**TITLE:** Case Study on United State's Trading with Enemy Act: Relationship Between Compulsory Licensing and Domestic Invention

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## INTRODUCTION

This report is trying to figure out the relationship between Compulsory licensing and domestic invention. More specifically, this report attempts to answer the question of whether compulsory licensing increases or decreases domestic inventions in countries that license foreign technology. We use the event of Trading with the Enemy Act (TWEA) as an exogenous factor to test the effect of compulsory licensing on the change in the number of patents by domestic inventors in the field of chemical technology industries. The Trading with the Enemy Act allows US companies to infringe on patents owned by enemies if the companies contribute to WWI. By February 1919, all German patents were licensed to US companies. One of the benefits of using the TWEA as an exogenous factor is that we could exclude the situation that compulsory licensing may be influenced by other confounding factors like education, skills, demand-driven and so on and so for.

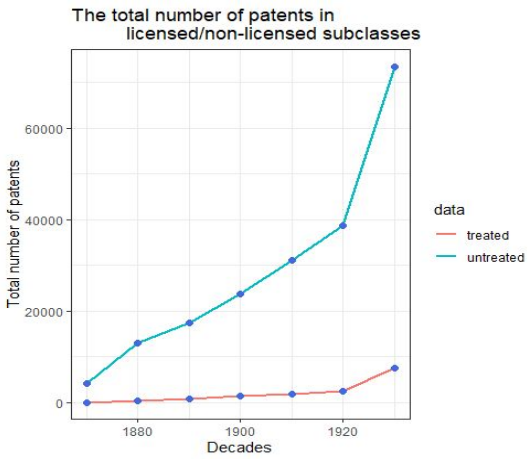
By using difference-in-differences analysis, our hypothesis suggests that compulsory licensing may increase domestic inventions. In this empirical analysis, we use dummy variables to identify the subclasses received at least one license and the remaining time for licensing is larger than 7 years which denotes the novelty of licensed patents under the TWEA. The data are collected from the United States Patent and Trademark Office(USPTO) and altogether with 128,953 patents between 1875 and 1939 and covered each 7248 subclasses with 336 subclasses treated and 6912 subclasses untreated under 19 main classes. Moreover, to assess the direction and size of selection bias, we use Intention-to-treat(ITT) principle, which involves the subclass having at least one patent available for licensing to capture the number of enemy-owned patents that could have licensed under the TWEA and use it to examine how does compulsory licensing influenced the domestic inventions.

## EMPIRICAL EVIDENCE AND DISCUSSION

TABLE 1. THE NUMBER OF PATENTS IN LICENSED AND UNLICENSED BY US INVENTORS FOR EVERY DECADE

| decade | number of patent in untreated subclasses | number of patent in treated subclasses |
|---|---|---|
| 1870 | 3840 | 59 |
| 1880 | 11000 | 147 |
| 1890 | 13100 | 147 |
| 1900 | 18000 | 319 |
| 1910 | 26100 | 631 |
| 1920 | 31800 | 1220 |
| 1930 | 54500 | 3810 |

FIGURE 1. THE TOTAL NUMBER OF PATENTS IN LICENSED AND UNLICENSED SUBCLASSES FOR EVERY DECADE




*Data on annual patents and inventor nationalities were constructed from www.uspto.gov and the Lexis Nexis Chronological Patent Files (1790-1970). Treated subclasses received at least one license under the TWEA. Data include 7,248 subclasses, 336 of which are treated. Subclass with at least one license are treated. Sources of data: Dataset of subclasses and patent information are collected by Petra Moser (2012).*

Figure 1 shows the total number of patents in licensed and non-licensed subclasses for every decade. From above, we could observe that the overall trend is upward sloping. However, there exists a substantial increase around 1919 which indicates the influence of TWEA. Table 1 shows the number of patents by American inventors in licensed and non-licensed subclasses for every decade. Among the decade of 1920 and 1930, there is 212.3% increase in the treated subclasses, and 71.4% increase in the untreated subclasses licensed by German patent. From the simple comparison, we could find that the increase in patents in treated subclasses is larger than the untreated subclasses. So it gives us a forehead to show that compulsory licensing may increase the domestic invention.

TABLE 2. THE SHARE OF AMERICAN, GERMAN, FRENCH INVENTORS IN TREATED VS NON-TREATED SUBCLASSES

| treat | share of American inventors | share of German inventors | share of French inventors |
|---|---|---|---|
| 0 | 0.773 | 0.113 | 0.0251 |
| 1 | 0.502 | 0.306 | 0.0192 |

*Sources of data: Dataset of subclasses and patent information are collected by Petra Moser (2012).*

In Table 2, it represents the share of American, German, and French inventors in treated and non-treated subclasses. We could observe that the share of American inventors is higher than other countries' inventors in both treated and untreated subclasses, so the result of studying how

compulsory licensing affects domestic invention in the United States is of universal significance in some sense.

