THE CONSEQUENCES OF INVENTION SECRECY:
EVIDENCE FROM THE USPTO PATENT SECRECY PROGRAM IN WORLD WAR II

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ABSTRACT

This paper studies the effects of the USPTO's patent secrecy program in WorldWar II, under
which approximately 11,200 U.S. patent applications were issued secrecy orders which halted
examination and prohibited inventors from disclosing their inventions or filing in foreign
countries. Secrecy orders were issued most heavily in areas important to the war effort — such as
radar, electronics, and synthetic materials — and nearly all rescinded at the end of the war. I find
that compulsory invention secrecy was effective at keeping affected technology out of the public
domain, but it appears to have reduced and delayed follow-on invention, restricted
commercialization, and temporarily hampered post-war entry into patenting. The results shed
light on the consequences of invention secrecy, which is widely used by inventors to protect and
appropriate the returns to innovation, and yield lessons for ongoing policy debates over potential
measures to protect U.S. invention against the growing incidence of foreign IP theft today.

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Information plays a critical role in technological progress: it enables competitors to replicate innovation, allows inventors to build on prior art, reveals competition, delineates property rights, and more. Invention disclosure has been a policy objective in the U.S. since the Patent Act of 1790, which required inventors filing for a patent to include a replicable specification of their invention so that "the public may have [its] full benefit" after the patent expired. U.S. science policy agencies are similarly tasked with promoting scientific communication. Surveys, however, suggest that secrecy is increasingly viewed by firms as the most effective mechanism for protecting and appropriating the returns to innovation (Levin et al. 1987, Cohen et al. 2000), and both historical and modern evidence suggests that as much as 90% of invention is not patented (Moser 2005, Moser 2012, Fontana et al. 2013), and therefore not necessarily public. Although research has made significant strides in explaining who patents, when, and why, the actual consequences of this widespread preference for keeping invention secret have not been as thoroughly studied.

This question is of more than just academic interest: with U.S. inventors, policymakers, and law enforcement agencies increasingly concerned about intellectual property (IP) theft by foreign competitors and governments, the preference for trade secrets – and efforts to protect them – seems to only be intensifying.[1] In exploring potential responses to the growing threat, the U.S. House of Representatives recently instructed the U.S. Patent and Trademark Office (USTPO) to study the possibility of extending an existing compulsory patent secrecy policy (the historical antecedent of which is the focus of this paper) to cover inventions whose disclosure could risk harming U.S. economic security, broadly defined (U.S. Congress 2012). The potential repercussions of these trends and policy proposals, however, are not yet very well understood.

In this paper, I study the effects of invention secrecy in World War II, a unique episode in U.S. history when the USPTO ordered inventions in over 11,000 patent applications into secrecy, for which it was thought that disclosure might be detrimental to the war effort, and then abruptly rescinded the majority of these secrecy orders at the end of the war. The scope and scale of the policy, and its abrupt conclusion, creates a rare opportunity to systematically study the effects of secrecy on subsequent invention, commercialization, and the diffusion of new ideas, when secrecy

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[1]In a December 2018 Senate hearing, the FBI's top counterintelligence official identified Chinese corporate espionage as the "most severe counterintelligence threat facing our country today" (WSJ 2018). Anecdotally, R&D-intensive firms such as SpaceX have publicly discussed their avoidance of patenting because "Chinese competitors would just use [SpaceX patents] as a recipe book" (Business Insider 2012).

is otherwise (by definition) hard to observe. Although patents with secrecy orders were positively selected, I find that those with longer secrecy terms were less likely to be cited by future patents, and when cited, were cited more slowly – this being particularly true for patents of firms which were not government R&D contractors during the war. Novel ideas in secret patents, as measured by new technical terms entering the patent record, also diffuse more slowly than those in non-secret patents. The consequences of secrecy extend to the product market, where terms from chemical patents with a secrecy order are less likely to be included in chemical company product catalogs, as well as to aggregate inventive activity, where entry into patenting is depressed for several years after the war in the most-affected technology classes. However, new terms in secret patents also see limited mention in the public record until after the war ends, such that the repercussions must be evaluated against the apparent effectiveness of the policy in achieving its primary goal of keeping sensitive technological content out of the public domain.

U.S. invention secrecy policy has its roots in a law enacted in October 1917, near the end of World War I, which authorized the USPTO to order that inventions in patent applications be kept secret, and withhold the grant of a patent, whenever its "publication or disclosure" might "endanger the successful prosecution of the war," although it was not systematically applied until World War II. In 1940, in anticipation of entry into the war in Europe, the U.S. Congress renewed this legislation, and between July 1940 and August 1945, the USPTO issued secrecy orders on over 11,000 patent applications in technology areas considered important to the war effort. Once issued, secrecy orders prohibited inventors from any unauthorized disclosure of the invention and from filing in foreign countries, punishable by up to two years of jail and a $10,000 fine (for disclosure), and loss of all existing patents and disbarment from future filing (for filing abroad). Most secrecy orders remained in effect for the duration of the war, until the Patent Commissioner issued a General Rescinding Order which removed most of the outstanding secrecy orders en masse, effective November 30, 1945, allowing examination to proceed and the patents to issue.

I combine several sources of data to study the effects of this program, beginning with the universe of patents granted between 1920 and 1979 and the network of patent citations among them. Using the archival records of government agencies which reviewed patent applications and advised the USPTO on the issuance of secrecy orders, I identify the serial numbers of roughly 8,500 patent applications issued secrecy orders during World War II, and an additional 20,000 which were formally evaluated

for secrecy but disapproved, which in turn link to 6,352 granted patents with secrecy orders, and 13,151 more which were reviewed but not ordered secret.

Secrecy orders were issued continuously throughout the war, with the program at its peak intensity between 1942 and 1944. The technology areas in which secrecy orders were heavily issued reflected the priorities of the war effort, with radar and electronics, synthetic materials, and cryptography (for example) being particularly intensively affected; at the height of the war, more than half of all new patents in these classes were "going dark". Patents with secrecy orders were also positively selected, on average being cited nearly two-thirds more over the long run than contemporaries from the same class and filing year which were not ordered secret.

Given that a commonly-cited benefit of information is that it enables follow-on innovation, the first question this paper tackles is whether secrecy impeded follow-on. However, because secrecy is a selected condition, a simple comparison between secret and non-secret patents is problematic. I instead estimate the effects of secrecy off of the intensive margin (duration), comparing forward citations of secret and non-secret patents filed earlier versus later in the war, which experienced longer or shorter secrecy terms (respectively) as a result of the mass rescindment in late 1945. For patents filed by firms which were not contracting with the government to provide R&D for the war effort, and after accounting for cohort effects, I show that patents with shorter secrecy are subsequently more likely to be cited than patents with longer secrecy, and that those which do get cited are cited more quickly. In robustness checks, I show that these patterns are (i) driven by non-self citations, with no effects for self-citations; (ii) a result of secrecy itself, as there are no such differences for patents which were evaluated for secrecy but not ordered secret; and (iii) not a result of differential selection into secrecy over time. The point estimates suggest that a secret patent filed in 1945 has a 15% higher probability of being cited than a secret patent filed in 1940, and that it realizes its median forward citation two years sooner.

Although patent citations are the traditional measure of information flows used with patent data (e.g., Jaffe et al. 1993 and the subsequent literature), it also has important limitations (e.g., Alcacer et al. 2009, Bryan et al. 2018), the most important (for this paper) being that the citation record only begins in 1947, which is when the USPTO began requiring that patents reference prior art. As an alternative, I develop a content-based measure of follow-on proposed by Iaria et al. (2018): I identify word stems which first appeared in the title of patents filed between 1940 and 1945, as

a proxy for new ideas which entered the patent record in this period, and compare the cumulative distribution of long-run usage of words originating in secret versus non-secret patents. I find that words which originated in secret patents realize their 30-year usage significantly more slowly, taking over 20 years to catch up to their counterparts from non-secret patents – with no such effect for words from patents evaluated for secrecy but not ordered secret.

An expansive invention secrecy policy such as that implemented in World War II – or a common, voluntary preference for trade secrecy – also has the potential for systemic impacts on the inventive sector. Not only could it slow aggregate invention, but it could also distort incentives for R&D in sensitive subject matter, keep inventions out of the product market, and hinder firms' competitiveness abroad. In this paper I focus on the two phenomena which we have the data to measure: aggregate invention and the commercialization of invention.

To estimate effects on aggregate invention, I compare patenting over time in classes which were more versus less intensively affected by secrecy orders, measured by the fraction of 1940-1945 filings which were ordered secret. The most affected classes (top quartile) were growing quickly relative to the least (no secrecy orders) both before and after the war, indicating that it will be difficult to identify effects of secrecy on the level of patenting. However, in these same classes, the fraction of patents from entrants (assignees who are new to the patent record) drops sharply (nearly 10%) after the war, with no evidence of pre-trends, and takes nearly a decade to recover – suggesting that invention secrecy may have impeded entry into invention.

Compulsory secrecy may have also impeded commercialization by forcing firms to keep inventions out of the product market when the product risks disclosure. This constraint would be particularly binding in industries where an invention often *is* the product, such as the chemical industry. To evaluate this question, I identify new words and stems in chemical patents filed 1940-1945 and look for these words in DuPont chemical product catalogs before, during, and after the war. The evidence suggests that secrecy indeed interfered with commercialization: words which first appeared in secret patents were significantly less likely to be included in the product catalog during and immediately after the war (most were not), but the effects vanish by 1949.

The final test of the paper is whether secrecy orders were ultimately effective at keeping invention secret. I return to word stems from titles of war-era patents and look for the use of these words in the Google Books corpus around the time of the war, using Google's N-grams data, which provide

an approximate measure of the public discourse. Words which first entered the patent record in secret versus non-secret patents were not used at differential rates prior to 1945, but after the war, use of words from secret patents discretely, permanently jumps.

Collectively, these results yield lessons on the consequences of invention secrecy. Previous research in this area has focused primarily on inventors' choice between patenting and trade secrecy, with a mix of theoretical papers, surveys, and empirical analysis studying the characteristics of – and conditions under which – inventors opt for patents versus trade secrecy to protect IP.[2] With the exception of recent work on the effects of changes in the strength of trade secrecy laws on publicly-listed firms' R&D (Png 2017a) and the intensity of patenting in process versus product innovation (Ganglmair and Reimers 2019), there is little research on the impacts of invention secrecy beyond the private returns to the inventor choosing its IP strategy.

This paper also connects to a growing literature on patents' disclosure function, which has examined the effects of increasing access to patent publications through the USPTO's Patent and Trademark Depository Library network (Furman et al. 2018) and of recent policy changes which accelerated the publication of U.S. patent applications (e.g., Hegde et al. 2018, Hegde and Luo 2017). Although these papers detect positive effects on local patenting, patent citations, and licensing, these results are in tension with skepticism from legal scholars (e.g., Roin 2005, Fromer 2009, Devlin 2010), who point out that much of the information in patents is available through other sources, and that inventors and applicants are incentivized not only to obscure the specification of inventions in the patent, but also to avoid reading patents at all. Contemporary evidence from the 1940s is thin, but two later reports from the National Science Foundation and National Academy of Sciences (NSF 1958, NAS 1969) suggest that patent documents were not in and of themselves a major source of technical information at that time.[3] Moreover, because the invention secrecy policy studied in this paper is broader than the suppression of patent publication alone, extending to all channels of communication, these concerns are less relevant to the present setting.

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[2] See Hall et al. (2014) for a review. The theoretical literature includes Anton and Yao (2004), Kultti et al. (2007); surveys: Levin et al. (1987), Cohen et al. (2000), Arundel and Kabla (1998), Arundel (2001); empirical analysis: Moser (2005, 2012), Fontana et al. (2013), Png (2017b), Ganglmair and Reimers (2019).

[3] These sources do document that many R&D-intensive firms had technical libraries with books, journals, conference proceedings, and patents and weekly editions of USPTO Official Gazette, so in many cases, patents were available to be read (or ordered) as needed. However, according to NAS (1969), "of the communication that is used by each researcher as an inspiration and as a data flow that makes his own work possible, some 80 percent [comes] from other researchers at a stage before formal communication, through informal channels of the grapevine, the conference, the seminar, the preprint, and the other tentacles of... the Invisible College."

The two World Wars have served as laboratories for many other questions about intellectual property rights and innovation, including the effects of compulsory licensing of foreign-owned invention (Moser and Voena 2012, Baten et al. 2017), the effects of eliminating copyright on access to and use of foreign-owned scientific publications (Biasi and Moser 2018), and the effects of reduced access to foreign science on research output (Iaria et al. 2018). Iaria et al. (2018) is perhaps the most closely related to this paper, as they also study the effect of a disruption in scientific communication, in the form of a boycott of Central powers' scientists during and after World War I, and show that this boycott led to a reduction in citations of foreign publications, the similarity of paper titles, and ultimately the production of basic science. This paper adds a new dimension to this literature, focusing on the consequences of a systematic and sweeping domestic invention secrecy program in World War II which was later adapted into a peacetime policy.

Indeed, secrecy orders continue to be issued – albeit at lower frequency than in the 1940s – and Freedom of Information Act (FOIA) requests by the Federation of American Scientists (FAS) have revealed there are 5,792 secrecy orders in effect as of 2018 (FAS 2018). Motivated by the growing incidence of IP theft by foreign firms and governments, the USPTO also recently (in 2012) solicited public comments about the feasibility of expanding secrecy orders to inventions whose disclosure could impact economic security, defined as "ensuring that the United States receives the first benefits of innovations conceived within this country, so as to promote domestic development, future innovation and continued economic expansion" (Federal Register 2012), although the idea faced substantial public resistance and has not yet been adopted.

The paper proceeds as follows. Section 1 describes the wartime patent secrecy policy, the context in which it arose, and its legacy today. Section 2 introduces the data, and Section 3 summarizes the empirical characteristics of the secrecy order program. Section 4 estimates the effects of secrecy orders on the level, composition, and timing of follow-on invention, using both citation- and content-based measures. Section 5 examines the effects of the secrecy order program on aggregate patenting and explores whether its effects may have extended to the product market. Section 6 then asks whether the program was ultimately effective at limiting mentions of sensitive technological subject matter in the public domain. Section 7 concludes by discussing the implications of these findings for research and policy relating to invention secrecy today.

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1 Historical Background

Although the U.S. did not enter World War II until December 1941, preparations for war began in 1940. Among them was legislation enacted by the U.S. Congress to renew an invention secrecy policy established near the end of World War I, which had empowered the USPTO to issue secrecy orders on patent applications with content deemed sensitive for national security, but which had lapsed with the cessation of hostilities. Public Law 700 of the 76th Congress (henceforth P.L. 700), enacted July 1, 1940, authorized the USPTO to order that inventions in patent applications be kept secret, and withhold the granting of a patent, for as long as needed if its disclosure might be "detrimental to the public safety or defense." Recipients of secrecy orders were, however, permitted to "tender" their inventions to the U.S. government for its use, and later sue for compensation after the patent is granted if the invention was used.[4] Violations were initially punishable by abandonment of the application (i.e., loss of patent rights), but follow-up legislation on August 21, 1941 (77th Congress, P.L. 239) threatened up to two years in prison and a fine of up to $10,000.[5] In 1942, the policy was further amended to remain in force for as long as the U.S. was at war.

To implement P.L. 700, the USPTO immediately created a new internal office named the Patent Office Defense Committee (which later evolved into the Patent Office War Division, or POWD) on July 9, 1940 to handle secrecy evaluations (Donnelly 1942).[6] When patent applications arrived at the USPTO, they were first assigned to one of 65 patent examining divisions, each led by a primary examiner and specializing in a particular subject matter. The secrecy evaluation process began with these primary examiners, who forwarded applications for inventions which in their opinion

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[4]The importance of the statute's provision for the tender of inventions lay in the fact that patent applications at the USPTO were treated as private property and could not be disclosed to other parties, including government agencies, without the consent of the filer. Even technical experts evaluating patent applications for secrecy on behalf of the War Department and other agencies were sworn to not divulge any information they may acquire in doing so. As a result, without tender, "it was possible that an invention of importance would rest in the Patent Office unexploited by the inventor and unavailable to interested agencies" (JAG 1945). Although many inventions were so tendered, there are only a handful of examples of claims for ex-post compensation by inventors who did so, and only a fraction of these concluded in a favorable outcome for the inventor (U.S. Congress 1980).

[5]The initial legislation prohibited the disclosure of inventions ordered secret, including via foreign filing, except with approval from the USPTO. This statute left a loophole for inventions filed in foreign countries prior to being filed at the USPTO, which were as such previously-disclosed. The 1941 amendment closed this loophole by prohibiting individuals from filing *any* patent on U.S. inventions in foreign countries without prior consent of the USPTO, irrespective of the issuance of a secrecy order, punishable by dispossession of existing patents and permanent disbarment from filing or assisting in the filing of patents thereafter. When permits for foreign filing were granted, they were typically to file in the U.K., which had an invention secrecy program of its own.

[6]Information on the administration of secrecy orders described here compiled from Fenning (1940), Donnelly (1942), OSRD (1944), JAG (1945), U.S. Government Manual (1945).

"discloses a matter related to the national defense" to the POWD (OSRD Administrative Circular 10: Patents, April 27, 1944). At the POWD, representatives of four agencies – the War Department (represented by the Army and Navy Patent Advisory Board, or ANPAB), War Production Board (WPB), Office of Scientific Research and Development (OSRD), and Petroleum Administration for War (PAW) – reviewed these applications and made recommendations for the issuance of secrecy orders. Appendix A shows examples of secrecy determination forms that would accompany each application and which circulated among the evaluators with a possible interest in the invention. As soon as any of these reviewers recommended secrecy, a secrecy order would be issued and patent examination indefinitely suspended for as long as the secrecy order was in place. The applicant would then be sent a standardized notification letter explaining that a secrecy order has been issued, instructing the inventor not to disclose the invention without the permission of the USPTO at risk of a fine, jail time, and forfeiture of the patent, suggesting that the inventor tender his or her invention to the government, and offering no means for appeal, as there was none at the time (example notification letters are shown in Appendix B). Upon enactment of P.L. 700, the USPTO commenced the secrecy order program by reviewing recently-allowed patents which were ready to issue, followed by pending applications and new applications.

