Assessing the Impact of the Establishment of Japan Advanced Semiconductor Manufacturing on Taiwan's Foreign Direct Investment in Japan: An Interrupted Time Series Analysis

Yi-Chun Ko
Asian Growth Research Institute

Working Paper Series Vol. 2025-06

March 2025

Asian Growth Research Institute

Assessing the Impact of the Establishment of Japan Advanced Semiconductor Manufacturing on Taiwan's Foreign Direct Investment in Japan: An Interrupted Time Series Analysis

Yi-Chun Ko*
Asian Growth Research Institute

Abstract

This study examines the impact of the establishment of Japan Advanced Semiconductor Manufacturing (JASM) on Taiwan's foreign direct investment (FDI) trends in Japan. Using interrupted time series analysis, we analyze both the immediate and long-term effects of JASM's creation on FDI, while controlling for external shocks such as the Great East Japan Earthquake in 2011, the United States–China trade war in 2018–2019, and the COVID-19 pandemic (2020–2022). Our results indicate an immediate decline in the number of FDI cases following JASM's establishment, accompanied by a positive post-event trend, suggesting gradual recovery and long-term growth. In contrast, the monetary value of FDI did not exhibit a significant immediate effect but demonstrated a positive trend over time. However, further analysis reveals that the initial negative impact on FDI may have been confounded by the effects of the pandemic rather than the JASM establishment itself. These findings highlight the complex dynamics of large-scale corporate investments and their influence on FDI patterns. They underscore the importance of maintaining investor confidence and policy stability to support long-term economic growth, especially in the face of external shocks.

Keywords: Foreign direct investment, Interrupted time series analysis, Japan Advanced Semiconductor Manufacturing, Taiwan semiconductor industry

* E-mail: yichunko@agi.or.jp

1. Introduction

Foreign direct investment (FDI) significantly contributes to economic growth and development by facilitating technology transfer, knowledge spillover, improved managerial practices, and access to international markets (e.g., Alfaro, 2017; Borensztein et al., 1998). These benefits enhance productivity, diversify exports, create jobs, and foster structural transformation in recipient economies (Balasubramanyam et al., 1996). Analyzing FDI from specific source countries allows policymakers to identify trends and design strategies aligned with national development goals. However, the impact of significant corporate actions on FDI remains underexplored, particularly in contexts in which external shocks might also influence investment trends. Thus, this study examines how the establishment of Japan Advanced Semiconductor Manufacturing (JASM), a joint venture with the Taiwan Semiconductor Manufacturing Company (TSMC), has influenced Taiwan's FDI in Japan. By employing interrupted time series (ITS) analysis, we aim to provide robust insights into the immediate and long-term effects of this development while accounting for external factors such as the Great East Japan Earthquake in 2011, United States–China trade war in 2018–2019, and the COVID-19 pandemic in 2020–2022.

Using quarterly data from 2007 Q1 to 2024 Q2, our findings indicate an immediate decline in the number of Taiwanese FDI cases in Japan following JASM's establishment, suggesting initial disruptions to investment flows. However, a positive post-event trend suggests a gradual recovery and long-term growth in FDI cases. In contrast, the monetary value of Taiwan's FDI into Japan did not exhibit a significant immediate decline but showed a positive trend over time, implying resilience in investment commitments. Further analysis indicates that the initial decline in the number of FDI cases may have been confounded by the effects of the COVID-19 pandemic rather than the JASM establishment itself. These results highlight the complex dynamics between large-scale corporate investments and FDI trends and, emphasizing the importance of maintaining investor confidence and policy stability.

The remainder of this paper is organized as follows: Section 2 provides a background on the establishment of JASM, Section 3 describes the empirical methodology and data, Section 4 presents the estimation results, and Section 5 concludes the study.

2. Background: The Establishment of JASM

TSMC is the world's largest and most advanced dedicated semiconductor foundry. As a pure-play foundry, TSMC manufactures semiconductors for clients across various industries, including major players such as Apple, NVIDIA, and AMD. Known for its cutting-edge process technologies, TSMC has consistently led the global semiconductor market in terms of both innovation and production capacity. Its specialization in high-performance chips for applications such as smartphones, automotive systems, and artificial intelligence technologies has made it an essential pillar of the global tech supply chain.

In November 2021, TSMC expanded its global footprint with the establishment of JASM in Kumamoto Prefecture, Japan. JASM represents TSMC's first semiconductor manufacturing facility in Japan, marking a strategic move to bolster Japan's semiconductor supply chain and address growing concerns over regional stability amid global chip shortages. The joint venture was established in collaboration with Sony Semiconductor Solutions, Denso Corporation, and Toyota Motor Corporation, with TSMC holding the majority stake.