For difference-in-differences analysis, we use dummy variables to represent whether a subclass has any foreign and at the same time, whether the remaining lifetime of licensed patents is larger than 7 years to differentiate the control group and treated group. The remaining year of patents is one of the ways to shed light on the novelty of the licensed patent, which means more years remaining and high-value patents are positively related. To examine the effect of compulsory licensing on the number of U.S. patents around 1919, we first shortened the period from 1875 to 1939 to the period from 1900 to 1939. Then we calculate the change between the sum of the U.S. patents before 1919 and the sum after 1919 for different treated groups. When we put the data into the t-test, we got the result with a p-value equal to 0.0000164, which is significantly smaller than the 0.005. In the result, the mean of patents in the control group is 6.11 and the mean of the patent in the treated group is 12.4. We reject the null hypothesis, so that there exists a significant difference between the change in the treated and control group before and after TWEA.

Figure 2 shows that before 1919, the trend of the treated group and the control group had a similar parallel slope; however, after 1919, the trends were not parallel anymore. We could expect to see the same parallel trend if compulsory licensing does not affect the number of patents. From the graph, we could observe that there exists a significant increase around 1930, that could be explained by the time lag for licensed patents which means that the full impact of compulsory licensing occurred with a lag of around ten years. In this way, we could claim that compulsory licensing increases domestic inventions.

In the empirical analysis, we use binary variables to denote whether a subclass has licensed or not. However, some of the subclasses may not have only one license; instead, those subclasses may have multiple licenses. So what is the relationship between the number of licenses and the number of patents created by U.S. inventors? In Figure 4, it shows the average number of patents by U.S. inventors along with the change in the number of licenses in treated subclasses. We could see that there exist some fluctuations when licenses lower than 8, and after that, it shows a positive relationship. That indicates that for some of the subclasses with much more licenses, the innovation in those subclasses is higher.

FIGURE 2. PATENTS BY U.S. INVENTORS PER 100 WITH INVENT
TREATED AND NON-TREATED SUBCLASSES FROM 1900-1939

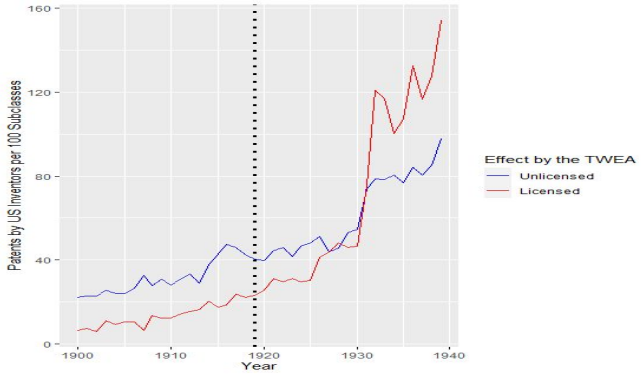
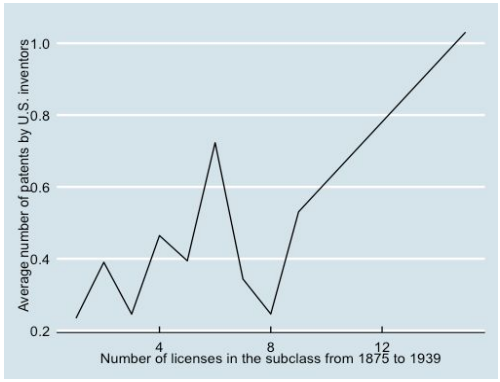



FIGURE 3. AVERAGE NUMBER OF PATENTS BY U.S. WITH NUMBER OF LICENSES IN SUBCLASSES IN ALL YEARS




*Note: Figure 3, average number of patents group by license class and the result using mean of the U.S. patents. Sources of data: Dataset of subclasses and patent information are collected by Petra Moser (2012).*

