The Dynamics and Spillovers of Management Interventions: Evidence from the Training within Industry Program

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This paper examines the long-term and spillover effects of management interventions on firm performance. Under the Training Within Industry (TWI) program, the US government provided management training to firms involved in war production between 1940 and 1945. Using a newly collected panel data set on all 11,575 US firms that applied to the program, we find that the TWI training had positive and long-lasting effects on firm performance and the adoption of beneficial managerial practices. Moreover, it generated complementarities among different types of training and had positive spillover effects on the supply chain of trained firms.

I. Introduction

Economists have documented large and persistent variations in productivity across establishments in both developed and developing countries

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(Syverson 2004; Foster, Haltiwanger, and Syverson 2008; Hsieh and Klenow 2009), which are strongly correlated with the adoption of different managerial practices (Ichniowski, Shaw, and Prennushi 1997; Bloom and Van Reenen 2007). Moreover, more recent papers have shown that management has causal effects on firm performance, confirming its role in driving differences in productivity (Bloom et al. 2013b; Giorcelli 2019).

However, much less is known about the long-term dynamic impact of management on firm outcomes and its spillover effects on other companies. On the one hand, the so-called Toyota Way hypothesis states that a single management intervention can put firms on a virtuous cycle of continuous improvements (Liker 2004). For example, after an initial positive shock to management, complementarities among managerial areas or positive spillovers along the supply chain could make it easier for firms to get better over time (Womack, Jones, and Roos 1990). On the other hand, the beneficial effects of management interventions may be not sustainable over time if turnover of good managers and changes in market conditions lead firms to abandon good practices (Bloom et al. 2020).

This paper studies the long-term dynamic and spillover effects of management interventions on firm performance, using evidence from a unique historical episode, the Training Within Industry (TWI) program. The TWI program was a voluntary US government–sponsored program that offered free in-plant management training to US firms involved in war production between 1940 and 1945. It encompassed interventions in three main areas, called J-modules. The Job-Instructions (J-I) module taught supervisors and managers how to establish standard procedures for operations, the Job-Relations (J-R) module taught how to manage and motivate workers, and the Job-Methods (J-M) module taught how to introduce improvements to current production processes. While the initial plan of the US government was to train all 11,575 US applicant firms in all the three J-modules, limited funding and personnel constraints made this goal unreachable. As a result, only 7% of applicants received training in all three J-modules, 48% received

as seminar and conference participants at Bocconi University, the University of Bologna, Chicago Booth, Columbia Business School, the Empirical Management Conference, Erasmus University Rotterdam, Harvard Business School, Katholieke Universiteit Leuven, Massachusetts Institute of Technology, Monash University, the Mountain West Economic History Conference, the National Bureau of Economic Research Summer Institute, the Barcelona School of Economics Summer Forum, New York University Stern, the Organisation for Economic Co-operation and Development Productivity Forum, PUC (Pontifical Catholic University) Rio de Janeiro, PUC Santiago, Queen's Smith School of Business, the University of British Columbia, the University of California Los Angeles, the University of California San Diego, Torcuato Di Tella University, the University of New South Wales, the University of Queensland, the University of Sydney, and Yale University. We are grateful to Dmitri Koustas and James Lee for kindly sharing with us the war contracts data and the 1939 Manufacturing Census data, respectively. Juan Rojas and Zhihao Xu provided outstanding research assistance. This paper supersedes a previous version entitled "Not All Management Training Is Created Equal: Evidence from the Training Within Industry Program." Data are provided as supplementary material online. This paper was edited by Chad Syverson.

no training at all, and the others received training in either one or two J-modules.

We use a new panel data set with information on the population of 11,575 US firms that applied to the TWI program. For each applicant, we digitized detailed information on its participation in the program, the J-module training received (if any), and its upstream and downstream companies. We then matched this information to their balance sheets and income statements from 1935 to 1955. Overall, applicant firms were large companies operating in different economic sectors and geographical areas. In 1939, they employed 40% of the US manufacturing workforce. In spite of their prominence in the US economy, the data indicate that they were not well managed, which confirms the need of management training.

Our empirical strategy measures the effects of the TWI program by comparing applicant firms that received the training to applicant firms that did not receive it, over a period of time from 5 years before to 10 years after the training period. We show that trained and nontrained firms had statistically similar characteristics at baseline and were located in statistically similar counties. Moreover, the probability of being trained in a given location was not autocorrelated over time, indicating that the TWI administration did not favor firms located in certain regions during the implementation of the program. Finally, and more importantly for our difference-in-differences specification, trained and nontrained firms were following statistically indistinguishable trends in performance before the start of the TWI program.

The historical records revealed that the fact that only some firms were eventually trained depended on idiosyncrasies in the implementation of the TWI program. For organizational purposes, applicant firms were divided into smaller geographical groups, called subdistricts. The in-plant training was then carried out by TWI instructors, whom the TWI administration trained to teach one J-module before assigning them to a given subdistrict. The lack of sufficient manpower and the inability of TWI instructors to teach in multiple subdistricts or to teach more than one module created imbalances in the composition of instructors across subdistricts and over time. As a result, some applicants received training only in some J-modules, while others did not receive any training at all.

We find four key results. First, the effects of the TWI training on firm performance were positive and lasted for at least 10 years after the program implementation. For example, sales of trained firms increased by 5.3% within 1 year of the TWI training, compared with those of nontrained applicants. This effect peaked at 21.7% in period 8 and then decreased to 16% in period 10. The effects on productivity were large and persistent, spanning from a 6% increase within 1 year of the training to a 27% increase after 10 years. These results were large and significant in all economic sectors, but manufacturing and services firms enjoyed the largest benefits.

Second, after assessing the overall effect of the TWI program, we start opening the black box of training by establishing a link between the content of the J-modules and the adoption of different managerial practices. The data indicate that trained firms achieved higher productivity by improving only the managerial practices related to the specific J-module received. For example, firms trained in J-R learned how to motivate workers and resolve internal disputes. Consistent with their training, they increased spending for performance-based bonuses, became more likely to report spending for on-the-job training, and experienced fewer strikes. We find this result analyzing both plant-level survey data and firm-level financial statements. Overall, our initial findings support the "Toyota Way" hypothesis. Trained firms were able to improve their performance for many years after training. Moreover, they experienced long-lasting changes in managerial practices.

Third, we document the existence of complementarities among managerial practices by exploiting the fact that some applicant firms received training in multiple J-modules. For example, firms that received the J-R training with another module experienced fewer strikes and were more likely to report spending for on-the-job training than firms that received the J-R module by itself. This finding is one of the first empirical tests of a core component of the "Toyota Way" hypothesis. Because of complementarities, receiving one type of training can decrease the cost of further improvements in other managerial areas, making it easier for trained firms to keep getting better over time.

Fourth, the TWI program generated positive spillover effects on the supply chain of trained firms. Specifically, after applicants received the training, their upstream and downstream firms started becoming more productive. Remarkably, both the trained applicants and the firms in their supply chain improved their management practices in similar ways, which suggests that there was a transfer of managerial knowledge from the trained firms. For example, firms in the supply chain of applicants that received the J-R training also became less likely to experience worker strikes and more likely to report spending for on-the-job training, mimicking the same changes implemented by the trained firm. In addition to sharing their newly acquired knowledge, trained applicants became more likely to select better upstream and downstream firms after receiving the training. These findings suggest another channel through which the program might have allowed trained firms to achieve long-lasting improvements.

Conversely, we do not find evidence of spillovers on other US war contractors that had been eligible to participate in the TWI program but did not apply. The fact that these firms were not damaged by the presence of trained firms nearby does not necessarily mean that they were immune to losing customers to the trained firms. While it is true that the trained firms may have gained higher market shares at the expense of nonapplicant companies, in fact they could have done this without poaching the latter's

current customers—because of the strong economic growth experienced in the United States during the post-WWII (World War II) era.