JASM is designed to respond to the increasing demand for advanced semiconductors, particularly in sectors such as automotive, industrial electronics, and high-performance computing. With an expected combined production capacity of over 100,000 wafers per month (300 mm wafer equivalent), JASM plans to produce chips using cutting-edge 40, 22/28, 12/16, and 6/7 nm process technologies. The establishment of JASM plays a key role in reinforcing Japan's semiconductor industry by advancing innovations in image sensors and automotive semiconductors and enhancing Japan's economic competitiveness.

The project has also attracted significant investment, with key players such as Denso Corporation and Toyota Motor Corporation joining the venture and further strengthening the Taiwan–Japan collaboration in the semiconductor sector. While the establishment was initially anticipated to attract foreign investments and catalyze related industries, concerns have emerged about potential short-term disruptions to FDI patterns owing to heightened uncertainty. This study aims to empirically evaluate these dynamics and their implications for Japan's investment landscape.

2.1 JASM's Impact on Taiwan's FDI in Japan

Taiwan and Japan are major players in the global semiconductor supply chain, with Taiwan's TSMC being the leading semiconductor foundry and Japan playing a critical role in supplying essential materials and equipment for chip manufacturing. In fact,

Japan's chip equipment sales reached a record high of 2.831 trillion JPY from January to August 2024, marking a 17.3% year-on-year increase, according to the Semiconductor Equipment Association of Japan (SEAJ).[1,2] This growth in the semiconductor equipment market underscores Japan's importance in the broader global semiconductor ecosystem.

JASM represents a joint effort to strengthen semiconductor production within Japan, which is a key step in enhancing the country's manufacturing capabilities amid global supply chain concerns. The establishment of JASM could potentially attract related investments from Taiwanese firms, which may seek to align with Japan's growing semiconductor ecosystem through supply chain integration and strategic partnerships. One example is the agreement signed by ASE Technology Holding Co., the world's largest back-end semiconductor processing company, with the city of Kitakyushu for the acquisition of municipal land (as of July 31, 2024), signaling Taiwan's increasing interest in investing in Japan's semiconductor sector.

Moreover, Taiwan's FDI in Japan has been heavily concentrated in sectors related to semiconductor production. Figure 1 shows the components of Taiwan's FDI in Japan by both case and amount at the beginning of 2024. In both cases, manufacturing and information and communication account for more than half of the total. The key manufacturing sectors include electronics, electronic parts and components, computers, electronic and optical products, and chemical product manufacturing. This pattern indicates that Taiwan's investments are closely aligned with the semiconductor industry. The establishment of JASM could serve as a catalyst for Taiwan's FDI in Japan, particularly in industries that support the semiconductor value chain.

[1] For detailed information, please see the MoneyDJ article (first source) https://www.moneydj.com/kmdj/news/newsviewer.aspx?a=fa450566-9b76-47c1-a852-458e4175af90, and the SEAJ website (second source) https://www.seaj.or.jp/english/.

[2] Approximately 19.14 billion USD; at the time of writing, 1 USD = 147.89 JPY.

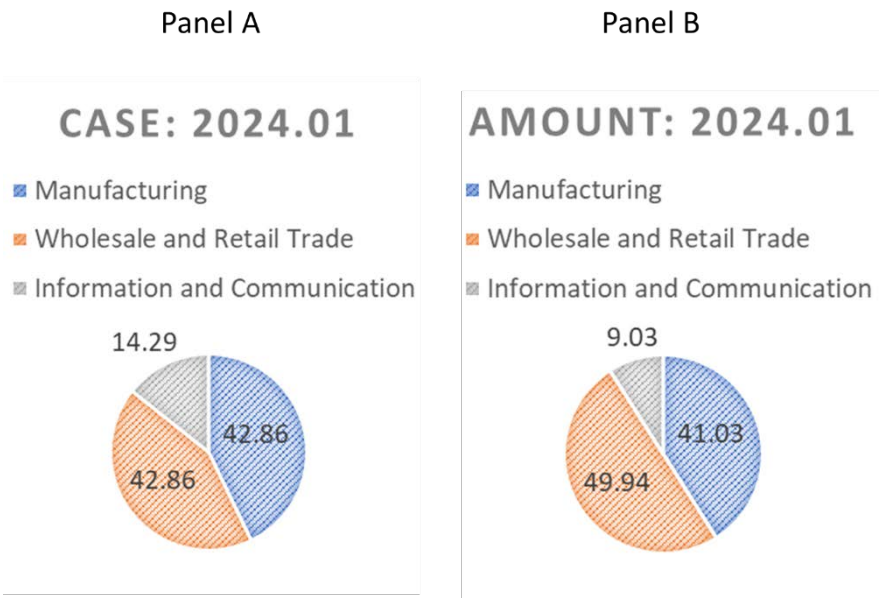


Figure 1. Distribution of Taiwan's FDI in Japan by sector
(Panel A: Case, Panel B: Amount) in early 2024

Notes: The numbers in each panel represent the share of the total FDI in percentage.

