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The Impact of Military Technology Development on Innovation: Evidence from prewar and wartime Japanese secret patents[1]

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Abstract

Innovations in military technology potentially drive significant societal transformations through applications to civilian use. This study aims to quantitatively measure the impact of military technology development on civilian innovation activities using prewar and wartime Japanese patent data from 1916 to 1945. By exploiting Japan's secret patent system, which classified particularly critical military-related technologies not disclosed to the public, we identify important technological developments. The result shows that the filing of secret patents led to a significant increase in the number of patents within the corresponding technological classifications. Furthermore, this effect is not limited to organizations that registered secret patents; a significant impact is also observed among organizations that did not register secret patents. This suggests that the development of militarily important technologies generates a substantial spillover effect on other organizations.

Keywords: Innovation, Secret patent, Military technology, Knowledge spillovers
JEL classification: N15; O31; R11

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1 Introduction

Innovations in military technology can potentially drive significant societal transformations through applications to civilian use, as exemplified by the Internet and Global Positioning Systems (GPS). Some military innovations can not only directly induce societal changes, but can also generate significant external effects on research and development for civilian technologies, fostering subsequent technological advancements.

An empirical question is whether the external effect from military technology actually exists, and if it does, how large it is is also a question. However, there are challenges in addressing this question due to the availability of data. Although patent data are often used to quantitatively assess the impact of technological advancements, it is difficult to identify the patents related to military technology based solely on patent data. Patent technology classifications in the United States, Europe, and Japan do not have categories specific to military technology. Furthermore, military organizations do not exclusively develop military technology, and at the same time, private companies and universities are sometimes involved in development of military technology. Thus, it is also difficult to identify military technology development relying on the information on inventors or applicants of patents. These challenges are significant obstacles to quantifying the impact of military technology development.

This study overcomes the challenges by using the patent data from prewar Japan. Before World War II, Japan had a system that classified particularly critical military-related patents as secret patents, which ensured that the specific details of these inventions were not disclosed to the public. Hence, patents recognized as secret patents can be assumed to be military-related technologies with significant importance. This system was abolished by the revision of the Patent Law in 1948, and all the secret patents were disclosed to the public. Thus, we can comprehensively identify the important military-related inventions in prewar Japan, by using the list of secret patents registered in that period.

In this study, we use a list of the secret patents to quantitatively examine the characteristics of the secret patents and their impacts on civilian innovation activities. We first compile descriptive statistics on the number of secret patents, their technological classifications, and the characteristics of their inventors. Subsequently, we conduct a quantitative analysis of the impact of secret patents on civilian innovation activities using a difference-in-differences (DID) approach. Specifically, we regard technological classifications in which secret patents were filed at least once as the treatment group, and those classifications without secret patents as the control group. To apply the staggered DID technique, we define the timing of the first secret patent registered in each classification as the treatment timing.

The results show that registration of a secret patent led to a significant increase in the number of civilian patents within the corresponding technological classifications. Furthermore, this effect is not limited to organizations that registered secret patents; a significant positive impact is also observed for organizations that did not register secret patents. This suggests that the development of militarily important technologies generated a substantial spillover effect on other organizations.

This study relates to several strands of the existing literature. First, it contributes to the literature on innovation in the context of military research. For example, Moretti et al. (2025) finds that public spending on defense-related R&D stimulates private-sector R&D investment. Gross and Sampat (2023) demonstrate that wartime public investments in R&D by the US government played a pivotal role in the long-term development of high-tech clusters in the United States. A broader set of studies examines how government subsidies and investments influence private-sector innovation. For instance, Kantor and Whalley (2025) shows that the Apollo Program in the United States spurred growth in related industries, while Azoulay et al. (2019) provides evidence that public research funding has a positive effect on private sector patenting.

Second, this study also contributes to the literature on knowledge spillovers. Seminal work by Jaffe et al. (1993) demonstrates the existence of such spillovers and their attenuation with geographic distance. More recently, Bloom et al. (2013) show that R&D conducted by a firm generates positive externalities for other firms, particularly for those that are technologically proximate. Our study adds to this literature by examining how major military-related inventions influence subsequent innovation activity among other organizations operating in related technological fields.

2 Historical Background and Data

2.1 Prewar Japanese Innovation and Secret Patent System

The system of secret patents in Japan was established with the revision of the Patent Law in 1899. According to the revised law, "Inventions deemed necessary for military purposes or requiring confidentiality, as recognized by the Director of the Patent Office or upon request from the competent authority, may be subject to restrictions, denial of patent rights, or revocation of previously granted patents at the discretion of the Director of the Patent Office." (authors' translation). Patents requiring military confidentiality were not published in the official bulletins of the Patent Office (*Tokkyo Koho*), and the associated documents could not be requested.