Notably, trained firms were able to sustain their increased productivity in the long run even in the face of high turnover of top managers after WWII. This result indicates that the TWI program had a strong firm-specific component that stayed within the firm even after many trained managers left. Finally, we find that other war-related factors, such as war contracts awarded by the government, exposure of manpower to the WWII draft, or shifts to war production, did not play a big role in determining the effects of the TWI training.

The contribution of this paper is fourfold. First, it contributes to the growing literature on management and firm performance. While recent randomized controlled trials (RCTs) have documented large and positive effects on firm performance of management consulting (e.g., Bloom et al. 2013b; Bruhn, Karlan, and Schoar 2018; Iacovone, Maloney, and McKenzie 2022) and mixed effects of management training (McKenzie and Woodruff 2014; Gosnell, List, and Metcalfe 2020), the existing evidence is mostly focused on the short term. To the best of our knowledge, only two papers have estimated the long-term impact of management interventions. Bloom et al. (2020) measured the effects of management consulting on the adoption of management practices, although not on financial performance, between 7 and 9 years after an RCT involving 17 Indian textile firms. Giorcelli (2019) estimated the effects of management training on the performance of 130 small and medium-sized Italian firms over 15 years.

While the TWI program was primarily a management training scheme, it also had a consulting component, so our results are related to both of those papers.[1] Specifically, our paper complements this prior work by (1) investigating the channels that determine the long-term dynamics of management interventions and (2) focusing on large businesses. It tracks the effects of management training on firms in the supply chain of trained companies and on other nonapplicant firms. Moreover, it explores complementarities among different areas of management training.

Second, our paper contributes to the literature on personnel and organizational economics. Previous works have shown that a key correlate of both plant and worker productivity is the adoption of human resource management practices (Ichniowski, Shaw, and Prennushi 1997; Lazear 2000; Lazear and Shaw 2007; Gosnell, List, and Metcalfe 2020), which in turn can be improved by managers' skills (Lazear, Shaw, and Stanton 2015; Hoffman and Tadelis 2021). Our paper contributes to these findings by studying the role of human resource management practices (taught via the J-R module) in a large-scale experiment on thousands of firms that operated in different

[1] Although the TWI lectures were standardized as a training program, most of the in-class time was spent on student-led discussions on how to apply the J-modules to firm-specific problems.

sectors, rather than leveraging data from a single firm or from a few firms in the same industry. Moreover, it corroborates prior suggestive evidence on complementarities between human resources practices and other areas of management (Bloom and Van Reenen 2011) by exploiting as-good-as-random variation in the type of training received by applicant firms.

Third, this paper contributes to the large literature on spillover effects across firms. Previous works have documented sizable spillover effects determined by the opening of large plants (Greenstone, Hornbeck, and Moretti 2010; Alfaro-Ureña, Manelici, and Vasquez 2019), technological externalities (Javorcik, Keller, and Tybout 2008), an increase in trade (Pavcnik 2002), and worker mobility (Stoyanov and Zubanov 2012). In relation to management interventions, Bloom et al. (2020) documented the spillover of some positive managerial practices across plants within the same firm. Our paper complements their findings by tracking the flow of managerial knowledge along the supply chain.

Finally, our paper contributes to the literature on the relationship between the US government's wartime economic policies and the postwar economic boom. Existing works have documented that large public investments in manufacturing during WWII did not substantially increase industrialization in the long term (Jaworski 2017) but had more persistent positive effects on population growth (Fishback and Cullen 2013; Koustas and Li 2019), employment, and wages (Garin 2019). Moreover, Gross and Sampat (2020) shows that large government-sponsored R&D programs during WWII affected both the direction and the location of US inventions after the war. We argue that the publicly funded wartime diffusion of "soft" management technologies, which had a long-lasting effect on firm performance, represented a previously unexplored channel through which government interventions affected the postwar boom.

The rest of the paper is structured as follows. Section II describes the origin and development of the TWI program. Section III describes the data. Section IV presents the empirical framework and discusses the identification strategy. Section V examines the long-run effects of the TWI program on firm performance and the complementarities among different types of training. Section VI analyzes the effects of the TWI program on nontrained firms in the economy. Section VII discusses war-related events and heterogeneous effects. Section VIII concludes.

II. Historical Background

A. Setup of the TWI Program

From the onset of WWII in September 1939, the Allied forces needed a large amount of war supplies. Many US companies started receiving an increasing number of war-related orders, especially from France and Britain, that

were well in excess of their productive capacity (TWI Administration 1940). As the war escalated, it became apparent that if and when the United States would join the Allies by declaring war, that event would make the situation even more critical. A great fraction of the men of working age would then be called up to serve, depriving the workforce of many productive employees.

The US government responded to these concerns by launching the TWI program. The TWI program was aimed at providing in-plant management training to US war contractors to increase their production and productivity and to teach them how to make new workers productive in the shortest possible amount of time.

The TWI administration was established in August 1940 by the National Defense Advisory Commission (after the fall of France on June 22, 1940) and was moved to be under the jurisdiction of the newly established War Manpower Commission (WMC) on April 18, 1942. It remained under the supervision of the WMC until it ceased operations in September 1945, after Japan's surrender. Overall, the TWI maintained the same organization and functioned under the same leadership throughout its existence, in spite of the shift in jurisdiction in 1942 (Dooley 1945, 106).

The TWI program was set up to operate as a decentralized service. In September 1940, the TWI administration divided the United States into 22 geographical districts (fig. 1; table A1; tables A1–A18, B1–B3, and C1–C4 are available online). These districts were centered around established industrial areas, which often crossed state boundaries. Each of them had its own headquarters and was headed by a district director.[2] To better reach peripheral areas, the TWI administrators decided to decentralize the program even further and divided each district into smaller geographical units, which we call subdistricts, headed by resident representatives. In total, they created 364 subdistricts (Dooley 1945, 7).

While the TWI program had the ambitious goal of offering management training to all US war contractors, a limited budget and a lack of manpower made this initial plan not viable. More importantly, the TWI administration soon realized that the success of the program hinged on the full support of trained firms' top management. As a result, the policy of the program became to train only firms that wanted to be part of it (TWI Administration 1944). Accordingly, the TWI program established different application windows.[3] The only condition for applying was that firms had to have a war contract with the US government. Moreover, firms could apply only once. In total,

[2] Most district directors were business executives who volunteered their expertise to the program. They were called "dollar-a-year" men, since they worked for free for the TWI. In addition to the directors, the TWI program was run by men and women with extensive business experience who temporarily left the private sector, hence the title of training "within industry."

[3] Each window was closed when a target number of firms to be trained in each district was reached. However, as outlined in sec. III, even these limited targets were often overly optimistic, and many applicant firms ended up without training because of a lack of resources.