3. Methodology and Data

3.1 Methodology

This study employs ITS to evaluate the impact of JASM's establishment on FDI trends. ITS analysis is a statistical technique used to evaluate the effects of an intervention or event on a time series dataset by comparing trends before and after the intervention or event. It helps identify whether changes in the outcome variable can be attributed to the event, isolating its impact from other factors. The analysis involves measuring pre-event trends, immediate effects (discontinuity) at the time of the event, and post-event trends. We employ the following empirical model:

$$(1) \quad Y_t = \alpha + \beta_1 Time_t + \beta_2 PostJASM_t + \beta_3 (Time\_since\_PostJASM_t) + \gamma X_t + \epsilon_t$$

where

Y_t is the outcome variable at time t (Taiwan FDI in Japan) while $Time_t$ denotes a continuous variable representing the time period (year-quarter). It captures the underlying trend in the data over time, reflecting general growth or changes not attributed to JASM.

$PostJASM_t$ is a dummy variable that takes the value of 1 for periods after the establishment of JASM and 0 for periods before. It helps identify the immediate shift in Y as a result of the establishment of JASM. $Time\_since\_PostJASM_t$ is a continuous variable indicating the time that has passed since the event occurred. This interaction measures how the growth trend in Y changes after JASM's establishment, indicating any long-term changes in the post-event period. A vector $\mathbf{X}_t$ accounts for other factors that could influence outcome Y, ensuring that the observed effects are not due to omitted variables.[3]

3.1.1 How Trends Should Appear

When applying the ITS approach, the trend prior to the event should remain relatively stable, showing a consistent pattern (e.g., an upward, downward, or flat trend) without significant fluctuations (pre-event stability). Additionally, we must observe a noticeable change in either the level (e.g., a sudden jump or drop) or slope (e.g., a shift in the direction or rate of the trend) following the event (post-event change). Figures 2 and 3 illustrate the pre- and post-event trends of Taiwan's FDI in Japan in terms of case and amount, respectively. The trends meet the criteria for pre-event stability and post-event change, thereby providing a suitable foundation for conducting the ITS analysis.

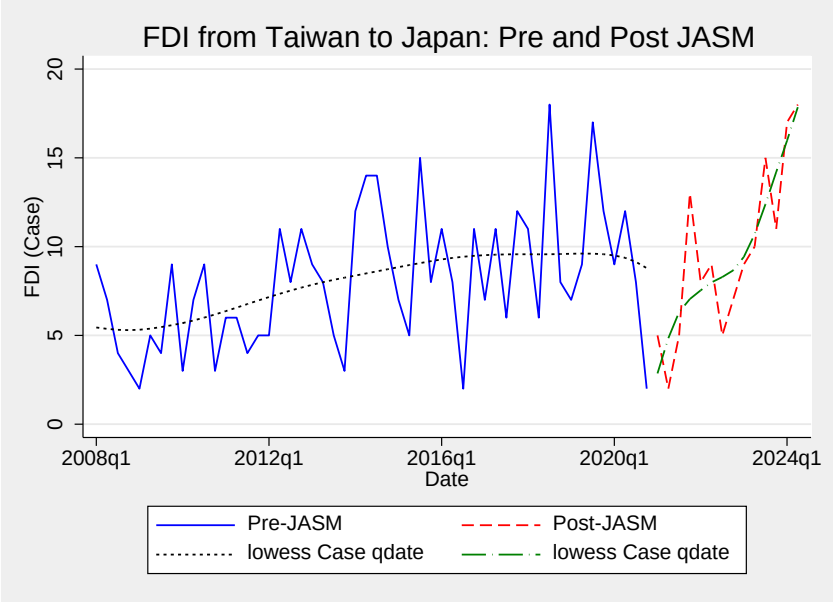


Figure 2. Pre- and post-event trends of Taiwan's FDI in Japan by case

[3] We include economic indicators following Kimino et al. (2007).

