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Does official development assistance benefit the donor economy?

New evidence from Japanese overseas infrastructure projects

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Abstract

Given the growing pressure on donors to curtail foreign aid budgets, analyzing the effectiveness of bilateral official development assistance (ODA) in realizing national interests has become more significant than ever. From the viewpoint of economic interests, prior research has revealed that ODA can help expand donor exports and outward foreign direct investments. This study provides evidence that ODA can also help firms from donor countries to win infrastructure projects in recipient countries. Employing unique contract data on Japanese overseas infrastructure projects, I estimate a fixed effects Poisson model with a panel dataset for 158 recipients for the period between 1970 and 2020. The results suggest that 17% of the total number of overseas infrastructure projects contracted to Japanese firms during 1970–2020 were attributable to Japanese ODA disbursement. I also explore the potential mechanism, finding that the Japanese ODA-infrastructure link is strengthened when Japanese loans and grants are simultaneously provided to a recipient country. This finding is consistent with the view that pre-investment studies conducted as part of technical cooperation could generate goodwill effects on Japanese firms during their bidding for Japanese yen loan projects.

Keywords: Official development assistance; overseas infrastructure projects; Poisson regression model; Japan

JEL codes: F35, F21, O18

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1. Introduction

Rapid economic growth and urbanization in developing countries are projected to generate considerable infrastructure demand in the coming decades. For example, 32 developing countries in Asia need an estimated investment of US$1.7 trillion per year in the transport, power, telecommunications, and water supply and sanitation sectors from 2016 to 2030 (Asian Development Bank 2017). Given its natural monopolistic characteristics and underlying roles in social equity and stability, infrastructure has been predominantly supplied by government or public agencies. However, the critical role of private enterprises in meeting infrastructure investment needs has increasingly been recognized because of the limited source of public finance. Technological progress and deregulation in recent decades have also rendered the infrastructure sectors more competitive (Asian Development Bank 2017).

Securing growing infrastructure demands in developing countries has become a key policy issue in advanced economies. While domestic infrastructure stocks have already reached a sufficient level, some advanced economies, such as Japan, are also confronted with an aging and shrinking population (Yamamoto 2015; Endo and Murashkin 2022). In addition, the development of quality infrastructure in developing countries has reduced communication and transaction costs, enabling multinational enterprises to organize their value chains globally (Baldwin 2012; Blyde and Molina 2015; Nishitateno 2013, 2015).

In May 2013, the Japanese government announced the Infrastructure System Overseas Promotion Strategy (ISOPS) to facilitate securing of overseas infrastructure projects worth 30 trillion yen (US$ 300 billion) by 2020, approximately 6% of Japan’s real gross domestic product (GDP), by Japanese firms. In December 2020, ISOPS was renewed, with a new target of 34 trillion yen (US$ 340 billion) by 2025. Under the ISOPS, together with “top-sale” by the prime minister and ministers, the utilization of official development assistance (ODA) has been a key policy tool to achieve the targets. For example, tying arrangements in Japanese yen loans have increased by relaxing conditions and expanding applicable areas for the Special Terms for Economic Partnership (STEP), which directly links Japanese firms to yen loan projects.[1] The utilization of Japanese yen loans has also expanded to cover the risks of exchange rate fluctuations and compensate for capital shortfalls of Japanese firms for executing overseas infrastructure projects.

A positive relationship between Japanese ODA and infrastructure projects is presented in Figure 1, which shows a scatter plot of the mean number of overseas infrastructure projects contracted to Japanese firms and the mean value of Japanese ODA commitment flows for the 158 recipients during 1970–2020. The figure applies natural logarithms to both indicators and normalizes the recipient population. The figure implies that Japanese ODA helps Japanese firms win bids for infrastructure projects in the recipient country.

A causal interpretation based on Figure 1 is less convincing as it masks a temporal variation within the variables and potential confounding factors are not controlled for. In addition, how much, or even whether Japanese ODA is linked to overseas infrastructure projects executed by Japanese firms has been questioned. Despite the heavy involvement of Japanese ODA in the early stages of project formation, recent years have witnessed Japanese firms losing over some infrastructure project biddings, such as the 2015 high-speed rail bid in

[1] The STEP was introduced in July 2002 to raise the visibility of Japanese ODA among citizens in both recipient countries and Japan by optimal utilizing advanced technologies and know-how of Japanese firms. For more details, see: https://www.jica.go.jp/english/our_work/types_of_assistance/oda_loans/step/index.html

Indonesia (Harding et al. 2015). According to the Japan International Cooperation Agency (JICA 2020), Japanese firms accounted for only 25% of all Japanese yen loan projects in 2020.

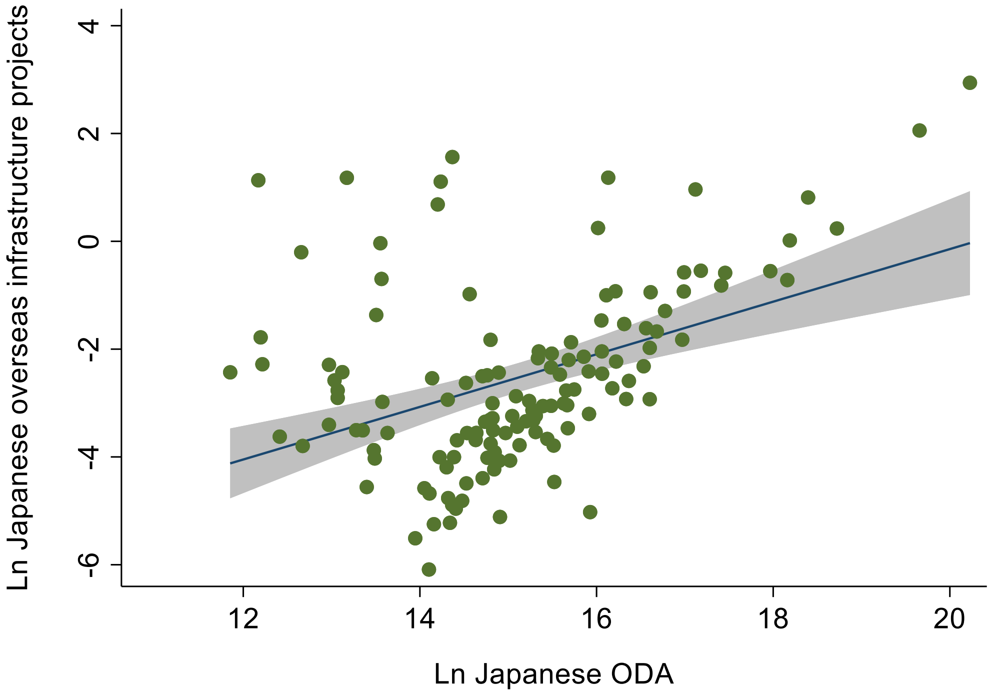

Figure 1. Japanese ODA and Infrastructure Projects

Notes: The figure shows a scatter plot of the logarithm of the mean number of overseas infrastructure projects contracted to Japanese firms (y-axis) and the logarithm of the mean value of Japanese ODA commitment flows (x-axis) during 1970–2020. Both variables are normalized by the recipient population (one million terms). The correlation coefficient is 0.43. The figure includes all the recipients (158) in the sample. See Appendix B for a list of recipients.

Empirical evidence on ODA-infrastructure links is scarce. Prior research analyzing the effect of ODA on the donor economy has predominantly focused on merchandise and service exports (Hoekman and Shingal 2020; Kruse and Martínez-Zarzoso 2021; Nishitateno and

Umetani 2023) and outward foreign direct investment (Kimura and Todo 2010; Lee and Ries 2016). Nishitateno and Umetani (2023) has analyzed ODA-infrastructure links, however the mechanism behind the links was not explored. The lack of evidence regarding ODA-infrastructure links primarily emanates from the difficulty in accessing reliable and comprehensive data on overseas infrastructure projects. This study employed unique contract data on Japanese infrastructure projects worldwide, combining with various ODA data including tied aid.

The empirical method involves estimating a fixed effects Poisson regression model with a panel dataset covering 158 recipient countries for the period between 1970 and 2020. The Poisson regression is employed because the outcome variable in this study (total number of infrastructure projects contracted to Japanese firms) is count data that takes many zero values. To disentangle the effect of Japanese ODA from other effects, the model controls for various time-varying factors: income, population, bilateral trade, exchange rates, free trade agreement status, other ODA inflows, mutual visits of top political dignitaries, and natural disasters. To address the concern over potential serial correlation, I report robust standard errors clustered by recipient throughout the analyses.