FIGURE 4. AVERAGE REMAINING LIFETIME OF LICENSED PATENTS WITH NUMBER OF SUBCLASSES FOR ALL YEARS

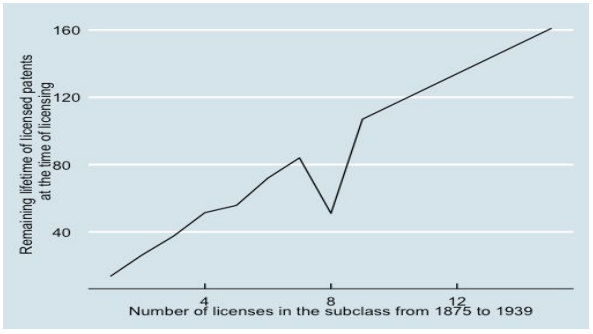
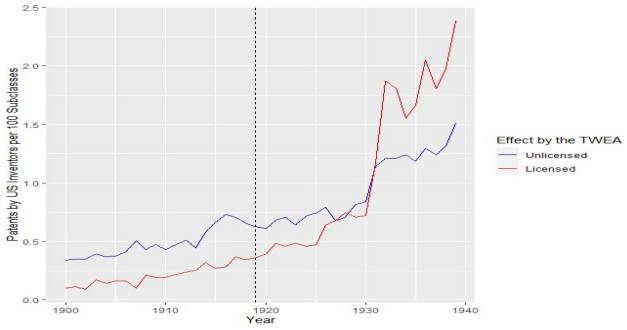



FIGURE 5. U.S. INVENTORS'S PATENT PER 100 WITH TREATED NON-TREATED SUBCLASSES FROM 1900-1939 (WITH IIT)

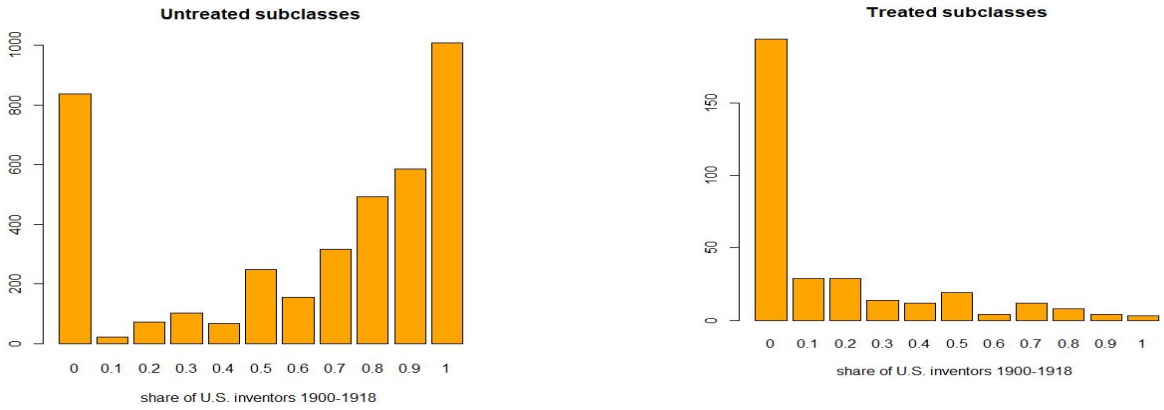



*Notes: Data on annual patents and inventor nationalities were constructed from www.uspto.gov and the Lexis Nexis Chronological Patent Files (1790-1970). Treated subclasses received at least one license under the TWEA. Data include 7,248 subclasses, 336 of which are treated.Sources of data: Dataset of subclasses and patent information are collected by Petra Moser (2012).*

What is the relationship between the number of licenses in treated subclasses and the average remaining lifetime of licensed patents at the time of licensing? Figure 4 answers that by showing a positive relationship on the whole. Overall speaking, while the number of licenses increases, that means the subclasses are valued more and reflect on the enormous remaining time.

To improve the quantity of our difference-in-difference analysis above, we need to involve the IIT principle because the licensing decisions that U.S. firms make may not be entirely driven by the exogenous factor which is the establishment of TWEA. Through Figure 6, we could see that for the treated subclasses, U.S. firms are more likely to choose with low initial innovation value. So this incentive may affect us to separate the treated groups and control groups. To identify the selection bias, we use IIT and replace the original label for licensing to the number of enemy patents that were available for licensing under the TWEA. The p-value from the t-test result turns out to be 0.0000124 indicates that there exists a significant difference between the mean before and after TWEA. Figure 5 shows the difference-in-difference graph when we apply to the IIT, and the result stays the same, which is the compulsory licensing encourages the domestic inventions still held.

FIGURE 6. SHARES OF DOMESTIC INVENTORS: TREATED VERSUS UNTREATED SUBCLASSES FROM 1900 TO 1918




## CONCLUSION

This report uses the TWEA as a natural experiment to test the relationship between compulsory licensing and domestic innovation. By using difference-in-difference empirical analysis, we found that compulsory licensing may encourage domestic innovation which could be applied to policy making. However, due to different circumstances, compulsory licensing may also discourage innovation if it increases the competition in some situations. So when we apply the results to the policy field, it will require systematic analysis and additional information.

Work Cited

Moser, Petra., & Voena, Alessandra. (2012). Compulsory Licensing: Evidence from the Trading with the Enemy Act.The American Economic Review, Vol. 102, No. (FEBRUARY 2012), pp. 396-427