Notes: The blue and red marks represent the actual values for the pre- and post-establishment of JASM, respectively, while the black and green marks indicate the trends predicted using LOWESS.[4]

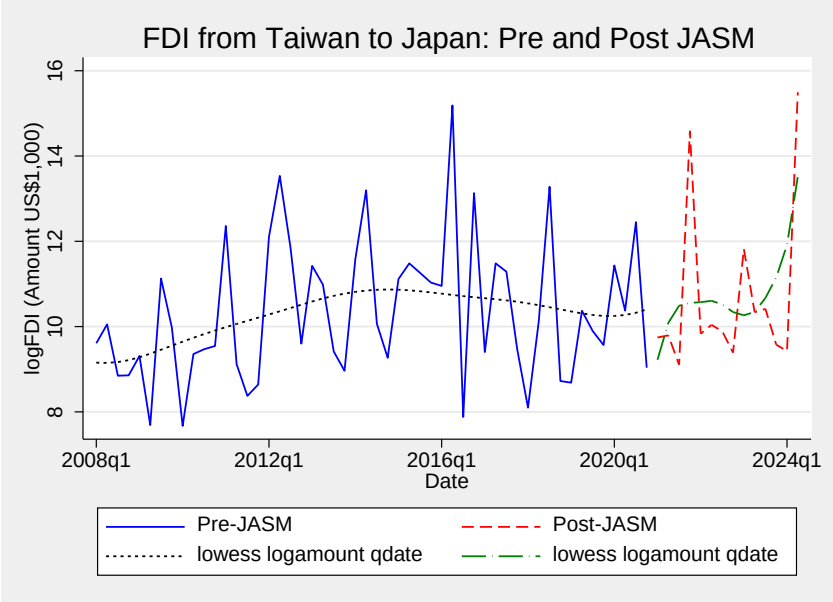


Figure 3. Pre- and post-event trends of Taiwan's FDI in Japan by amount

Notes: The blue and red marks represent the actual values for the pre- and post-establishment of JASM, respectively, while the black and green marks indicate the trends predicted using LOWESS.[5]

3.2 Data

The variables included in the analysis, their respective measurements, and the data sources used in this study are summarized in Table 1. This table provides a clear overview of the key components used to examine the trends and effects in the study. The dataset comprises annual FDI statistics, including the number of FDI cases and their monetary values, spanning a 15-year period. The data sources include official government publications and international economic databases. The control variables account for broader economic trends to isolate the effects of JASM's establishment on FDI.

[4] LOWESS (locally weighted scatterplot smoothing) is a nonparametric regression technique used to estimate trends by fitting weighted least squares regressions to local subsets of the data.

[5] See footnote 4.

Table 1. Overview of variables, measurements, and data sources used in the analysis.

Variables	Measurement	Data source (2007q1-2024q2)
FDI	Real Taiwan's approved outward investment in Japan (case and amount)	Department of Investment Review, Ministry of Economic Affairs, R.O.C.
GDP	Real GDP of Taiwan	National Statistics, Republic of China (Taiwan)
Export performance	The ratio of real Taiwan export to and real Taiwan import from Japan	
Exchange rate	Real Taiwan exchange rate to Japanese yen	
Borrowing cost	Real lending rate of Taiwan minus lending rate of Japan	1. National Statistics, Republic of China (Taiwan) 2. Bank of Japan
CPI Taiwan	General CPI of Taiwan (2021 =100)	National Statistics, Republic of China (Taiwan)
CPI export Taiwan	Export CPI of Taiwan (2021 = 100)	
CPI import Taiwan	Import CPI of Taiwan (2021 = 100)	
CPI Japan	General CPI of Japan (2021 = 100)	Statistics Bureau of Japan
GDP deflator Taiwan	GDP deflator of Taiwan (2021 = 100)	National Statistics, Republic of China (Taiwan)

The summary statistics for the data are provided in Table 2, which offers a detailed overview of the key characteristics of the dataset. We note an average of 8 cases per quarter, with a quarterly value of 251,564 thousand USD. Taiwan's average quarterly real GDP is 4,559,349 million NTD.[6] The ratio of real Taiwan exports to real Taiwan imports is approximately half. The quarterly real Taiwan exchange rate against the Japanese yen is 0.3, and the quarterly difference between Taiwan's and Japan's lending rates is 0.67.

[6] Approximately 138.84 billion USD; at the time of writing, 1 USD = 32.84 NTD.

Table 2. Sample descriptive statistics (quarterly).

	Obs.	Mean	SD	Min	Max
FDI1 (Case)	65	8.35	4.10	2	18
FDI2 (Amount) US$ 1 thousand	65	251,563.6	854,429.7	2,145.87	5,371,686
GDP NT$ 1 million	65	4,559,349	707,021.5	3,181,276	5,989,713
Export performance	65	0.49	0.09	0.33	0.77
Exchange rate	65	0.30	0.06	0.21	0.40
Borrowing cost	65	0.67	1.43	-2.21	4.23

The augmented Dickey–Fuller test for unit roots is conducted to check the stationarity of the variables. The results presented in Table 3 indicate that all the variables are significant, suggesting that they are stationary at this level. To avoid nonstationarity for some economic indicators, we take the first difference or log transformation of certain variables. This step ensures that all variables are appropriately transformed for further analysis.