I find that the elasticity of the total count of overseas infrastructure projects contracted to Japanese firms in Japanese ODA projects is 0.17 on average, holding other factors constant. The results suggest that Japanese ODA promoted 1,590 Japanese overseas infrastructure projects from 1970 to 2020, accounting for 17% of the total infrastructure projects that Japanese firms had received during the sample period.

Additional analyses complement the main results described above. First, analyzing heterogeneous ODA-infrastructure elasticities, I find that the elasticity of Japanese grants, particularly technical cooperation, is greater than that of Japanese loans and that the elasticity is the largest in South Asia. Second, to examine potential endogeneity biases, I estimate the specification that accounts for recipient-specific time trends and adopt a two-step system generalized method of moments (GMM) estimator to the dynamic panel model. I find that the ODA-infrastructure elasticities are reduced to 0.09–0.10, suggesting that the estimated elasticity in the main specification should be regarded as an upper bound. Finally, I explore the potential mechanisms underlying the Japanese ODA-infrastructure link, finding that the link is strengthened when loans and grants are simultaneously provided. No noticeable effect of the tying arrangements, including STEP, is observed in this study.

The remainder of this paper is organized as follows. Section 2 describes the data used in the analysis. Section 3 provides an overview of Japanese ODA in terms of its trends and characteristics, tying arrangements, and institutional setup. Section 4 explains the empirical approach, including model specifications and estimation techniques. Section 5 reports the estimation results, the robustness of the main estimates, and the potential mechanisms underlying the ODA-infrastructure links. Finally, Section 6 concludes the study.

2. Data

Data on overseas infrastructure projects executed by Japanese firms were obtained from "Plant Exports for 50 Years" compiled by the Heavy & Chemical Industries News Agency Co., Ltd. (HCINA) in Japan. Infrastructure projects comprise sectors such as energy and chemicals, electric power, transport, metalwork, water utility, garbage disposal, communication, and urban development. The HCINA provides information on project plans (e.g., construction of hydrogen power plant), contract year and duration, project site (country), contractee, contractor, service, and value for 12,903 projects across 181 countries from 1965 to 2014. In most cases, contractees are public entities whereas contractors are private firms. The services provided by contractors include equipment procurement, engineering, construction, operation, technical support, and design. To extend the time horizon, I extracted data from the Annual Report on Plant Exports compiled by the HCINA for 2015–2020.

Using the HCINA data, I constructed an outcome variable measuring the total count of infrastructure projects in the recipient country contracted to Japanese firms in each (contract) year. This outcome variable is a count variable that takes on relatively few non-negative integer values ranging from 0 to 70, with a highly skewed distribution (see (a) Raw data in Appendix A). Zero count accounts for 72% of the observations, followed by one-count (10%), two-count (5%), three-count (3%), and four-count (2%).

Using the Organisation for Economic Co-operation and Development (OECD)'s OECD.Stat database, I obtained data on bilateral ODA flows for Japan, Development Assistance Committee (DAC) countries excluding Japan, non-DAC countries, and multilateral ODA flows during 1970–2020. The OECD database also allows the collection of ODA data by loans, grants, and technical cooperation. By subtracting grants from technical cooperation, I created a grant-in-aid for assistance. All ODA variables were measured based on constant US$ (2020 price) and commitments. I used commitment rather than disbursement data to align with the tied ODA data for Japan, which are available only for commitments.

The Japanese ODA variables include missing values that appear non-random, potentially resulting in biased estimates. For example, richer recipients tend to exhibit more missing observations as they are less likely to receive aid, or even if they do, the aid amounts are too small to be recorded. In addition, Japanese loans are concentrated in Asian countries. To address this issue and simultaneously avoid a loss of observations, I added one (US$ 1) to the Japanese ODA variables before their logarithmic transformations. I included a dummy variable in the model to account for instances when the Japanese ODA equaled zero, similar to existing works such as Wagner (2003).

The tied ODA data for Japan were obtained from the ODA Loan Project Data compiled by JICA.[2] The JICA database provides information on each yen loan project, including the project site (country), sector, contract year, project value, tying status, and adoption of STEP, for 3,564 projects across 110 countries from 1966 to 2022. The status of tying arrangements can be classified into "tied," "untied," and "partially untied." In this paper, I regarded a project as a tied arrangement when the project was either "tied," or "partially untied." The JICA database does not provide the Japan's tied ODA data for grant projects.

Using the JICA database, I created three dummy variables: (i) a dummy variable taking the value of one if a recipient received a tied yen loan in each year, (ii) a dummy variable taking the value of one if a recipient received a completely tied yen loan in each year (excluding the partially untied), and (iii) a dummy variable if a recipient received a tied yen loan based on the STEP in each year. Note that (iii) takes values only after 2002 when the STEP was introduced, and (iii) is a subset of (i).

I obtained data on recipient GDP per capita, measured in current US$, and population from the World Development Indicators compiled by the World Bank. I used the United Nations (UN) Comtrade database compiled by the UN to obtain information on bilateral trade flows (exports + imports) between Japan and each recipient, measured in current US$. I extracted the bilateral nominal exchange rate, measured as the national recipient currency per Japanese yen, from the United Nations Conference on Trade and Development (UNCTAD). Recipient data on natural disasters were obtained from the International Disaster Database

[2] https://www2.jica.go.jp/en/yen_loan/index.php

compiled by UCLouvain.[3] Natural disasters in this database include a wide range of phenomena such as earthquakes, storms, floods, droughts, and epidemics. The natural disaster variable in this study counts all the above phenomena.

Data on overseas visits by Japanese prime ministers and ministers were collected from the Diplomatic Bluebook compiled by the Ministry of Foreign Affairs of Japan (MOFA). All ministers were counted, regardless of the ministries and government offices. Using the same data source, I also collected data on visits to Japan by the recipient prime ministers (or presidents). Finally, I obtained information on the recipient status of the Economic Partnership Agreement (EPA) with Japan from the MOFA's website.

Combining the information explained above, I constructed a long-run panel dataset covering 158 recipients from 1970 to 2020.[4] The sample accounts for 92% of all recipients who received ODA from Japan at least once during 1970–2020. The period before 1970 was excluded because UNCTAD data on bilateral nominal exchange rates are available from 1970 onwards. The latest year available for many variables when authoring this paper was 2020. The panel is unbalanced because (i) some developing countries graduated from aid recipients during the sample period, (ii) some variables include missing values, and (iii) data are not available for some years. The number of observations in the sample was 6,646, accounting for 82% of the full observations.

[3] https://public.emdat.be/

[4] Appendix B lists the recipients in the sample.

Table 1: Summary Statistics

	Mean	S.D.	Min	Max
Infrastructure projects contracted to Japanese firms	1.4	4.5	0	70
Ln Japanese ODA	14.6	5.0	0	23
Ln Japanese loan	3.6	7.3	0	23
Ln Japanese grant	14.2	4.7	0	22
Ln Japanese technical cooperation	13.3	4.6	0	20
Ln Japanese grant-in-aid for assistance	10.5	7.4	0	22
Zero Japanese ODA dummy	0.08	0.27	0	1
Zero Japanese loan dummy	0.80	0.40	0	1
Zero Japanese grant dummy	0.08	0.28	0	1
Zero Japanese technical cooperation dummy	0.09	0.29	0	1
Zero Japanese grants-in-aid for assistance dummy	0.32	0.47	0	1
Dummy if a Japanese loan is tied	0.06	0.23	0	1
Dummy if a Japanese loan is completely tied	0.03	0.16	0	1
Dummy if Japanese tied loan is based on STEP	0.01	0.11	0	1
Ln ODA from DAC countries excluding Japan	18.2	2.6	0	24
Ln ODA from non-DAC countries	5.8	7.3	0	23
Ln ODA from multilateral institutions	17.4	3.1	0	22
Ln GDP per capita	7.2	1.3	3	11
Ln population	15.1	2.3	9	21
Number of natural disasters	1.5	3.1	0	43

Ln bilateral trade	18.2	2.6	7	27
Dummy if EPA was in force	0.02	0.13	0	1
Dummy if Japan’s prime minister visited the recipient	0.04	0.19	0	1
Dummy if Japan’s ministers visited the recipient	0.09	0.28	0	1
Dummy if the recipient prime minister visited Japan	0.11	0.31	0	1
Exchange rates	4.61	22.18	0	393

Notes: This table presents summary statistics for the sample in the recipient-year panel dataset (158 recipients, 1970–2020). I add US$ 1 to all ODA variables. The number of observations is 6,646 for all variables.