Although the issuance of secrecy orders may have been noisier in the earliest stages of the program (as review procedures were being developed), contemporary evidence suggests administrators were generally careful to avoid issuing secrecy orders without compelling reasons (Moore 1945). Once issued, secrecy orders could be reviewed and rescinded if it was determined that the enemy had access to comparable technology or an invention was no longer of strategic value. When one of the reviewing agencies sought to have a secrecy order rescinded, a copy of the application in question would be re-circulated to reviewers from the other three agencies, who then had to concur in the rescission for the secrecy order to be lifted – a process which could take two to six months – but the "natural tendency [was] to 'play it safe' and leave the secrecy order in effect" (Stoutenburgh 1945). Records of OSRD correspondence suggest that these case-by-case rescissions were relatively rare, and that most were issued in 1945, near the end of the war.[7]

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[7]For example, of the 4,837 secrecy orders identified in OSRD records, only 311 were noted in these records as having been rescinded. Contemporary documents do indicate, however, that the WPB conducted a review in 1944 of the 1,700 applications which it had recommended for secrecy, and that by September 1945, nearly all had been rescinded (Moore 1945). Of the 6,352 patents with secrecy orders observed in the data, 1,134 (17.9%) were granted before the General Rescinding Order took effect on November 30, 1945, implying that their secrecy orders were rescinded early – though it appears that the vast majority of these were rescinded that year.

On August 30, 1945 – after the end of hostilities in Europe, and shortly before the end in the Pacific theatre – a recently-appointed new Patent Commissioner (Ooms) organized an inter-agency meeting to discuss the "expedited removal" of outstanding secrecy orders (Moore 1945). When representatives from the War Department raised concerns about a subset of cases which they wished to remain secret, the participants agreed to a 90-day grace period in which these advisory agencies could compile a list of those patents which they wished to be excepted from a mass rescindment. The meeting ended in the issuance of a "General Rescinding Order" (henceforth GRO) under which all outstanding secrecy orders were rescinded effective November 30, 1945, excepting applications which the recommending agencies requested be kept secret.

Contemporary records from the U.S. Army's Judge Advocate General's office (JAG 1945) indicate that 11,182 secrecy orders were issued through June 14, 1945. Given that the program wound down that summer, the true total is likely on the order of 11,200.

Secrecy orders issued by year, July 1940 to June 1945

	Secrecy orders issued	Inventions tendered
Jul-40 to Dec-41	918	95
1942	2,611	555
1943	3,508	1,966
1944	3,165	2,143
Jan-45 to Mar-45	613	319
Apr-45 to Jun-45	367	unknown
Total	11,182	5,078

Post-war invention secrecy policy

By December 31, 1945, there were less than 800 outstanding secrecy orders, with most being on inventions related to atomic energy research (JAG 1945, U.S. Congress 1980). Although the war had ended, the wartime secrecy order program remained in effect, as the national emergency declared by Congress was not terminated until 1952. In the intervening years, the number of outstanding secrecy orders grew to nearly 2,400 (Lee 1997), as secrecy orders continued to be issued on inventions considered a security risk – especially those related to nuclear energy.

In 1951, Congress converted the wartime invention secrecy policy to a peacetime policy with the enactment of the Invention Secrecy Act of 1951. Although the restrictions and penalties remained the same, the Invention Secrecy Act made a few key departures from P.L. 700 and its subsequent

amendments, the most notable being fixed, one-year terms subject to renewal by the requesting agency, which at least nominally subjected outstanding secrecy orders to annual review, and a provision granting inventors the right to appeal a secrecy determination. Secrecy orders continue to be issued under the authority of this legislation today, albeit at much lower frequency than during World War II: between 2005 and 2015, the USPTO issued just 1,171 secrecy orders, out of a total of nearly 5.8 million applications filed (FAS 2018).

Concerns about adverse effects of an invention secrecy policy

Though the benefits of secrecy orders were undisputed in a time of war, contemporaries also raised concerns about adverse consequences. Fenning (1940), for example, writes in the *Journal of the Patent Office Society* about the potential for secrecy orders to "prevent disclosure of applications to interfering parties and [thus] decision of interferences." Vannevar Bush noted that OSRD contractors were uneasy about the possibility that "foreign companies would be able to enter the world commercial market... in the lead of the U.S. manufacturers" when U.S. firms' patent applications were held up by secrecy orders (Stoutenburgh 1945). Even those in charge of administering the program had hesitations: in a discussion about the possibility of a peace-time invention secrecy policy at the August 30, 1945 meeting, participants raised several objections, including that it would delay the utilization of invention, drive invention underground and slow technological progress, and preclude civilian users from being able to access and work out the "bugs" in inventions with both civilian and military value "so that when the military forces need them [they] can quickly be added to war uses" – with radio and radar being given as examples (Moore 1945).

The full range of concerns was recently on display after a USPTO request for comments in 2012 on the feasibility of placing "economically significant" patents under secrecy order (Federal Register 2012), issued at the behest of Congress. Respondents included several organizations with an interest in such a policy, such as the American Bar Association (ABA), American Intellectual Property Law Association (AIPLA), and the Intellectual Property Owners Association (IPOA). Their concerns included (i) undermining the public notice function of patents and depriving inventors of technical information, at the risk of "stifling innovation" (IPOA 2012); (ii) precluding commercialization of inventions which are readily ascertained by observation or reverse-engineering (AIPLA 2012); (iii) driving R&D underground or overseas, away from the U.S. patent system (IPOA 2012); or even (iv)

discouraging invention altogether (IPOA 2012, ABA 2012). These concerns would have applied in the 1940s as well – (i) and (ii) are both a focus of this paper – though it appears they were treated by policymakers as second-order issues against the backdrop of war.

2   Data

To study the effects of the secrecy order program, I combine several sources of data, beginning with a complete record of the nearly 2.5 million patents granted between 1920 and 1979 from the USPTO historical master file (Marco et al. 2015), which lists the universe of granted patents and their grant dates, patent class (USPC), and 2-digit NBER technology category (Hall et al. 2001). I supplement these data with patent serial numbers (i.e., application numbers) and filing dates collected from FreePatentsOnline.com, from which I also collect the complete network of forward and backward front-page citations, and with standardized assignee names from the Clarivate Derwent Innovation (previously Thomson Innovation) patent research database.

Using these assignee names, I classify assignees into four categories: firms, universities and hospitals, government agencies, and individuals. At certain points in the paper I will also distinguish between patents assigned to OSRD contractors (i.e., assignees which were performing R&D for the war effort) and non-contractors, which were identified from the archival records of the OSRD. Appendix A describes in more detail how these data were prepared, as well as additional steps taken to improve the quality of the data on serials, filing dates, and assignee names.

I use archival records from three agencies – the OSRD, the Office of Production Research and Development (OPRD), and the U.S. Army Judge Advocate General (JAG) – to identify patent applications issued secrecy orders. Collectively, these records identified 8,475 serials which were ordered secret during the war (roughly 75% of the likely true total of $\approx 11,200$), of which 6,352 (75%) were granted by 1979, with the remainder either abandoned or still secret (for example, two such applications on cryptographic inventions remained secret until they were granted in 2000).[8] The OSRD and OPRD records also identify nearly 20,000 patent applications which were formally evaluated for secrecy but disapproved, and the 13,131 of these which were granted will be used

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[8]Although we only observe a subset (albeit a considerable majority) of secrecy orders, this undercounting only presents a risk of bias in a conservative direction due to attenuation (if the control group includes unobserved secret patents, then treatment-control differences will simply be understated).

later as a comparison group for patents which were ordered secret.

In addition to numeric data on patents and citations, this paper also uses information from patents' textual content.[9] I obtain from Google the title of each patent in the 1920-1979 sample, and I identify words (more precisely, word stems) first used in the title of a patent filed between 1940 and 1945. New words are invoked in this paper as a measure of "new concepts" which entered the patent record during World War II (an approach pioneered by Iaria et al. 2018), whose diffusion can be traced both within the patent record and beyond it, using other sources of data such as books and product catalogs (which I describe in Section 5).

3   Characteristics of Secrecy Orders

To better understand the potential impacts of the secrecy order program and contextualize results throughout the paper, it is useful to begin with a descriptive overview of patenting in the 1940s and the characteristics of patents with secrecy orders. Figure 1 presents the time series of monthly patent applications at the USPTO from the late 1930s to the early 1950s (in blue, measured by left axis), as well as monthly applications issued secrecy orders (in red, measured by right axis). Aggregate patenting declined by nearly 50% by the height of the war in 1943, as resources were diverted away from invention and into war and military production. Naturally, however, this is also when secrecy orders were being issued most intensively.

[Figure 1 about here]

Figure 2 shows the distribution of patenting and secrecy orders across one-digit NBER patent categories (Hall et al. 2001) during the wartime period. Although aggregate patenting declined during the war, its distribution across technology areas was relatively stable (Figure 2, Panel A). The distribution of secrecy orders, on the other hand, varied significantly over the course of the war, shifting from chemical patent classes in 1939/1940 to classes related to communications and electronics by 1945 (Panel B), reflecting the growing importance of radar and electronics to the war effort. These were also the technology areas most intensively affected by the secrecy order program as a fraction of annual patent applications (Panel C).

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[9]Appendix A discusses the inner workings of these data and methods in detail.

[Figure 2 about here]

The technological priorities of the war effort can be seen more precisely in the set of patent classes in which secrecy orders were issued at particularly high frequency. Table 1 lists the top ten classes by the fraction of applications between 1939 and 1945 issued a secrecy order; among these are classes related to radar, synthetic rubber, and catalytic cracking (for fuel production). At the height of the war, roughly half of filings in these classes were ordered secret.

[Table 1 about here]

Even within classes, secrecy orders were inevitably not randomly issued: the historical record suggests that patent applications were evaluated carefully and in good faith, out of a concern for interfering with the usual functioning of intellectual property rights (Moore 1945), with more-sensitive and important inventions being the focus of the program. As a simple test for selection, Table 2 estimates mean differences in patents' forward citations as a function of whether a given patent was (i) issued a secrecy order or (ii) evaluated for a secrecy order, conditional on fixed effects for each patent's primary class and filing year. Patents formally evaluated for secrecy were cited more, by more parties, and by patents in more classes than those which were not. Patents which received a secrecy order were cited even more, on average receiving more than 1.5x as many citations as the typical patent from the same class and year.

[Table 2 about here]

Immediate effect: Delayed grant and publication

Recall that the immediate effect of a secrecy order was to suspend examination and prohibit the filer from unauthorized invention disclosure for as long as the secrecy order was in effect. Although secrecy orders were sometimes rescinded early, the majority remained in place until the GRO took effect in November 1945. As a result, patents with a secrecy order filed early on in the war should have on average taken more time to grant than those filed near its end.

To verify that secrecy orders generated the predicted effect on pendency, Table 3 estimates the incremental grant lag (years from filing to grant) of patents filed between 1939 and 1945 with a

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secrecy order, relative to others in the same class and filing year. The effect of secrecy on time-to-grant is large early on in the war – on average roughly 2.5 extra years for 1940 and 1941 applications, an approximate doubling from the mean – and not significantly different from zero by 1945. Note that although the table includes 1939 filings for completeness, as many were ordered secret, patents filed in 1939 which received a secrecy order were necessarily still pending as of the enactment of P.L. 700 in July 1940, and their longer grant lags are thus in part selected.

[Table 3 about here]

Figure 3 shows the full distribution of grant lags for secret patents shifting down monotonically over time to match that of their non-secret counterparts (in the same class and filing year) by 1945. No comparable differences emerge when comparing patents evaluated for secrecy but not ordered secret against those not evaluated for secrecy at all (Appendix Figure C.1), suggesting it was the secrecy order, rather than the evaluation, generating these delays.

[Figure 3 about here]

4   Invention Secrecy and Follow-on Invention

4.1   Effects on the level and timing of forward citations

We begin by examining the effects of secrecy on patents' forward citations, the traditional measure of follow-on invention. As we have previously seen, simple comparisons on the extensive margin are problematic, since secrecy orders were selected on technological importance (Table 2). The approach taken here will instead be to compare the difference in outcomes of secret and non-secret patents *filed earlier versus later in the war*, in effect a difference-in-differences design. Variation in filing dates in turn generates intent-to-treat variation in the duration of secrecy – i.e., in treatment intensity – due to the mass rescindment in late 1945.[10] The initial sample for this analysis will be all patents filed between July 1, 1940, when P.L. 700 was enacted, and June 30, 1945, when the secrecy

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[10]Noncompliance (in the econometric sense) exists in the form of early rescindments, but as Section 1 explains, these were relatively uncommon, and most were issued in 1945, shortly before the mass rescindment, such that the effects of noncompliance are limited – as confirmed by Figure 3 and Table 3.

order program was mostly concluded. Restricting the sample to patents filed after July 1, 1940 causes us to lose some earlier filings which were still pending as of that date and were subsequently ordered secret, but because these are selected on longer examination, I choose to focus on patents filed when P.L. 700 was in place and actively being applied.

Throughout this section, I estimate variants of the following specification via OLS:

$$Y_{ict} = \sum_{t=1941}^{1945} \beta_{1t} \cdot \mathbb{1}(\text{Secret})_i + \sum_{t=1941}^{1945} \beta_{2t} \cdot \mathbb{1}(\text{Evaluated})_i$$

$$+ \gamma_1 \cdot \mathbb{1}(\text{Secret})_i + \gamma_2 \cdot \mathbb{1}(\text{Evaluated})_i + \alpha_{ct} + \varepsilon_i \qquad (1)$$

where i indexes patents (the unit of observation), c and t represent the patent's class and filing year (fixed for each patent i), and Y_{ict} will alternately be (i) whether the patent was ever cited, or (ii) the time it takes for a patent to achieve 50% of its eventual citations (each measured through 1979, by which point most patents from this era will have realized the majority of their eventual citations, e.g. see Hall et al. 2001). I estimate separate effects by filing year to enable comparisons between secret and non-secret patents filed earlier or later in the war, with 1940 being the omitted reference category. With this specification, for example, we will be able to make statements about the difference between secret patents and their non-secret contemporaries in the same class filed in 1945, and compare it to same such difference for those filed in 1940, for which a secrecy order was far more imposing. As a placebo test, I also separately estimate Equation 1 for non-self citations and self citations, as secrecy should only be limiting for the former.

One direct threat to this empirical strategy is the possibility of time-varying selection into secrecy, which could confound or even explain the results: if evaluators applied more stringent standards later in the war than earlier in the war, then what appears to be an effect of a shorter secrecy term may simply be positive selection. To evaluate whether the quality of secret patents varied over time, I look for patent characteristics which were fixed (or approximately fixed) at the time of application and which correlate with long-run citations, and test whether these characteristics of secret patents varied over the sample period. The observable feature which correlates most strongly with eventual citations for patents filed in this period is simply the length of the patent document itself, yet secret patents exhibit almost no variation in this characteristic over the course of the war, relieving concerns about time-varying selection (Appendix Figure C.2).

The main limitation of historical citation-based analysis is the fact that the citation record only begins in February 1947, which is when the USPTO first required granted patents to include formal references to prior art. As a result, any citations observed in these data are necessarily from patents granted after 1947, and the measures will undercount follow-on granted prior to this date (although modern evidence suggests that the bulk of forward citations are accumulated over longer horizons, e.g. Hall et al. 2001). All else equal, the truncation of the citation record will more severely affect earlier applications (which have more years of "missing" citations) than later applications, but it should affect secret and non-secret patents of the same class and vintage in a similar way, and the class-year fixed effects will account for these differences.

Forward citations: levels

The first set of results estimates Equation 1 for three outcomes: an indicator for whether the patent had (i) any forward citations, (ii) any non-self citations, and (iii) and any self citations.[11] In Figure 4, I plot the β_{1t} parameters, with 95% confidence intervals around each point estimate produced from heteroskedasticity-robust standard errors. There are no clear differences in the likelihood that earlier or later secret patents are subsequently cited. Based on this evidence, one might be tempted to conclude either that invention secrecy did not have a meaningful effect on forward citations, or that the comparisons are muddied by other confounding patterns.

[Figure 4 about here]

The latter concern may in fact have merit. This period was a time of national emergency: the U.S. economy and population were mobilized for a major war, with the Federal government contracting with firms and universities around the country to supply the war effort, including supplying R&D on war-related technology – an effort led by the OSRD. In these circumstances, firms contributing to the scientific war effort may have been permitted to share information on otherwise-secret invention to further contract work. Contemporary records suggests this was the case in at least

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[11]The results below are qualitatively similar when the outcome variable is forward citation counts, rather than $\mathbb{1}$(Any forward citations), but the estimates are noisier. Using a count variable as the outcome introduces estimation challenges under any approach: OLS is misspecified, Poisson regression cannot accommodate overdispersion, and Negative Binomial regression exposes the results to an incidental parameters problem. For these reasons, my focus in these regressions is simply on an indicator for forward citations.

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some industries: in his minutes from the August 1945 inter-agency meeting to discuss secrecy order rescindment, Moore (1945) quotes a representative of the Petroleum Administration for War who "pointed out that secrecy orders strictly interpreted would have hampered the petroleum industry enormously in its war effort, so they had worked out a system of general permits for the exchange of information." A similar pool was created in the synthetic rubber industry (Herbert and Bisio 1985, Morris 1989). This could well be true for other industries too.

To clear the results of this potential confounding influence, I use data on the identities of OSRD contractors to restrict the sample to patents with non-contractor assignees (i.e., assignees not known to have supplied R&D to the war effort, and thus unlikely to have been sharing information during the war about otherwise-secret inventions), and in particular non-contractor firms. As Appendix C shows, OSRD contractors were disproportionately large, R&D-intensive U.S. firms (although not all such firms were OSRD contractors). Figure 5 shows the analogous estimate plots to those in Figure 4 for the sample of patents from non-OSRD firms.

[Figure 5 about here]

With this focus, the point estimates look materially different (albeit similarly noisy). In this case, patents with shorter secrecy terms (filed in 1945) are 15% more likely to later be cited than those with longer secrecy terms (filed in 1940 or 1941), with differences significant beyond the 5% level. This result is entirely driven by non-self citations, as there are no such differences observed for self citations. Moreover, no such differences emerge for patents which were evaluated for secrecy but not ordered secret. These patterns are consistent with patents with shorter secrecy terms having more follow-on invention, although as previously discussed, the citation record is an imperfect measure – for this reason, later sections will focus on content-based measures.

These results raise the question of why a temporary invention secrecy policy in the 1940s would affect long-run, post-war citations, and especially citations from a population of patents which were mostly filed after secrecy orders were rescinded. One possibility is that it could be the consequence of a "lost generation" of follow-on, in the form of inventions which might have been produced in the 1940s if information had not been suppressed. In additional (unreported) analysis, I break the outcome measures out into citations from patents filed in the 1940s versus patents filed after

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1950, and I find that the results are driven by the former: patents which had secrecy orders were specifically less likely to be cited by contemporary invention.

Forward citations: timing

The second outcome is the time it takes for a patent to achieve a fixed percentage of its long-run citations, which we can use to evaluate whether patents with longer secrecy accrue citations more slowly. Here I estimate Equation 1 with four new outcomes: each patent's number of years to its median (i) non-self citation, (ii) self citation, (iii) citation from firms, and (iv) citation from individuals. Figure 6 plots the β_{1t} parameters for regressions run on all patents from 1940 to 1945 (not restricting to those filed by any particular assignee type).