The first secret patent was registered in 1903. This patent, titled "Method for Manufacturing Smokeless Gunpowder," was filed by Ichioka Tajiro, an engineer in the Japanese Navy. The specific inventions that were registered as secret patents are detailed in Sakurai (2020). Among the secret patents, some technologies appear to be highly specialized for military use with little potential for civilian applications, such as cluster bombs and torpedoes. However, there are also technologies with high potential for civilian use, such as jet engines for aircraft, motorized automobile wheels, and acoustic sonar.

This secret patent system continued to exist throughout the pre-war period. However, with Japan's defeat in World War II, the provisions related to secret patents were removed in the 1948 revision of the Patent Act, leading to the abolition of the secret patent system in Japan. A total of 1,610 patents were registered as secret patents by 1948.

2.2 Data

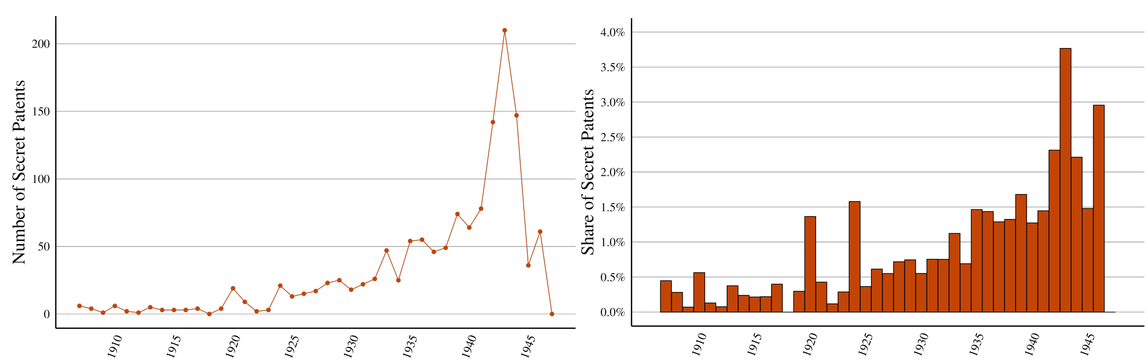
We use a novel historical patent database in Japan developed by Inoue et al. (2020). The database covers all the Japanese patent information from 1887, when the modern patent system was established in Japan to 1950. The database provides the information on the inventor's name and address, the applicant's name and address, and the technology classifications for all the patents registered in those periods.

The official technology classification system was sometimes revised in our sample period. To make the technology class consistent throughout the sample period, we use the Catalogue of Patents by Technology Classification published by the Japan Patent Office in 1958 (Japan Patent Office, 1958). This is the list of all the patents registered by that time, which reassigned a technology class to each patent according to the technology classification system at that time. The reassigned technology class in the Catalogue is a so-called Japan Patent Classification (JPC) established in 1952, which has 135 sections, 865 classes, and 3834 subclasses.

This patent database was compiled using the complete set of the photo images of the Patent Specification (Tokkyo Meisai-sho) provided by the Japan Patent Office and the Industrial Property Information and Training Center (INPIT), encompassing all the patents since the first patent, including former secret patents. However, the information on which patents were classified as former secret patents is not explicitly documented in the database. To fill this gap, we utilized a book by Sakurai (2020) to identify secret patents. This book provides a comprehensive list of all former secret patents in Japan, along with their patent numbers. By merging this list with the database, we are able to extract information on secret patents.

Figure 1 shows the number of secret patents and the share of secret patents relative to all patents in Japan. We observe that both the number and the share of secret patents increased from the middle of the 1930s, coinciding with Japan's progression from the Second Sino-Japanese War to the World War II.

Figure 1: Trends of Secret Patents



Notes: These figures show the trends in secret patents. The left panel displays the number of secret patents, while the right panel presents their percentage share among total domestic patents. The x-axis represents the registration year.

Table 1 lists the top 10 patent subclasses with the highest proportion of secret patents relative to the total number of patents. While the inclusion of subclasses such as weapons and firearms, which are likely associated with military technologies, is not surprising, it is noteworthy that even within these subclasses, the share of secret patents is not particularly high. For example, weapons rank at the top with 15.2%, which is relatively high. However, the remaining 85% of patents in this subclass are not secret patents, suggesting that these patents are likely of lesser military significance.