Table 1 reports the summary statistics for all variables used in the estimations. The mean count of infrastructure projects contracted to Japanese firms was 1.4. The mean Japanese ODA was 14.6 in the natural logarithm term. The mean scale of Japanese loans was far smaller than that of grants, reflecting a larger share of zero value for loans (80%) than for grants (8%).[5] The tied loans account for only 6% of the observations. The completely tied loans and the STEP loans were even smaller. As expected, the mean scales of ODA flows from DAC countries (excluding Japan) and multilateral institutions are larger than those from Japan. The EPAs that were in force during 1970–2020 accounted for 2% of the observations. The visits of Japanese prime ministers and ministers to recipient countries accounted for 4% and 9% of the observations, respectively. The interpretation of exchange rates is not meaningful because currency units differ among recipients.

[5] The mean scale of Japanese loan (17.9 in the natural logarithm term) is larger than that of grant (15.5), when the observation is limited to nonzero values.

3. Japanese ODA

3.1. Trends and characteristics

The origin of the Japanese ODA dates to October 1954, when Japan joined the Colombo Plan, through which Japan began to provide economic support to South and Southeast Asian nations, including the first ODA loan to India in 1958. The first Japanese grant was provided in 1969. Japan's aid programs gradually evolved into a full-fledged Western-style ODA after joining the DAC and OECD in the 1960s (Jain 2020). As described below, the Japanese ODA has contributed to the development of economic infrastructure in Asia through yen loans over the past 50 years.

Figure 2 plots the trend in bilateral Japanese ODA flows to 158 recipients in the sample and its share in the world ODA flows, including bilateral and multilateral flows, from 1970 to 2020. Although some fluctuations exist, Japanese ODA has grown from US$ 3.3 billion in 1970 to US$ 19.5 billion in 2020. While the share of Japanese ODA increased until the 1990s, peaking at 22% in 1997, it declined continuously thereafter, largely because of the prolonged recession and alarmingly high public debt level (Kato 2016). As of 2020, Japanese ODA accounted for 11% of the global ODA.

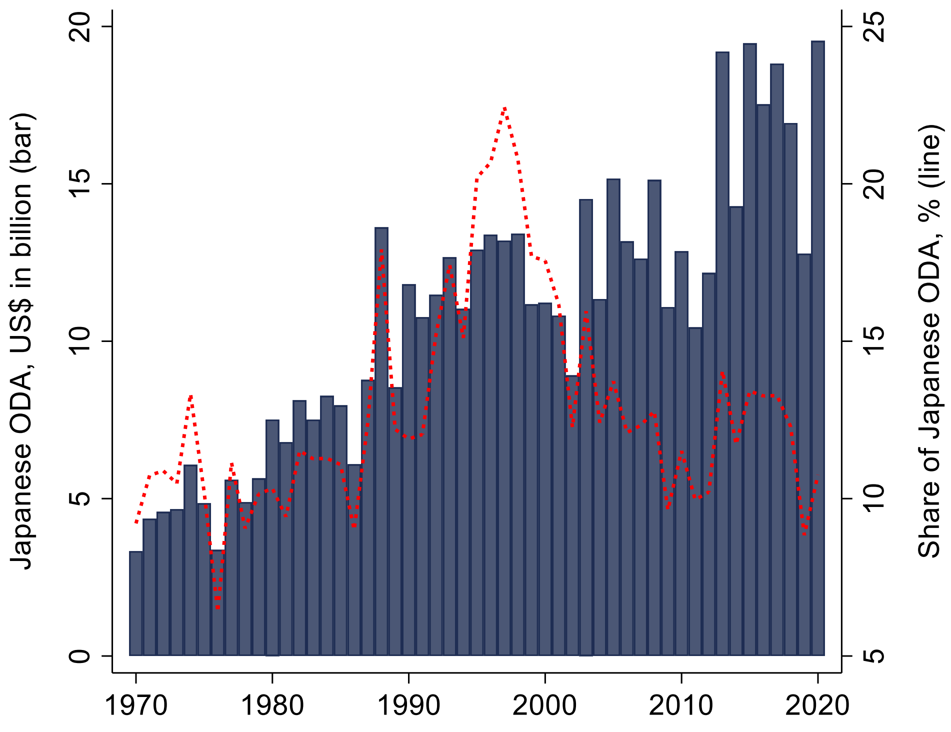

Figure 2. Trends in Japanese ODA

Notes: The bars represent the total commitment of bilateral Japanese ODA flows to 158 recipients in the sample. The dotted line shows the share of Japanese ODA in world ODA commitment flows, including both bilateral and multilateral flows.

Source: Created using OECD.Stat.

Table 2 reports the aggregated amounts of ODA flows during 1970–2020 for Japan, DAC countries (excluding Japan), non-DAC countries, and multilateral institutions. Japanese ODA is characterized by several aspects. The first is its high share of loans (71%), largely because of the "self-help" principle and the large savings in the postal saving system available even under budgetary constraints (Akiyama and Nakao 2005). By contrast, the grant is dominant for DAC and non-DAC countries. The second is that Japanese ODA is highly concentrated in Asia. Approximately 73% of Japanese ODA is accounted for by East Asia and Pacific and South Asia. The principal recipient of Japanese ODA is Indonesia (US$ 65 trillion), followed by India (62), the Philippines (40), China (37), and Bangladesh (31).

Unlike DAC countries and multilateral institutions, Japan's ODA distribution to Sub-Saharan Africa is limited.[6] Finally, a large part of Japanese ODA is allocated to economic infrastructure and services (39%), whereas social infrastructure and services is the main target sector for DAC countries (34%) and multilateral institutions (35%).

Table 2: ODA Modality for Japan, DAC, Non-DAC and Multilateral Institutions

	Bilateral ODA			Multilateral ODA
	Japan	DAC (ex. Japan)	Non-DAC	
ODA, US$ billion	550	2,280	162	1,330
ODA by types, %				
Loan	71	22	37	52
Grant	29	78	62	44
Technical cooperation	11	22	1	7
Grant-in-aid for assistance	18	56	61	37
ODA by regions, %				
East Asia and the Pacific	48	15	2	10
Europe and Central Asia	2	2	3	5
Latin America and the Caribbean	7	12	1	7
Middle East and North Africa	9	22	65	10
North America	0	0	0	0

[6] Notably, Japan initiated the Tokyo International Conference on African Development in 1993 and has held the conference periodically. The share of Sub-Saharan Africa in Japanese ODA increased from 4% in the 1970s to 11% in the 2010s.

South Asia	25	15	7	21
Sub-Saharan Africa	10	34	12	46
ODA by sectors, %				
Social infrastructure and services	19	34	17	35
Economic infrastructure and services	39	12	12	26
Production sectors	13	10	4	18
Multi-sector/cross-cutting	5	6	7	6
Commodity aid/program assistance	6	9	12	8
Action relating to debt	7	6	2	0
Humanitarian aid	2	8	42	4
Unallocated/unspecified	8	15	4	3

Notes: This table reports the aggregated amounts of ODA commitment flows during 1970–2020 based on 2020 prices. See Appendix B for the list of recipients. Social infrastructure and services comprise education, health, population policies/programs & reproductive health, water supply & sanitation, and government & civil society. Economic infrastructure and services comprise transport & storage, communications, energy, banking & financial services, and business & other services. Production sectors comprise agriculture, forestry & fishing, industry, mining & construction, trade policies & regulations, and tourism.

Source: Created using OECD.Stat.

3.2. Tying arrangements

Figure 3 illustrates the trend in total bilateral Japanese tied loans to 158 recipients during 1970–2020 and its share in Japanese loans. During the 1970s, tying arrangements played a critical role in Japanese loans with an annual share of 80%.[7] However, the share of tying arrangements declined during the 1980s and the 1990s, reaching a minimum of 1% during

[7] The share of tying arrangements had been even higher before the 1970s. For example, the average share of tying arrangements in Japanese loan during 1964–1969 was 99%.

1995–1997.[8] This decline in Japanese tying arrangements reflects the compliance with a series of untying agreements among DAC countries between 1969 and 1979 (Manning 2016).