[Figure 6 about here]

Secret patents filed in 1945 achieve their median non-self citation on average nearly two years more quickly non-secret patents of the same vintage, relative to the difference for patents filed in 1940, and the magnitude of the effect grows monotonically in between.[12] These effects are primarily driven by citations from individual inventors (rather than firms), suggesting that the information-reducing effects of secrecy orders may have been particularly limiting for individuals working in the same technology area as the secret patent. These effects are present at other quantiles of citation timing as well, particularly at the earlier quantiles, consistent with the effect being driven by a reduction in citations from contemporary invention. Self citations, in contrast, do not exhibit these same differences for earlier versus later filings. Additionally, as before, no such differences appear for patents evaluated for secrecy but not ordered secret.

Figure 7 shows analogous estimates for the timing of citations to patents of non-OSRD firms. The effects are broadly similar for this sample, albeit larger in magnitude.

[Figure 7 about here]

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[12]Note that the class-year fixed effects in Equation 1, which partial out differences between earlier and later non-secret patents, are especially important here to account for the fact that citations begin in 1947, and hence mechanically accrue more quickly for the later filings in the wartime sample. The estimates presented in the figures are effectively differences-in-differences (secret versus non-secret, earlier versus later).

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4.2 Alternative measure: Diffusion of new words

Although researchers have traditionally used patent citations as a proxy for information flows and follow-on invention (from Jaffe et al. 1993 to Galasso and Schankerman 2015), several papers have also highlighted their limitations, including the fact that citations can be strategic and that a large fraction are added by examiners rather than applicants (Alcacer et al. 2009, Sampat 2010, Cotropia et al. 2013, Roach and Cohen 2013).[13] As such, citations more reliably measure related invention than follow-on per se, and in practice it is difficult to distinguish between them. However, the limitation of citation data that is most germane to this paper is that the patent citation record only begins in 1947, as the USPTO did not require published patents to list references to prior art until February 4, 1947. As a result, although we can study long-run citations of wartime patents, as we did above, it is more difficult to interpret differences between secret and non-secret patents in the short-run, or any gradient over different citation horizons.

As an alternative to citation data, I therefore develop content-based measures of follow-on, which can be constructed for patents throughout this period. The focus here will be new word stems in the titles of patents filed between 1940 and 1945, as a measure of new ideas which entered the patent record during the war (see Section 2). We can then compare subsequent usage of stems which first entered the patent record in secret versus non-secret patents, as a measure of inventions which incorporate new ideas embodied in these patents – similar to the approach taken in Iaria et al. (2018), who study the introduction of new words in the title of scientific publications as a proxy for new scientific concepts, and the use of these words in patents.

In preparing the data, I take the 1,129 stems which first appeared in the title of a patent filed between July 1, 1940 and June 30, 1945, and for each stem I identify all subsequent patents with that stem in its title. This approach yields a panel of usage for every stem, and it allows us to compare the nearly 100 stems which originated in secret patents against the remainder which did not. Comparisons in levels remain difficult, due to positive selection: new stems from secret patents are subsequently used more than their non-secret counterparts, and the small sample precludes a more-refined comparison of stems from earlier versus later secret patents, as we did for citations.

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[13]Most of this literature relies on front-page (or historically, final-page) citations, which are the more traditional and widely-available measure. Other research, however, has argued that in-text citations mentioned in the patent specification – especially citations to scientific publications – are more indicative of the true knowledge inputs to invention (Bryan and Ozcan 2018, Bryan et al. 2018).

However, normalizing annual counts by total long-run usage, we can use these data to examine the cumulative distribution (CDF) over time and see if secrecy delays cumulative use.

For this exercise, I calculate 30-year CDFs for each stem from the date of its earliest filing, binned into years, and regress annual values of this CDF on indicators for whether the stem originated in a patent ordered secret or evaluated for secrecy, as follows:

$$\text{CDF}_{it} = \beta_{1t} \cdot \mathbb{1}(\text{Secret})_i + \beta_{2t} \cdot \mathbb{1}(\text{Evaluated})_i + X_i \gamma + \alpha_t + \varepsilon_{it} \tag{2}$$

where i indexes stems and t indexes years since earliest filing. The X_i is a set of controls, consisting of (i) fixed effects for the patent class of the originating patent, and (ii) a third-order polynomial in years to the last observed use of the stem, which is included to account for the fact that the CDF of more heavily used stems may shift outward simply because they are longer-lived. To be consistent with previous results, I run this regression on two samples: stems originating in patents of all assignees, and stems originating in patents of non-OSRD firms.

The results are shown Table 4, where each column shows estimated differences in the CDF at the given number of years post-initial use. The results for the full sample (Panel A) indicate that stems introduced by secret patents are used significantly more slowly than those from their non-secret counterparts in the same class: out of the gate, stems from secret patents on average have realized 5% less of their cumulative long-term usage than those from non-secret patents, and this difference persists for nearly 20 years. The effects for the subset of stems from non-OSRD patents (Panel B) are even larger and longer-lived, although the estimates are noisier with the smaller sample. For comparison, there are no such differences for stems from patents which were evaluated for secrecy but not ordered secret, suggesting a causal interpretation.

[Table 4 about here]

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5 Broader Consequences of Invention Secrecy

5.1 Aggregate patenting and entry into patenting in affected classes

Given the scale of the secrecy order program in key fields of invention, it could have plausibly had systemic consequences for innovation in affected technology areas. For example, by curtailing the spread of information about new invention, secrecy orders may have increased barriers to entry in the affected fields and slowed technological progress, and by delaying the granting of property rights over new inventions and possibly hindering commercialization, the program may have distorted incentives for R&D and patenting in sensitive subject matter.[14]

To explore these questions, I study patterns in aggregate patenting over time at the patent class level, comparing classes which were more versus less affected by secrecy orders in the 1940s, where class-level treatment is defined as the fraction of patents filed between July 1940 and June 1945 which were issued a secrecy order (which I term the class-level "secrecy rate"). Because this measure is skewed (with a few classes heavily affected by secrecy orders, and many only modestly or not at all affected), and sensitive to small numbers, I bin classes into quartiles. My baseline specification for these tests takes the following form, where i indexes patent classes and t indexes years, run on a sample of all patent classes between 1930 and 1960:

$$Y_{it} = \sum_{q=1}^{4} \sum_{t=1931}^{1960} \beta_{qt} \cdot \mathbb{1}(\text{Class } i \text{ in secrecy rate quartile } q) \ + \alpha_i + \delta_t + \varepsilon_{it} \tag{3}$$

This regression compares patent classes in different quartiles of the class-level secrecy rate, with the omitted category being the set of classes in which no patents in the 1940 to 1945 period received a secrecy order (38.4% of 429 classes), and the omitted year being 1930, such that β_{qt} should be interpreted as the mean difference in the given year between classes in quartile q versus classes without any secrecy orders, relative to the difference in 1930. The outcomes I examine are (i) log patents, and (ii) the fraction of patents with assignees who are entrants (defined as being new to

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[14]There are multiple channels through which incentives may be distorted. The previous evidence showed that secrecy orders increased pendency – and although this did not in turn reduce patent terms (which for the USPTO at this time was 17 years from the date of grant), the invention may grow obsolete while the secrecy order is in effect. The reduced information environment likely also increased uncertainty over the prior art, potentially discouraging invention and patenting for fear of accidental infringement or invalidity (Fenning 1940).

the patent record). Standard errors are clustered at the patent class level.[15]

Figure 8 plots the effects for the top quartile of classes (the β_{4t} parameters), with estimates for log patents on the left and for the fraction of patents from entrants on the right. Given that the subject matter on which secrecy orders were issued is selected (on its importance to the war effort), identifying their effect on the level of patenting may be difficult, particularly if these classes were higher- or lower-growth classes for independent reasons. The left panel confirms this was the case: the most-affected classes were growing quickly before the war, and continued growing quickly after the war. The composition of patenting, however, appears to have experienced more discernable effects: the fraction of patents from new filers drops sharply after the war (nearly 10%, with no such pre-trends) and does not return to pre-war levels until the mid-1950s. This temporary shock is consistent with the temporary nature of the program, and its delayed onset (relative to the period in which the secrecy order program was active) is consistent with the likely reality that it takes several years for the full force of an invention secrecy policy on the overall information environment to be realized. In Appendix Figure D.3, I examine the effects for other quartiles of the secrecy rate, and find similar but attenuated effects as the treatment intensity declines.

[Figure 8 about here]

5.2 Availability of inventions in product market

Secrecy orders prohibited the inventor from disclosing "the invention or any hitherto unpublished details" of the invention (Appendix B). Contemporary sources (including statute) are unclear on whether this restriction would have impeded the commercial use or sale of the invention, particularly when the invention is a component or a method of manufacture that would not be easily detected or reverse-engineered. However, in the case of inventions which are themselves final goods, such as drugs and specialty chemicals, this restriction could have conceivably interfered with commercialization and kept new inventions out of the product market.

The most accessible setting for testing this question is in the specialty chemicals industry. Much as they do now, large chemical manufacturers in the 1940s circulated product catalogs which listed

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[15]For these regressions, I restrict the class-level patent counts to patents with a single, known assignee ($> 95\%$ of patents filed from 1930 to 1960) to avoid classification ambiguities for patents with both incumbent and entrant assignees, thereby ensuring that (i) the class-level patenting composition measures add to 100 percent, and (ii) all regressions are run on the same sample, although the restriction does not affect the results.

their commercially available products and where we can search for chemical terms from the titles of patents which were subjected to secrecy orders. Although many such catalogs have likely not been preserved, several editions of the Du Pont Products Index (DPPI) are available from the Du Pont collection at the Hagley Museum. For the purposes of this paper, I extracted the text of five editions – 1938, 1944, 1946, 1949, and 1955-56 – to be used below.[16]

To build a sample of words to search for in these catalogs, I began with the set of words whose stems first entered the patent record in the title of a patent filed in the 1940 to 1945 period (as before) *and* was classified in a chemical patent class (according to the NBER classification system of Hall et al. 2001). I then manually reviewed these words to identify those which were chemical compounds or processes – yielding a sample of 633 "chemical words" and 542 unique stems – and programmatically searched for these words and stems in each edition of the DPPI. The test is then to see whether the stems from secret versus non-secret patent titles were differentially likely to appear in each edition of the catalog. Specifically, I regress an indicator for a stem's presence in the given edition of the DPPI on indicators for whether the stem originated in a patent which was issued a secrecy order or evaluated for secrecy, as follows:

$$\mathbb{1}(\text{Word is in DPPI})_i = \beta_1 \cdot \mathbb{1}(\text{Secret})_i + \beta_2 \cdot \mathbb{1}(\text{Evaluated})_i + \alpha + \varepsilon_i \qquad (4)$$

where i indexes stems, and α is a constant (for stems from non-secret, non-evaluated patents). Table 5 shows the results: stems which first appeared in a secret patent are less likely to be included in the catalog in 1944 and 1946, with no significant differences in the other years, nor for stems which first appeared in a patent which was evaluated for secrecy but not ordered secret. When compared against the baseline rate of $\approx 10\%$ of non-evaluated stems appearing in the catalog, the effect size indicates that almost none of the words with stems from secret patents show up in 1944 and 1946. Results are similar for a sample of the full words themselves, rather than stems, when testing for the presence of each of these words in the DPPI volumes.

[Table 5 about here]

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[16]The Du Pont Products Index was the only major chemical manufacturer catalog from the 1940s that could be located (others company catalogs searched for included Dow Chemical and American Cyanamid). Du Pont was also the firm with (i) the most patents and (ii) the most secret patents in chemical classes in the 1940s. These editions were chosen to enable a search for keywords in the pre-war, mid-war, and short- and long-run post-war periods, but the Hagley collection includes many more volumes, spanning the 1910s to the 1980s.

These results could reflect different underlying phenomena: they could be due to suppression of new Du Pont inventions from the product market; a reduction in Du Pont's licensing and sale of third party inventions; a reduction in Du Pont products using technology first introduced in third party inventions which are not yet disclosed; or even just concealing language. Distinguishing these channels is difficult, not only due to measurement challenges but also due to the sample size. In unreported results I split Table 5 into stems originating in the titles of Du Pont patents versus other patents, and find that the results are driven by the words from non-Du Pont patents, but the Du Pont-only sample is too small (with $N = 72$ stems, only 12 of which first appeared in the title of secret patents) to draw strong conclusions.[17]

6   Were secrecy orders effective at preventing disclosure?

Whether or not the consequences of the secrecy order program on invention were understood at the time, the original intent behind the policy was to prevent the disclosure of subject matter which might be "detrimental to the public safety or defense," as stated in the text of P.L. 700 and secrecy order notification letters (Appendix B). The question thus remains: were secrecy orders effective at keeping sensitive new technology out of the public's view?

To answer this question, I turn to the Google Books corpus as a data source which can measure the broader use (beyond the inventive sector) of new words whose stem first appeared in secret versus non-secret patents. Google makes available for download data on the annual usage of individual words and phrases (N-grams) in the books that have been scanned into the Google Books corpus as of 2012. For this exercise, I retrieved the annual usage of words with stems which entered the patent record in the title of a patent filed in the 1940 to 1945 period (as before), as well as the total number of words in the corpus by year, to calculate focal stems' frequency as a fraction of the corpus in a given year. 1,050 (93% of the original 1,129) stems from patent titles match to the Google Books data in this way. I then compare the annual frequency of stems first appearing in

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[17] Another natural question is whether the unavoidably noisy nature of the optical character recognition used to extract text from the DPPI catalogs might be interfering with these results. Although the best available commercial software (ABBYY FineReader 14) was used for the OCR, its output is imperfect. The analysis described above was repeated with fuzzy matching to the DPPI catalogs, allowing matches with a Levenshtein edit distance of up to one character – though it is not obvious that this is an improvement, given that one character differences can represent distinct molecular structures (e.g., octane versus octene). The results with fuzzy matching are similar to those in Table 5 for the sample of words, but the effects fade for the sample of stems.

secret patents versus non-secret patents, by year, truncating to stems above the 90th percentile of pre-patent usage (in levels) in the Google Books corpus so as to eliminate already-common language – although the results below are similar for 75th, 95th, or 99th percentile truncation. Specifically, I run the following regression on a sample of 945 unique stems from 1935 to 1955, where i indexes stems and t indexes years, and standard errors are clustered by stem:

$$\text{Pct. of corpus}_{it} = \sum_{t=1936}^{1955} \beta_{1t} \cdot \mathbb{1}(\text{Secret})_i \ + \ \sum_{t=1936}^{1955} \beta_{2t} \cdot \mathbb{1}(\text{Evaluated})_i + \alpha_i + \delta_t + \varepsilon_{it} \qquad (5)$$

Figure 9 plots the annual differences (the β_{1t} parameters), along with the associated 95% confidence intervals. The results indicate that prior to 1945, there was not differential usage of words whose stem first entered the patent record in secret or non-secret patents, but that beginning in 1945, the use of words from secret patents discretely jumps, with the difference persistent through at least 1955 – consistent with previously-documented positive selection into secrecy, and delayed usage in this broader literature.[18] Though not reported here, no such differences are present for stems originating in patents evaluated for secrecy but not made secret (the β_{2t} parameters), which are precisely-estimated zeros. The sharp jump in 1945 in the use of technical words with stems from secret patents around the time that the secrecy orders were rescinded suggests that the policy was indeed effective at achieving its intended objective – although whether or not the benefits exceeded the costs is a question beyond the scope of this paper.

[Figure 9 about here]

7   Implications and Conclusion

In the context of the World War II-era secrecy order program, I thus find that compulsory invention secrecy can be effective, but that it has the potential to reduce and delay follow-on invention, reduce entry into patenting, and restrict commercialization. The impacts of the policy were strongest in the technology areas where inventions were ordered into secrecy at high rates during the war, and most of the outcomes studied in this paper recovered within a few years of the mass rescindment

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[18]The simple difference-in-difference estimate before versus after 1945 is statistically significant at the 5% level with robust standard errors, and at the 10% level with clustered standard errors.

in late 1945. Altogether, the results suggest there are consequences to a compulsory secrecy policy to be weighed against the security concerns – and analogously, potential welfare consequences of voluntary trade secrecy over patenting, despite private benefits to the inventor – although the costs and benefits are difficult to precisely quantify and compare.

These results add to a sizable literature on invention secrecy, which thus far has primarily studied the question of who chooses patents over trade secrecy, and when, rather than the spillovers generated by secrecy – especially when aggregated across thousands of inventors. The secrecy order policy in World War II presents a unique opportunity to identify inventions which were temporarily held secret and subsequently released, and study the consequences of this administrative action, when secret inventions are otherwise, by definition, hard to observe. The results also connect to a growing literature on the disclosure function of patents, though the World War II secrecy policy was more sweeping than the suppression of patent publication alone.

Secrecy orders are still issued today, under the authority of the Invention Secrecy Act of 1951, but at lower frequency than during the war. More recently, motivated by recurrent theft of U.S. IP by foreign firms and governments, the USPTO solicited public comments in 2012 about the feasibility of expanding secrecy orders to "economically significant" patents. The request for comments elicited strong negative reactions from several legal trade groups, whose concerns included some of the questions studied in this paper. As of yet it has not evolved into legislation or agency action, but policymakers continue to debate solutions to foreign IP theft and illegal technology transfer, which could conceivably include promoting, or imposing, invention secrecy.

The focus of this paper is on the repercussions of concealing new invention. An important question this paper leaves for future research is the incentive effects of this policy: by suspending patent examination and precluding commercialization, secrecy orders may discourage subsequent patenting or invention in sensitive subject matter by those who receive them. Concerns about the detrimental impact on domestic invention, namely stifling U.S. innovation and driving R&D abroad, were among those raised by the ABA and IPOA in their responses to the USPTO's 2012 request for comments. An answer to this question would complement existing literatures on both the incentive effects of intellectual property rights and the decision to patent.