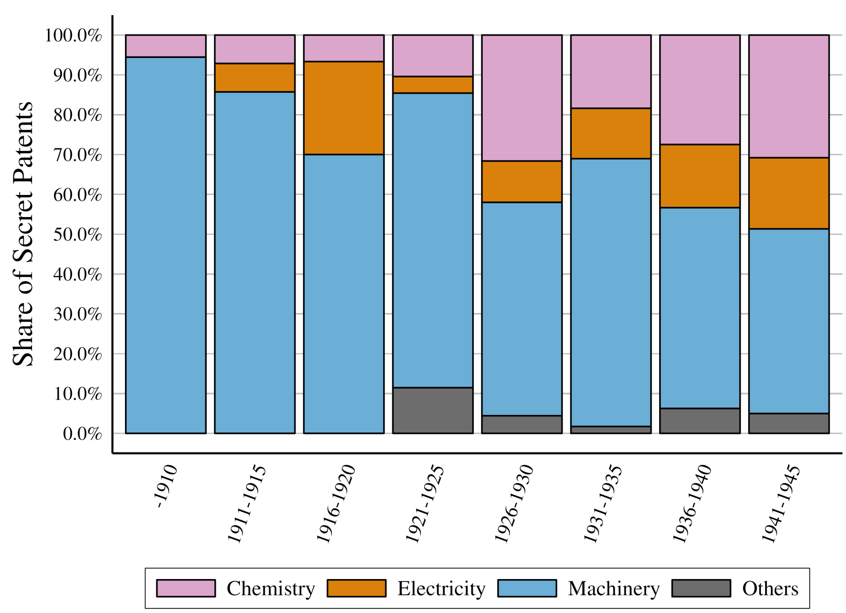
It is also important to note the presence of secret patents in subclasses outside the clearly military-related categories, such as weapons and firearms. For instance, subclasses like organic compounds/hydrocarbon, which likely include patents developed in response to resource shortages during WWII, also contain a

Table 1: Top Ten Patent Subclasses of Secret Patent

		Secret patents		Patents (1907-1950)	
Subclass	Description	Percent	Rank	Percent	Rank
95E0	Weapons	15.2	1	0.34	14
16B1	Organic compound /hydrocarbon	4.6	2	0.14	130
51B8	Reaction propulsion engine	3.9	3	0.03	756
98F1	High-frequency specialized communication	3.6	4	0.22	52
18B4	Alternative source petroleum production	2.3	5	0.12	170
18C3	High-pressure hydrogenation cracking	2.3	5	0.07	344
95E2	Firearms	2.1	7	0.22	51
100C4	Radar	1.9	8	0.03	935
29C2	Composite explosives	1.8	9	0.03	893
98F3	Underwater communication	1.2	10	0.01	1780

Notes: The table presents the top ten patent subclasses in terms of the shares of secret patents in those subclasses. The figures in the right column indicate the shares and ranks of those subclasses in the all patents (secret and non-secret) from 1907 to 1950. It is noted that the total number of subclasses is 3,834.

Figure 2: The Proportion of Each Technology Category in Secret Patents



Notes: This figure shows the proportion of each technology category in the total number of secret patents for each year bin. ”Others” includes patents in Agriculture, Textiles, and Daily Necessities. The x-axis represents the registration year.

significant number of secret patents. This highlights the challenge of identifying military technologies at the level of technology classifications, as many secret patents belong to subclasses that cannot be easily identified as military-related.

Note that in the registration of secret patent, while Navy and Army play an important role as is shown in the list of top ten secret patent applicants in Tables A1-A4, Apart from secret patents, private firms, for example, Tokyo Shibaura Electric, Hitachi, and Mitsubishi Heavy Industries, register more patents than Navy and Army.

Figure 2 shows the share of each technological category in total secret patents, presented in five-year intervals. The figure reveals that, whereas secret patents in the early period were predominantly related to mechanical technologies, the later period saw an increased share of those related to chemical technologies.

3 Empirical Strategy

The hypothesis of this study is that *major innovations in military research stimulate research and development activities in the corresponding field.* To test this hypothesis, we conduct a Difference-in-Differences (DID) analysis. We examine whether innovation activity increases in the technology class where secret patents are registered. Here innovation activity is captured by number of patents in the class.

First, we aggregate patent data by technology class (subclass i) $\times$ time (five-year bins t), defining this as our unit of observation. Then, for each subclass, we count the number of secret patents for each five-year bin and define Patent_{it}. The time of registration of a secret patent in a particular field for the first time is defined as an event, and we examine its impact on subsequent patent registrations in that field.

The treatment group consists of subclasses that had at least one secret patent registered during the period 1916 to 1945. In contrast, the control group comprises all other subclasses, meaning those that never had a secret patent registered. The timing of secret patent registrations varies across the treatment group. In this study, we define the timing of treatment as five-year bin when a secret patent was first registered in a given subclass i and denote it as $\tau(i)$. Accordingly, the post time variable Post_{it} takes the value of 1 when $t >= \tau(i)$ and 0 otherwise.