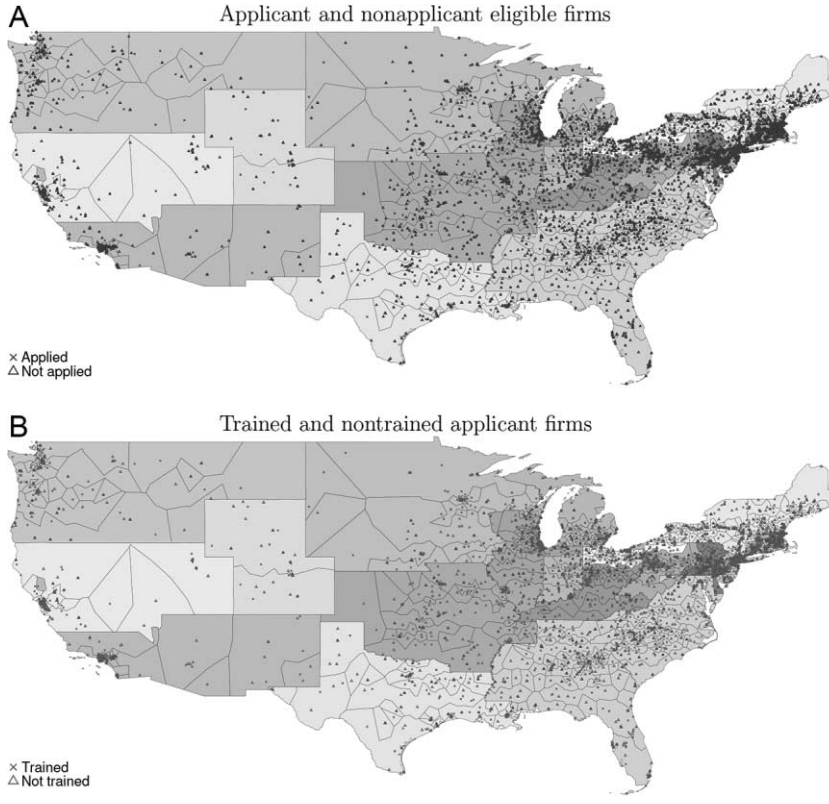

FIG. 1.—Map of the 22 TWI districts. The borders within the 22 districts identify the 364 subdistricts, the level of aggregation at which the program was delivered. *A* divides 25,393 war contractors between 11,575 firms that applied to the TWI program (crosses) and 13,818 firms that did not apply to the TWI program (triangles). *B* divides applicant firms between 6,056 firms that received the TWI training (crosses) and 5,519 firms that did not receive the TWI training (triangles). A color version of this figure is available online.

there were 10 application windows: one each in the years 1940, 1941, and 1945, two each in 1943 and 1944, and three in 1942. Within each subdistrict and application window, eligible firms that applied received the TWI training in the order in which they had applied.

B. Content of the TWI Management Training

The TWI training was divided into three so-called J-modules, as follows (TWI Administration 1944).[4]

[4] In designing their intervention, the leaders of the TWI service adapted to the 1940s context a popular training program used during WWI. In 1917, the Emergency Fleet Corporation of the United States Shipping Board initiated a training program to increase the number of

- Job-Instructions (J-I). This module gave supervisors "practice in how to break in men on new jobs." As a result, trained firms started establishing standard procedures for operations, improving lighting, enhancing job safety measures, keeping the factory floor tidy to reduce accidents and facilitate the movement of materials, performing regular maintenance of machines, and recording the reasons for breakdowns. Overall, this module improved the factory operation practices described in Bloom et al. (2013b).[5]
- Job-Relations (J-R). This module gave supervisors "practice in how to promote teamwork." Firms trained in J-R started relying more heavily on performance-based incentive systems for workers and managers, investing more in on-the-job training, and defining more precisely job descriptions and responsibilities; one major result was a decrease in worker complaints and strikes at these firms. Overall, this module acted upon the practices related to human resources described in Bloom et al. (2013b).
- Job-Methods (J-M). This module helped supervisors "simplify and improve methods of doing a job." Firms trained in J-M learned to constantly innovate and improve their business processes. For example, they started managing their inventory more efficiently, improving production planning, and tracking production to prioritize customer orders by delivery deadline. After the end of WWII, they became more likely to develop a marketing research unit and to introduce new product lines. This module mainly operated on the inventory control and sales and order practices described in Bloom et al. (2013b).

The TWI program was initially thought of as a combination of management consulting and training. However, almost immediately after its implementation in 1940, the TWI administration realized that it lacked the resources to provide effective consulting tailored to the individual needs of each war contractor. As a result, for the duration of the program, the TWI administration focused primarily on preparing the instructors for in-plant training (Dooley 1945, 16).

The content of the J-modules was constant across all trained firms and formalized in training manuals that the instructors had to follow closely.

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shipyard workers tenfold. To do so, they hired Charles R. Allen, a vocational instructor from Massachusetts. Allen developed a four-step system for training new workers—Show, Tell, Do, Check—as documented in his 1919 book *The Instructor, the Man and the Job.* This four-step methodology formed the basis for the TWI program developed over 20 years later (Huntzinger 2005).

[5] When this program was exported to Japan after the end of WWII, this module was split into two components: one was related to standard procedures for operations and maintenance of machines; the other one, called Job-Safety (J-S), focused on workers' safety.

This standardization was considered a necessary step to ensure the quality of the TWI training and to allow an understaffed organization to serve a vast group of war contractors. In spite of their rigid format, the J-modules were designed to incorporate the specific challenges faced by each trained firm. The first lecture of each J-module was a supervisor-led demonstration that had the goal of sharing how bad habits could improve by following the core concepts of TWI training. All the following meetings were a combination of formal lectures and "student presentations," in which the workers under training were asked to show how they could apply the TWI teachings to their job (Dooley 1945, 32).

In short, each J-module had been designed to share at least three key characteristics. First, the content was basic and easily learned. Instead of introducing novel concepts, the J-modules were based on accepted principles taught in an effective way.[6] Second, the program limited the time dedicated to instructors' lectures in favor of practical demonstrations in which the workers could learn by doing. Third, the J-modules intended to ignite a virtuous cycle of improvements within trained firms by stressing the importance of disseminating the TWI training to all workers of the firm and by teaching how to apply the scientific method in approaching current and future challenges (Dooley 1945, 41).

C. Implementation of the Training

In addition to designing the content of the J-modules, the main responsibility of the TWI administration was the training of the instructors who delivered the TWI program to the plants of applicant firms.

Most instructors were men and women with extensive business experience who were sent by their employers to volunteer for the TWI program either part-time or full-time (Dooley 1945, 4). Others were paid staff already working for a government agency. In spite of their different backgrounds, prospective instructors were selected on the basis of their prior expertise in business and teaching.

Upon recruitment, candidates had to attend a "TWI institute," a 50-hour course, to become an instructor; they were taught by a TWI staff member either in their district of residence or in Washington, DC. During the first part, candidates had to attend a full J-module. The second part was divided between lectures on the fundamental concepts of a J-module and practice in teaching the course (Dooley 1945, 202).

[6] As stated by the director of the TWI program, "There is nothing new about TWI programs—they are built on accepted principles. The only new thing is that something was done about getting them used" (Dooley 1945, ix). As an example, upon completion of the program, trained workers received an instruction card to keep in their pockets with the main takeaways of the modules they had attended (fig. A1; figs. A1–A12 and B1 are available online).

Although the original plan was to prepare well-rounded instructors able to teach all three J-modules, the urgency needed to reach war contractors quickly induced the TWI administration to form training specialists. As a result, each instructor was trained to teach only one J-module (Dooley 1945, 58). After being certified, TWI instructors usually returned to their subdistricts of residence, where they visited participating firms (often including their employers)—in the order of those firms' applications— to teach the J-module in which they had been trained. After volunteering in a single subdistrict and application window, they returned to their previous employers to resume their regular jobs.

In each firm, the TWI training targeted managers, line executives, supervisors, and other employees with "functional responsibility for planning of training" (Dooley 1945, 17). In each plant of the participating firms, the instructors delivered their J-modules to groups of at most 10 workers each. Training one group in one module required five meetings of 2 hours. Most applicant firms had hundreds of managers and supervisors who were slated to received the training. Therefore, the need to create small groups of at most 10 workers implied that the delivery of a J-module could take weeks or even months within each firm. In total, 1,750,650 workers were trained in at least one J-module between 1940 and 1945 (Dooley 1945, 126).