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Figure 1: Monthly patent applications, 1935-1955
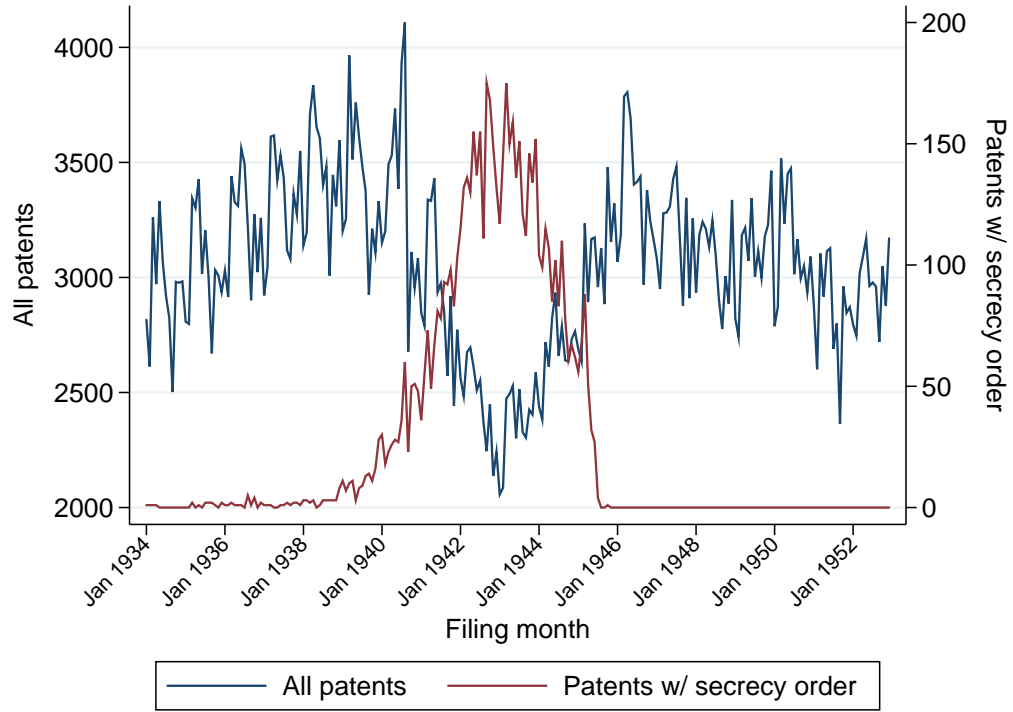
Notes: Figure shows monthly counts of (i) patent filings from 1935 to 1955 (in blue/left axis), and (ii) filings observed in the data as having been issued secrecy orders under P.L. 700 (in red/right axis).

Figure 2: Patterns in distribution of patent applications across NBER patent categories
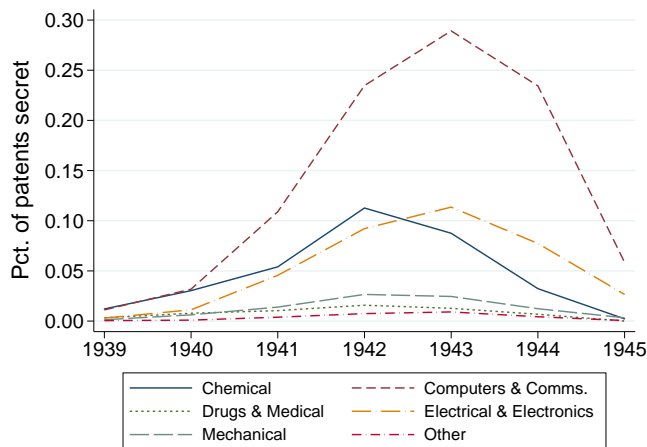
Panel (A): Fraction of applications in each top-level NBER category, 1939-1945
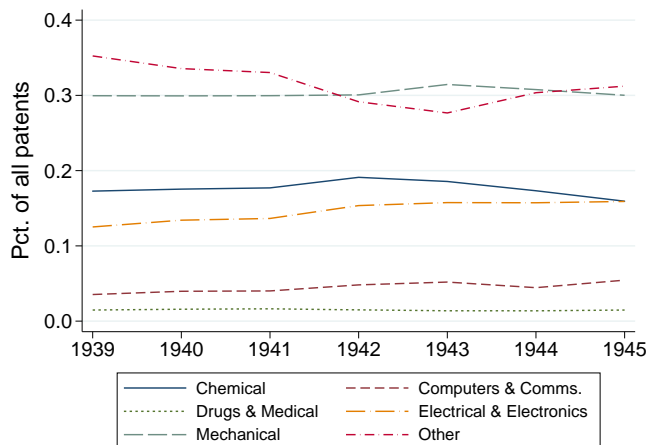
Panel (B): Fraction of secrecy orders in each top-level NBER category, 1939-1945
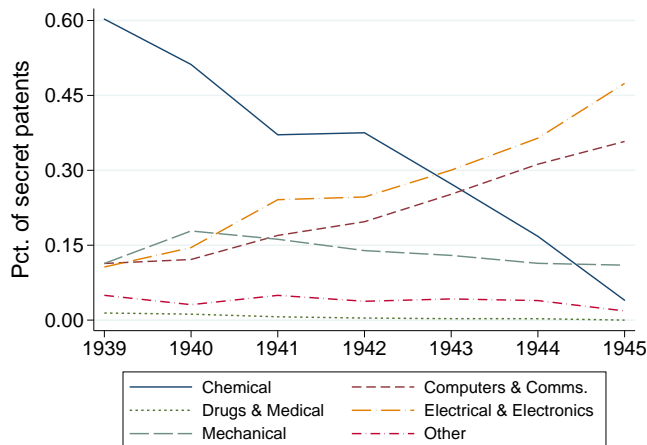
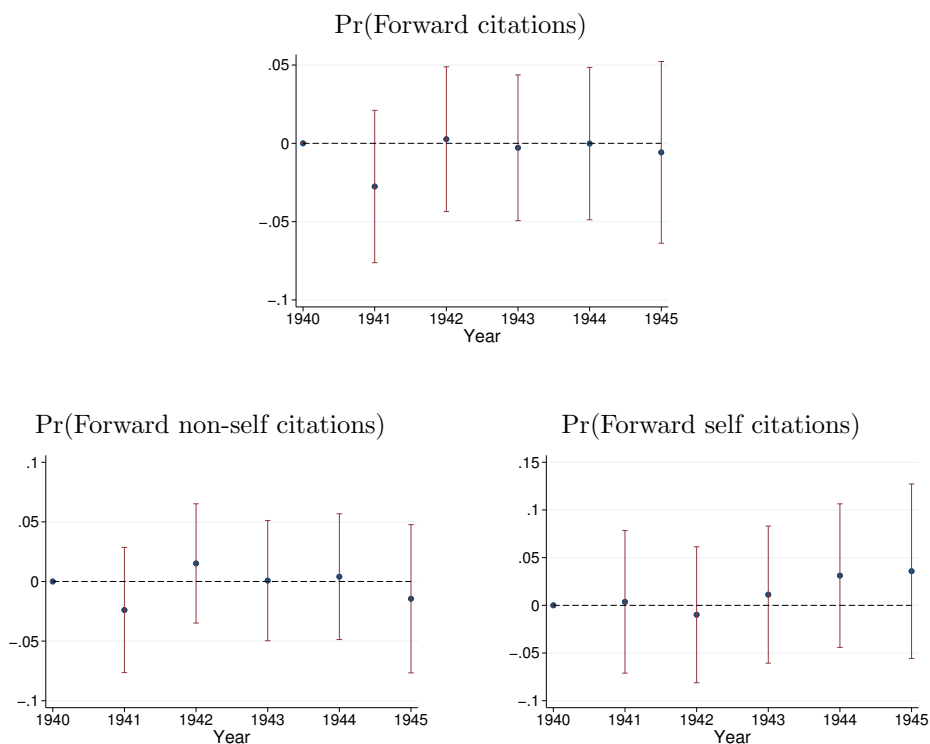Panel (C): Fraction of applications in each top-level NBER category issued secrecy order

Notes: Panel (A) shows the distribution of patent filings across NBER categories in each year from 1939-1945. Panel (B) shows the annual distribution across NBER categories of filings known to have been issued secrecy orders. Panel (C) shows the rate at which filings in each top-level NBER category were issued secrecy orders over time.

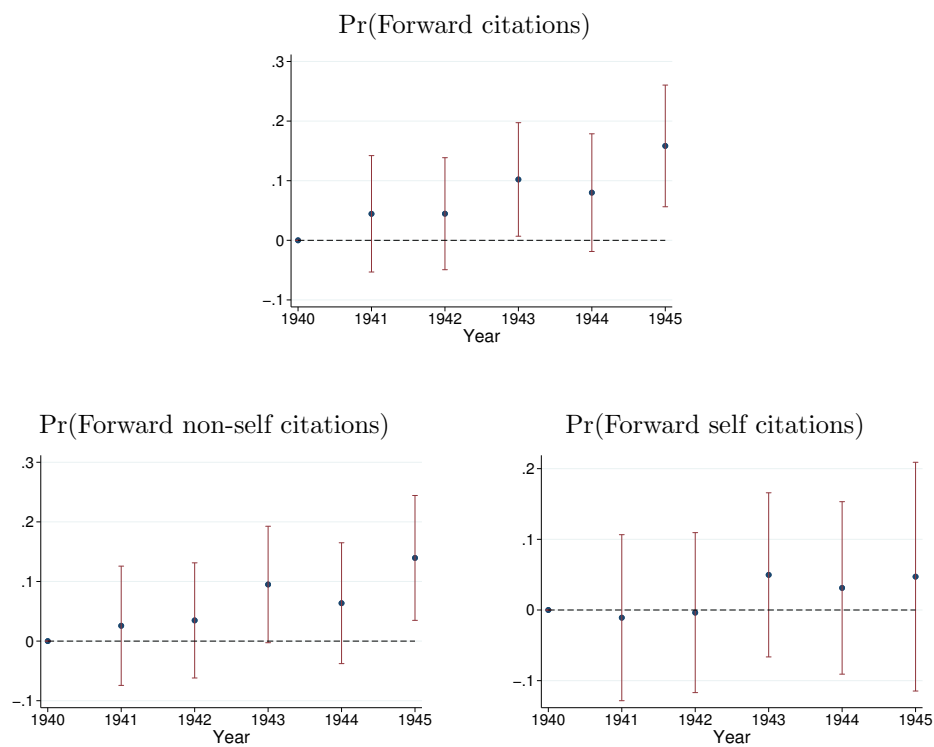Figure 3: Grant lags of applications placed under secrecy, vs. others, 1939-1945
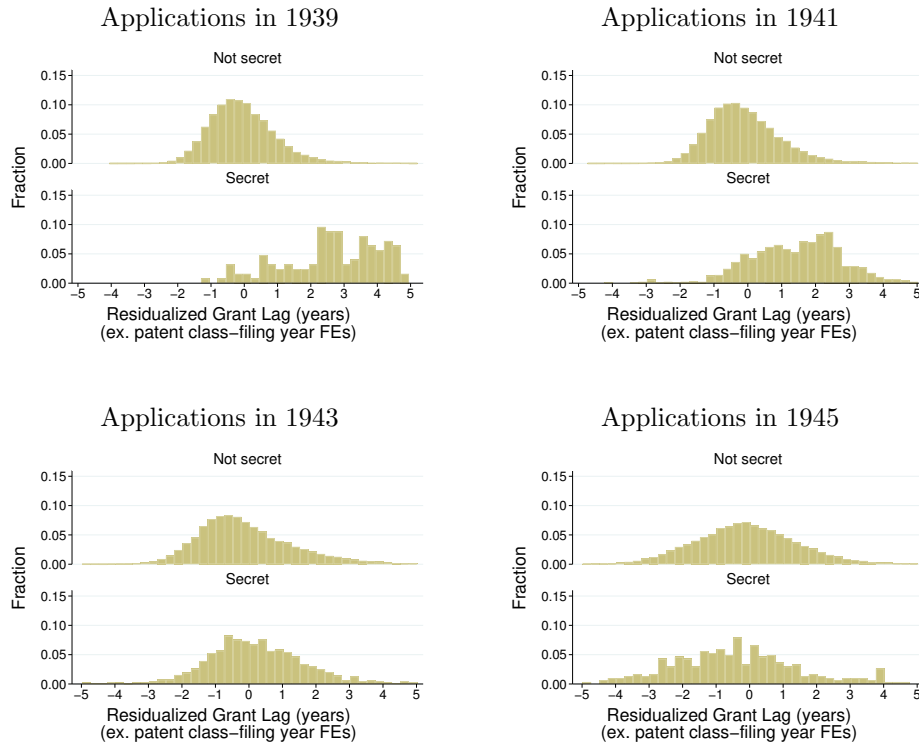
Notes: Figure shows the distribution residual grant lags of patent applications with versus without secrecy orders, after controlling for patent class-year FEs. Note that patent applications filed prior to July 1940 were only evaluated for secrecy if still under examination (such that pre-1940 differences in total pendency are in part selected).

Figure 4: Effects of secrecy on forward citations (all assignees)

Pr(Forward citations)

Pr(Forward non-self citations)

Pr(Forward self citations)

Notes: Figure shows estimates from a comparison of the probability of forward citations for patents filed by all assignees between July 1940 and June 1945 and issued a secrecy order, relative to those which were not, with estimates by filing year, and with 1940 being the omitted (reference) year. Underlying regressions control for whether each patent was evaluated for secrecy (with effects similarly estimated by filing year, not registering significantly different from zero), as well as class-year FEs. Error bars represent 95% confidence intervals, computed from heteroskedasticity-robust SEs. Noisy estimates relative to 1940 may reflect higher variance in the issuance of secrecy orders at the beginning of the program (see text).

Figure 5: Effects of secrecy on forward citations (non-OSRD firms only)

Pr(Forward citations)

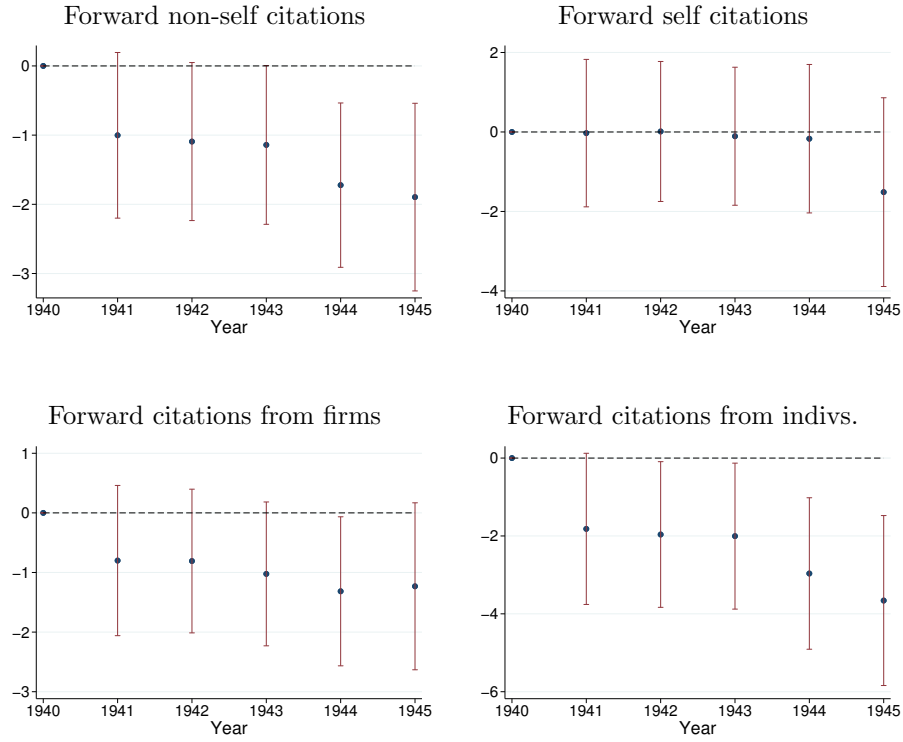Pr(Forward non-self citations)

Pr(Forward self citations)

Notes: Figure shows estimates from a comparison of the probability of forward citations for patents filed by non-OSRD firms between July 1940 and June 1945 and issued a secrecy order, relative to those which were not, with estimates by filing year, and with 1940 being the omitted (reference) year. Underlying regressions control for whether each patent was evaluated for secrecy (with effects similarly estimated by filing year, not registering significantly different from zero), as well as class-year FEs. Error bars represent 95% confidence intervals, computed from heteroskedasticity-robust SEs. Noisy estimates relative to 1940 may reflect higher variance in the issuance of secrecy orders at the beginning of the program (see text).

Figure 6: Effects of secrecy on time to median forward citation (all assignees)

Notes: Figure shows estimates from a comparison of median forward citation timing (measured as years since the cited patent's filing) for patents filed by all assignees between July 1940 and June 1945 and issued a secrecy order, relative to those which were not, with estimates by filing year, and with 1940 being the omitted (reference) year. Underlying regressions control for whether each patent was evaluated for secrecy (with effects similarly estimated by filing year, not registering significantly different from zero), as well as class-year FEs. Error bars represent 95% confidence intervals, computed from heteroskedasticity-robust SEs. Noisy estimates relative to 1940 may reflect higher variance in the issuance of secrecy orders at the beginning of the program (see text).

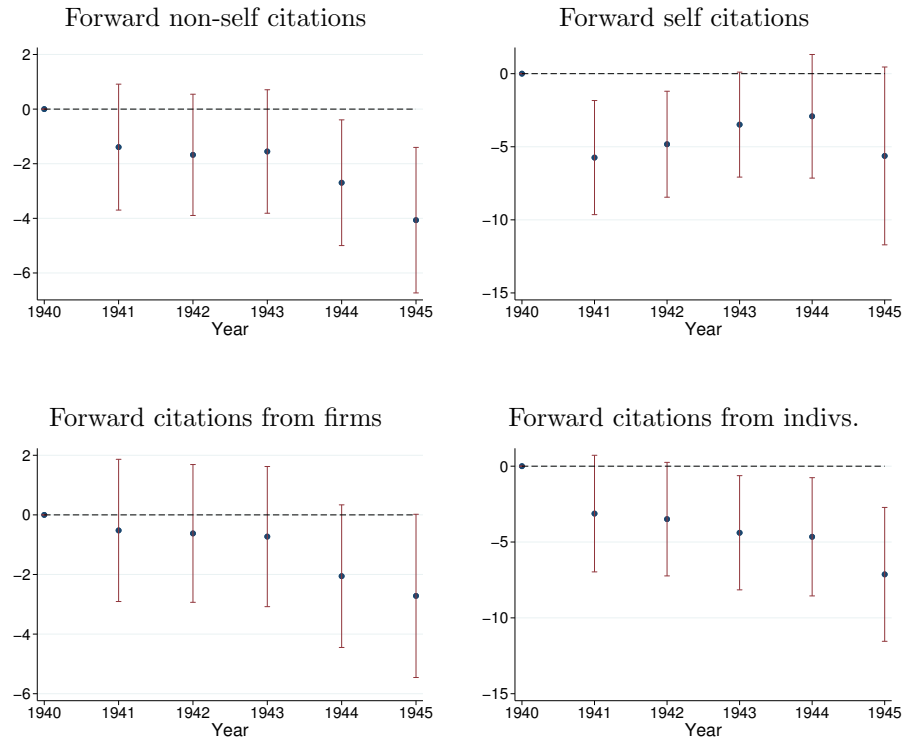Figure 7: Effects of secrecy on time to median forward citation (non-OSRD firms only)


Notes: Figure shows estimates from a comparison of median forward citation timing (measured as years since the cited patent's filing) for patents filed by non-OSRD firms between July 1940 and June 1945 and issued a secrecy order, relative to those which were not, with estimates by filing year, and with 1940 being the omitted (reference) year. Underlying regressions control for whether each patent was evaluated for secrecy (with effects similarly estimated by filing year, not registering significantly different from zero), as well as class-year FEs. Error bars represent 95% confidence intervals, computed from heteroskedasticity-robust SEs. Noisy estimates relative to 1940 may reflect higher variance in the issuance of secrecy orders at the beginning of the program (see text).