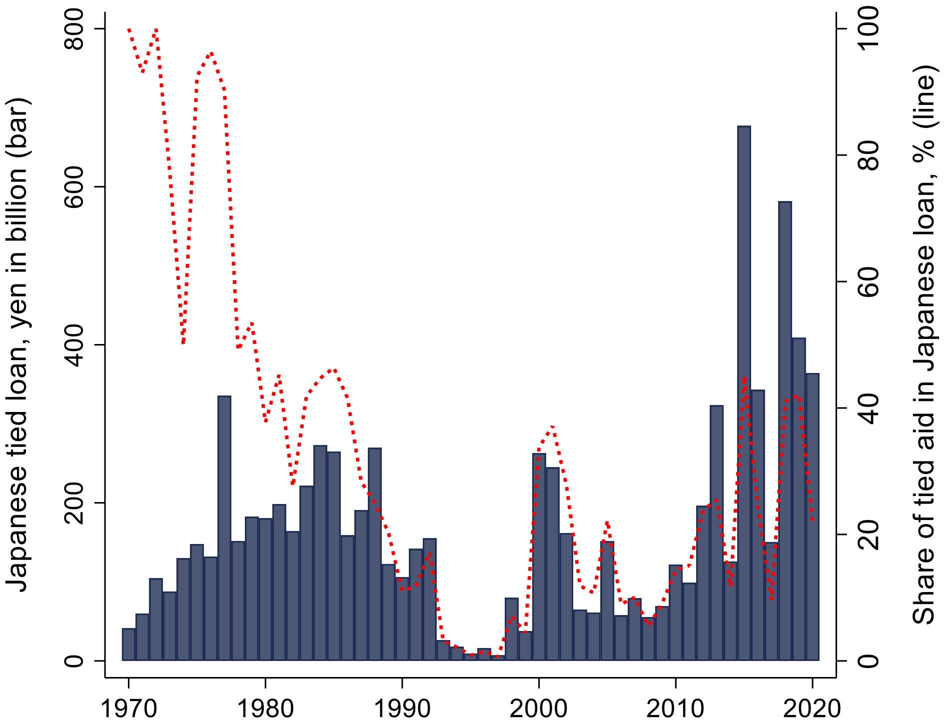

Figure 3. Trends in Japanese Tied Loan

Notes: The bars represent the total bilateral Japanese tied loans to the 158 recipients in the sample. The dotted line shows the share of tying arrangements in Japanese loans.

Source: Created using JICA's ODA Loan Project Database.

[8] Appendix C demonstrates that the Japanese tying arrangements had declined faster than any other major donors during 1980s and 1990s. It reports the tying arrangement trends in the total bilateral commitments during1979–2020, for Japan, United States, United Kingdom, France, Germany, and the DAC average. Note that tying arrangements cover both loans and grants. Appendix C is created using OECD.Stat.

However, recent decades have witnessed the reemergence of tying arrangements, emanating from growing domestic pressures to reassess the extent of untying, given the persistent weakness of the Japanese economy (Manning 2016). The average value of tied loans during the 2000s was approximately 140 billion yen, which increased to 308 billion yen during the 2010s. The average share of tying arrangements in the total Japanese yen loans also increased from 19% to 24% during the same period.[9]

The expansion of tying arrangements during the 2000s and the 2010s was largely attributable to the STEP introduced in 2002 (Endo and Murashkin 2022). Appendix D shows the shares of the STEP projects in Japanese tied loans in terms of value and count. As evident, the STEP projects accounted for 73% and 76% of the total tied loans during 2002–2020 in terms of value and count, respectively.

3.3. Institutional setup

The Japanese ODA is currently implemented by JICA, which was established in 1974. Originally, the Japanese ODA administration was divided by aid type. JICA was responsible for technical cooperation, the Japan Bank for International Cooperation for yen loans, and the MOFA for grant-in-aid assistance. All bilateral ODA administrations were consolidated into JICA in 2008 through a series of organizational reforms to improve aid effectiveness.[10]

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[9] Note that the rise in Japanese tied aids is not consistent with the 2005 Paris Declaration on Aid Effectiveness that aim for reducing the share of tied aids.

[10] The operations of funding multilateral organizations are undertaken by the MOFA.

Japan's ODA policy has been primarily based on the ODA Charter that stipulates the principles and priorities for the Japanese ODA. The first and second Charters were officially announced in 1992 and 2003, respectively. Approved in the Cabinet Meeting in 2015, the latest Charter, called the Development Cooperation Charter, prioritizes the following areas: (i) quality growth and poverty eradication, (ii) sharing universal values and realizing a peaceful and secure society, and (iii) building a sustainable and resilient international community through efforts to address global challenges (MOFA 2015). In this Charter, Japanese ODA has been explicitly placed as a means of realizing national interests.

JICA's ODA implementation is administered by the ministers of the Ministry of Foreign Affairs, Ministry of Finance, and Ministry of Agriculture, Forestry, and Fisheries. The JICA formulates a five-year plan that needs to be approved by the above-mentioned ministers. As of 2022, JICA has been running under the fifth five-year plan (2022–2026). In addition to the above-mentioned ministries, the Ministry of Economy, Trade, and Industry is also involved in Japan's ODA policy and budget, particularly aiming to promote Japan's economic and commercial interests.

4. Empirical Approach

4.1. Baseline specification and estimation technique

Adopting the Poisson maximum likelihood (PML) estimator, I estimate the following fixed effects model in the exponential function as a baseline specification:

$$JINF_{c,y} = \exp(\beta_1 \ln JODA_{c,y} + \boldsymbol{\gamma X}_{c,y} + \varphi_c + \omega_y) \times \varepsilon_{c,y} \quad (1)$$

where subscript c is the recipient country, c = 1,…,158, and y represents year, y = 1970,…, 2020. The ln denotes the natural logarithm. *JINF* is the total count of infrastructure projects contracted to Japanese firms. *JODA* denotes Japanese ODA flows. ***X*** is a vector of compounding factors discussed later. φ represents recipient fixed effects to account for time-invariant factors that are relevant for Japanese infrastructure projects abroad, such as geographical proximity, and historical ties, including war reparation. ω denotes year fixed effects to control for any changes, such as altered Japanese aid policies, organizational reforms, and Japan's fiscal conditions, across recipients during the sample period. ε is an error term. My primary interest is to identify β_1.

The PML seeks to exploit the non-negative and integer-valued aspects of the count variable (Cameron and Trivedi 2013). As shown in Appendix A, the PML conditional mean distribution (c) is similar to the skewed distribution of the original data (a). By contrast, the linear regression using ordinary least squares (OLS) generates a less skewed conditional mean distribution (b), and more importantly, 32% of the predicted values are negative. In addition, the PML is an efficient estimator in the panel setting, as heterogeneity is well controlled through recipient and year fixed effects (φ, ω) (Cameron and Trivedi 2013).

The vector of compounding factors includes the potential confounding factors: GDP per capita, population, bilateral trade flows with Japan, exchange rates per Japanese yen, ODA inflows from DAC countries (excluding Japan), non-DAC countries, or multilateral organizations, the mutual visits of top political dignitaries such as prime ministers and ministers, and the number of natural disasters. Data availability for potential confounding factors is limited, given that the sample consists of developing countries and many years. $\boldsymbol{X}$ also includes a zero Japanese ODA dummy variable, as discussed in Section 2.

Using a long-run panel dataset raises concerns that model errors may be serially correlated over time. Failure to adjust for within-cluster correlations may lead to misleadingly small standard errors. Hence, I report robust standard errors clustered by recipients throughout the analyses. The number of clusters is 158, sufficient for the standard cluster adjustment to be reliable.

4.2. Estimation challenges

The key estimation issue is that *JODA* may be correlated with unobserved time-variant factors in ε in Equation (1). One such variable may be the change in recipient policy environments, including control of corruption, government effectiveness, political stability, and the rule of law. An improvement in recipient policy environments may be positively associated with both Japanese ODA and overseas infrastructure projects contracted to Japanese firms, and their long-run trends are more likely to vary across recipients. Failure to control for such differential trends might cause β_1 to be biased upward.

Reverse causality is another identification threat. Japanese overseas infrastructure projects over previous years may induce Japanese ODA in the current year, owing to additional financial support. For example, a Japanese project company can borrow money through a Japanese yen loan scheme to compensate for capital shortfalls. To examine potential reverse causality, I estimate the lead effects of Japanese ODA on overseas infrastructure projects contracted to Japanese firms. Appendix E reports the results, finding that the same year effect is the largest and that 2- and 3-year lead effects are positive and statistically significant.

