829	**	0.1040	0.0081	0.0959	**	−0.0005	−0.0034	0.0029	*
Other Cities	0.1872	−0.0094	0.1966	**	0.2797	0.0254	0.2542	**	0.0073	0.0010	0.0062	*
Main Libraries	0.3060	−0.0221	0.3281	**	0.4206	0.0411	0.3795	**	0.0111	0.0015	0.0095	
Annexes	0.0597	0.0018	0.0579	**	0.0819	0.0138	0.0681		0.0038	0.0006	0.0033	**
Towns and Villages	0.4163	−0.1120	0.5283	*	−0.0901	−0.0922	0.0021		−0.0131	0.0017	−0.0148	
Main Libraries	0.4531	−0.1196	0.5727		−0.0905	−0.0946	0.0041		−0.0146	0.0017	−0.0163	
Annexes	0.0727	−0.0566	0.1293	*	−0.0855	−0.0734	−0.0121		0.0075	0.0015	0.0060	

4.3 DD Analysis with Matching

Table 6 shows the results of the DD analysis with matching. In Table 6, the average gate count per capita for all libraries that introduced outsourcing increased 0.2261 after the introduction (consistent with the results in Table 5). This is (A) as mentioned in subsection 3.2. By contrast, the average gate count per capita of all direct management libraries (and judged as similar to outsourcing ones by matching) increased 0.0203. This is (B) as mentioned in subsection 3.2. The "DD" is the difference between (A) and (B), which reached 0.2058 for all libraries. This difference between (A) and (B) was statistically significant at a 0.01 level (the "S" column). Moreover, "—" in Table 6 indicates that the difference or ATET could not be calculated because of the small sample size.

Significant difference was observed in the gate count per capita, at a 0.01 significance level for libraries in the ordinance-designated cities. Significant differences were observed in the number of loans, at a 0.01 significance level for all libraries, including those in ordinance-designated cities, Tokyo special wards, and other cities.

Similar results are presented in Tables 5 and 6. However, Table 6 presents more reliable results than Table 5 because the compared direct management libraries are similar to outsourcing libraries in terms of the following factors: (a) the number of holdings, (b) number of acquisition, (c) size of the floors, (d) number of staffs, and (e) service population, as mentioned in subsection 3.2. The parallel trend assumption ($\beta^1 = \beta^0$ in subsection 3.2) was more reliable in the DD analysis with matching than in the simple DD analysis[2].

[2] Here, we ignore the difference of the number of samples used in these methods.

Table 6. Results of DD analysis with matching

	Gate Count				Loans				Reference Transactions			
	Differences		DD	S	Differences		DD	S	Differences		DD	S
	OutSrc	DirectM	(ATET)		OutSrc	DirectM	(ATET)		OutSrc	DirectM	(ATET)	
All Libraries	0.2261	0.0202	0.2058	**	0.1679	0.0049	0.1630	**	0.0041	0.0015	0.0026	
Prefectures	0.3753	0.0451	0.3302		0.2368	—	—		0.0170	—	—	
Main Libraries	0.3753	—	—		0.2368	—	—		0.0170	—	—	
Annexes	—	—	—		—	—	—		—	—	—	
Ordinance-designated Cities	0.0208	0.0012	0.0196	**	0.0421	−0.0121	0.0543	**	0.0005	−0.0005	0.0010	
Main Libraries	−0.0060	—	—		0.0442	—	—		0.0059	—	—	
Annexes	0.0219	−0.0071	0.0289	**	0.0421	−0.0113	0.0534	**	0.0003	−0.0003	0.0005	
Tokyo Special Wards	0.2772	−0.0179	0.2951		0.1389	−0.0176	0.1566	**	0.0048	—	—	
Main Libraries	13.8551	—	—		2.5164	—	—		0.2240	—	—	
Annexes	0.0582	−0.0354	0.0936	**	0.1040	−0.0299	0.1339	**	−0.0005	−0.0004	−0.0001	
Other Cities	0.1872	0.0389	0.1483	*	0.2797	0.0043	0.2754	**	0.0073	0.0013	0.0060	*
Main Libraries	0.3060	0.0550	0.2511		0.4206	0.0356	0.3850	**	0.0111	−0.0006	0.0116	
Annexes	0.0597	0.0278	0.0319		0.0819	0.0178	0.0640		0.0038	0.0004	0.0034	**
Towns and Villages	0.4163	−0.8283	1.2446		−0.0901	−0.4522	0.3621		−0.0131	−0.0008	−0.0123	
Main Libraries	0.4531	−1.0244	1.4775		−0.0905	−0.0727	−0.0178		−0.0146	−0.0023	−0.0123	
Annexes	0.0727	0.0391	0.0337		−0.0855	−0.3200	0.2345		0.0075	—	—	