Once the last group of targeted employees had attended the training, firms had to pick at least one representative who acted as a point of contact between the firm's top management and the TWI program. The TWI administration used firms' representatives to check on the continuing adoption of TWI criteria and to collect posttraining data on firm performance (Dooley 1945, 166).

The historical accounts indicate that all J-modules were a resounding success. For example, an electric manufacturing company recorded a 50% decrease in defective products within 1 month of the delivery of the J-I module. A steel company that received the J-R training reported a 54% decrease in complaint cases, which induced its grievance committee to change the meeting schedule from three times a week to three times a month. A warehouse that received the J-M module documented the introduction of an improvement in the operation of wrapping large rolls of cloth that resulted in a 48% decrease in man-hours (TWI Administration 1944). Our analysis investigates the effects of the program using a more systematic approach, as outlined in section IV.

III. Data

We collected and digitized several types of data on the firms that applied to the TWI training. We matched separate data sets using firm name, municipality, and state. What follows is a description of these data sources and key summary statistics. Additional details on the data collection process

and the definitions of the variables can be found in appendix B (apps. A–C are available online).

A. *Firm-Level Government Records during WWII*

We started our data collection by identifying all firms that were eligible to participate in the TWI program. Because the only application requirement was that firms had to be war contractors located in the United States, we retrieved the list of eligible companies from the tabulation of war supply contracts published by the Civilian Production Administration in 1946.[7] This data set includes information on all contracts for war supplies worth at least $50,000 and awarded between June 1940 and September 1945. By restricting the sample to war contractors based in the United States, we obtained a list of 25,393 companies eligible to participate in the TWI program.

We then used the monthly records of the TWI Service—compiled between August 22, 1940, and September 19, 1945, and stored at the NARA (National Archives and Records Administration) archives—to identify the firms that applied to the TWI program. Out of 25,393 eligible firms, we found applications from 11,575 companies. For each application, the monthly records indicate the application date, the district and subdistrict in which the applicant firm was located, whether it eventually received the TWI training, in which of the J-modules it was trained, and the year in which each module was delivered.

Out of 11,575 applicants, 6,056 were eventually trained in at least one J-module. Among them, 62% got two J-module trainings and 24% got one J-module training, while the remaining firms received all three J-module interventions (fig. 2*A*). The bulk of the TWI training was carried out between 1943 and 1945, when the US involvement in the war was most intense. Only 8% of trained firms received a J-module intervention between 1940 and 1942, while the other firms were trained starting in 1943 (fig. 2*B*).

From the NARA archives, we also collected data from the plant-level surveys that the TWI administration conducted in treated firms before and after the training. Specifically, the surveys indicate whether a plant was performing each of 11 managerial practices linked to the teachings of the TWI program before the start of each J-module training, 3 months after the TWI training, and then each year thereafter until 1945.

Finally, we collected information on the workforce composition of applicant firms by digitizing the Selective Service's so-called replacement schedules, accessible at the NARA archives. After Executive Order 9279 of December 5, 1942, firms in which at least one worker had been drafted

[7] Dmitri Koustas kindly shared the digitized version of this data set with us (Koustas and Li 2019).

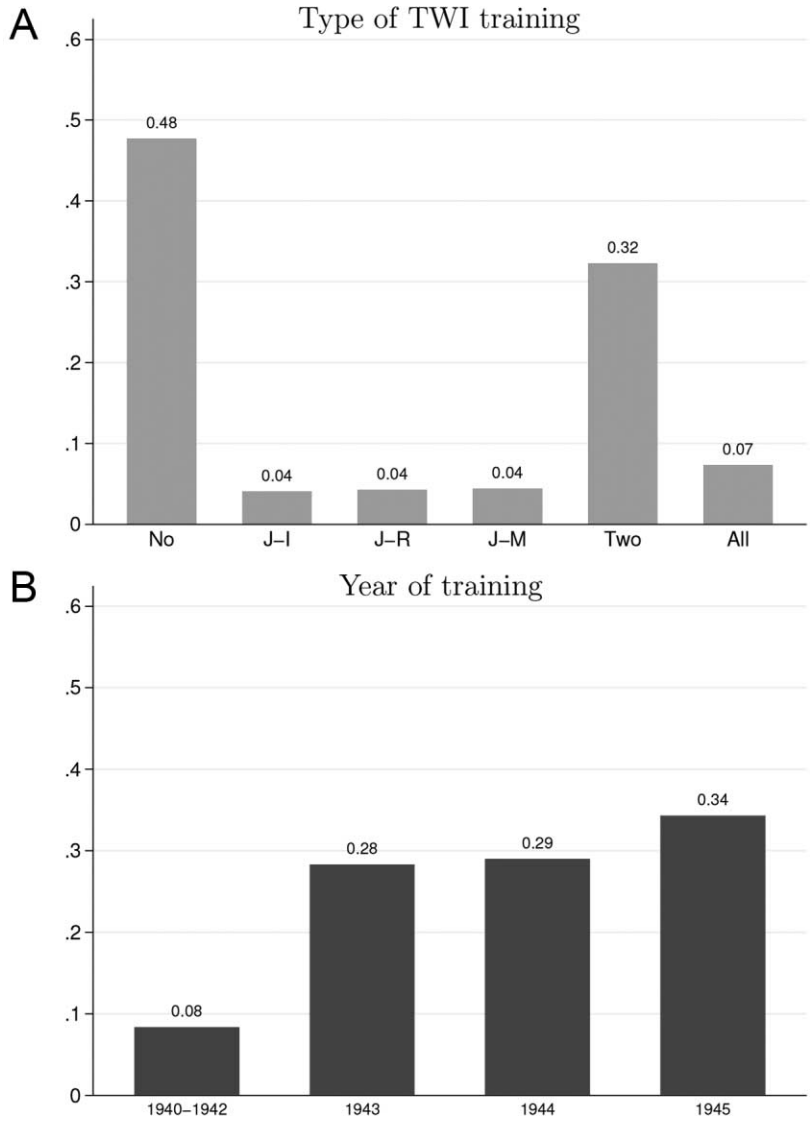

FIG. 2.—Distribution of TWI training among applicant firms. This figure shows the distribution of the type of training received (*A*) and year of training (*B*) for the 11,575 firms that applied to the TWI program. In *A*, "No" is 1 for firms that did not get any TWI intervention; J-I is 1 for firms that received the J-I training; J-R is 1 for firms that received the J-R training; J-M is 1 for firms that received the J-M training; "Two" is 1 for firms that received two trainings; "All" is 1 for firms that received all three trainings. A color version of this figure is available online.

had to submit a replacement schedule to their regional Bureau of Manpower Utilization. In these documents, firms described the composition of their labor force, specifically indicating the shares of African American workers and of women, as well as the average years of education and age of all their employees. Moreover, they had to propose a replacement for each drafted worker and indicate how long it would take for the new workers to become fully productive.[8] We used this information to determine the labor force composition, as well as the share of drafted employees, of each firm between 1941 and 1945.[9] Finally, firms had to indicate the name of the companies with which they had an existing contract, as well as the list of products bought from or sold to them. We used this information to identify the TWI applicants' upstream and downstream firms, as described in greater detail in section VI.A and appendix B.

B. Data on Firm Performance

We constructed a panel data set of firm outcomes between 1935 and 1955, using information from the annual reports collected by the Mergent Archives. Specifically, we relied on the Historical Annual Reports, a collection of over one million corporate documents covering more than 100 years.[10] For each firm in our sample, we searched the database of Mergent's historical annual reports available at the University of California, Irvine, library, using firm name, municipality, and state. We then digitized the information contained in the documents in order to link data on firm performance to the other data sources.