Figure 8: Changes over time in level and composition of patenting in patent classes in the top quartile of secrecy order issuance rate from 1940-1945, relative to classes without secrecy orders
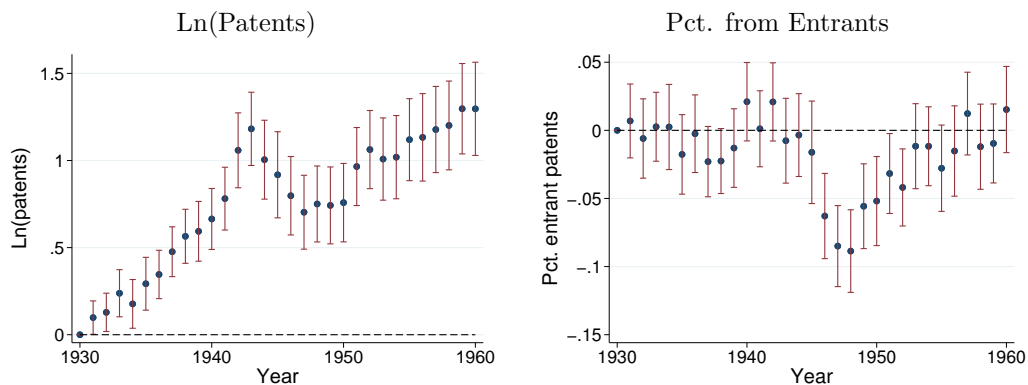
Notes: Left panel shows the estimated mean difference in log patents for classes in the highest quartile of class-level wartime secrecy rates (defined as the fraction of patents filed in a given class between 1940 and 1945 which were issued a secrecy order), relative to classes without any secrecy orders, by year. Right panel shows the estimated mean difference in the fraction of filings from new entrants, by year. Sample aggregates patents with a single, known assignee (> 95% of patents in the sampling window) up to the patent class-year level, and is restricted to class-years with at least 10 patents (to allow for meaningful variation in composition measures). Error bars represent 95% confidence intervals, computed from SEs clustered at the patent class level.

Figure 9: Use of new words from secret vs. non-secret patent titles in the Google Books corpus
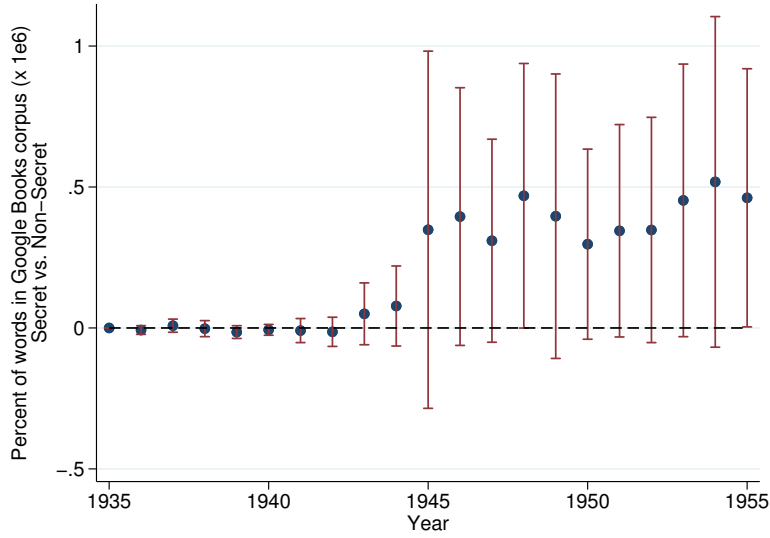
Notes: Figure shows estimated differences over time in usage in the Google Books corpus of words whose stem which first appeared in the title of a secret versus non-secret patent filed between July 1940 and June 1945. In the underlying regression, observations are new stems in patent titles from this period, crossed by year, and the outcome variable is each stem's fraction of all words in the Google Books corpus in the given year. This outcome is regressed on indicators for the year, interacted with an indicator for whether the stem was first used in the title of a patent which was (i) evaluated for secrecy or (ii) issued a secrecy order. The figure plots effects for the latter. Specification includes stem fixed effects, such that comparisons are within stems, over time. Omitted category is 1935 for stems from both secret and non-secret patents. Sample censors stems at the 90th percentile of pre-patent usage in the Google Books corpus, to eliminate already-common language. Error bars represent 95% confidence intervals, computed from SEs clustered at the stem level.

Table 1: Top 10 patent classes with applications placed in secrecy, 1939-1945

USPC	Description	Pct. of Applications w/ Secrecy Order, 1939-1945	Max Pct. Secret in Any Year, 1939-1945
380	Cryptography	21.3%	71.4%
342	Directive radio wave systems/devices (radar)	16.2%	61.0%
585	Chemistry of hydrocarbon compounds	12.8%	51.9%
367	Acoustic wave systems/devices	11.7%	55.9%
526	Synthetic resins or natural rubbers	8.6%	62.4%
333	Wave transmission lines and networks	8.3%	51.8%
315	Electric lamp and discharge device systems	7.7%	42.4%
375	Pulse or digital communications	7.5%	37.0%
343	Radio wave antennas	7.0%	56.0%
331	Oscillators	6.4%	38.0%

Notes: Table lists the 10 patent classes with the highest fractions of applications in 1939-1945 issued secrecy orders, in descending order, and the maximal fraction of applications in any single year ordered secret. Data for eventually-granted patents only.

Table 2: Forward citations of secret vs. non-secret patents

	Cites	Citers	Citing classes	Non-self	Self
Secrecy ordered	1.837***	1.446***	0.450***	1.651***	0.155***
	(0.140)	(0.101)	(0.040)	(0.128)	(0.024)
Secrecy evaluated	1.018***	0.693***	0.324***	0.827***	0.177***
	(0.069)	(0.051)	(0.022)	(0.064)	(0.013)
Constant	4.441***	4.082***	2.005***	4.100***	0.254***
	(0.011)	(0.009)	(0.004)	(0.011)	(0.002)
N	243193	243193	243193	243193	243193
R^2	0.09	0.09	0.11	0.08	0.06
Class x Filing Year FEs	X	X	X	X	X

Notes: Table estimates mean differences in the forward citations of patents filed between 1939 and 1945 issued a secrecy order, evaluated for secrecy but not issued a secrecy order, and not evaluated for secrecy, relative to others in the same class and filing year. *, **, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively. Heteroskedasticity-robust SEs in parentheses.

Table 3: Effect of secrecy on patent grant lags

	Applications filed in:						
	1939	1940	1941	1942	1943	1944	1945
Incremental grant lag (years)	3.272***	2.527***	2.309***	1.334***	0.834***	0.388***	0.205
	(0.189)	(0.103)	(0.073)	(0.064)	(0.074)	(0.110)	(0.173)
N	40739	40361	35207	29535	28502	32130	36719
R^2	0.17	0.20	0.23	0.22	0.20	0.20	0.21
Class FEs	X	X	X	X	X	X	X
Mean lag	2.25	2.31	2.42	2.70	2.99	3.48	4.06

Notes: Table shows effects of secrecy orders on grant lags of patents in the same class and filing year, with estimates by filing year. *, **, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively. Heteroskedasticity-robust SEs in parentheses.

Table 4: Use of word stems which first appeared in titles of secret vs. non-secret patents

Panel A: Stems from patents of all assignees

	Year 3	Year 6	Year 9	Year 12	Year 15	Year 18	Year 21	Year 24	Year 27	Year 30
Secrecy ordered	-0.041**	-0.042*	-0.049*	-0.059**	-0.070**	-0.062*	-0.014	-0.016	0.004	0.000
	(0.016)	(0.021)	(0.026)	(0.029)	(0.030)	(0.032)	(0.028)	(0.023)	(0.016)	(.)
Secrecy evaluated	0.024	0.020	0.003	0.007	0.027	0.032	0.014	0.022	0.009	0.000
	(0.016)	(0.020)	(0.023)	(0.024)	(0.023)	(0.023)	(0.022)	(0.018)	(0.012)	(.)
Constant	1.066***	1.203***	1.228***	1.105***	0.981***	0.895***	0.862***	0.884***	1.041***	1.000
	(0.090)	(0.066)	(0.079)	(0.066)	(0.055)	(0.051)	(0.048)	(0.042)	(0.026)	(.)
N	1129	1129	1129	1129	1129	1129	1129	1129	1129	1129
R^2	0.44	0.46	0.49	0.52	0.53	0.53	0.52	0.49	0.51	.
USPTO Class FEs	X	X	X	X	X	X	X	X	X	X
Mean of DV	0.08	0.15	0.22	0.29	0.37	0.46	0.57	0.70	0.85	1.00

Panel B: Stems from patents of non-OSRD firms

	Year 3	Year 6	Year 9	Year 12	Year 15	Year 18	Year 21	Year 24	Year 27	Year 30
Secrecy ordered	-0.053	-0.065	-0.062	-0.113	-0.142**	-0.167**	-0.125**	-0.109**	-0.040	0.000
	(0.039)	(0.060)	(0.071)	(0.069)	(0.067)	(0.073)	(0.057)	(0.051)	(0.035)	(.)
Secrecy evaluated	0.029	0.015	-0.036	-0.034	-0.019	0.050	0.055	0.027	0.020	0.000
	(0.031)	(0.043)	(0.048)	(0.047)	(0.051)	(0.047)	(0.041)	(0.032)	(0.024)	(.)
Constant	1.047***	0.974***	1.008***	0.960***	0.862***	0.737***	0.777***	0.797***	0.969***	1.000
	(0.101)	(0.133)	(0.132)	(0.131)	(0.115)	(0.110)	(0.110)	(0.104)	(0.052)	(.)
N	379	379	379	379	379	379	379	379	379	379
R^2	0.58	0.57	0.65	0.65	0.64	0.64	0.68	0.64	0.66	.
USPTO Class FEs	X	X	X	X	X	X	X	X	X	X
Mean of DV	0.08	0.15	0.22	0.29	0.38	0.47	0.59	0.70	0.85	1.00

Notes: Table estimates the effects of secrecy on subsequent usage of word stems which first appeared in the title of a patent filed between July 1940 and June 1945, for all such stems (Panel A) and for those which originated in patents of non-OSRD firms (Panel B). Observations are new stems from this period (see text and appendix for details), and the outcome variable in each column is the fraction of future titular uses of the stem over the next 30 years from the date of filing which had been achieved by the given year (i.e., the CDF of its usage over 30 years). This outcome is regressed on indicators for whether the first use of the stem occurred in a patent which was (i) evaluated for secrecy or (ii) issued a secrecy order. All regressions include originating patent class fixed effects and a third-order polynomial in the time to the last use observed in the data (through 1979), as inventions issued secrecy orders may be longer-lived, mechanically shifting back the time profile. *, **, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively. Heteroskedascity-robust SEs in parentheses.

Table 5: Presence of new chemical word stems in the Du Pont Products Index

	1938	1944	1946	1949	1955
Secrecy ordered	-0.018	-0.071***	-0.060*	-0.017	0.006
	(0.038)	(0.026)	(0.035)	(0.045)	(0.059)
Secrecy evaluated	-0.015	-0.023	-0.023	-0.033	-0.028
	(0.027)	(0.030)	(0.031)	(0.032)	(0.037)
Constant	0.076***	0.093***	0.104***	0.114***	0.149***
	(0.013)	(0.015)	(0.015)	(0.016)	(0.018)
N	542	542	542	542	542
R^2	0.00	0.01	0.01	0.00	0.00
Mean of DV	0.07	0.08	0.09	0.10	0.14

Notes: Table estimates the probability that a stem which first appeared in the title of a patent filed in a chemical class in the 1940-1945 period appears in the Du Pont Products Index in 1938, 1944, 1946, 1949, and 1955, as a function of whether the first patent with the stem was issued a secrecy order. The stems in this sample were further screened by the author to identify cases related to chemical content and processes, so as to eliminate false positives. *, **, *** represent significance at the 0.1, 0.05, and 0.01 levels, respectively. Heteroskedascity-robust SEs in parentheses.

Web Appendix

A Data Appendix

A.1 Construction of patent datasets

A.1.1 Base data

The construction of the core patent-level dataset used in this paper begins with the USPTO historical master file (Marco et al. 2015), which provides a master list of granted patents with grant dates, patent class/subclass (USPC), and two-digit NBER category (Hall et al. 2001). In building this paper's dataset, I restrict the sample to patents granted between January 1, 1920 and December 31, 1979 – although most of the paper invokes only a subset of these. For all granted patents in this set, I obtain additional patent characteristics from the following sources:

- FreePatentsOnline.com (FPO): serial numbers, filing dates, and the network of forward and backward citations (front-page citations only)

- Derwent Innovation database (DI): (mostly) standardized assignee names[1]

A small subset of patents are missing filing dates and assignees. Table A.1 shows the number patents with missing data, by decade of grant. For the period sampled in this paper (1930-1960), approximately 2.4% of patents are missing a filing date and 2.5% missing an assignee (note: these percentages calculated for patents granted between 1930 and 1960, whereas the paper uses the sample of patents known to have been filed between 1930 and 1960).

Table A.1: Number of patents with missing data, by decade

| | | No filing date | | No assignee data | |
Decade of grant	Patents	Number	Percent	Number	Percent
1920-1929	414901	25738	6.2%	25918	6.2%
1930-1939	442842	11102	2.5%	11221	2.5%
1940-1949	307630	5470	1.8%	5546	1.8%
1950-1959	425985	12461	2.9%	12661	3.0%
1960-1969	567761	11203	2.0%	11363	2.0%
1970-1979	689027	2	0.0%	73	0.0%
Total	2848146	65976	2.3%	66782	2.3%

Notes: Table shows counts of patents with missing data, and their fraction of all patents, by decade (of grant).

Because secrecy orders were issued to patent applications, they are identified by serial number. For the purposes of this paper, it is thus critical to have accurate data on serial numbers. The

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[1]Note that serial numbers, filing dates, and the network of patent citations were also retrieved from the Derwent database for comparison against the FPO data, as a validation exercise. The two data sources overwhelmingly agreed, and where they disagreed, spot checks revealed that FPO was consistently the more accurate of the two, and when there was an error in the FPO data, it typically reflected the occasional typographical error on the printed patent publication itself, such as two flipped digits, or a digit one unit off the correct value. Given their reliability, the data for this paper thus use serial numbers, filing dates, and citations from FPO.

application-level data (serials and filing dates) from FPO were therefore manually reviewed and validated for the period around the secrecy order program, by checking patents with serial numbers or filing dates which are out of sequence. The important feature of the USPTO's application numbering system for my purposes here is that applications are organized into application "series", which span several years, and identified by a serial number within that series, generally issued in the order in which patent applications arrive at the USPTO, with serial numbers never exceeding six digits. Application series increment, and serial numbers reset, at the beginning of a year in which the serial numbers from the previous series are expected to surpass 1,000,000. Series 2 begins January 1, 1935 and ends December, 1947 and is the focus of this data cleaning effort. I take all patents identified by FPO as belonging to Series 2 and sort these patents by serial. I then look for patents where the previous and next serial have the same filing date but the given patent has a different filing date, and then manually validate the serial and filing date for these patents. Out of over 370,000 patents in Series 2, corrections were made to 279 serials and 188 filing dates. Although these corrections are valuable for matching patents to secrecy orders, the low error rate for this sample also indicates that such errors are not widespread in the data.

A.1.2 Harmonizing assignee names

Although the assignee names from DI are largely already standardized, closer examination reveals that there are still variants on individual assignee names (e.g., BELL TELEPHONE LABOR INC with $> 10,000$ patents, and BELL TELPHONE LAB INC, BELL TEL PHONE LAB INC, and BELL TEIEPHONE LAB INC with 1 patent each). I undertake several procedures to further harmonize assignee names. I begin by sorting a unique list of assignees in alphabetical order, and for each assignee recording other nearby assignees up to 9 positions before and after in the sorted list. I then calculate the edit distance between the given assignee name and each of these nearby assignee names. When this edit distance is less than 25% of the length of the longer name in each pair, I flag that pair as a candidate for manual review. I then review all such matches for several categories of assignees, and standardize names when a match is found:

- Assignees with ≥ 15 patents between 1930 and 1960
- Assignees with at least 1 secrecy order
- Assignees which were OSRD contractors
- Assignees identified as government agencies (see next section)
- Assignees identified as universities or hospitals (see next section)
- Assignees which were synthetic rubber manufacturers
- Assignees which were spinouts from Standard Oil

This process is repeated (because each round of harmonization may bring new assignees into the set with ≥ 15 patents between 1930 and 1960) until no new matches are found.

This harmonization is neither perfect nor exhaustive, but it is believed to be effective for the purposes of this paper. It is also worth noting that for the vast majority of assignee names which were standardized by this procedure, there was clearly a primary spelling for that assignee in the original DI data, with hundreds or thousands of associated patents in the case of large assignees, and at worst a handful of secondary spellings with one or two associated patents – such that the actual effects of both (i) performing this harmonization for the priority assignees above, and of (ii) *not* performing it for non-priority assignees, are likely minimal.

A.1.3 Determining assignee types

Assignees are then classified into four categories – firms, universities and hospitals, government agencies, and individuals – through a combination of rule-based and manual classification. I begin by classifying assignees as firms when the assignee name includes any of roughly 120 words which indicate firms (e.g., CO, CORP, INC, LTD, SPA, GMBH, etc., as well as technical words such as AERO, AUTO, CHEM, ENG, MACHINE, OIL, PROD, TECH, WORKS; full list available on request). I then manually classify remaining assignees with ≥ 15 patents between 1930 and 1960, as well as assignees whose name includes any of the following strings:

- COLLEGE, INST, UNIV, HOSP, RES FOUND
- US, CANADA, UK, FRANCE, GERMANY, SWITZERLAND, AUSTRALIA, JAPAN, ISRAEL, and assorted other countries
- ATOM (to identify international atomic energy commissions)

Assignees with > 200 patents in the 1920-1979 period which are thus far unclassified are then classified as firms. Any remaining unclassified assignees are classified as individuals.

This classification procedure was developed over several years, and although – like the name harmonization – it is neither perfect nor exhaustive, random spot checks suggest it is overwhelmingly effective at categorizing assignees into the right bins. In total, 60.1% of patents with an assignee in the 1920-1979 sample are assigned to a firm, 0.2% to a university, 0.8% to a government agency, and 39.1% to an individual (numbers sum to $> 100\%$ because 5% of patents have multiple assignees, and 0.2% have assignees in multiple categories).