Table 3. Results of augmented Dickey–Fuller test for unit roots.

	(1) FDI1 (Case)	(2) FDI2 (log amount)	(3) d.log GDP	(4) d.log Export perform.	(5) d.log Exchange rate	(6) Borrow. cost
Without trend	−5.23***	−7.90***	−4.28***	−7.80***	−6.22***	−3.69***
With trend	−6.09***	−8.11***	−4.27***	−7.76***	−6.47***	−4.10***

Notes: Lag lengths are based on the automatic maximum selection of the Akaike information criterion. ***, **, and * denote the levels of significance at the 1%, 5%, and 10% levels, respectively.

4. Empirical Results

The estimation results are presented in Table 4. Columns 1 and 2 exclude other economic indicators while columns 3 and 4 include them. Additionally, columns 1 and 3 do not account for the year trend while columns 2 and 4 account for it. Across all specifications,

the results are consistent, showing that the establishment of JASM led to an immediate reduction in FDI, which dropped by approximately 6–8 cases. This trend indicates initial disruptions in investor confidence. The negative coefficient for the number of cases during the post-JASM period suggests a noticeable drop in FDI activities (e.g., fewer projects or establishments) immediately after the event. This decrease potentially reflects investor caution owing to uncertainties or other factors related to the establishment of JASM.

Furthermore, the positive trend in FDI cases following JASM's establishment indicates gradual recovery and growth, pointing to improved stability and attractiveness over time. This trend suggests that as investors adjusted to the new circumstances, confidence and investment activities began to rise. Notably, the slope of the post-establishment trend is steeper than that of the pre-event trend, highlighting the accelerating recovery and growth following JASM's establishment.

Table 4. Impact of JASM's establishment on Taiwan's FDI in Japan.

	(1)	(2)	(3)	(4)
Quarter trend	0.11***	0.04	0.10**	−0.33
	(0.03)	(0.37)	(0.04)	(0.49)
Post-JASM	−8.10***	−6.72***	−7.31***	−6.20**
	(2.02)	(2.41)	(2.59)	(2.93)
Quarter trend post-JASM	0.80***	1.04***	0.72***	0.96***
	(0.18)	(0.25)	(0.21)	(0.25)
Control var.	No	No	Yes	Yes
Year trend	No	Yes	No	Yes
F statistic	16.11***	10.64***	8.09***	7.66***

Notes: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively.

Figure 4 illustrates the impact of JASM's establishment on Taiwan's FDI in Japan, as estimated from column 4 of our preferred empirical model. The graph shows the predicted results, emphasizing both the immediate and subsequent effects on FDI.

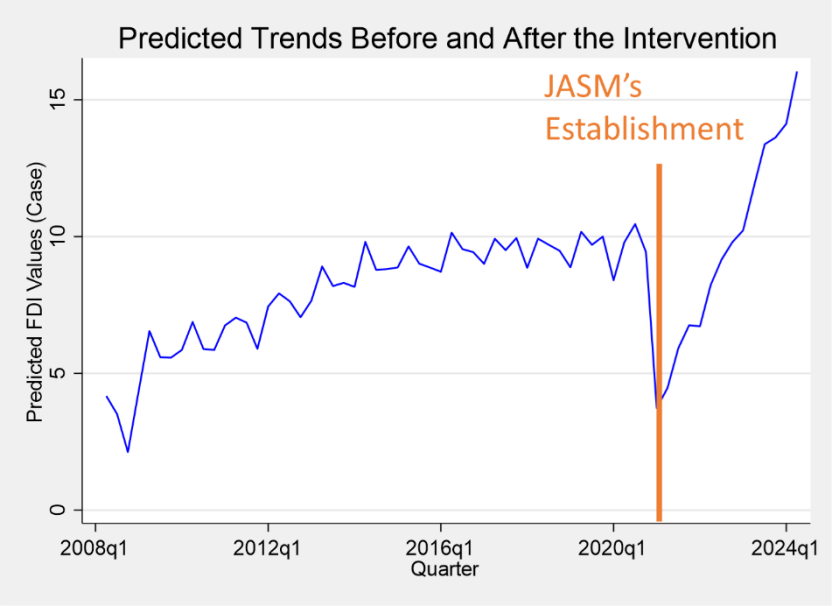


Figure 4. Predicted impact of JASM's establishment on Taiwan's FDI in Japan

4.1 Autocorrelation Check: Durbin–Watson Test

To assess the potential autocorrelation in the regression model, we perform the Durbin–Watson test. A value close to 2 suggests no autocorrelation, a value lower than 2 indicates positive autocorrelation, and a value higher than 2 indicates negative autocorrelation. The test result of 2.09 indicates that autocorrelation is not a concern in our analysis.