We were able to find a match for all 11,575 applicant firms. Moreover, we retrieved information on 11,536 of the 13,857 nonapplicants in order to investigate the spillover effects of the program on nonparticipating firms (sec. VI.B).[11]

The annual reports are a very rich source of information. The balance sheets report, among other variables, the value of inventory, current assets, investments, and capital. The income statements often include information on spending in several areas, such as maintenance and repair of machinery, worker injuries, and on-the-job training. We used these variables

[8] Through the replacement schedules, they could also ask for draft exemptions for some categories of their workers. Managers were usually deferred "in support of national health, safety, or interest" (category II-A).

[9] While the replacement schedules started being submitted in 1942, the first schedule contained data on both 1941 and 1942.

[10] https://www.ftserussell.com/data/mergent-archives.

[11] We believe that the lower matching rate among nonapplicants is due to their smaller size. Even though there is not a formal threshold on firm size in order to be included in the Mergent's Historical Annual Reports Collection, in practice publicly traded firms, firms issuing bonds, and larger firms are more likely to be included because it is easier to retrieve their financial information.

to create measures of firm performance, such as sales revenues, productivity, and profitability, and to estimate the adoption of various managerial practices (for more details, see app. B).

C. *Characteristics of Applicant Firms*

In 1939, the year before the TWI program started, applicant firms had, on average, six plants and $191.78 million in sales (in 2020 USD) and had been in operation for 8 years (table 1, col. 1). They were fairly heterogeneous in terms of employment: while the average number of employees per firm was 1,038, it ranged from a low of 543 to a high of 11,283 workers. Out of all applicant firms, 86% were operating in the manufacturing sector, 9% in transportation, 3% in agriculture, and 2% in services.[12] Between 1940 and 1945, they were awarded 0.68 war contracts per year, with an average value of $25 million. Moreover, all characteristics were perfectly balanced between trained and nontrained applicants at baseline, a fact that we explore more in section IV (table 1, col. 7).

At least for the manufacturing sector, it is possible to compare the applicant firms to the average US firm with data from the 1939 Manufacturing Census.[13] The applicant firms included 60,521 manufacturing establishments, 9.8% of all US manufacturing establishments reported in the 1939 Manufacturing Census. Moreover, they employed 12,018,503 workers, 40% of the total US manufacturing labor force in 1939. In short, the average number of employees per establishment was 49 in the 1939 Manufacturing Census and 199 in our sample.

In spite of their large size, applicant firms did not appear to be well managed. For example, inventory accounted for more than 80% of current assets, indicating that these firms were not proficient in production planning. Interestingly, the poor management of inventory was one of the main bad practices highlighted by Bloom et al. (2013b). Moreover, expenses for workers' injuries were higher than spending for performance-based bonuses, suggesting that these firms were more likely to react to problems instead of setting up systems to reward positive behavior. Finally, it should be noted that all these firms suffered major disruptions from WWII: 57% of them had to start producing products in a different 2-digit SIC code, and, on average, 23% of their workers were drafted and ended up leaving their jobs. To summarize, in spite of their large size and high

[12] The information on the firm's sector is not included in the annual financial reports. To retrieve this piece of information, we imputed to each firm the 3-digit SIC (Standard Industrial Classification) codes—specifically, the classification published in 1939—associated with the firm's products listed in their replacement schedule in 1941 (see app. B).

[13] We used data from the 1939 Manufacturing Census that James Lee digitized and kindly shared with us (Lee 2015).

sales, several pieces of evidence indicate that the TWI applicants could have greatly benefited from management training.

IV. Identification Strategy

A. *Baseline Specification*

We estimate the effect of receiving TWI training on firm performance with the following difference-in-differences event-study equation:

$$y_{i\tau} = \sum_{\tau=-5}^{10} \beta_\tau(\text{TWI}_i \cdot \text{Years after TWI} = \tau_{i\tau}) + \gamma \cdot \text{TWI}_i + \eta \cdot \text{App}_i + \delta_{cs\tau} + \epsilon_{i\tau}, \quad (1)$$

where the dependent variable, $y_{i\tau}$, is one of several key performance metrics, such as logged sales, total factor productivity (TFP), and return on assets (ROA) of firm i in period τ;[14] TWI_i is an indicator that equals 1 if firm i received the TWI training; Year after TWI $= \tau_{i\tau}$ is a dummy equal to 1 when a calendar year is τ years before or after the year in which firm i received its first TWI training. The excluded year is $\tau = -1$. The regression controls for the date of application to the program (App_i) because it might be correlated with unobservable characteristics affecting firm performance.[15] Specifically, we include fixed effects for the application window in which firm i submitted its application and for the number of days between the opening of the application window and the application date. County c, sector s, and period τ fixed effects $\delta_{cs\tau}$ control for nonlinear variation in outcomes over time and within sectors and counties. Standard errors are clustered at the subdistrict and application-window level.

Unless otherwise specified, the sample contains a balanced group of firms that were always active between period -5 and period 10.[16] Finally, because equation (1) is an event study, we need to impute values of Years after TWI $= \tau_{i\tau}$ to applicant firms that never received any training. To this end, we assume that they would have been treated contemporaneously with the first trained firm in their subdistrict and application window. However, our results do not crucially depend on this imputation.

[14] TFP is calculated using the methodology proposed by Gandhi, Navarro, and Rivers (2020), and the estimated factor weights are reported in table B2. The results are robust to alternative TFP calculations (fig. A5). ROA is computed as the ratio between profits and fixed gross assets. Appendix B includes a longer discussion of the construction of all variables and more details on the calculation of TFP.

[15] For example, early applicants might have been quicker in recognizing the value of the TWI program and therefore might have been better managed even before the intervention.

[16] In sec. V.A, we show that estimating eq. (1) on all available firms, and therefore including those that entered the sample after the first period or exited before the last, leads to qualitatively similar findings.

TABLE 1
Summary Statistics for 11,575 Applicants to the TWI Program

	All Applicant Firms				Trained Firms	Nontrained Firms	Difference
	Mean (1)	Standard Deviation (2)	Minimum (3)	Maximum (4)	Mean (5)	Mean (6)	*p*-Value (7)
	A. Data from Annual Financial Statements in 1939						
Plants	6.08	1.90	3	14	6.09	6.07	.588
Employees	1,038.32	378.53	543	11,283	1,036.99	1,039.77	.686
Foundation year	1931	3.73	1912	1936	1930.96	1931.05	.229
Agriculture	.03	.16	0	1	.03	.03	.678
Manufacturing	.86	.34	0	1	.86	.86	.746
Transportation	.09	.29	0	1	.09	.09	.400
Services	.02	.14	0	1	.02	.02	.624
Sales	191.78	77.12	75.74	2,506.72	191.27	192.34	.444
Current assets	18.40	8.02	5.31	170.72	18.47	18.33	.341
Total assets	64.45	25.79	23.03	900.89	64.40	64.51	.808
TFP	3.87	.49	2.68	5.02	3.87	3.86	.316
ROA	.03	.01	.01	.09	.03	.03	.010
Inventory	15.37	6.24	5.21	181.02	15.36	15.38	.854
Injuries	10.40	5.09	2.40	139.78	10.33	10.47	.141
Repairs	15.37	7.26	4.04	226.42	15.28	15.48	.134
Bonus payments	8.27	3.97	1.97	118.42	8.22	8.32	.176