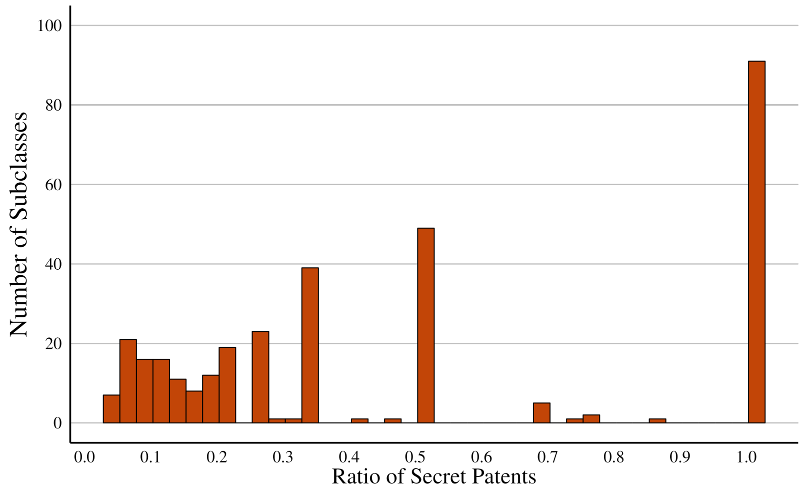
Additionally, frequency of registration of secret patents differs by technology class and it might cause different effect of secret patents since more important military technologies are developed in that field. To account for such variations in treatment intensity, we introduce a variable First Secret Ratio_i, the ratio of secret patents registered in the subclass in the five-year bin when the first secret patent was recorded ($\tau(i)$) and interact with the post-time variable. The distribution of First Secret Ratio_i is shown in Figure 3.

Specifically, we estimate the following equation:

$$\ln(\text{Patent}_{it} + 1) = \beta \ln(\text{Fitst Secret Ratio}_i + 1) \times \text{Post}_{it} + \alpha_i + \delta_t + \upsilon_{it},$$

where i is subclass, t is five-year bin (i.e., 1916-1920, $\cdots$, 1936-1940, 1941-1945), α_i is subclass FE, and δ_t is five-year bin FE. To estimate this equation, it is weighted by the of subclass defined by number of lower classes in the subclass, and standard errors are clustered at the subclass level. As a robustness check, we

Figure 3: The Distribution of Ratio of Secret Patents



Notes: This figure shows the distribution of the ratio of secret patents, excluding values of zero. The ratio of secret patents is defined as the number of secret patents in a subclass in a given year (registration year) divided by the total number of patents in the subclass in that year.

also control change in innovation by broader class of technology by $\gamma_{k(i)t}$ where $k(i)$ can be section of field of technology. Note that we add 1 before taking the logarithm for variables Patent_{it} and $\text{Fitst Secret Ratio}_i$ since these variable can take the value 0.

Next, an event study will be conducted to examine the dynamic effects of secret patent registration. Instead of Post_{it} in DID estimation, we look at event time dummy $I[t = \tau(i) + j]$ which takes 1 when $t = \tau(i) + j$ and 0 otherwise. The estimation equation is as follows:

$$\ln(\text{Patent}_{it} + 1) = \sum_{j \neq -1} \theta_j \{\ln(\text{First Secret Ratio}_i + 1) \times I[t = \tau(i) + j]\} + \alpha_i + \delta_t + \upsilon_{it},$$

where i is subclass, t is five-year bin, α_i is subclass FE, and δ_t is five-year bin FE. As in the previous DID estimation, it is weighted by the size of subclass, and standard errors are clustered at the subclass level . Note that $\tau(i) - 1$ is the time right before the event, and we fix it as a reference point and exclude $j = -1$ in summation. Since we have 6 five-year bin in the sample period, j can take the values from -5 to 5.

4 Results

4.1 Main Result

Table 2 presents the main DID estimation results. Column (1) reports the results with two-way fixed effects, including subclass fixed effects and five-year bin fixed effects. The findings indicate that as the share of secret patents increases, the number of other patents in the same field also rises. Column (2) includes field fixed effects interacted with five-year bin fixed effects, while column (3) incorporates section fixed effects interacted with five year bin fixed effects. Column (4) controls for the number of cumulative patents filed in the subclass before 1905 to control for the initial innovation activities in the subclass, and Column (5) includes all fixed effects. Regardless of the specification used, the results robustly show that an increase in the share of secret patents leads to a rise in other patents in the same field. Those results support our main hypothesis.