A.1.4 Identifying patents of OSRD contractors

As part of a broader data collection effort around U.S. science during World War II, I retrieved information on R&D contracts let by Office of Scientific Research and Development (OSRD), the

primary R&D contracting agency during the war, from its archival collection at the U.S. National Archives and Records Administration (NARA). A complete list of contractors was compiled from contract lists and contractor directories. These contractors were then manually matched to the harmonized assignee names, making it possible to identify patents by government R&D contractors versus non-contractors. Contractors spanned all sectors of the economy but were primarily firms and universities. Given that universities were not heavy filers of patents in this period, the vast majority of patents by OSRD contractors are by firms.[2]

A.1.5 Identifying patents with secrecy orders

Patent applications with secrecy orders were identified from the archival records of three U.S. government agencies: (i) the Office of Scientific Research and Development (OSRD), whose records yielded 4,837 serials with a secrecy order; (ii) the Office of Production Research and Development (OPRD), which yielded 2,047 serials; and (iii) the U.S. Army Office of the Judge Advocate General (JAG), which yielded 5,976 serials. These sets partly overlap, and collectively they identify a total of 8,475 patent applications which were at some point ordered secret.[3] According to other contemporary records from the JAG office, a total of 11,182 secrecy orders were issued through June 14, 1945, when the war – and the secrecy program – were winding down and few new secrecy orders were being issued. The data thus identify roughly 75% of all secrecy orders. Undermeasurement is not a significant concern, particularly because it will only tend to attenuate comparisons between patents known to have been issued a secrecy order versus those not so observed. Of these 8,475 identified serials with secrecy orders, 6,352 (75%) were eventually granted.[4]

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[2]The OSRD contract and contractor data can be found at:
- "Index to Contracts, 1941-1947" in RG 227 (Records of the Office of Scientific Research and Development), located in Stack Area 130, Row 20, Compartment 11, Shelf 1, Boxes 1-5. Online catalog entry at https://catalog.archives.gov/id/6882818.
- "Contractor Lists, 1940-1946" in RG 227 (Records of the Office of Scientific Research and Development), located in Stack Area 130, Row 20, Compartment 11, Shelf 4, Boxes 1-2. Online catalog entry at https://catalog.archives.gov/id/16955595.
- "Contract Ledgers, 1941-1946" in RG 227 (Records of the Office of Scientific Research and Development), located in Stack Area 130, Row 22, Compartment 18, Shelf 2-3, Boxes 1-6. Online catalog entry at https://catalog.archives.gov/id/6920064.

[3]These counts tally serials of utility patent applications only. Design patents account for a small fraction of patenting and of secrecy orders (<100 total) and are excluded from the paper.

[4]The OSRD records which yielded data on secrecy orders can be found at:
- "D-1 Forms Used by the War Division of the Patent Office, 1942-1946" in RG 227 (Records of the Office of Scientific Research and Development), located in Stack Area 130, Row 20, Compartment 34, Shelf 3, Boxes 1-3. Online catalog entry at https://catalog.archives.gov/id/6882835.
- "Correspondence Relating to Secrecy Orders, 1942-1945" in RG 227 (Records of the Office of Scientific Research and Development), located in Stack Area 130, Row 20, Compartment 42-43, Shelf 7 and 1-3, Boxes 1-27. Online catalog entry at https://catalog.archives.gov/id/16955603.

The OPRD records which yielded data on secrecy orders can be found at:
- "Index to Patent Applications, 1945-1945" in RG 179 (Records of the War Production Board), Office of Production Research and Development, located in Stack Area 570, Row 64, Compartment 12, Shelf 4. Online catalog entry at https://catalog.archives.gov/id/567665.

The OSRD records contain two sources of data on secrecy orders: a 27-box collection of secrecy determination forms ("Form D-1"), which were used to evaluate patent applications for secrecy, and miscellaneous agency correspondence discussing the secrecy order program and patent applications affected by it. Together with wartime administrative histories of the agencies involved, the D-1 forms and internal correspondence from the OSRD records provide a rich picture of how P.L. 700 was implemented at the USPTO, and how the review process was executed.

Recall from the historical background section of the paper that when a patent application arrived at the patent office, it was assigned to an examining division, and the primary examiner for that division would forward applications he or she viewed as a candidate for a secrecy order to the Patent Office War Division (POWD), where representatives from various other agencies (namely: the Army and Navy Patent Advisory Board, the War Production Board, the OSRD, and/or the Petroleum Administration for War) would review these applications and make a recommendation for or against secrecy. For every application sent to the POWD, a D-1 form was drawn up with identifying information including the serial, filing date, title, inventor, assignee, patent attorney, patent office examining division and primary examiner, and date of receipt at the POWD (see Figures A.1 and A.2 for examples). The application was then read by the relevant reviewers, who would each sign or stamp the form with their recommendation. Often, reviewers would defer to other reviewers' judgments (typically, to the armed services). If all reviewers declined to recommend secrecy, the application would be "disapproved" (for secrecy) and sent back to Washington; if any reviewer requested secrecy, the application was issued a secrecy order.

There are approximately 24,000 D-1 forms in the OSRD records. I had these forms scanned and transcribed via double entry with verification (under which discrepancies in the transcription are manually reviewed). Given the importance of these data, and that the original print on some of these forms is hard to read, I had them transcribed via the same procedure a second time by a distinct contractor. I then personally reviewed all differences between the two transcriptions and performed numerous checks to validate the data, making corrections as needed, and sometimes even catching typographical errors on the original forms themselves (these checks include: (i) ensuring serials are consistent with filing dates, (ii) ensuring that date of receipt is after filing date, (iii) ensuring that date of review is after date of receipt (although there are a few cases where it appears the application arrived at the POWD already-recommended for secrecy), (iv) harmonizing primary examiner name spellings and ensuring that examiner names and examining divisions were paired

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The JAG records which yielded data on secrecy orders can be found at:

- "Records Pertaining to Patent Applications under Secrecy Orders Tendered to the Federal Government, 1941-1945" in RG 153 (Records of the Office of the Judge Advocate General), located in Stack Area 270, Row 2, Compartment 28, Shelf 6, Boxes 1-2. Online catalog entry at https://catalog.archives.gov/id/26335074.

- "Records Relating to Patents Tendered to the Federal Government Under Secrecy Orders, 1941-1949" in RG 153 (Records of the Office of the Judge Advocate General), located in Stack Area 270, Row 2, Compartment 28, Shelf 7, Box 1. Online catalog entry at https://catalog.archives.gov/id/17396215.

- "Patent cases, 1941-1952" in RG 153 (Records of the Office of the Judge Advocate General), located in Stack Area 270, Row 2, Compartment 28, Shelf 6, Box 1. Online catalog entry at https://catalog.archives.gov/id/17382698.

in a consistent way). Although most of the contents of each form were transcribed, currently the only data being used in this paper are the serial and the recommendation.

Of these $\approx 24,000$ forms, 23,690 were for utility patent applications, covering 22,549 unique serials (some patent applications were evaluated multiple times), of which 3,557 were issued a secrecy order. Given that many more secrecy orders are known to have been issued during the war than are in this record set, it does not comprise an exhaustive list of applications formally reviewed for secrecy, let alone issued a secrecy order, but knowing patents which were evaluated for secrecy but disapproved allows us to specify a more refined control group than just the set of all patents which were not secret. Presumably, the applications covered by these forms are those which were reviewed by an OSRD representative, but the precise sampling conditions are not known. Unfortunately, no additional D-1 forms could be located in other NARA collections.

In addition to these forms, OSRD agency correspondence related to secrecy orders identifies 1,484 serials with a secrecy order. Most of this correspondence consists of letters between OSRD staff members notifying about the issuance of a secrecy order. The two sets of serials overlap, however, resulting in a total of 4,837 secrecy orders identified in OSRD records.

The next source of information on secrecy orders is an eight-box set of index cards in the archived records of the Office of Production Research and Development (OPRD), an agency whose mission was to promote the development of new materials and efficient methods for war production during World War II. According to documentation in the records, one set of index cards served as an index to patent applications "on which secrecy orders were imposed by the War Production Board and its predecessor agencies during the period 1941 to August 30, 1945." A second set indexed patent applications "on which no secrecy orders were issued... after examination by the War Production Board." A total of 2,047 unique serials appear in the set with secrecy orders, and 2,021 in the set without them. For unknown reasons, 135 serials appear in both sets. These serials are presumed to have been issued a secrecy order at some point in the war.

The final source of data on secrecy orders is a set of files from the records of the U.S. Army Judge Advocate General's office (JAG), which received patent applications with secrecy orders which were tendered to the government for its use, pursuant to the statutory terms of P.L. 700. These records contain lists of tendered inventions (see Figure A.3 for an example). The records also contain extensive agency correspondence that identifies additional serials with secrecy orders. In total, the lists of tendered inventions identify 5,957 unique serials with a secrecy order, and the correspondence identifies 928 serials. As with the other agencies, the two sets of serials overlap, resulting in a total of 5,976 secrecy orders found in JAG records.

Figure A.1: Sample secrecy determinations from OSRD records with secrecy recommended

Form D-1
ebf

COPY   MAILED d
JAN 12 1944

DIVISION 20 ____ . CLASS 154-43 . (December 3, 1943 .
                                    (Make no entries here.)
                                    SERIAL NUMBER 468,992

FILING DATE December 14, 1942

INVENTION IMPACT RESISTANT PLASTIC PRODUCT

INVENTOR Edwin R. Laning

ATTORNEY Albert Sperry

ASSIGNEE Joseph Stokes Rubber Co., Inc.

DRAWINGS 1 SHEETS   EXAMINER L. M. Brown

- -

DISAPPROVED BY PATENT OFFICE DEFENSE COMMITTEE

SUBMITTED TO:

ARMY & NAVY PATENT ADVISORY BOARD   X

WAR PRODUCTION BOARD   X

OFFICE OF SCIENTIFIC RES. & DEV.   X

OFFICE OF PETROLEUM COORDINATOR

- - - - - - - - - - - - - - + + + + + + + +

DISAPPROVED

SECRECY RECOMMENDED December 21, 1943

- - - - - - - - - - - - - - + + + + + + + +

In view of the attached request, it is recommended
that a secrecy order be issued in this application under
the provisions of Public No. 700, as amended August 21,
1941 by Public No. 239, and June 16, 1942 by Public No.
609.

Concur with services
D. Z. Beckler 12-7-43
J. P. Wilkins 12-8-43

Placing of this application
under the provision of
"Public 700" is recommended

L. T. Phelan 12-13-43

Secrecy recommended in letter from
J. H. Byers 12-21-43
for F. E. Bailey

Secrecy not recommended
H. P. Grace Q.M.C.

APPROVED
JAN 14 1944

COMMISSIONER OF PATENTS

FORM D-1S Feb '44
BW

MAILED
AUG 13 1945

DIVISION 54 . CLASS 315-12 . REC'D IN WAR DIV. July 14, 1945 .
                                                      (Examiner Leave Blank)
                                    SERIAL NUMBER 544,947

FILING DATE July 14, 1944

INVENTION ELECTRON-OPTICAL APPARATUS

INVENTOR Christian O. Larson

ATTORNEY Edwin M. Martin

ASSIGNEE Farnsworth Television and Radio Corporation

DRAWINGS 1 SHEETS   EXAMINER O. S. Strachan

- -

DISAPPROVED BY PATENT OFFICE WAR COMMITTEE

SUBMITTED TO ADVISORY AGENCIES

SECRECY (DISAPPROVED
         (RECOMMENDED August 6, 1945

RECOMMENDATION, SIGNATURE, AGENCY & DATE
Every expert examining the indicated application must sign
this form, and should indicate an express recommendation
as to secrecy.

Submitted for:

A & N P A B
A
S.C.   Placing of this application under the pro-
            visions of "Public 700" is recommended
            J. W. Greer 7-23-45

N

O S R D

P A W   In view of the attached request, it is recommended
            that a secrecy order accompanied by permit A
            be issued in this application under the provisions of
            Public No. 700, as amended.

W P B

            Edward L. Blaggett Jr.
            Patent Office War Division

Approved, Date AUG 11 1945

Conder C. Geary
Assistant Commissioner of Patents

8

Figure A.2: Sample secrecy determinations from OSRD records, with secrecy disapproved

Form D-1

FEB 26 1943

DIVISION 51 . CLASS 250-40.6 . (Make no entries here.) SERIAL NUMBER 464,856

FILING DATE November 7, 1942

INVENTION Automatic Frequency Control

INVENTOR Winfield R. Koch

ATTORNEY Harry Turiok

ASSIGNEE Radio Corp. of America

DRAWINGS 2 SHEETS EXAMINER G. D. Beckus (License)

- - - + + + + - - - + + + + - - -

VN DISAPPROVED BY PATENT OFFICE DEFENSE COMMITTEE

SUBMITTED TO:

ARMY & NAVY PATENT ADVISORY BOARD X

WAR PRODUCTION BOARD X

OFFICE OF SCIENTIFIC RES. & DEV. X

OFFICE OF PETROLEUM COORDINATOR

DISAPPROVED May 31, 1943

SECRECY RECOMMENDED

- - - + + + + - - - + + + + - - -

Concur with service
A.L.Elder 2-27-43

Secrecy not recommended
L.T.Phelan 3-5-43

Concur
R.G.Felton 3-11-43

Secrecy not recommended
J.C.Batcheler 3-16-43
J.F.McClean 5-31-43

Form D-1

NOV 20 1942

DIVISION 65 . CLASS 179-171 . (Make no entries here.) SERIAL NUMBER 467,009

FILING DATE June 15, 1942

INVENTION Volume Control

INVENTOR Winfield R. Koch

ATTORNEY Harry G. Grover

ASSIGNEE Radio Corporation of America

DRAWINGS 1 SHEETS EXAMINER F. P. McDermott Request LIC

- - - + + + + - - - + + + + - - -

d1 DISAPPROVED BY PATENT OFFICE DEFENSE COMMITTEE

SUBMITTED TO:

ARMY & NAVY PATENT ADVISORY BOARD

WAR PRODUCTION BOARD

OFFICE OF SCIENTIFIC RES. & DEV. (X)

OFFICE OF PETROLEUM COORDINATOR

DISAPPROVED December 10, 1942

SECRECY RECOMMENDED

- - - + + + + - - - + + + + - - -

Secrecy not recommended
J. C. Batcheler 12/10/42

Figure A.3: Sample page from lists of tendered inventions in JAG records

CONFIDENTIAL

10 APR 1944

Patents Division
Room 2631
Munitions Building

MEMORANDUM for Dr. Murray O. Hayes, Office of The Judge Advocate General of the Navy.

Subject: Tenders of Inventions under the act of October 6, 1917, as amended.

In connection with obtaining records of any use that may be made of inventions tendered to the Government under the provisions of the act of October 6, 1917, as amended (54 Stat. 710; 55 Stat. 657; 56 Stat. 370; 35 U.S.C. 42), and in an effort to make known to the directly interested branch of the Army the inventions under secrecy order that are available by reason of tender under the act, supra, it is requested that the following disclosures, understood to be available in the Navy files, be loaned for a brief period to this office for study and preparation of photostatic copies where deemed advisable, for transmission to the Army branch specifically connected with the subject matter:

Serial No.	Inventor	Title	Assignee
D-104,614	William P. Yant	Facepiece for Breathing Apparatus	Mine Safety Appliances Co.
D-105,236	John B. Littlefield et al.	Breathing Apparatus	Mine Safety Appliances Co.
333,158	Hugo Benioff	Electroacoustic Transducer	Submarine Signal Co.
338,949	James B. Fisk	Producing and Transmitting Electromagnetic Waves	Bell Telephone Labts., Inc.
344,363	Hugo Benioff	Piezoelectric Oscillator	Submarine Signal Co.
407,461	Milton E. Mohr	Electrical Wave Transforming System	Bell Telephone Labts. Inc.
428,698	Wilmer L. Barrow et al	Radio Target Detector	Sperry Gyroscope Co.
429,508	William W. Hansen et al	High Frequency Power Measuring Device	Sperry Gyroscope Co.
442,477	Alfred Henry Chilton	Electrically Propelled Torpedoes	
447,242	Jacob Neufeld	Navigational Method and Apparatus	
449,102	George C. Southworth	Wave Guide System	Bell Telephone Labts., Inc.

CONFIDENTIAL   CONFIDENTIAL

A.2 Textual analysis: new words in patent titles

The text-based analysis in this paper requires additional data on patents' content. For the pre-1976 period, patent text is not available in a clean, USPTO-issued machine-readable format. Google Patents makes available OCR full text for historical patents, but the quality of the character recognition is less than great and generally declines going further back in time, due to older documents and lower-quality typesetting, which increases the OCR error rate. Other data sources, including Derwent Innovation, also provide the full text of pre-1976 patents, but with the same limitations. To minimize concerns about how the OCR quality and spelling errors may influence the results of the paper, particularly given the focus on identifying and measuring the subsequent use of new words in the patent record, I therefore seek out a cleaner source of data.

Google also makes available, via the Google Cloud Platform and its BigQuery web service, additional textual and text-based patent data. I used this service to retrieve titles (which are cleanly transcribed) and top terms (according to Google, "the top 10 salient terms extracted from the patent's title, abstract, claims, and description) of patents granted from 1920-1979. For each patent, Google also provides a 64-element machine-learned component vector which can be used to compute pairwise similarity measures (according to Google: this component vector is "based on document contents and metadata, where two documents that have similar technical content have a high dot product score of their embedding vectors" and "trained on full text bag of words to predict CPCs using the WSABIE classification model" – in other words, a model designed to predict each patent's classification from its content and metadata). I take these vectors off-the-shelf and use them to calculate the measure of similarity invoked at the end of Section 4.[5]

New words (more specifically, new stems) are identified from patent titles as follows. After loading the patent titles, I remove numeric tokens, punctuation, and special characters. I then tokenize the remaining text in the title, splitting it into a list of constituent "words". I then loop over this list and drop (i) words which match a set of stop words, (ii) words with < 4 or > 25 characters, and (iii) words with a numeric character.[6] The remaining words are then stemmed by the NLTK toolkit and reduced to a set of unique stems for each patent. To restrict our focus to stems which are neither exceedingly common nor vanishingly rare, and to minimize the computational burden of the remaining steps, I further reduce these stems to those (i) used by at least 5 patents but no more than 20% of patents in the complete 1920-1979 sample, and (ii) used by at least one patent filed between 1940 and 1945, since the stems of interest will be from this set.

After reshaping the data to patent-stem pairs, the next step is to identify stems which were *first* used in a patent filed between 1940 and 1945 – that is, stems which are ostensibly new to the patent

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[5]Patent titles are from the BigQuery *Patents* dataset (patents-public-data → patents → publications → title_localized; see https://console.cloud.google.com/bigquery?p=patents-public-data&d=patents&t=publications), and top terms and component vectors from the *Google Patents Research* dataset (patents-public-data → google_patents_research → publications → top_terms, embedding_v1; see https://console.cloud.google.com/bigquery?p=patents-public-data&d=google_patents_research&t=publications)

[6]Stop words used in this step are a combination of off-the-shelf stop words from the NLTK toolkit for Python, stop words from Iaria et al. (2018), and stop words from Younge and Kuhn (2016).

record when they are used in the title of a patent filed in the early 1940s. The 1920 to 1939 period is used to define a stock of "existing" stems; this interval is considered sufficient for constructing an existing stock of words, since it includes nearly one million patents and covers the 20+ most recent years of invention. The final step is to then reduce the data to stems which were first used in a patent filed in the 1940 to 1945 period. The empirical output from this procedure is a dataset of these stems and the patents using them between 1940 and 1979.