4.2 Autocorrelation Check: Residual Plot Analysis

To further examine the autocorrelation, we analyze the plot of the residuals. Figure 5 shows the residual autocorrelation plot. The gray area represents the 95% confidence intervals for autocorrelations at each lag. As the autocorrelation line remains within these boundaries, autocorrelation is not statistically significant at any particular lag, thus confirming the robustness of our model's residuals.

Figure 6 presents the Q-Q plot, which visually assesses the normality of the residuals by comparing their distribution with a theoretical normal distribution. If the residuals are normally distributed, then the points should be closely aligned with the 45-degree reference line. Our results indicate that the residuals follow this pattern, suggesting that they are approximately normally distributed.

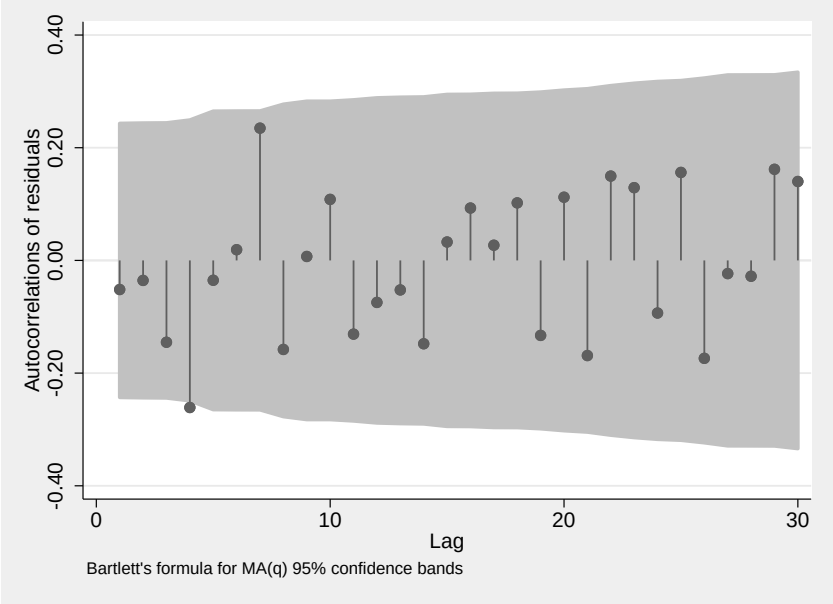


Figure 5. Residual autocorrelation check

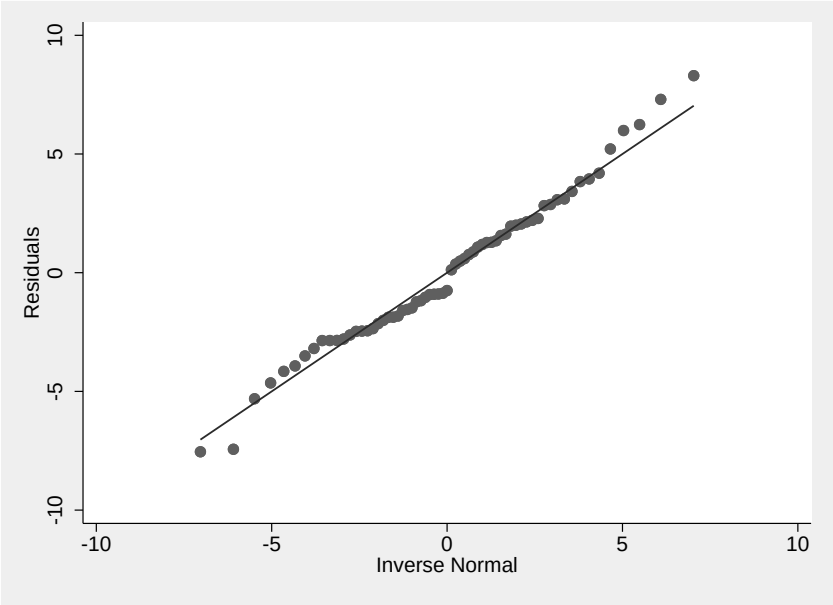


Figure 6. Q-Q plot of residuals

To assess the robustness of our findings, we conduct additional analyses by using the log of the FDI amount as the outcome variable and incorporating year dummies for 2011, 2018–2019, and 2020-2022. Table 5 presents the results.

First, we find no significant immediate decline in the log amount of FDI following the establishment of JASM. While the number of FDI cases decreased significantly, the financial scale of investments that did take place remained largely unaffected. This trend

suggests that the event primarily influenced the decision to initiate new ventures rather than the overall magnitude of investment flows.