Table 2: Main Results: Effects of the Secret Patent Filing on Innovation

	ln (Patents + 1)				
	(1)	(2)	(3)	(4)	(5)
ln(First Secret Ratio+1) × Post	1.033***	1.159***	0.602**	1.004***	0.601**
	(0.340)	(0.317)	(0.276)	(0.340)	(0.277)
Subclass FE	✓	✓	✓	✓	✓
Five Year Bin FE	✓	✓	✓	✓	✓
Field FE × Year FE		✓			
Section FE × Year FE			✓		✓
Pre-Development × Year FE				✓	✓
Observations	14,184	14,184	14,184	14,184	14,184
Adjusted R^2	0.74	0.76	0.81	0.74	0.81
Mean of dep.var	1.1	1.1	1.1	1.1	1.1

Notes: This table shows the estimated effects of secret patents on subclass-level patenting. The unit of observation is subclass × five year bin (filing year), where subclasses are defined by the Japanese Patent Classification (JPC) and five-year bins range from 1916-1920 to 1941-1945. Robust standard errors, clustered at the subclass level, are reported in parentheses. The dependent variable is the number of patents filed in a given subclass during a given five year bin. The independent variable, "First Secret Ratio", indicates the ratio of secret patents to total patents in the subclass in the bin when the secret patent was first registered. The control variable, "Pre-Development", is the number of patents filed in the subclass before 1905. ***, **, and * indicate significance at the 1%, 5%, and 10% levels.

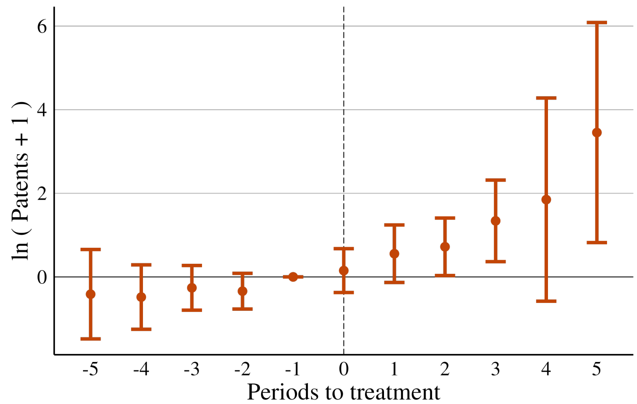
Figure 4 presents the results of the event study analysis. In the periods before the treatment, all coefficients are insignificant, indicating that the assumption of parallel trends holds. In contrast, after the treatment begins, a positive effect emerges gradually. This suggests that the registration of secret patents stimulated innovation activities in the relevant field. [1]

Additionally, Figure 5 shows the results of a similar analysis conducted by patent technology field (Chemistry, Machinery, Electricity). The assumption of parallel trends holds across all technology classifications. However, regarding the treatment effect, no effect is observed in the electrical field, whereas significant effects are found in the chemical and machinery fields. Notably, in the machinery field, the variance is smaller, indicating a particularly pronounced impact.

Summarizing the baseline results, we find that in subclasses where secret patents are registered, the number of non-secret patents increases after the registration of secret patents. This effect is primarily driven by machinery fields, but a significant impact is also observed in chemistry. These findings suggest that the development of militarily important technologies promotes research and development outcomes in the corresponding patent fields.

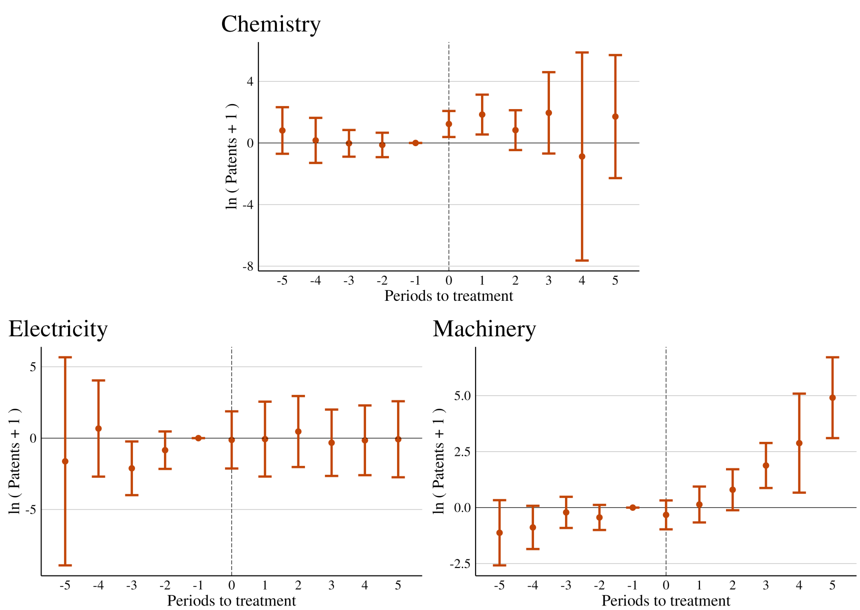
[1] As shown in Figure A1, the main results remain unchanged even when the variable of intensity of treatment in the subclass is defined by ratio of secret patents over the entire period instead of first five-year bin $\tau(i)$.