To address these estimation issues, I adopt two approaches. The first is to estimate Equation (1) that accounts for recipient-specific time trends using the PML estimator. The second approach is to adopt a two-step system GMM estimator for the following dynamic panel model (Arellano and Bover 1995; Blundell and Bond 1998; Roodman 2009):

$$JINF_{c,y} = \beta_0 JINF_{c,y-1} + \beta_1 \ln JODA_{c,y} + \boldsymbol{\gamma X}_{c,y} + \varphi_c + \omega_y + \varepsilon_{c,y}. \quad (2)$$

Section 4 demonstrates how much the estimate obtained by these approaches deviates from the baseline estimate and discusses the implications of the main findings of this study.

4.3. Alternative specifications

To estimate Japanese ODA-infrastructure elasticities by aid type, I split the Japanese ODA variable (*JODA*) in two ways and estimate the following specifications:

$$JINF_{c,y} = \exp\left(\beta_1 \ln JLOAN_{c,y} + \beta_2 \ln JGRANT_{c,y} + \boldsymbol{\gamma X}_{c,y} + \varphi_c + \omega_y\right) \times \varepsilon_{c,y}, \quad (3)$$

$$JINF_{c,y} = \exp\big(\beta_1 \ln JLOAN_{c,y} + \beta_2 \ln JTECH_{c,y} + \beta_3 \ln JGIAFA_{c,y} + \boldsymbol{\gamma X}_{c,y} + \varphi_c + \omega_y\big) \times \varepsilon_{c,y}, (4)$$

where *JLOAN* denotes Japanese loan ODA flows, *JGRANT* represents Japanese grant, *JTECH* Japanese technical cooperation, and *JGIAFA* Japanese grant-in-aid for assistance. The remaining elements are identical to those in Equation (1).

Equation (1) ignores the lagged effects. Japanese ODA over previous years may be relevant for Japanese overseas infrastructure projects in the current year because of postponed projects. To investigate the effect of lagged Japanese ODA, I add lagged terms to the model as follows:

$$JINF_{c,y} = \exp\left(\sum_{j=0}^{3} \beta_j \ln JODA_{c,y-j} + \boldsymbol{\gamma X}_{c,y} + \varphi_c + \omega_y\right) \times \varepsilon_{c,y}. (5)$$

Summing the β coefficients from Equation (5) provides an estimate of the *J*-year ODA-infrastructure elasticity. The three-year elasticity, for example, may be calculated as $\beta_0 + \beta_1 + \beta_2 + \beta_3$. I focus only on three lags because the results remain unchanged even if longer lags are considered.

Finally, to estimate heterogeneous Japanese ODA-infrastructure elasticities among the regions, I examine the following specification:

$$JINF_{c,y} = \exp\left[\beta_1 \ln JODA_{c,y} + \sum_{d=1}^{5} \delta_d\big(\ln JODA_{c,y} \times \rho_d\big) + \boldsymbol{\gamma X}_{c,y} + \varphi_c + \omega_y\right] \times \varepsilon_{i,j,t} \quad (6)$$

where ρ_d are regional dummies: $\rho_1 = 1$ if the recipient is in East Asia and the Pacific (and zero otherwise), $\rho_2 = 1$ if the recipient is in Latin America and the Caribbean, $\rho_3 = 1$ if the recipient is in the Middle East and North Africa, $\rho_4 = 1$ if the recipient is in South Asia, and $\rho_5 = 1$ if the recipient is in Sub-Saharan Africa. Here, β_1 is interpreted as the Japanese ODA-infrastructure elasticity for Europe and Central Asia, which is the benchmark region in this analysis; δ_d measures the different slopes of Japanese ODA-infrastructure elasticities relative to the benchmark region. Thus, $(\beta_1 + \delta_d)$ represents the individual ODA-infrastructure elasticities for the five regions.

5. Results

5.1. Japanese ODA-infrastructure elasticities

Table 3 presents the estimation results for Equation (1) obtained by adopting the PML estimator. All estimations use the same recipient-year panel dataset (158 recipients, 1970–2020). The first column shows that the Japanese ODA-infrastructure elasticity is 0.49 at the 1% significance level. However, this estimate is substantially reduced by controlling for recipient fixed effects, year fixed effects, and time-varying confounding factors. Column 3 shows that the Japanese ODA-infrastructure elasticity is 0.17, with a 95% confidence interval ranging from 0.12 to 0.22. This suggests that a 1% increase in Japanese ODA led to a 0.17% increase in the number of overseas infrastructure projects contracted to Japanese firms, on average, during 1970–2020 for 158 recipients. This implies that Japanese ODA contributed to an increase in the number of infrastructure projects by approximately 1,600, thereby accounting for 17% of the total count of overseas infrastructure projects contracted to Japanese firms during 1970–2020.

Apart from the effect of Japanese ODA, I find that economic and diplomatic relationships between Japan and recipients are determinants of overseas infrastructure projects contracted to Japanese firms. For example, the results suggest that a 1% increase in bilateral trade leads to a 0.5% increase in Japanese overseas infrastructure projects. The average count of Japanese overseas infrastructure projects when the Japanese prime minister visited the recipient country was 18% ($\approx [\exp(0.166) - 1] \times 100$) larger than that in the case without visits. I find no evidence that overseas infrastructure projects contracted to Japanese firms are associated with other ODA inflows to recipients.

Table 3: Baseline Estimates

Dependent variable: Total count of infrastructure projects contracted to Japanese firms			
Ln Japanese ODA	0.493***	0.147***	0.167***
	(0.058)	(0.030)	(0.025)
Ln GDP per capita			−0.007
			(0.056)
Ln population			0.573
			(0.379)
Ln bilateral trade			0.510***
			(0.062)
Exchange rates			−0.000
			(0.002)
Dummy if Japan’s prime minister visited recipient countries			0.166***
			(0.045)
Dummy if Japan’s ministers visited recipient countries			0.089*

			(0.053)
Dummy if recipient countries' prime ministers visited Japan			−0.001
			(0.070)
Dummy if EPA was in force			−0.190
			(0.191)
Ln ODA from DAC countries excluding Japan			−0.044
			(0.035)
Ln ODA from non-DAC countries			0.006
			(0.004)
Ln ODA from multilateral institutions			0.073
			(0.047)
Number of natural disasters			−0.009
			(0.010)
Zero Japanese ODA dummy			1.917***
			(0.470)
Pseudo R^2	0.316	0.676	0.699
Recipient dummy	No	Yes	Yes
Year dummy	No	Yes	Yes
Recipients		158	
Years		1970–2020	
Observations		6,646	

Notes: This table presents the results for estimating Equation (1) by the PML technique. Standard errors are clustered at the recipient level. See Appendix B for recipients in the sample.

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5.2. Heterogeneous ODA-infrastructure elasticities

Table 4 reports the results for heterogeneous ODA-infrastructure elasticities, based on Equations (3)–(6). Note that all specifications include recipient fixed effects, year fixed effects, and time-varying confounding factors listed in Table 3. I suppress the coefficients for the time-varying confounding factors and the zero Japanese ODA dummies to save space. Instead of a zero Japanese ODA dummy, (i) zero Japanese loan dummy and zero Japanese grant dummy are included in the first column, and (ii) zero Japanese loan dummy, zero Japanese technical cooperation dummy, and zero Japanese grants-in-aid for assistance dummy are included in the second column.

Table 4: Heterogeneous ODA-Infrastructure Elasticities

Dependent variable: Total count of infrastructure projects contracted to Japanese firms				
Ln Japanese loan	0.064***	0.057***		
	(0.014)	(0.012)		
Ln Japanese grant	0.168***			
	(0.034)			
Ln Japanese technical assistance		0.251***		
		(0.049)		
Ln Japanese grant-in-aid for assistance		0.032		
		(0.021)		
Ln Japanese ODA			0.131***	0.152***
			(0.023)	(0.053)
Ln Japanese ODA (1-year lag)			0.068***	
			(0.014)	

Ln Japanese ODA (2-year lag)			0.022	
			(0.017)	
Ln Japanese ODA (3-year lag)			0.003	
			(0.011)	
Ln Japanese ODA × East Asia & Pacific				0.063
				(0.062)
Ln Japanese ODA × Latin America & Caribbean				−0.111*
				(0.058)
Ln Japanese ODA × Middle East & North Africa				−0.079
				(0.060)
Ln Japanese ODA × South Asia				0.142**
				(0.071)
Ln Japanese ODA × Sub-Saharan Africa				0.043
				(0.065)
Pseudo R^2	0.701	0.704	0.703	0.702
Observations	6,646	6,611	6,214	6,646

Notes: This table presents the results for estimating Equations (3)–(6) using the PML technique, with the recipient-year panel dataset (158 recipients, 1970–2020). All specifications include recipient fixed effects, year fixed effects, and time-varying confounding factors listed in Table 3. Standard errors are clustered at the recipient level.