Second, to address potential confounding factors, we control for the key years associated with major economic disruptions: 2011 (the Great East Japan Earthquake), 2018–2019 (the United States–China trade war), and 2020-2022 (the COVID-19 pandemic). By including these year dummies, we account for external shocks that may have influenced investment patterns, ensuring that our estimated effects are not driven by unrelated macroeconomic events. Upon incorporating this variable, we observed that the initially significant immediate decline in Taiwanese FDI in Japan became insignificant, suggesting that the short-term impact was less pronounced than initially observed. Furthermore, the investment trend following the establishment of JASM remained significantly positive.

The lack of an immediate effect in investment may be attributed to the effects of the COVID-19 pandemic. The negative coefficient for the COVID dummy indicates that the pandemic had a suppressive effect on Taiwanese FDI in Japan. This may be due to increased caution among firms during the pandemic, leading to a reduction in cross-border investments. Consequently, while the establishment of JASM was expected to stimulate investment, the short-term effects were likely suppressed by the pandemic. This finding is consistent with the positive post-event investment trend, suggesting that investment recovery occurred gradually as the pandemic’s impact diminished.

Table 5. Robustness checks: Impact of JASM's establishment on Taiwan's FDI in Japan (log amount and year dummies).[7]

	(1) Log amount as outcome	(2) Add year dummies
Quarter trend	−0.56**	-0.32
	(0.25)	(0.49)
Post-JASM	−0.18	−4.18
	(1.41)	(3.17)
Quarter trend post-JASM	0.28*	0.91**
	(0.16)	(0.41)
Control var.	Yes	Yes
Year trend	Yes	Yes
F statistic	2.02*	6.76***

Note: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively.

5. Conclusion

In this study, we applied the ITS approach to analyze the short- and long-term impacts of the establishment of JASM on Taiwan's FDI in Japan. The objective was to assess how the event affected the frequency of FDI cases and the financial value of these investments.

Our results indicate that the establishment of JASM led to a significant immediate decline in the number of FDI cases, suggesting a temporary disruption in investor confidence. However, we did not find a significant decrease in the monetary value of FDI, implying that the financial scale of investments was not affected in the short term. The decline in the number of new FDI projects could be due to investor caution, but the stable scale of the investments suggests that firms still made large investment commitments despite the initial disruption.

After accounting for external shocks, particularly the impact of COVID-19, we found that the significant decline in FDI cases might be largely attributable to the pandemic rather than the establishment of JASM itself. The pandemic likely caused a reduction in cross-border investments, exacerbating the short-term disruption in FDI flows.

Over the longer term, we observed a significant positive trend in FDI, indicating

[7] The robustness checks also pass the autocorrelation test. The results are presented in Appendix Figure A1 and Figure A2.

a recovery and adjustment to the new environment following JASM's establishment. The positive post-event trend suggests that, as the effects of COVID-19 diminished, firms adapted to the new conditions, leading to a gradual increase in FDI.

The robustness of these findings across different model specifications supports the conclusion that the observed growth in FDI post-JASM is a genuine response to the event, rather than a temporary fluctuation. After accounting for COVID-19 and other economic factors, the results underscore that the establishment of JASM has had a lasting positive impact on FDI in Japan.

The findings underscore the importance of the semiconductor industry in driving FDI, especially between Taiwan and Japan. Policymakers in Japan should consider strategies to further enhance the attractiveness of high-tech sectors, particularly the semiconductor industry, to maintain and grow foreign investment. Stability in economic policies is also crucial for ensuring that investor confidence is preserved over the long term.

Finally, external factors such as geopolitical risks that could affect FDI flows should be considered. For example, uncertainties arising from shifts in U.S. foreign policy under the new administration could potentially affect Taiwan's semiconductor industry, which may have indirect consequences for FDI from Taiwan to Japan. Policymakers should be mindful of these risks and adapt strategies to mitigate potential disruptions.

Future research could build on this study by examining the long-term effects of the establishment of JASM on broader economic indicators, such as employment rates, wage growth, and technology transfer. Understanding how these factors evolve post-event would provide a more comprehensive view of the broader economic impact of FDI, particularly in high-tech industries, such as semiconductors. By evaluating these long-term outcomes, future studies could explore how foreign investments contribute to local economic development, including their effects on labor markets, technological progress, and overall economic growth.

Data availability

Data will be made available on request.

References

Alfaro, L., 2017. Gains from foreign direct investment: macro and micro approaches. World Bank Econ. Rev. 30, 2–15.

Balasubramanyam, V.N., Salisu, M., Sapsford, D., 1996. Foreign direct investment and growth in EP and IS countries. Econ. J. 106, 92–105.

Bank of Japan. Japan lending rate, 2007–2024. https://www.stat-search.boj.or.jp/ssi/mtshtml/ir04_m_1.html (in Japanese). Accessed 10 Dec. 2024.