Figure 4: Event Study Plot: Effect of the Secret Patent on Innovation



Notes: This figure presents the estimated dynamic effects of secret patents on subclass-level patenting (θ_τ in the equation). The unit of observation is subclass $\times$ five-year bin (filing year), where subclasses are defined by the Japanese Patent Classification (JPC), and year bins range from 1916-20 to 1941-45. Estimates are obtained from a staggered difference-in-differences model, controlling for subclass fixed effects and section-year bin fixed effects. Confidence intervals are calculated at the 95% level, with robust standard errors clustered at the subclass level.

Figure 5: Event Study Plot: Effect of the Secret Patent on Innovation By Technology Fields



Notes: These panels present the estimated dynamic effects of secret patents on subclass-level patenting (θ_τ in the equation), by technology fields. The unit of observation is subclass $\times$ five-year bin (filing year), where subclasses are defined by the Japanese Patent Classification (JPC), and year bins range from 1916-20 to 1941-45. Estimates are obtained from a staggered difference-in-differences model, controlling for subclass fixed effects and section-year bin fixed effects. Confidence intervals are calculated at the 95% level, with robust standard errors clustered at the subclass level.

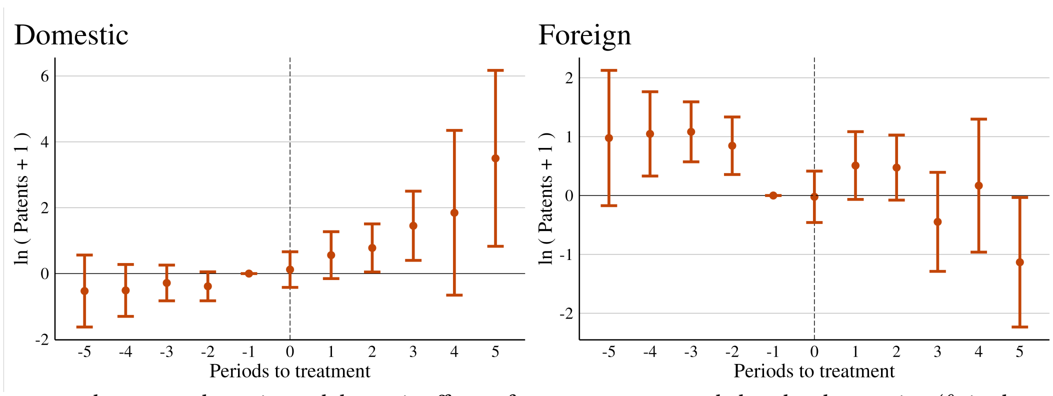
4.2 Mechanism

Why does the registration of secret patents in a particular field stimulate innovation activities within that field? This subsection analyzes the underlying mechanisms, focusing in particular on the characteristics of the applicants.

First, we conduct an analysis based on the nationality of patent applicants. Using applicant address information, we classify patents into those filed by domestic applicants and those filed by foreign applicants. We then calculate the total number of patents in each technological class separately for domestic and foreign applicants and use these as outcome variables in an event study analysis.

The results are presented in Figure 6. The left panel shows the number of patents filed by domestic applicants shown in Figure 4 as the reference. The right panel shows the number of patents filed by foreign applicants. A slight downward trend is observed, but no significant pattern emerges. These findings indicate that the increase in innovation activity following the registration of secret patents is primarily driven by domestic applicants.

Figure 6: Event Study Plot: Effect of the Secret Patent on Innovation by Nationality



Notes: These panels present the estimated dynamic effects of secret patents on subclass-level patenting (θ_l in the equation) by nationality The unit of observation is subclass × five-year bin (filing year), where subclasses are defined by the Japanese Patent Classification (JPC), and year bins range from 1916-20 to 1941-45. Foreign patents are identified based on the applicant's address information. Estimates are obtained controlling for subclass fixed effects and section-year bin fixed effects. Confidence intervals are calculated at the 95% level, with robust standard errors clustered at the subclass level.