	B. Workforce Data from Replacement Lists in 1941						
Share African Americans	.06	.01	.01	.12	.06	.06	.180
Share women	.05	.01	.01	.09	.05	.05	.703
Years of education	8.51	1.36	5	12	8.50	8.52	.457
Age of workforce	28.98	3.53	23	40	28.96	29.00	.611
	C. WWII-Related Data from Replacement Lists and War Contracts						
Share drafted employees (1942–45)	.23	.03	.13	.33	.23	.23	.180
Switched 3-digit SIC (1940–45)	1	0	1	1	1	1	. . .
Switched 2-digit SIC (1940–45)	.57	.50	0	1	.57	.57	.556
Switched 1-digit SIC (1940–45)	.37	.48	0	1	.37	.38	.257
No. of contracts (1940–45)	.68	2.61	0	152	.68	.68	.719
Value of contracts (1940–45)	25.11	293.01	0	27,145.94	23.87	26.48	.507

NOTE.—Summary statistics for 11,575 firms that applied to the TWI program. Column 7 shows the *p*-value of the difference between cols. 5 and 6. Panel A includes variables from the firm's financial statements in 1939. Plants is the total number of plants per firm; Employees is the number of employees per firm; Agriculture, Manufacturing, Transportation, and Services are indicators that equal 1 if a firm operates in the respective sector; Sales, Current assets, Total assets, Inventory, Injuries, Repairs, Bonus payments are expressed in millions of 2020 USD; TFP is the log of total factor productivity revenue, estimated with the method proposed by Gandhi, Navarro, and Rivers (2020); ROA is returns on assets, measured as profits over total assets. Panel B includes variables from the wartime replacement schedules in 1941. Share African Americans is the share of African American workers; Share women is the share of female workers; Year of education is the average years of formal education of the workforce; and Age of workforce is the average age of the workers. Panel C shows data on the firm exposure to WWII from either replacement schedules or war contracts. Share drafted employees is the share of employees drafted between 1942 and 1945; "Switched *x*-digit SIC" is 1 if a firm's war products were in different *x*-digit SIC codes from its 1939 products; No. of contracts is the yearly number of war contracts between 1940 and 1945; and Value of contracts is the yearly value of war contracts (in millions of 2020 USD).

In section V.A, we show that alternative choices for the timing assigned to nontrained applicants generate similar findings.

B. *Tests of the Identification Strategy*

In our main specification, each coefficient β_τ captures the effect of the TWI program between periods τ and -1, compared to firms operating in the same sector that applied to the program on the same date and from the same county but did not get any training. The identifying assumption is that, conditional on nonlinear trends correlated with county-sector pairs and the application date, the performance of firms with and without TWI training would have been on parallel trends in the absence of the TWI program. While the identification assumption cannot be tested directly, here we discuss four pieces of evidence that corroborate our identification strategy.

As it is standard for difference-in-differences regressions, we start by testing whether firms with and without TWI training were on parallel trends before the beginning of the intervention. We estimate equation (1) using only data from the five periods before the start of the TWI training. The estimated coefficients are all precisely estimated zeros. Therefore, this finding clearly rejects the hypothesis that firms with and without TWI training experienced different pre-TWI trends in their sales, TFP, and ROA (fig. A2*A*–A2*C*). The results remain unchanged if we compute the pre-TWI trends separately for any combination of J-modules, instead of pooling all trained firms in one group (fig. A2*D*–A2*F*).

Even if trained and nontrained firms followed parallel pre-TWI trends, the TWI administration might still have chosen to offer their free training to the contractors that were more important for war production: for instance, on the basis of their large size or the value of war contracts they received. Therefore, as a second piece of evidence, we show that firm characteristics in period -1, the year before the start of the program, do not predict the probability of receiving the training. Specifically, we regress the dummy variable TWI_i on 15 different variables, as well as fixed effects for application date and county-sector pairs.[17] We then test the joint significance of these firm variables. The *p*-value associated with this test is 0.32 and therefore fails to reject the hypothesis of no correlation between the

[17] The regressors, all measured in period -1, are the logs of sales, value added, number of employees, number of plants, foundation year, the value of inventory, capital, current assets, investments, number of workers' strikes, monetary compensation for workers' injuries, performance-based bonus payments, and number of subsidiaries as well as distance to the nearest railroad station and distance to the nearest port. Adding the inverse hyperbolic sine function of the number and value of government contracts makes some observations drop as a result of collinearity but leads to the same finding of zero correlation between firm characteristics and training (table 2, panel B).

training and firm characteristics (table 2, panel A, col. 1). Similarly, we can replace the dependent variable with several indicators for the different combinations of J-modules received by trained firms (e.g., only J-R vs. J-R and J-M). The test of joint significance fails to find any correlation between different types of training and baseline firm characteristics (table 2, panel A, cols. 2–8). Finally, we show the same lack of correlation between the TWI training and firm-level variables even when we split the sample by year of training (table A2, panel A). Overall, these findings indicate that the TWI administration did not favor applicant firms with better preexisting characteristics, not even in the last stages of WWII, when the need to increase production became more pressing.

Next, we show that the TWI administration did not choose to favor firms that were located in the most industrialized or economically developed areas of the United States before the start of the program. In fact, the baseline characteristics of the counties in which applicant firms were located do not predict the probability of receiving the training. We regress the variable TWI_i on 14 county-level variables from the 1940 census, imputed to each applicant firm on the basis of its location, as well as fixed effects for application date and subdistrict-sector pairs.[18] A p-value of 0.48 indicates that the null hypothesis of zero correlation cannot be rejected (table 2, panel C, col. 1). Moreover, a similar exercise using county characteristics from either the 1920 census or the 1930 census confirms this finding, which rules out the hypothesis that the previous result depended on the fact that the Great Depression had eroded much of the cross-county variation in economic outcomes (table 2, panels D and E, col. 1). We obtain the same findings if we replace TWI_i with indicators for different combinations of J-modules (table 2, panels C–E, cols. 2–8). Finally, as shown for firm-level characteristics, we do not find any correlation between county variables and training even when we break down applicant firms by training year (table A2, panels C–E). These results show that the coefficients of the TWI training did not conflate differential post-WWII economic trends between richer and poorer US counties.

As a last piece of evidence, we show that there is no autocorrelation within subdistricts in the share of trained firms (table A3). This finding rules out the possibility that the TWI administration favored, over time, applicant firms located in certain subdistricts (even though these areas were not necessarily more developed at baseline, as shown in the previous paragraph).

[18] The regressors are log population, log number of manufacturing establishments, log number of manufacturing employees, log average manufacturing wage, log total expenses in manufacturing, log of the manufacturing value added, log value of manufacturing production, farms per capita, unemployment share (available only in 1930 and 1940), population per square mile, share of male residents, share of African American population, share of urban population, and share of illiterate population (available only in 1920 and 1930).

TABLE 2
CORRELATION BETWEEN FIRM AND COUNTY CHARACTERISTICS AND TRAINING RECEIVED

	TWI (1)	J-I (2)	J-R (3)	J-M (4)	J-I and J-R (5)	J-R and J-M (6)	J-I and J-M (7)	All (8)
	A. Regressions of Training Variables on Firm Characteristics in Period −1							
p-Value of joint significance	.32	.76	.69	.55	.92	.14	.76	.65
Observations	10,735	10,735	10,735	10,735	10,735	10,735	10,735	10,735
	B. Regressions of Training Variables on Firm Characteristics, Including Number and Value of Government Contracts, in Period −1							
p-Value of joint significance	.35	.60	.77	.40	.94	.14	.86	.55
Observations	10,727	10,727	10,727	10,727	10,727	10,727	10,727	10,727
	C. Regressions of Training Variables on County Characteristics in 1940							
p-Value of joint significance	.48	.25	.36	.21	.45	.47	.86	.51
Observations	10,745	10,745	10,745	10,745	10,745	10,745	10,745	10,745
	D. Regressions of Training Variables on County Characteristics in 1930							
p-Value of joint significance	.08	.44	.26	.34	.07	.11	.69	.66
Observations	10,859	10,859	10,859	10,859	10,859	10,859	10,859	10,859
	E. Regressions of Training Variables on County Characteristics in 1920							
p-Value of joint significance	.45	.32	.32	.35	.15	.46	.68	.50
Observations	10,873	10,873	10,873	10,873	10,873	10,873	10,873	10,873