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The first and second columns of Table 4 show that the effect of Japanese grants is greater than that of Japanese loans and that technical cooperation plays a dominant role in the effect of Japanese grants. The third column reports the results for the distributed lag model. The three-year ODA-infrastructure elasticity is 0.22 (≈0.131+0.068+0.022+0.003), statistically different from zero at the 1% significance level. The same year effect is stronger than the lagged effects.

The last column of Table 4 reports the results on the extent to which the Japanese ODA-infrastructure elasticity differs among the five regions relative to the benchmark elasticity for Europe and Central Asia. The benchmark elasticity is 0.15 at the 1% significance level. An interesting finding is that the Japanese ODA-infrastructure elasticity for South Asia is 0.29 (≈0.152+0.142), which is about twice as large as the benchmark elasticity at a significant level.

5.3. Robustness

Table 5 examines the robustness of the baseline estimate (0.17; Column 3 of Table 3). The first column reports the PML estimation results for Equation (1), which accounts for recipient-specific time trends. The estimated Japanese ODA-infrastructure elasticity is reduced to 0.09 but is highly statistically significant. The result suggests that failure to control for unobserved time-varying factors is likely to overestimate the Japanese ODA-infrastructure elasticity. However, the potential estimation bias is not as great as the extent to which the conclusion is overturned.

The second column of Table 5 reports the results of estimating Equation (2), adopting the two-step system GMM estimator, where regressors in levels are instrumented with suitable lags of their own first differences. I put every regressor in Equation (2), except for the recipient- and year-fixed effects ($\varphi,\ \omega$), into the instrument matrix that takes a collapsed form to limit the number of instruments. The number of instruments in this setting is 922. As with other specifications, standard errors are clustered at the recipient level.

Table 5: Robustness Checks

Dependent variable: Total count of infrastructure projects contracted to Japanese firms					
	Recipient-specific time trends	System GMM	Negative binominal	Zero-inflated negative binominal	ODA disbursements
Ln Japanese ODA	0.091***	0.136*	0.185***	0.168***	0.155***
	(0.018)	(0.070)	(0.024)	(0.024)	(0.041)
Pseudo R^2	0.729	-	0.324	-	0.692
Observations	6,646	6,453	6,646	6,646	6,425

Notes: All specifications use the recipient-year panel dataset (158 recipients, 1970–2020) and include recipient fixed effects, year fixed effects, and time-varying confounding factors listed in Table 3. Column 1 reports the result for estimating Equation (1) that accounts for recipient-specific time trends using the PML technique. Column 2 reports the result for estimating Equation (2), adopting the system GMM estimator. Column 3 reports the result for estimating Equation (1) with the negative binominal models. Column 4 reports the result for estimating Equation (1) with the zero-inflated negative binominal models. Column 5 reports the result for estimating Equation (1) where all ODA variables are measured based on disbursements rather than commitments. Standard errors are clustered at the recipient level.

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

I find that a 1% increase in Japanese ODA led to an increase in the number of overseas infrastructure projects contracted to Japanese firms by 0.0014 on average. Given that the mean count of overseas infrastructure projects contracted to Japanese firms during 1970–

2020 is 1.4, the estimated elasticity is approximately 0.10. The Arellano–Bond tests for autocorrelation reject the null hypothesis that the error term in Equation (2), ε, is serially correlated.[11] The Hansen test of over-identification does not reject the null hypothesis that the instruments are jointly valid.[12] Overall, the result based on the two-step system GMM estimation suggests that, although the baseline estimate might be biased upward owing to endogeneity, the main conclusion holds.

The third and fourth columns of Table 5 report the results for alternative count models. The use of the PML is likely to underestimate the standard errors because the conditional variance and mean of the count-dependent variable are not equalized. To address this overdispersion, the third column reports the results for estimating Equation (1) in the negative binomial model, in which the variance is assumed to be quadratic in the mean, often called NB2. The fourth column reports the results for estimating Equation (1) in the zero-inflated negative binominal model, in which the excess zeros in the outcome variable (i.e., the total counts of infrastructure projects contracted to Japanese firms) are modelled by the log bilateral trade in the logit analysis.[13] The results suggest that the main conclusion holds, regardless of different count models.

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[11] The Arellano–Bond test for AR (1) in first differences: z = −3.47, Pr > z =0.001. The Arellano–Bond test for AR (2) in first differences: z = 2.57, Pr > z =0.010.

[12] The Hansen test of overidentifying restrictions: chi^2 (700) = 85.77, Pr > 1.000.

[13] The coefficient of the log bilateral trade is −0.61 at the 1% significance level, suggesting that the log odds of being an excess zero would decrease by 0.006 for every additional bilateral trade between Japan and each recipient country. In other words, the stronger the economic relationships were in terms of trade, the more likely that Japanese firms invested in infrastructure.

Finally, the fifth column of Table 5 reports the PML estimation result for Equation (1), where the ODA variables are measured based on disbursements instead of commitments. While bilateral commitments are recorded as the full amount of expected transfers, disbursements record the actual international transfer of financial resources. Thus, ODA disbursements might better capture the ODA-infrastructure links. This result suggests that the estimate is similar to the baseline estimate.

5.4. Mechanisms

In the previous subsection, I found robust evidence that Japanese ODA increased overseas infrastructure projects contracted to Japanese firms. In this subsection, I discuss the potential mechanisms underlying the Japanese ODA-infrastructure links.

5.4.1. Do tying arrangements matter?

Japanese ODA-infrastructure links may be strengthened by tying arrangements, where a recipient receiving tied aid is required to contract with donor firms for some projects. As explained above, this is particularly relevant to tied yen loans based on the STEP. To examine the impact of tying arrangements on overseas infrastructure projects contracted to Japanese firms, I estimate the following specification:

$$JINF_{c,y} = \exp\left[\beta_1 \ln JLOAN_{c,y} + \beta_2 \ln JGRANT_{c,y} + \beta_3 TIED_{c,y} + \beta_4 (\ln JLOAN_{c,y} \times TIED_{c,y}) + \boldsymbol{\gamma X}_{c,y} + \varphi_c + \omega_y\right] \times \varepsilon_{c,y} \quad (7)$$

where *TIED* is either (i) a dummy variable taking a value of one if the recipient receives any Japanese tied loans, (ii) a dummy variable taking a value of one if the recipient receives any Japanese completely tied loans, or (iii) a dummy variable if the recipient receives any Japanese tied loans based on the STEP. I am interested in β_4, which captures the extent to which the effect of tied loans differs from that of untied ones. The other elements are identical to those in Equation (3).

Table 6 reports the results. Overall, we find no evidence of differential effects between tied and untied loans. The first column suggests that the effect of tied loans on overseas infrastructure projects contracted to Japanese firms is 0.032 percentage points greater than the effect of untied loans. However, the estimate is statistically indistinguishable from zero. This result remains unchanged even when the completely tied loan dummy is examined (Column 2). The third column also suggests that the effect of tied loans based on the STEP is 0.074 percentage points greater than the effect of non-STEP loans. However, the estimate is not precisely estimated.

Table 6: Examination of Tying Arrangements

Dependent variable: Total count of infrastructure projects contracted to Japanese firms			
Ln Japanese loan	0.062***	0.063***	0.066***
	(0.014)	(0.014)	(0.015)
Ln Japanese grant	0.168***	0.168***	0.166***
	(0.035)	(0.035)	(0.034)
Tied loan dummy	−0.660		
	(0.959)		
Ln Japanese loan × Tied loan dummy	0.032		
	(0.048)		
Completely tied loan dummy		−0.134	
		(1.181)	
Ln Japanese loan × Completely tied loan dummy		0.007	
		(0.059)	
STEP dummy			−1.654
			(2.313)
Ln Japanese loan × STEP dummy			0.074
			(0.110)
Pseudo R^2	0.701	0.701	0.701

Observations	6,646	6,646	6,646

Notes: This table presents the results for estimating Equation (7) using the PML technique, with the recipient-year panel dataset (158 recipients, 1970–2020). All specifications include recipient fixed effects, year fixed effects, and time-varying confounding factors listed in Table 3. Instead of a zero Japanese ODA dummy, a zero Japanese loan dummy and a zero Japanese grant dummy are included. Standard errors are clustered at the recipient level.