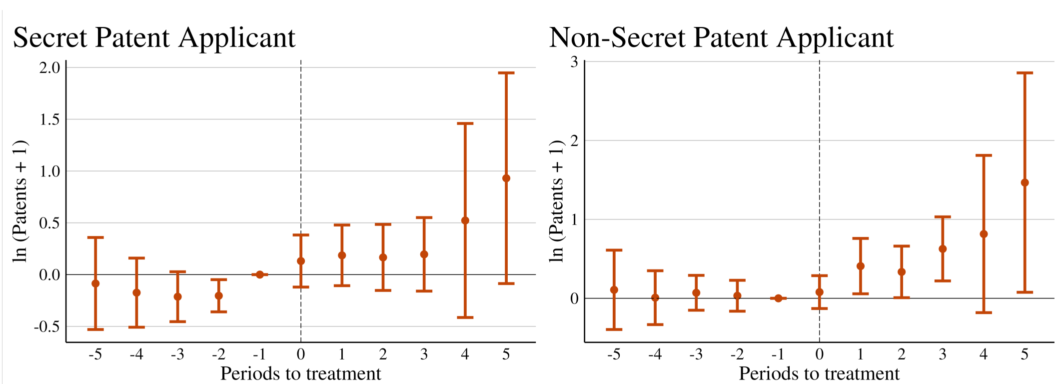
Next, we conduct a more detailed classification of patent applicants. Research in military technology may enhance the research and development (R&D) capabilities of the applicants through the accumulation of technical expertise. If this is the case, we would expect an increase in the number of patents produced by applicants who have registered secret patents after their registration. At the same time, military technology research may generate spillover effects for other firms specialized in civilian technology. Once militarily significant research is registered and implemented, other firms specialized in civilian technology may file new patents referencing these technologies. In such cases, the registration of secret patents could lead to an increase in patent production by applicants who do not file secret patents themselves.

To examine these mechanisms, we classify patent applicants into two groups: (1) those who have registered at least one secret patent during the study period ("secret patent applicants") and (2) those who have never registered a secret patent during the same period ("non-secret patent applicants"). We then decompose the total number of patents in each technological class into those filed by secret patent applicants and non-secret patent applicants, using these as outcome variables in an event study analysis.

Figure 7 presents the results. The left panel shows the total number of patents filed by secret patent applicants as the outcome variable. As in previous analyses, the assumption of parallel trends holds, and the number of patents significantly increases after the registration of secret patents. This finding suggests that registration of secret patents stimulates patent production activities within firms engaged in military technology development. In other words, military technology research contributes to the expansion of the R&D capabilities of the firms conducting it.

The right panel presents the total number of patents filed by non-secret patent applicants. Similarly, the assumption of parallel trends holds, and the results show a significant increase in the number of patents in fields where secret patents have been registered. This indicates that the registration of secret patents also promotes research and development activities in firms that do not engage in military technology development. Moreover, the effect appears to be quite substantial. While the confidence intervals are wide, the point estimates suggest that the effect of secret patent registration is larger for non-secret patent applicants than for secret patent applicants. This implies that the development of critical military technologies may generate significant spillover effects for civilian innovation activities.

Figure 7: Event Study Plot: Effect of the Secret Patent on Innovation by Secret Patent Registration



Notes: These panels present the estimated dynamic effects of secret patents on subclass-level patenting (θ_l in the equation) by secret patent registration. The unit of observation is subclass × five-year bin (filing year), where subclasses are defined by the Japanese Patent Classification (JPC), and year bins range from 1916-20 to 1941-45. "Secret Patent Applicant" refers to those who have registered at least one secret patent during the sample period. Otherwise, they are referred to as "Non-Secret Patent Applicants." Estimates are obtained controlling for subclass fixed effects and section-year bin fixed effects. Confidence intervals are calculated at the 95% level, with robust standard errors clustered at the subclass level.

A natural question is how the positive spillover effects occurred, although the patent was secret. The following anecdote would address this question. In July 1917, the Navy registered a secret patent on the two-way simultaneous wireless telephone (Patent No.31375). What was announced by the Patent Office was just the patent number and the name of the invention, i.e. the two-way simultaneous wireless telephone. However, just after the announcement, Dr. Uichi Torigata, an engineer of the Electro-Technical Laboratory of the Ministry of Communication, published an article titled "On the two-way simultaneous wireless telephone" to an electric engineering journal, *Gendai no Denki (Contemporary Electric Machinery)* to explain the scientific mechanism of the two-way simultaneous wireless telephone in detail, based on his own original research and development (Torigata 1917) . This anecdote suggests that for engineers in the same field, challenges to overcome for an innovation and basic scientific ideas were shared, and hence a news of a breakthrough stimulated related research and development.

5 Conclusion

This study aims to quantitatively measure the impact of military technology development on civilian innovation activities using prewar and wartime Japanese patent data. By exploiting the list of secret patents, we quantitatively examine the impact of military technology development on civilian innovation activities. The results show that the filing of secret patents led to a significant increase in the number of patents within the corresponding technological classifications. Furthermore, this effect is driven primarily by the organizations that filed the secret patents, indicating that military technology development generated notable spillover effects within the inventors and organizations involved. Our results suggest that military technology development has a large impact on civilian research and development activities in the prewar periods.