4.4 Results on Particular Designated Administrator

The aforementioned results could be attributed to a particular designated administrator (or a particular corporation and foundation). We identified the three highest ranking corporations and foundations administrating most libraries, which are denoted as A, B, and C. Tables 7 and 9 presents the results of matching and DD analyses of the libraries administrated by them. Tables 8 and 10 present the number of samples of these analyses. Tables 7 and 9 reveal that numerous ATETs of “Others” (i.e., outsourcing libraries administrated by other than A, B, and C) were statistically significant. This observation indicates that significant ATETs in the previous subsections were not obtained by only A, B, and C. Because of the length restrictions, the results of the DD analysis with matching, which indicated similar tendencies, were omitted.

Table 7. Matching results on libraries administrated by A, B, and C

	Gate Count			Loans			Reference Transactions		
	OurSrc	ATET	S	OurSrc	ATET	S	OurSrc	ATET	S
A	1.1325	0.0918		2.2012	−0.0520		0.0139	−0.0032	
B	0.3747	−0.4311		0.5443	−0.9167	(**)	0.0053	−0.0103	
C	0.2514	−0.4220		0.3674	−1.0609	(**)	0.0142	0.0050	
Others	1.5297	0.6260	**	2.3748	0.4759	*	0.0176	0.0024	

Table 8. The number of sample libraries for matching regarding A, B, and C

	N	
	OutSrc	DirectM
A	104	2,822
B	17	
C	11	
Others	299	

Table 9. Results of DD analysis on libraries administrated by A, B, and C

	Gate Count				Loans				Reference Transactions			
	Differences		DD	S	Differences		DD	S	Differences		DD	S
	OutSrc	DirectM	(ATET)		OutSrc	DirectM	(ATET)		OutSrc	DirectM	(ATET)	
A	0.1816	−0.0343	0.2158	**	0.2055	−0.0044	0.2098	**	−0.0008	0.0008	−0.0016	
B	0.0219		0.0562	**	0.0002		0.0046		0.0009		0.0001	
C	0.0296		0.0639	**	0.0493		0.0537	**	0.0005		−0.0003	
Others	0.2770		0.3113	**	0.1706		0.1750	*	0.0082		0.0074	

Table 10. The number of sample libraries for DD analysis regarding A, B, and C

	N					
	Gate Count		Loans		Reference Transactions	
	OutSrc	DirectM	OutSrc	DirectM	OutSrc	DirectM
A	68	12,609	82	17,853	60	12,262
B	11		13		14	
C	11		11		11	
Others	146		150		93	

5 Conclusions

In this study, we examined the causal effects of introducing outsourcing on the usage of Japanese public libraries. In matching, the average gate count per capita of all the outsourcing libraries was higher than that of all the direct management libraries. Similar results were observed for “Other Cities” libraries. In the DD analysis, the average gate count per capita and number of loans per capita of all the outsourcing libraries were higher than those of all the direct management libraries, and similar results were obtained for libraries in “Ordinance-designated Cities” and “Other Cities”. Furthermore, among libraries in “Tokyo Special Wards,” the average number of loans of outsourcing libraries was higher than that of direct management ones. All of these differences were statistically significant at 0.01 level. In DD analysis with matching, almost the same could be said. Most of these results were different from the straightforward comparison of outsourcing libraries and direct management ones (see Table 3). Furthermore, these results could not be attributed to the influence of particular designated administrators (Tables 7 and 9).

These results validate that introducing the designated administrator system increases the gate count per capita. Considering the difference in the characteristics of the matching and DD analyses (as mentioned in the last paragraph of subsection 4.2), it is highly probable that the same can be said for the number of loans per capita. If the ordinance-designated cities and other cities intend to increase the gate count and the number of loans of their libraries, introducing outsourcing will be beneficial.

We must consider whether outsourcing libraries are attracting people with “popular” books, such as novels. However, a study by Mizunuma and Tsuji (2017b) [10] provides contrasting results. They reported that direct management libraries generally have more novels than outsourcing libraries, whereas outsourcing libraries generally have more reference books than direct management libraries.

In future, the condition of employment of librarians in outsourcing libraries, especially per-hour salaries, can be investigated. We must examine whether the aforementioned increase is achieved at the cost of outsourcing librarians overworking with low salaries.

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