Borensztein, E.R., de Gregorio, J.R., Lee, J.W., 1998. How does foreign direct investment affect economic growth? J. Int. Econ. 45, 115–135.

Department of Investment Review, Ministry of Economic Affairs, R.O.C. FDI Statistics, 2007–2024. https://www.moea.gov.tw/Mns/dir/bulletin/Bulletin.aspx?kind=59&html=1&menu_id=42808 (in Taiwanese). Accessed 10 Dec. 2024.

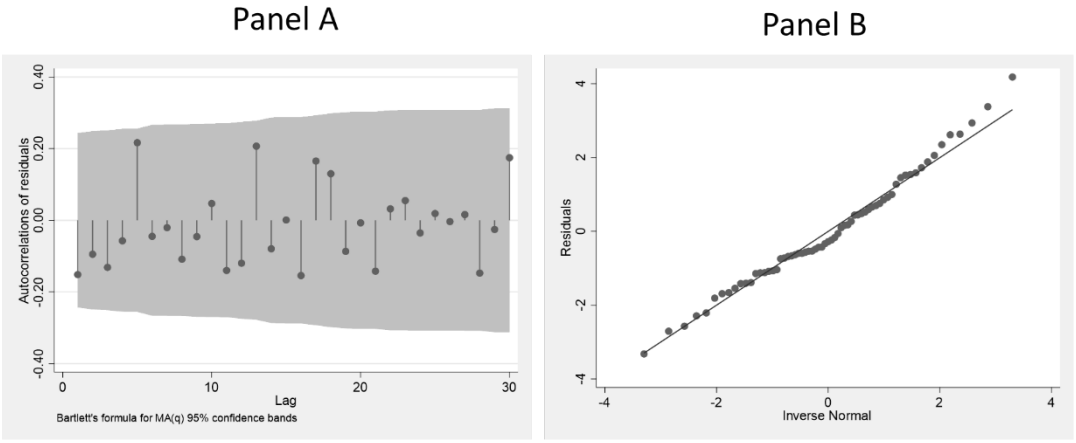
Kimino, S., Saal, D.S., Driffield, N., 2007. Macro determinants of FDI inflows to Japan: an analysis of source country characteristics. World Econ. 30, 446–469.

National Statistics. Republic of China (Taiwan). Taiwan CPI, exchange rate, export performance, GDP, GDP deflator, lending rate, 2007–2024. https://www.stat.gov.tw/ (in Taiwanese). Accessed 10 Dec. 2024.

Statistics Bureau of Japan. Japan CPI, 2007–2024. https://www.stat.go.jp/data/cpi/ (in Japanese). Accessed 10 Dec. 2024.

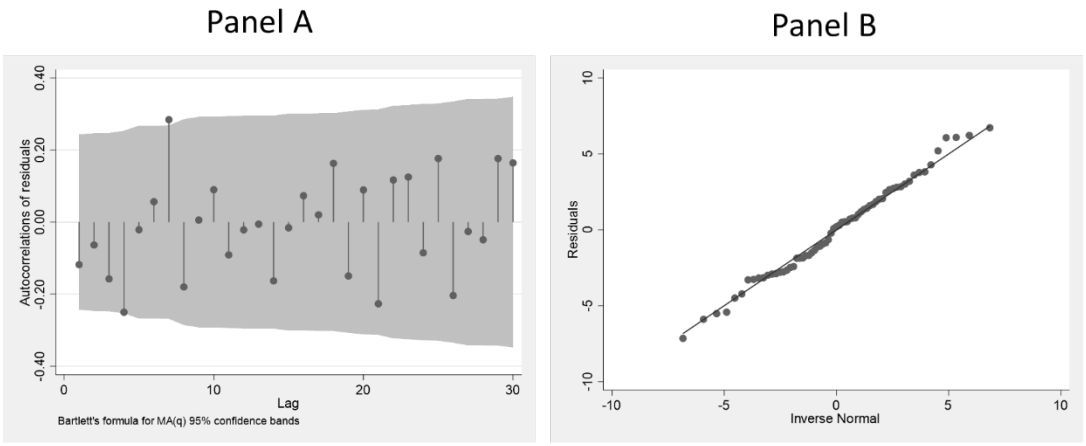
6. Appendix

Figure A1. Autocorrelation for log amount as outcome var.



Notes: Panel A presents the residual plot analysis, while Panel B displays the Q-Q plot. Durbin–Watson d-statistic is 2.22.

Figure A2. Autocorrelation for adding year dummies: 2011, 2018–2019, and 2020-2022.



Notes: Panel A presents the residual plot analysis, while Panel B displays the Q-Q plot. Durbin–Watson d-statistic is 2.21.