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Appendix A Historical Background

Table A1: Top Ten Secret Patent Applicants

	Secret patents		Patents (1907-1950)	
Institution	Count	Rank	Count	Rank
Navy	492	1	453	8
Army	281	2	387	10
Mitsubishi Heavy Industries, Ltd.	100	3	848	4
Nippon Chisso Fertilizer Co., Ltd.	32	4	285	17
Kyowa Chemical Industry Co., Ltd.	24	5	24	152
Kawanishi Machinery Works	19	6	356	12
Nakajima Aircraft Company, Ltd.	19	6	152	32
Tokyo Shibaura Electric Co., Ltd.	17	8	3942	1
Nippon Kogaku Kogyo Co., Ltd.	15	9	131	38
Hitachi, Ltd.	12	10	2387	2
International Electric Communications Co., Ltd.	12	10	221	21

Notes: The table presents the top ten applicants who registered secret patents, where ”Count” indicates the number of patents registered.

Table A2: Top Ten Secret Patent Applicants (Machinery)

	Secret patents		Patents (1907-1950)	
Institution	Count	Rank	Count	Rank
Navy	222	1	213	5
Army	184	2	156	9
Mitsubishi Heavy Industries, Ltd.	97	3	751	2
Nakajima Aircraft Company, Ltd.	19	4	139	10
Nippon Kogaku Kogyo Co., Ltd.	14	5	126	11
Kawanishi Machinery Works	11	6	55	28
Hitachi, Ltd.	11	6	842	1
Tokyo Keiki Inc.	10	8	71	23
Mitsubishi Shipbuilding Co., Ltd.	8	9	181	8
Kayaba Manufacturing Co., Ltd.	8	9	49	30

Notes: The table presents the top ten applicants who registered secret patents in the Machinery category, where ”Count” indicates the number of patents registered.

Table A3: Top Ten Secret Patent Applicants (Chemistry)

	Secret patents		Patents (1907-1950)	
Institution	Count	Rank	Count	Rank
Navy	154	1	194	9
Army	65	2	202	8
Nippon Chisso Fertilizer Co., Ltd.	30	3	264	5
Kyowa Chemical Industry Co., Ltd.	24	4	24	86
Kobe Steel, Ltd.	7	5	94	21
Riken (Institute of Physical and Chemical Research)	7	5	530	2
South Manchuria Railway Company	5	7	23	89
Dainippon Celluloid Co., Ltd.	3	8	89	22
Mitsubishi Chemical Industries, Ltd.	3	8	131	14
Mitsubishi Heavy Industries, Ltd.	3	8	83	24

Notes: The table presents the top ten applicants who registered secret patents in the Chemistry category, where "Count" indicates the number of patents registered.

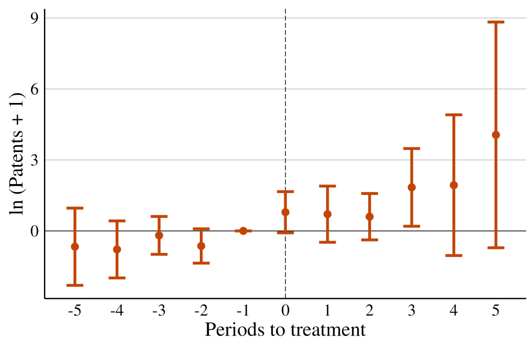
Table A4: Top Ten Secret Patent Applicants (Electricity)

	Secret patents		Patents (1907-1950)	
Institution	Count	Rank	Count	Rank
Navy	116	1	46	30
Army	32	2	29	38
Tokyo Shibaura Electric Co., Ltd.	9	3	2684	1
Kawanishi Machinery Works	8	4	271	7
Ministry of Communications	8	4	916	3
International Electric Communications Co., Ltd.	5	6	183	11
Mitsubishi Electric Co.	4	7	281	6
Oki Electric Industry Co., Ltd.	3	8	85	22
Riken (Institute of Physical and Chemical Research)	3	8	94	20
Fuji Telecommunications Manufacturing Co., Ltd.	2	10	87	21
Nippon Wireless Telegraph Co., Ltd.	2	10	171	12
Yokogawa Electric Works	2	10	99	19
Fujikura Electric Wire Co., Ltd.	2	10	55	28
Sumitomo Communication Industry Co., Ltd.	2	10	241	9

Notes: The table presents the top ten applicants who registered secret patents in the Electricity category, where "Count" indicates the number of patents registered.

Appendix B Additional Analysis

Figure A1: Robustness: Effect of the Secret Patent on Innovation using different intensity measures



Notes: This figure presents the estimated dynamic effects of secret patents on subclass-level patenting (θ_τ in the equation). The unit of observation is subclass $\times$ five-year bin (filing year), where subclasses are defined by the Japanese Patent Classification (JPC), and year bins range from 1916-20 to 1941-45. Estimates are obtained controlling for subclass fixed effects and section-year bin fixed effects. Confidence intervals are calculated at the 95% level, with robust standard errors clustered at the subclass level. Here we use secret ratio of entire sample period as an intensity measure for treatment as