NOTE.—Panel A shows the *p*-value of the test of joint significance of the coefficients of 15 firm characteristics observed in period −1. The variables are the logs of sales, value added, number of employees, number of plants, foundation year, the value of inventory, capital, current assets, investments, number of workers' strikes, monetary compensation for workers' injuries, performance-based bonus payments, and number of subsidiaries, as well as distance to the nearest railroad station and distance to the nearest port. Panel B adds the inverse hyperbolic sine function of the number and value of government contracts. The regressions also include fixed effects for county-sector pairs, the application window, and the number of days between the opening of the window and the firm application. Panels C, D, and E show the *p*-value of the test of joint significance of the coefficients of several county characteristics measured in 1940, 1930, and 1920, respectively. The county-level variables are imputed to firms on the basis of their location. These regressions include log population, log number of manufacturing establishments, log number of manufacturing employees, log average manufacturing wage, log total expenses in manufacturing, log of the manufacturing value added, log value of manufacturing production, farms per capita, unemployment share (available only in 1930 and 1940), population per square mile, share of male residents, share of African American population, share of urban population, and share of illiterate population (available only in 1920 and 1930). County data are from the IPUMS National Historical Geographic Information System (www.nhgis.org). The regressions also include fixed effects for subdistrict-sector pairs, the application window, and the number of days between the opening of the window and the firm application. Standard errors are clustered at the level of subdistricts and application windows.

C. *Assignment of Instructors*

At this point, it would be natural to wonder why, after controlling for application date and county-sector pairs, the delivery of the training was essentially as good as random. We argue that this was due to the way in which different types of TWI instructors were assigned to subdistricts and application windows, combined with several constraints on resources and personnel that the TWI administration faced throughout its existence.

The TWI administration would have certainly preferred to send enough instructors to train all war contractors in all three J-modules, but several bottlenecks made this goal unreachable. First, the TWI staff was not large enough to prepare the needed number of TWI instructors for in-plant training. At its peak in July 1944, the TWI administration had only 415 staff members. Moreover, the size of the TWI staff was much smaller during most of WWII, and many employees were working only part-time for the program (Dooley 1945, 14). Second, the lack of manpower was compounded by the fact that both the courses to certify instructors and the TWI training itself had to be carried out in small classes of at most 10 students, severely limiting scalability. Third, as discussed in section II.C, TWI instructors were trained to be specialists who could teach only one J-module. This decision sped up the delivery of the training but meant that some applicant firms could not receive one or more J-modules because there were not enough instructors who could teach them in their subdistrict and application window. To summarize, a small staff, as well as instructors with inflexible teaching skills, created variation across subdistricts and application windows in the number of firms eventually trained and the type of training they received.

We find three results that corroborate the historical accounts. First, within a subdistrict and application window, the share of instructors who could teach a given J-module is positively and strongly correlated with the probability that firms were trained in the same J-module (table C1). For example, firms located in subdistrict and application windows in which most TWI instructors could teach the J-I module had a 21.5 percentage point higher probability of receiving the J-I module as the first TWI training, equal to a 119% increase from the mean (table C1, col. 1). This effect implies that the allocation of instructors to subdistricts and application windows drove large differences in the type of training received by firms.

Second, the share of instructors who could teach a given J-module is not correlated with the baseline characteristics of firms that applied in the same subdistrict and application window (table C2, panels A and B). Similarly, there is no correlation between the share of instructors and the characteristics of counties in 1920, 1930, and 1940 (table C2, panels C–E). These two findings indicate that the TWI administration did not take into consideration the preexisting characteristics of applicants and counties

before assigning the TWI instructors to a subdistrict and application window.

Third, within a given subdistrict, there is no autocorrelation in the share of instructors who could teach a given J-module (table C3). This result is consistent with the historical data, which indicate that the TWI instructors were assigned to only one subdistrict and application window.[19] In fact, most instructors could volunteer to the TWI program only for a short length of time before returning to their regular employers. The lack of reassignment across application windows within a subdistrict led to an as-good-as-random assignment of new instructors in every period.

To conclude, our empirical strategy is designed to compare firms that were in the same county and industry and that applied to the program on the same day but were located in different TWI subdistricts. In spite of their many similarities (as shown in sec. IV.B), these firms could have received different types of TWI training. In this section, we showed that these differences in training are driven mainly by the assignment of TWI instructors to subdistricts and application windows. Moreover, we showed that the assignment of TWI instructors did not depend on the characteristics of applicant firms, the characteristics of the counties, or prior assignments in the same subdistrict. These results are consistent with the idea that the TWI administration did not act strategically in assigning their resources to applicant firms.

On the basis of these findings, we can modify the baseline equation (1) by instrumenting the training variables with the share of instructors who could teach different J-modules assigned to the subdistrict and application window in which firm i applied to the program. As expected, the instrumental variable and OLS (ordinary least squares) estimates are close and lead to the same conclusions (table C4). Considering that all the available evidence in sections IV.B and IV.C points to the unbiasedness of the OLS estimation of equation (1), we focus on OLS regressions for the remainder of the analysis because of their higher precision and easier interpretation.

V. Dynamic Effects of the TWI Program

In this section, we estimate the dynamic effects of the TWI program up to 10 years after the training. In order to show more clearly that each J-module induced changes in different managerial practices, section V.A limits the

[19] The strong correlations between instructors and training in table C1 corroborate the precision of the data. In fact, the presence of widespread and undocumented reallocation of instructors across subdistricts and application windows would produce substantial measurement error. In this case, we should expect to find a small and possibly insignificant relationship between the original assignment of instructors and the training delivered to firms.

sample to firms that received either one J-module or no training at all. In section V.B, we expand the sample to all applicants, including firms that received two or three J-modules, in order to study complementarity effects among different types of management training.

A. *Effects on Firm Performance and Managerial Practices*

1. Firm Exit

We start our analysis by investigating whether firms that received the TWI training experienced a lower exit rate than nontrained applicants. First, we estimate the following Kaplan-Meier survival function separately for trained and nontrained applicants: $\hat{S}_t(t) = \prod_{t_\tau \leq t}[1 - (d_\tau / n_\tau)]$, where n_τ is the number of firms that survived until time τ and d_τ is the number of firms that closed down at time τ. Compared with nontrained applicants, firms that received the training experienced a significantly lower exit rate (fig. A3*A*). Out of all trained firms, 90% survived for at least 10 years after the beginning of the TWI program, compared to 64% of nontrained firms. The log-rank test rejects the null hypothesis of equality between the two survival functions at the 1% level of significance. Second, we regress an exit dummy on an indicator for participation in the TWI program, controlling for application date and county-sector fixed effects via the following OLS regression: $\text{Exit}_i = \beta \text{TWI}_i + \eta \cdot \text{App}_i + \delta_{cs} + \epsilon_i$, where the dependent variable is an indicator equal to 1 for firms that dropped from the sample by the tenth year after the start of the TWI program, δ_{cs} are county-sector fixed effects, and the other variables are defined after equation (1). These estimates indicate that trained applicants experienced a 26 percentage point lower exit rate by the end of the tenth year after the beginning of the TWI program, corroborating the results of the Kaplan-Meier functions (table A4).[20]

2. Firm Performance

The estimates of equation (1) indicate that the TWI training had a long-lasting impact on firm performance. Annual sales of trained firms increased by 5.3% within 1 year of the TWI training, compared with nontrained applicants (fig. 3*A*). This differential effect reached a peak of

[20] As explained in app. B, we consider that a firm has exited the market if we stop finding it in the Mergent data after its last US war contract. This choice is based on the assumption that large firms do not usually stop compiling a balance sheet unless they go out of business. It may be possible that some firms stopped reporting financial outcomes for other reasons, such as a dramatic reduction in size or performance. If these instances are common, we would significantly overestimate the probability of firm exit. However, the survival rate in our sample is broadly consistent with that of publicly traded North American firms (Daepp et al. 2015).