Table A.2 lists the most-heavily used new stems from the 1940 to 1945 period, highlighting in red those which were first appeared in the title of a secret patent, and in light red those which ever appeared in a secret patent. The term *semiconductor* entered the patent record during this period, as did *radar*, *ultrasonic*, *monomer* and *elastomer*, and *antibiotics* and *penicillin*. As this table demonstrates, the stemming procedure is also imperfect, as both "elastom" and "elastomer" enter this table, the former likely stemmed from "elastomer" itself, and the latter from words like "elastomerization". There is no perfect solution to this problem, as iterative stemming will often reduce words down to unrecognizable objects and cause unrelated words to get binned together into the same stem of stems. I thus limit the text cleaning procedure to one round of stemming, so that similar words (e.g., singular and plural variants of a noun) will be grouped into a common stem, at the same time recognizing the limitations of the methods.

Table A.2: Most heavily used new stems in patent titles, 1940-1945

	Stem	Subseq. uses (1940-1979)		Stem	Subseq. uses (1940-1979)
1.	semiconductor	6935	9.	antibiot	940
2.	disc	3260	10.	phosphon	894
3.	radar	2255	11.	elastomer	848
4.	ultrason	2017	12.	curabl	810
5.	monom	1366	13.	cryogen	771
6.	elastom	1237	14.	readout	672
7.	waveguid	1160	15.	penicillin	627
8.	electrophotograph	1158	16.	recognit	601

Notes: Red = Stem *first* used in title of secret patent. Light red = Stem *ever* used in title of secret patent.

This same procedure was repeated for patents' top terms, as well as for the union of titles and top terms. Although my focus in the paper is on titles only, the results throughout Sections 4 and 5 are similar when the analysis is based on these top terms. (The analysis was not repeated for the union of titles and top terms; because they each measure distinct features of patents, their union is a strange object and was not considered suitable for analysis.)

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Other textual data sources

In addition to looking for these words in the patent record, the paper also studies two other corpora: Du Pont product catalogs, and the Google Books N-gram database.

The Du Pont Products Index (DPPI) was a Du Pont product catalog published at regular intervals, and is used to look for focal chemical terms in Du Pont literature as a proxy for the product market. The 1938 edition of the DPPI is available online from Hathitrust, and working with the Hagley Museum in Wilmington, Delaware, which houses the Du Pont archival collection, I had four other editions of the DPPI digitized: 1944, 1946, 1949, and 1955-56, all of which are now available as well. These catalogs were then converted to text using ABBYY FineReader 14, which is subject to similar limitations as the OCR of historical patents previously discussed, although the OCR quality is higher because the scans are higher-resolution and the source documents have cleaner typesetting. The implications of using OCRed text for this part of the paper, and some robustness checks explored in light of these issues, are discussed in the paper.[7]

As explained in the paper, I make use of the Google Books N-gram data, which are freely available for download, to measure the use of focal technical words in the broader public discourse.[8] These data provide annual usage of unique N-grams in the Google Books corpus. This paper uses the data on 1-grams (i.e., words), matching words from patent titles to words in this set (specifically, I identify all words in patent titles whose stem entered the patent record in a patent filed between 1940 and 1945, link these to words in the N-grams data, and measure their use by year, in levels and as a fraction of all words in the Google Books corpus in the given year).

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[7] For the 1938 volume, see https://catalog.hathitrust.org/Record/001042925; for the 1944, 1946, 1949, and 1955-56 volumes, see https://digital.hagley.org/islandora/search/%22Du%20Pont%20Products%20Index%22?type=edismax &f%5B0%5D=-RELS_EXT_isMemberOfCollection_uri_ms%3A%28%22info%3Afedora/islandora%3Aead%22%29.

[8] Data and documentation available at http://storage.googleapis.com/books/ngrams/books/datasetsv2.html.

B   Historical Appendix

This appendix provides supplementary material to accompany the discussion of the secrecy order program in Section 1 of the paper. Figure B.1 shows the text of Public Law 700, enacted July 1, 1940, which authorized the USPTO to issue secrecy orders. Figures B.2 to B.4 show examples of secrecy order notification letters mailed to inventors. Figure B.5 shows an announcement of the General Rescinding Order printed in the USPTO Official Gazette (the USPTO's weekly newsletter, accessible by subscription) on September 18, 1945.

Figure B.1: Public Law 700

[CHAPTER 501]

July 1, 1940
[H. R. 10058]
[Public, No. 700]

AN ACT

To amend the Act relating to preventing the publication of inventions in the national interest, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act of Congress approved October 6, 1917 (40 Stat. 394, ch. 95, U. S. C., title 35, sec. 42), be amended to read as follows:

Withholding of patents in national interest.

"Whenever the publication or disclosure of an invention by the granting of a patent might, in the opinion of the Commissioner of Patents, be detrimental to the public safety or defense he may order that the invention be kept secret and withhold the grant of a patent for such period or periods as in his opinion the national interest

Proviso.
Deemed abandoned if published, etc.

requires: *Provided,* That the invention disclosed in the application for said patent may be held abandoned upon it being established before or by the Commissioner that in violation of said order said invention has been published or disclosed or that an application for a patent therefor has been filed in a foreign country by the inventor or his assigns or legal representatives, without the consent or approval of the Commissioner of Patents.

"When an applicant whose patent is withheld as herein provided and who faithfully obeys the order of the Commissioner of Patents above referred to shall tender his invention to the Government of the United States for its use, he shall, if and when he ultimately receives a patent, have the right to sue for compensation in the Court of Claims, such right to compensation to begin from the date of the use of the invention by the Government: *Provided,* That the Secretary of War or the Secretary of the Navy or the chief officer of any established defense agency of the United States, as the case may be, is authorized to enter into an agreement with the said applicant in full settlement and compromise for the damage accruing to him by reason of the order of secrecy, and for the use of the invention by the Government."

Right of patentee to sue for compensation.

Proviso.
Settlement with applicant for damage, etc.

SEC. 2. This Act shall take effect on approval and shall remain in force for a period of two years from such date.

Effective date; period in force.

Approved, July 1, 1940.

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Figure B.2: Example Secrecy Order: Bell Labs

Form D-2

ADDRESS ONLY
THE COMMISSIONER OF PATENTS
WASHINGTON, D. C.

MAILED

AUG 24 1942

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

WASHINGTON

Serial No.   444,393   Filed   May 25, 1942

For   Radiation and Reception of Microwaves

Applicant   Archie P. King

Assignee   Bell Telephone Laboratories

NOTICE:- To the applicant above named, his heirs, and any and all his assignees, attorneys and agents:

Under the provisions of the Act of October 6, 1917 (Public No. 80), as amended July 1, 1940 (Public No. 700), as amended August 21, 1941 (Public No. 239), you are hereby notified that your application as above identified has been found to contain subject matter the disclosure of which might be detrimental to the public safety or defense, and you are hereby ordered to in nowise publish or disclose the invention or any hitherto unpublished details of the disclosure of said application, but to keep the same secret (except by written permission first obtained of the Commissioner of Patents), under the penalties of the amended Act. This application must be prosecuted under the Rules of Practice until a notice is received from the office that all the claims then in the case are allowable. Such notice closes the prosecution of the case. Furthermore, if previously allowed and now withdrawn from issue the prosecution of the case is likewise closed. When the application is in condition for allowance it will be withheld from issue during such period or periods as the national interest requires.

This order should not be construed in any way to mean that the Government has adopted or contemplates adoption of the alleged invention disclosed in this application, nor is it any indication of the value of such invention. In order to make the details of your invention available for inspection by the various national defense agencies for defense purposes and at the same time to preserve your rights under the Act, it is suggested that you promptly tender this invention to the Government of the United States for its use. Such tender may be effected by a communication directed to the Secretary of War or to the Secretary of the Navy and should be accompanied by a power to inspect the application and a copy of the application, including drawings.

Applicant and his assignees are authorized to disclose the subject matter of this application to the head of any Department or independent agency of the Government of the United States, to the head of any Bureau of any such Department, or to any subordinate officer or employee thereof known to the party making disclosure to be concerned directly in an official capacity with the subject matter, or designated specifically by the head of the Department, independent agency or Bureau as the proper party to receive confidential disclosures of such nature.
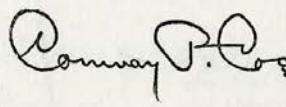
DATED

AUG 21 1942

Commissioner.

15

Figure B.3: Example Secrecy Order: Pittsburgh Plate Glass Co.

Form D-2

ADDRESS ONLY
THE COMMISSIONER OF PATENTS
WASHINGTON, D. C.

mlc

MAILED

DEPARTMENT OF COMMERCE

UNITED STATES PATENT OFFICE

WASHINGTON

AUG 24 1942

Serial No. 424,665   Filed   Dec. 27, 1941

For   Composition of Matter and Polymer Thereof

Applicant Irving E. Muskat and Franklin Strain

Assignee   Pittsburgh Plate Glass Company

NOTICE:- To the applicant above named, his heirs, and any and all his assignees, attorneys and agents:

Under the provisions of the Act of October 6, 1917 (Public No. 80), as amended July 1, 1940 (Public No. 700), as amended August 21, 1941 (Public No. 239), you are hereby notified that your application as above identified has been found to contain subject matter the disclosure of which might be detrimental to the public safety or defense, and you are hereby ordered to in nowise publish or disclose the invention or any hitherto unpublished details of the disclosure of said application, but to keep the same secret (except by written permission first obtained of the Commissioner of Patents), under the penalties of the amended Act. This application must be prosecuted under the Rules of Practice until a notice is received from the office that all the claims then in the case are allowable. Such notice closes the prosecution of the case. Furthermore, if previously allowed and now withdrawn from issue the prosecution of the case is likewise closed. When the application is in condition for allowance it will be withheld from issue during such period or periods as the national interest requires.

This order should not be construed in any way to mean that the Government has adopted or contemplates adoption of the alleged invention disclosed in this application, nor is it any indication of the value of such invention. In order to make the details of your invention available for inspection by the various national defense agencies for defense purposes and at the same time to preserve your rights under the Act, it is suggested that you promptly tender this invention to the Government of the United States for its use. Such tender may be effected by a communication directed to the Secretary of War or to the Secretary of the Navy and should be accompanied by a power to inspect the application and a copy of the application, including drawings.

Applicant and his assignees are authorized to disclose the subject matter of this application to the head of any Department or independent agency of the Government of the United States, to the head of any Bureau of any such Department, or to any subordinate officer or employee thereof known to the party making disclosure to be concerned directly in an official capacity with the subject matter, or designated specifically by the head of the Department, independent agency or Bureau as the proper party to receive confidential disclosures of such nature.

DATED

AUG 21 1942

Conway P. Coe

Commissioner.

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Figure B.4: Example Secrecy Order: Individual

Form D-2

ADDRESS ONLY
THE COMMISSIONER OF PATENTS
WASHINGTON, D. C.

MAILED

DEPARTMENT OF COMMERCE

AUG 24 1942

UNITED STATES PATENT OFFICE

WASHINGTON

Serial No. 441,535

Filed May 2, 1942

For   Production of Magnesium

Applicant   Roy C. Kirk

Assignee   -

NOTICE:- To the applicant above named, his heirs, and any and all his assignees, attorneys and agents:

Under the provisions of the Act of October 6, 1917 (Public No. 80), as amended July 1, 1940 (Public No. 700), as amended August 21, 1941 (Public No. 239), you are hereby notified that your application as above identified has been found to contain subject matter the disclosure of which might be detrimental to the public safety or defense, and you are hereby ordered to in nowise publish or disclose the invention or any hitherto unpublished details of the disclosure of said application, but to keep the same secret (except by written permission first obtained of the Commissioner of Patents), under the penalties of the amended Act. This application must be prosecuted under the Rules of Practice until a notice is received from the office that all the claims then in the case are allowable. Such notice closes the prosecution of the case. Furthermore, if previously allowed and now withdrawn from issue the prosecution of the case is likewise closed. When the application is in condition for allowance it will be withheld from issue during such period or periods as the national interest requires.

This order should not be construed in any way to mean that the Government has adopted or contemplates adoption of the alleged invention disclosed in this application, nor is it any indication of the value of such invention. In order to make the details of your invention available for inspection by the various national defense agencies for defense purposes and at the same time to preserve your rights under the Act, it is suggested that you promptly tender this invention to the Government of the United States for its use. Such tender may be effected by a communication directed to the Secretary of War or to the Secretary of the Navy and should be accompanied by a power to inspect the application and a copy of the application, including drawings.

Applicant and his assignees are authorized to disclose the subject matter of this application to the head of any Department or independent agency of the Government of the United States, to the head of any Bureau of any such Department, or to any subordinate officer or employee thereof known to the party making disclosure to be concerned directly in an official capacity with the subject matter, or designated specifically by the head of the Department, independent agency or Bureau as the proper party to receive confidential disclosures of such nature.
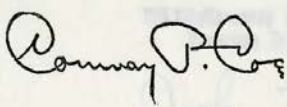
DATED

AUG 21 1942

Commissioner.

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Figure B.5: Notice of General Rescinding Order in USPTO Official Gazette

THE OFFICIAL GAZETTE

OF THE

United States Patent Office

CONTENTS

September 18, 1945

Trade-Marks	134—No.	416,469 to No. 416,602, inclusive.
T. M. Renewals	87	
Reissues	1—No.	22,674
Patents	539—No.	2,384,785 to No. 2,385,323, inclusive.
Total	761	

Notice

Under the provisions of Public Law 239, 77th Congress, Approved Aug. 21, 1941 (55 Stat. 657; 35 U. S. C. 42a), the optional procedure authorized in regulation 16 will apply to all foreign countries excluding Japan, Germany, Bulgaria, Italy, Austria, Roumania, and Hungary.
CONDER C. HENRY,
Assistant Commissioner of Patents.

General Rescinding Order

Subject to the exception hereinafter noted, all Orders of Secrecy heretofore issued by the Commissioner of Patents pursuant to the Act of October 6, 1917 (40 Stat. 394; U. S. C., title 35, sec. 42), as amended, are hereby rescinded.

The Commissioner of Patents may except any application from this order by written notice sent to the principals at their addresses of record on or before the effective date hereof.

This order shall take effect on November 30, 1945.
CASPER W. OOMS,
Commissioner.

August 30, 1945.

Notice of Cancellation

U. S. PATENT OFFICE, *Richmond, Va., Aug. 22, 1945.*

CeCo Manufacturing Company, Inc., its assigns or legal representatives, take notice:

A petition for cancellation having been filed in this Office by Argus, Incorporated, 405 Fourth St., Ann Arbor, Mich., to effect the cancellation of trade-mark registration of CeCo Manufacturing Company, Inc., 1200 Eddy St., Providence, R. I., No. 286,146, issued August 18, 1931, and the notice of such proceeding sent by registered mail to the said CeCo Manufacturing Company, Inc., at the said address having been returned by the post office undeliverable, notice is hereby given that unless said CeCo Manufacturing Company, Inc., its assigns or legal representatives, shall enter an appearance therein within thirty days from the first publication of this order the cancellation will be proceeded with as in the case of default. This notice will be published in the OFFICIAL GAZETTE for three consecutive weeks.

LESLIE FRAZER,
First Assistant Commissioner.

Disclaimer

2,259,527.—*Keith R. Manville,* Highland Park, N. J. SYNCHRONIZING MECHANISM. Patent dated Oct. 21, 1941. Disclaimer filed Aug. 24, 1945, by the inventor; the assignee, *Mack Manufacturing Corporation,* approving and consenting.

Hereby enters this disclaimer to claim 3 of said patent.

Notice of Opposition

U. S. PATENT OFFICE, *Richmond, Va., Sept. 4, 1945.*

James A. S. Furlonge, his assigns or legal representatives, take notice:

An opposition proceeding has been instituted by this Office upon the petition of San-Nap-Pak Co., Inc., 1440 Broadway, New York, N. Y., against the application for registration of a trade-mark to James A. S. Furlonge, 712 S. Olive St., Los Angeles 14, Calif. The Office has been notified of the death of said Furlonge. An opportunity was afforded the legal representative of the deceased to intervene. No response having been made thereto, notice is hereby given that unless said Furlonge, his assigns or legal representatives, shall enter an appearance therein within thirty days from the first publication of this order, the opposition will be proceeded with as in the case of default. This notice will be published in the OFFICIAL GAZETTE for three consecutive weeks.

LESLIE FRAZER,
First Assistant Commissioner.

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C   Additional Descriptives

This appendix section provides descriptive results which supplement those in the paper.

Figure C.1 provides a counterpart to Figure 3 in the paper, comparing the grant lags of (i) patents formally evaluated for secrecy but not ordered secret, versus (ii) those not evaluated for secrecy. The figure shows little difference in grant lags as a result of simply being *evaluated* for secrecy (note that 1939 filings are included in this figure for completeness, because many were evaluated for secrecy, but a necessary condition was that they were still pending as of July 1940 – such that this set is selected on longer pendency). Recall, on the other hand, that Figure 3 compared the grant lags of secret versus non-secret patents, and showed that secret patents on average took longer to issue than their non-secret counterparts in the same class and filing year, with the difference diminishing over time. The results suggest that it was secrecy orders – rather than secrecy evaluations – which were the cause of the time-varying delays in patent grant and publication.