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5.4.2. Does grant play a key role?

In the preparation stage of Japan's ODA loan project cycle, feasibility studies and environmental impact assessments play a crucial role in project formation in the recipient countries (JICA 2022b). In many cases, JICA conducts these pre-investment studies utilizing Japanese grant aids, potentially creating "goodwill" effects such that recipients favorably select Japanese firms as contractors for Japanese yen loan projects (Arvin and Choudhry 1997). This hypothesis is consistent with the large effect of Japanese grants, as reported in Tables 4 and 6. To examine the extent to which Japanese grants help Japanese firms win contracts under Japanese loan projects, I estimate the following specification:

$$JINF_{c,y} = \exp\left(\beta_1 DLOAN_{c,y} + \beta_2 DGRANT_{c,y} + \beta_3 DLOAN\_DGRANT_{c,y} + \boldsymbol{\gamma X}_{c,y} + \varphi_c + \omega_y\right) \times \varepsilon_{c,y} \quad (8)$$

where *DLOAN* is a dummy variable that takes the value of one if the recipient receives only a Japanese loan, *DGRANT* is a dummy variable if the recipient receives only a Japanese grant, and *DLOAN_DGRANT* is a dummy variable if the recipient receives both Japanese loans and grants simultaneously. Thus, the reference is the case of not receiving Japanese ODA. The other elements are identical to those in Equation (1).

Table 7 reports the results. I find robust evidence that the count of overseas infrastructure projects contracted to Japanese firms in cases of simultaneously receiving Japanese loans and grants are 1.1% ($\approx [\exp(0.740) - 1] \times 100$) greater than in cases of receiving no Japanese ODA, holding the other factors constant (Column 2). By contrast, I find no evidence that the mean count of overseas infrastructure projects contracted to Japanese firms differs from the reference case, for loan-only and grant-only cases. Similar results are found when a dummy of Japanese ODA being non-zero is used instead (Column 1), indicating that the use of disaggregated dummy variables matters in unveiling the potential mechanism underlying the Japanese ODA-infrastructure links.

Table 7: Examination of Grant in Loan Projects

Dependent variable: Total count of infrastructure projects contracted to Japanese firms		
Japanese ODA dummy	0.312	
	(0.293)	
Japanese loan dummy		0.427
		(0.577)
Japanese grant dummy		0.326
		(0.297)
Japanese loan and grant dummy		0.740**
		(0.291)
Pseudo R^2	0.691	0.695
Observations	6,646	6,646

Notes: This table presents the results for estimating Equation (8) using the PML technique, with the recipient-year panel dataset (158 recipients, 1970–2020). All specifications include recipient fixed effects, year fixed effects, and time-varying confounding factors listed in Table 3. The Japanese ODA dummy takes a value of one if the Japanese ODA is non-zero, and zero otherwise. The Japanese loan dummy takes a value of one if the recipient obtains only a Japanese loan. The Japanese grant dummy takes a value of one if the recipient obtains only a Japanese grant. The Japanese loan and grant dummy takes a value of one if the recipient obtains both Japanese loan and grant simultaneously. Zero Japanese ODA dummies are excluded in this analysis. Standard errors are clustered at the recipient level.

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

6. Conclusion

Given the growing pressure on foreign aid budget cuts among donors, the analysis of the effectiveness of bilateral ODA in realizing national interests has become more significant than ever. From the viewpoint of economic interests, prior research has revealed that ODA can lead to the expansion of donor exports and outward foreign direct investment. The novelty of this study is to provide, for the first time, evidence that ODA could also help donor country firms win infrastructure projects in recipient countries, by analyzing the case of Japanese ODA.

The key evidence obtained in this study highlighted the important role of grants, particularly technical cooperation, in promoting overseas infrastructure projects contracted to Japanese firms. In many cases, JICA conducts pre-investment studies, such as feasibility studies and environmental impact assessments, as part of technical cooperation, potentially creating goodwill effects for Japanese firms during their bidding for Japanese yen loan projects. Therefore, optimizing the dispatchment of the investigation team for pre-investment studies could be one option for improving the effectiveness of Japanese ODA. Dispatchment accounts for only 23% of technical cooperation disbursements as of 2021 (JICA 2022a).

The current study has focused on the implications of ODA from donor perspective. Then, it is natural to think about the implications from recipient perspective. For example, well-designed infrastructure could encourage private investment, unlock the constraint of connectivity that contributes to high spatial inequality in incomes and human development, and create jobs (Addison and Tarp 2016). Quality infrastructure is essential for adaptation to climate change. Exploring how much ODA-linked infrastructure projects by Japanese firms would benefit the recipient economy by reducing poverty and greenhouse emissions could be worthwhile as a future research direction.

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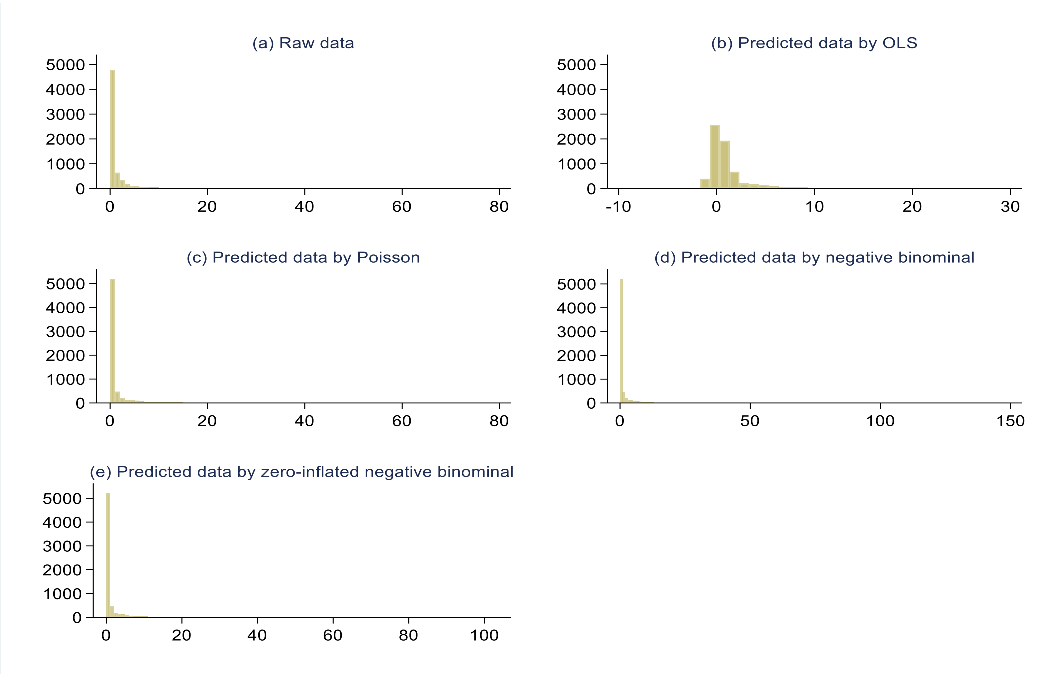
Appendix A

.Distributions of Overseas Infrastructure Projects Contracted to Japanese Firms



	Obs.	Mean	S.D.	Min	Max
(a) Raw data	6646	1.4	4.5	0	70
(b) Predicted data by OLS	6646	1.4	3.6	−3	29
(c) Predicted data by Poisson	6646	1.4	4.0	0	77
(d) Predicted data by negative binomial	6646	1.5	4.6	0	124
(e) Predicted data by zero-inflated negative binominal	6646	1.4	4.2	0	103

Notes: (a) is based on raw data on the total number of overseas infrastructure projects contracted to Japanese firms. (b) Predicted data from OLS with a set of all variables in Table 3. (c) shows the predicted data obtained by estimating Equation (1) using the PML technique. (d) shows the predicted data by estimating Equation (1) using the negative binomial model. (e) shows the predicted data by estimating Equation (1) using the zero-inflated negative binomial model.