Figure C.1: Grant lags of non-secret applications evaluated for secrecy, vs. others, 1939-1945
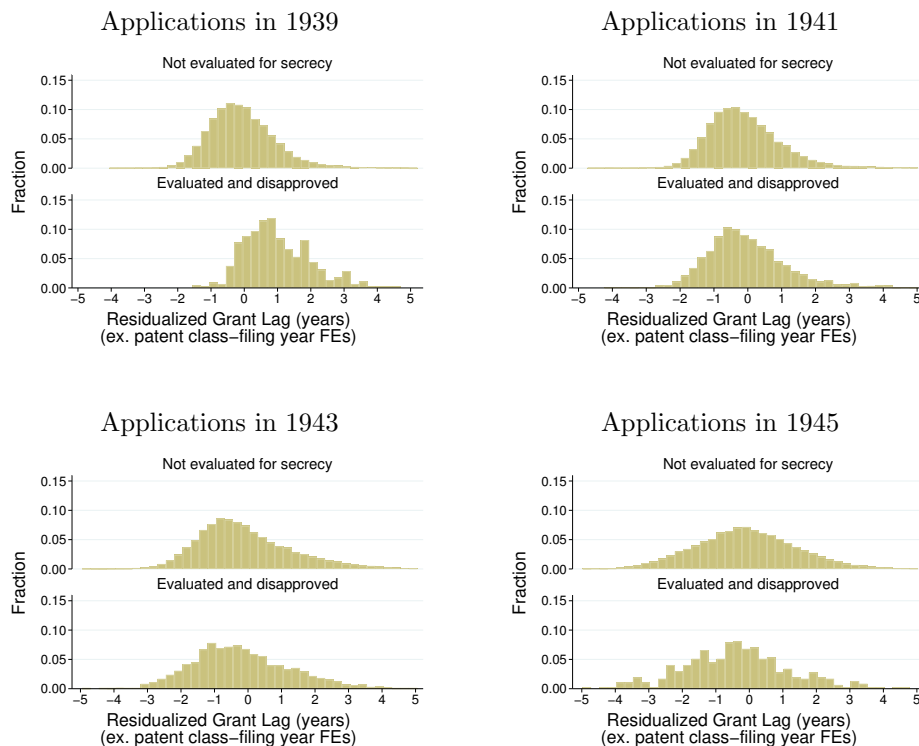

Notes: Figure shows the distribution residual grant lags of patent applications evaluated for secrecy but not issued a secrecy order versus those not evaluated for secrecy, after controlling for patent class-year FEs. Note that patent applications prior to July 1940 were only evaluated for secrecy if still under examination (such that pre-1940 differences in total pendency are in part selected).

Figure C.2 then illustrates that the differential grant delays for earlier versus later secret patents were not a function of changes in the underlying quality of these patents over time. For the empirical strategy invoked in Section 4 comparing the effects of secrecy for patents filed earlier versus later in the war – i.e., for inventions held secret for longer versus shorter terms – a principal concern is that there may be time-varying selection into secrecy, with the standards applied by evaluators possibly changing over time. This selection would confound the estimated effects if, for example, secrecy orders were applied more conservatively near the end of the war, with only the most important applications being ordered secret: in this case, what appears to be an "effect" of a shorter secrecy term would in fact be attributable to differential selection into secrecy.

To test for time-varying selection, I look for patent characteristics which are largely or fully determined at the time of filing and which correlate with ex-post measures of patent quality, namely forward citations, and I examine variation in these characteristics in secret and non-secret patents over the course of the war. Examples of observable patent characteristics which are fixed or approximately fixed at filing include the inventor(s), assignee(s), the patent class (determined by the subject matter), and the patent length (determined by the content of the invention and claims). In the data, a patent's length, measured as the number of pages in the patent document itself, is highly predictive of future citations, with longer patents being more heavily-cited: the left panel of Figure C.2 presents a binned scatterplot which illustrates this pattern for patents filed between July 1940 and June 1945, the focal sample for the patent-level analysis in the paper. This relationship could, for example, be driven by the complexity of the invention, or the number and breadth of the patent's claims.[9] Given this correlation, if later secret patents are on average longer than earlier secret patents, it would raise concerns about selection. Figure C.2 shows that this is not the case: the right panel shows a binned scatterplot of patent length over time, with secret patents in red and non-secret patents in blue. Although secret patents are on average longer than non-secret patents – reflecting the previously-documented selection into secrecy – the difference does not vary over time in a way that would suggest the results of Section 4 are confounded.

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[9]Although modern evidence has shown that patents' claims are often revised (typically narrowed) in the course of patent examination (e.g., Kuhn and Thompson 2017), such that the content of the issued patent is partly endogenously determined, claims are only one section of the patent document (which also includes a specification of the invention and diagrams). Moreover, for endogenously-determined claims to confound the results in Section 4, it would have to be the case that claims were revised in response to a secrecy order, which is unlikely given that secrecy orders in this period could not be appealed, and in particular that claims were differentially revised in earlier versus later applications such that the later applications ended up with more or broader claims – a hypothesis which, if claims correlate with patent length, is not consistent with the evidence in Figure C.2.

Figure C.2: Little evidence of time-varying selection into secrecy on patent quality

F. citations vs. patent length   Avg. length over time
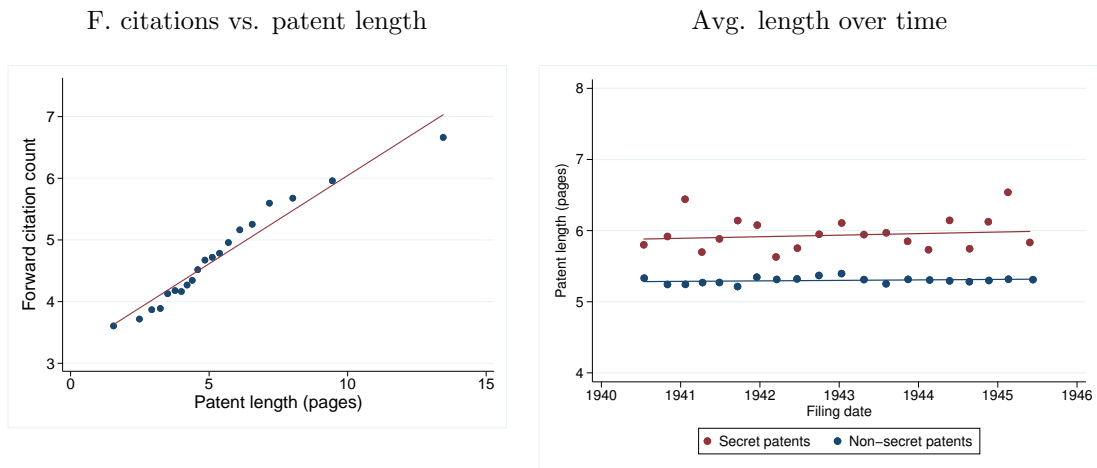
Notes: Figure demonstrates that patent length (measured as number of pages in the patent publication) strongly predicts forward citations, and that average patent length was stable over the sample period for both secret and non-secret patents, as an illustration that underlying characteristics of patents with secrecy orders (vs. without) do not differentially vary over time – with the implication being that time-varying selection into secrecy is unlikely to explain results in the paper which are estimated off of the duration of secrecy. Specifically, the left panel shows a binned scatterplot of forward citations against patent length for patents filed between July 1940 and June 1945. The right panel shows a binned scatterplot of patent length against filing date for patents in this sample, separating those with a secrecy order (in red) from those without (in blue), which shows a level difference between the groups but no trends over time.

Table C.1 provides a more detailed look at who the OSRD contractors are, providing context for the analysis in Section 4 which splits patents into subsamples of OSRD and non-OSRD firms – i.e., firms which were performing R&D under contract for the war effort, versus those which were not – to draw out differences in the effects. The table examines the set of all assignees who filed a patent in the 1940s, and the patents filed in this period with a known assignee. Out of nearly 135,000 unique assignees, roughly 21,000 were firms. Of these, the majority (66%) filed no patents in the 1930s, and nearly 90% filed fewer than 10 patents. Many of the OSRD assignees, on the other hand, were among the most active filers in this era. Nearly 85% were firms, and the distribution skews towards large, R&D-intensive outfits like Bell Labs, General Electric, Westinghouse, Du Pont, and so on. Although OSRD assignees comprise only 0.2% of assignees in the 1940s, they account for 19.1% of patents, and nearly 35% of patents filed by firms.

## Table C.1: Characteristics of OSRD and non-OSRD patent filing in the 1940s

	All assignees		Non-OSRD assignees		OSRD assignees	
	Number	**Percent of firms**	**Number**	**Percent of firms**	**Number**	**Percent of firms**
Patents	375,681		303,769		71,912	
Assignees	134,794		134,488		306	
Firms	21,117	100.0%	20,862	100.0%	255	100.0%
with 0 patents in 1930s	13,851	65.6%	13,808	66.2%	43	16.9%
with 1-5 patents	3,984	18.9%	3,949	18.9%	35	13.7%
with 6-10 patents	1,043	4.9%	1,028	4.9%	15	5.9%
with 11-20 patents	905	4.3%	891	4.3%	14	5.5%
with 21-50 patents	783	3.7%	740	3.5%	43	16.9%
with 51-100 patents	292	1.4%	256	1.2%	36	14.1%
with 101-200 patents	143	0.7%	119	0.6%	24	9.4%
with 501+ patents	85	0.4%	57	0.3%	28	11.0%
with 201-500 patents	85	0.4%	57	0.3%	28	11.0%
with 501+ patents	31	0.1%	14	0.1%	17	6.7%
OSRD percent of...						
Assignees	0.2%					
Patents	19.1%					
Patents by firms	34.7%					

Notes: Table shows characteristics of assignees who filing in the 1940s, focusing on the number of all / non-OSRD / OSRD assignees, the number which were firms, and the fraction of those with zero, few, or many patents in the prior decade. The table illustrates that the OSRD contractors are disproportionately large, R&D-intensive firms.
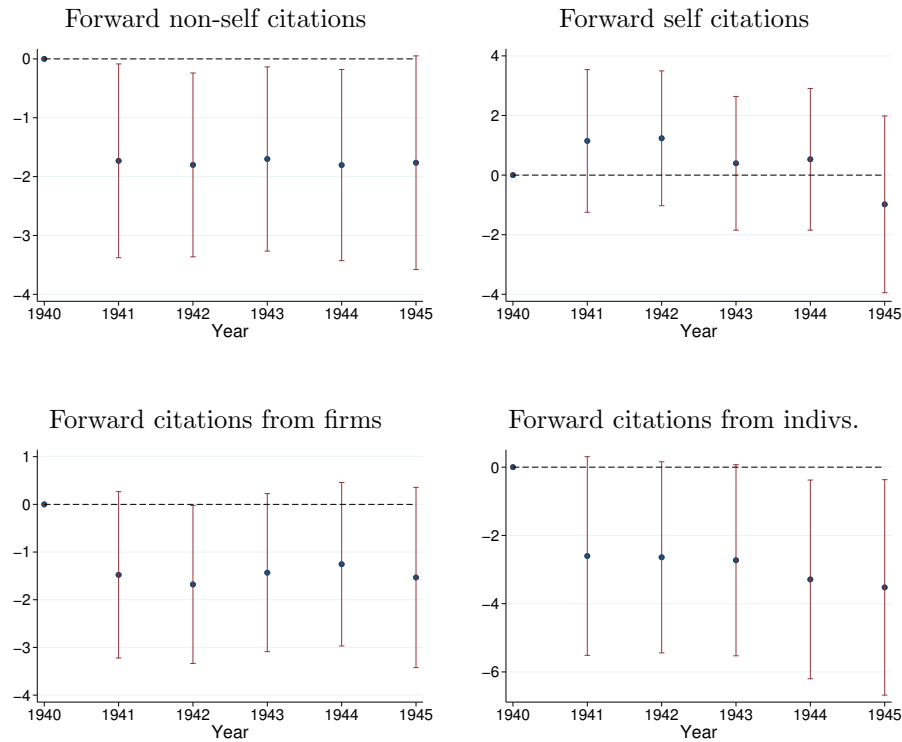
D Robustness Checks

This appendix section provides additional results which supplement those in the paper.

Figure D.1: Effects of secrecy on forward citations (OSRD firms only)
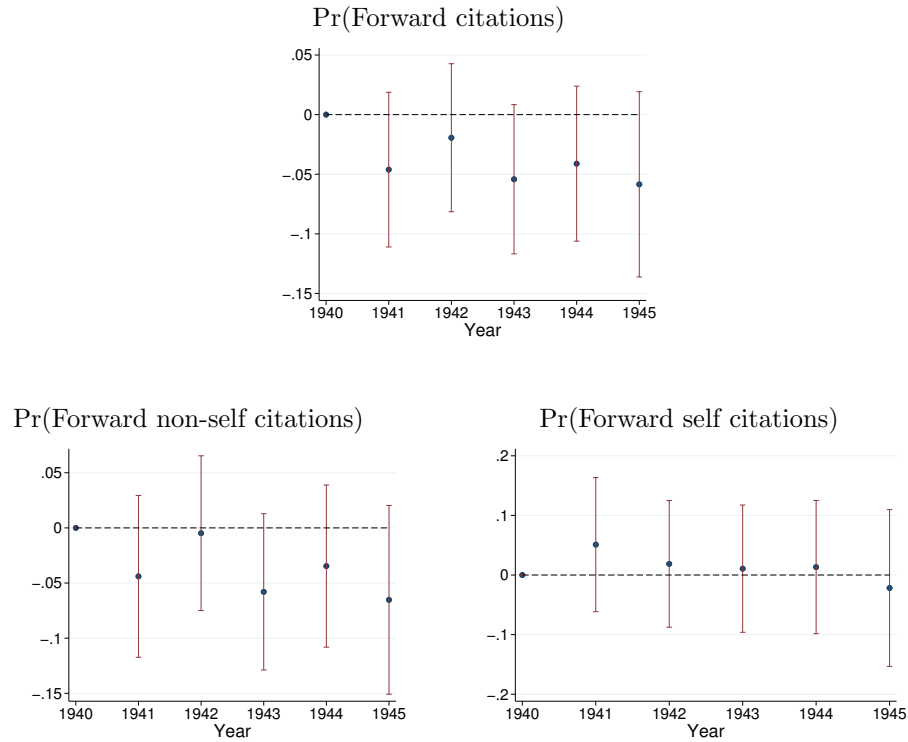
Notes: Figure shows estimates from a comparison of the probability of forward citations for patents filed by OSRD firms between July 1940 and June 1945 and issued a secrecy order, relative to those which were not, with estimates by filing year, and with 1940 being the omitted (reference) year. Underlying regressions control for whether each patent was evaluated for secrecy, as well as class-year FEs. Error bars represent 95% confidence intervals, computed from heteroskedasticity-robust SEs. Noisy estimates relative to 1940 may reflect higher variance in the issuance of secrecy orders at the beginning of the program (see text).

Figure D.2: Effects of secrecy on time to median forward citation (OSRD firms only)

Notes: Figure shows estimates from a comparison of median forward citation timing (measured as years since the cited patent's filing) for patents filed by OSRD firms between July 1940 and June 1945 and issued a secrecy order, relative to those which were not, with estimates by filing year, and with 1940 being the omitted (reference) year. Underlying regressions control for whether each patent was evaluated for secrecy, as well as class-year FEs. Error bars represent 95% confidence intervals, computed from heteroskedasticity-robust SEs. Noisy estimates relative to 1940 may reflect higher variance in the issuance of secrecy orders at the beginning of the program (see text).

Figure D.3: Changes over time in level and composition of patenting in patent classes in each quartile of secrecy order issuance rate from 1940-1945, relative to classes without secrecy orders
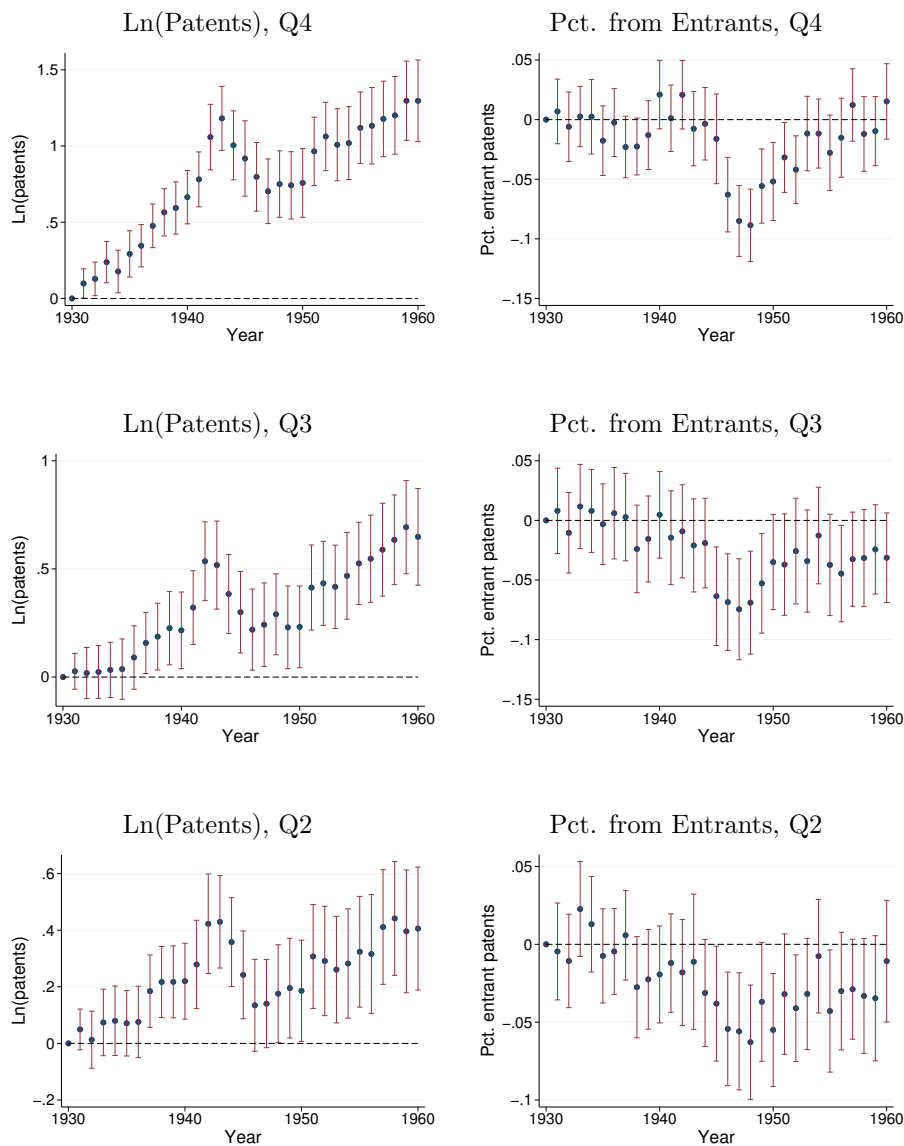
Notes: Left panel shows the estimated mean difference in log patents for classes in the given quartile of class-level wartime secrecy rates (defined as the fraction of patents filed in a given class between 1940 and 1945 which were issued a secrecy order), relative to classes without any secrecy orders, by year. Right panel shows the estimated mean difference in the fraction of filings from new entrants, by year. Sample aggregates patents with a single, known assignee (> 95% of patents in the sampling window) up to the patent class-year level, and is restricted to class-years with at least 10 patents (to allow for meaningful variation in composition measures). Error bars represent 95% confidence intervals, computed from SEs clustered at the patent class level.

Appendix references

Kuhn, Jeffrey M. and Neil C. Thompson. Forthcoming. "How to Measure and Draw Causal Inferences with Patent Scope," *International Journal of Business Economics.*

Younge, Kenneth A. and Jeffrey M. Kuhn. 2016. *Patent-to-Patent Similarity: A Vector Space Model.* SSRN working paper, available at https://ssrn.com/abstract=2709238.