Appendix B. Recipient Countries

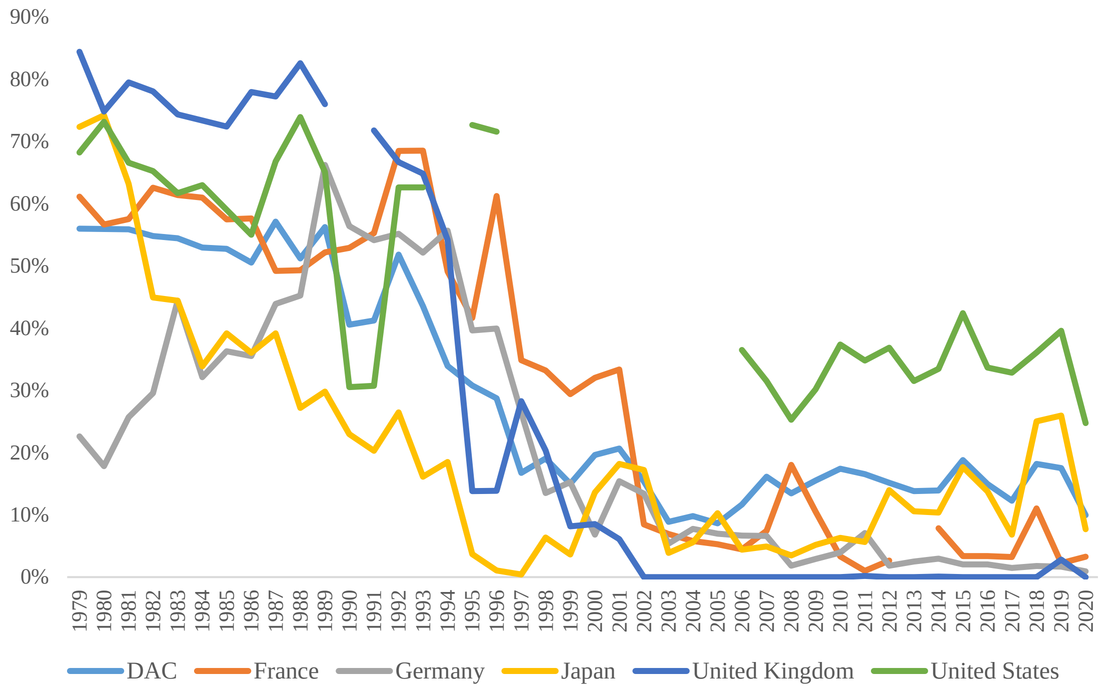
East Asia and the Pacific (31)		South Asia (8)	Europe and Central Asia (15)	Middle East and North Africa (21)	Sub-Saharan Africa (48)		Latin America and the Caribbean (35)	
Brunei	South Korea	Afghanistan	Armenia	Algeria	Angola	Madagascar	Antigua and Barbuda	Panama
Cambodia	Thailand	Bangladesh	Azerbaijan	Bahrain	Benin	Malawi	Argentina	Paraguay
China	Timor-Leste	Bhutan	Croatia	Djibouti	Botswana	Mali	Barbados	Peru
Fiji	Tonga	India	Georgia	Egypt	Burkina Faso	Mauritania	Belize	St. Kitts and Nevis
French Polynesia	Tuvalu	Maldives	Kazakhstan	Iran	Burundi	Mauritius	Bermuda	St. Lucia
Hong Kong	Vanuatu	Nepal	Kyrgyz Republic	Iraq	Cabo Verde	Mozambique	Bolivia	St. Vincent and the Grenadines
Indonesia	Vietnam	Pakistan	North Macedonia	Israel	Cameroon	Namibia	Brazil	Suriname
Kiribati		Sri Lanka	Moldova	Jordan	Central African Republic	Niger	British Virgin Isl.	Bahamas
Lao PDR			Montenegro	Kuwait	Chad	Nigeria	Chile	Trinidad and Tobago

Macao		Serbia	Lebanon	Comoros	Rwanda	Colombia	Uruguay
Malaysia		Slovenia	Libya	Congo	São Tomé and Principe	Costa Rica	Venezuela
Marshall Isl.		Tajikistan	Malta	Côte d'Ivoire	Senegal	Cuba	
Micronesia		Turkmenistan	Morocco	Dem. Rep. Congo	Seychelles	Dominica	
Mongolia		Ukraine	Oman	Equatorial Guinea	Sierra Leone	Dominican Rep.	
Myanmar		Uzbekistan	Qatar	Eritrea	Somalia	Ecuador	
Nauru			Saudi Arabia	Eswatini	South Africa	El Salvador	
New Caledonia			Syrian Arab Rep.	Ethiopia	South Sudan	Grenada	
Northern Mariana Isl.			Tunisia	Gabon	Sudan	Guatemala	
Palau			United Arab Emirates	Ghana	Tanzania	Guyana	
Papua New Guinea			West Bank and Gaza	Guinea	The Gambia	Haiti	
The Philippines			Yemen	Guinea-Bissau	Togo	Honduras	
Samoa				Kenya	Uganda	Jamaica	

Singapore		Lesotho	Zambia	Mexico
Solomon Islands		Liberia	Zimbabwe	Nicaragua

Notes: The table lists 158 recipients in the sample during 1970–2020.

Appendix C. Tying Arrangements in Total Bilateral Commitments



Notes: Tying arrangements include both loans and grants.

Source: Created using OECD.Stat.

Appendix D. STEP Projects in Japanese Tied Loans

Year	Value (yen in billion)			Count		
	Tied	STEP	STEP, %	Tied	STEP	STEP, %
2002	174	102	59	16	6	38
2003	65	49	76	2	1	50
2004	61	51	83	10	9	90
2005	335	151	45	7	5	71
2006	58	57	98	5	4	80
2007	79	78	99	7	6	86
2008	56	55	99	5	4	80
2009	69	63	91	4	2	50
2010	122	122	100	6	6	100
2011	99	99	100	6	6	100
2012	196	193	99	9	8	89
2013	324	324	100	12	12	100
2014	126	91	72	5	4	80
2015	677	675	100	15	14	93
2016	343	239	70	8	7	88

2017	151	145	96	5	4	80
2018	581	266	46	9	6	67
2019	409	361	88	6	5	83
2020	364	0	0	7	0	0
Total (2002–2020)	4,289	3,121	73	144	109	76

Notes: STEP stands for Special Terms for Economic Partnership.

Source: Created using JICA's ODA Loan Project Database.

Appendix E. Lead Effects of Japanese ODA

Dependent variable: Total count of infrastructure projects contracted to Japanese firms					
Ln Japanese ODA	0.138***	0.121***	0.119***	0.115***	0.120***
	(0.020)	(0.020)	(0.019)	(0.019)	(0.020)
Ln Japanese ODA (1-year lead)	0.063***	0.039**	0.028	0.023	0.021
	(0.019)	(0.017)	(0.017)	(0.017)	(0.018)
Ln Japanese ODA (2-year lead)		0.071***	0.053***	0.045***	0.046***
		(0.016)	(0.017)	(0.016)	(0.016)
Ln Japanese ODA (3-year lead)			0.061***	0.053***	0.056***
			(0.021)	(0.020)	(0.020)
Ln Japanese ODA (4-year lead)				0.029	0.025
				(0.021)	(0.021)
Ln Japanese ODA (5-year lead)					−0.003
					(0.015)
Pseudo R^2	0.701	0.705	0.709	0.713	0.716
Observations	6,478	6,318	6,158	5,997	5,815

Notes: This table presents the results for estimating Equation (1) with lead terms using the PML technique. All specifications use the recipient-year panel dataset and include recipient fixed effects, year fixed effects, and time-varying confounding factors listed in Table 3. Standard errors are clustered at the recipient level.

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix F. ODA-Infrastructure Elasticities by Periods

Dependent variable: Total count of infrastructure projects contracted to Japanese firms					
	1970−1979	1980−1989	1990−1999	2000−2009	2010−2020
Ln Japanese ODA	0.099***	0.018	0.081**	0.065	0.025
	(0.030)	(0.031)	(0.033)	(0.045)	(0.032)
Observations	1,172	1,268	1,376	1,361	1,469

Notes: This table presents the results for estimating Equation (1) using the PML technique, by periods. All specifications use the recipient-year panel dataset and include recipient fixed effects, year fixed effects, and time-varying confounding factors listed in Table 3. Standard errors are clustered at the recipient level.

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.