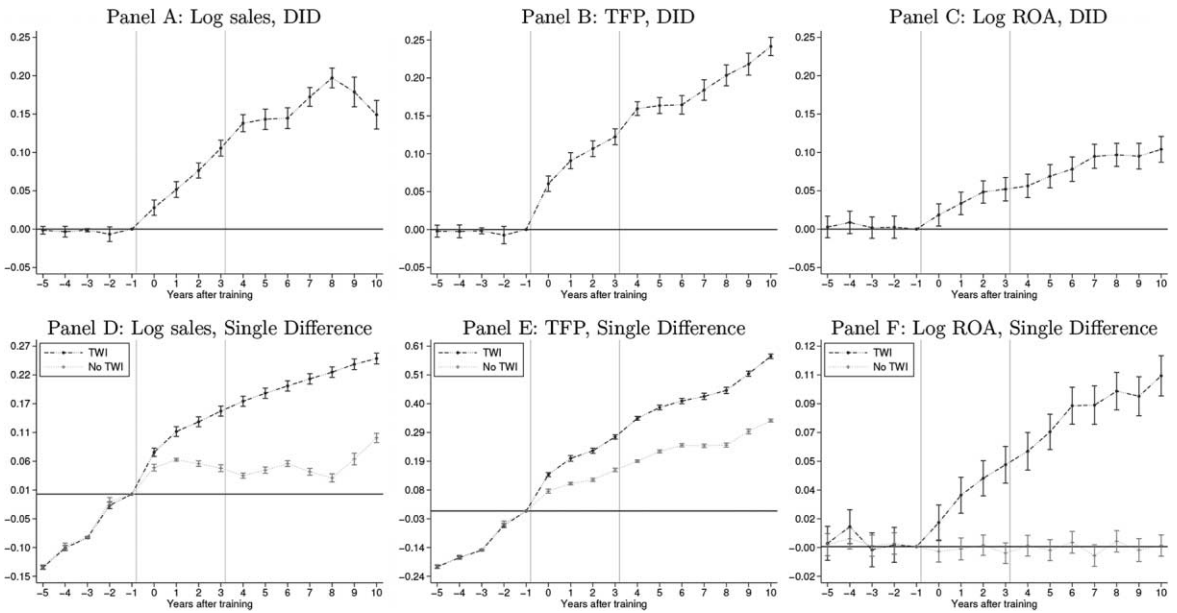

FIG. 3.—Yearly effects of TWI training. *A–C*, Difference-in-differences (DID) coefficients; *D–F*, single-difference coefficients. These regressions also include fixed effects for county-sector-period combinations, the application window, and the number of days between the opening of the window and the firm application. The distance from the TWI intervention for the nontreated firms is imputed, using the distance from the TWI intervention of the first participating firm in the same subdistrict and application window. The dependent variables are log sales (*A*, *D*), TFP computed with the Gandhi, Navarro, and Rivers (2020) method (*B*, *E*), and log of ROA (*C*, *F*). The sample includes applicant firms that received either only one TWI training or no training at all. The error bars denote 95% confidence intervals. The first vertical line identifies the beginning of the TWI program. The second vertical line identifies the end of WWII for most applicant firms. The standard errors are clustered at the level of subdistricts and application windows. A color version of this figure is available online.

21.7% in period 8 and then decreased to 16% in period 10. The treatment effects on productivity and profitability show monotonic increases in the post-TWI years. Specifically, the TFP of trained firms exceeded the TFP of nontrained firms by between 6% in period 0 and 27% in period 10 (fig. 3*B*). Similarly, their ROA increased by up to 11% by the tenth year after training (fig. 3*C*).

We can further explore the increase in productivity by focusing on the different components of the production function (table A5). In addition to the aforementioned increase in revenues from sales, we find that trained firms experienced a 1% decrease in capital and an 8% decrease in intermediate goods after the TWI program, compared with nontrained applicants.[21] These changes are associated with an increase in TFP and explain why TFP increased more than annual sales. Finally, trained firms experienced a 6% increase in the number of employees, compared with nontrained applicants. This variation contributed to a decrease in productivity, but it was not large enough to overcome the increase in sales and the decrease in intermediate goods.

At least three things are worth noting about these results. First, since most of the training was carried out between 1942 and 1945 (fig. 2*B*), for most trained firms the war ended within 3 years after the program began. However, the effects kept increasing after period 3. We further explore how war-related factors may have influenced the results in section VII. Second, the estimation of single-difference event studies indicates that firms with and without training had followed the same, and not just parallel, trends before the TWI program (fig. 3*D*–3*F*). This finding reinforces the notion that the delivery of the TWI training was not correlated with preexisting firm conditions. Finally, while the effects of the TWI program are fairly large, their magnitude is either in line with or smaller than the effect sizes found in similar studies (fig. A4). For instance, our treatment effects on sales are 4 percentage points smaller than the effects on output found by Bloom et al. (2013b) and at most 6 percentage points smaller than the effects on sales found by Giorcelli (2019). Moreover, they are consistent with the historical records that documented large effects of the program of firm productivity (sec. II.C).

The results are robust to a variety of modifications to the baseline specification and sample (fig. A5). Specifically, we replace county-sector-period

[21] A decrease in the value of intermediate goods used for production is consistent with the nature of the TWI program. One of the main goals of the TWI training was to increase production efficiency in a period in which the overall availability of inputs was scarce. Moreover, better human resource management (especially though the J-R module) decreased the cost of scaling up the workforce. Therefore, trained firms may have replaced externally sourced intermediate goods with internal labor. This hypothesis is consistent with the fact that trained firms experienced an increase in the number of employees (table A5, col. 5) and the number of subsidiaries (table A6, col. 4).

fixed effects either with firm and period or with district-sector-period fixed effects. We cluster the standard errors at different levels of aggregation. We also impute values of Years after TWI $= \tau_{it}$ to nontrained firms using the values of the last, instead of the first, trained firm in their subdistrict and application window. Moreover, we match trained and nontrained firms using different propensity score–matching algorithms (table A7).

Next, we investigate how the higher attrition of nontrained firms affected these findings. First, we reestimate equation (1) allowing for firm entry and exit instead of using a balanced sample (fig. A3*B*, A3*C*). The treatment effects in the unbalanced sample are larger than the baseline treatment effects in the balanced sample. Second, we bound the treatment effects by hypothesizing extreme cases of attrition based on pre-TWI performance. Specifically, the exit regressions indicate that attrition was 26 percentage points lower among trained applicants (table A4). Therefore, to rebalance the sample, we remove all trained applicants in either the top or the bottom quartile of the distribution of sales (fig. A3*D*) or TFP (fig. A3*E*) in period −1. The two resulting event studies are close to the baseline, indicating that attrition based on initial performance is not able to generate substantial bias in the main results. Third, we use the popular Lee bounds (Lee 2009) to bound the treatment effects by dropping treated firms on the basis of their post-TWI performance. The lower bounds, which are the more conservative margin in our context, are smaller than our baseline estimates but are always positive and significant (fig. A3*F*). This finding implies that, even if we exclude the most productive trained firms to match the exit rate of nontrained firms, the positive effects of the TWI program hold. Finally, instead of dropping high performers among the trained firms, we recalculate the treatment effects by imputing very high levels of productivity to nontrained firms with missing balance sheets. For instance, we ask how our conclusions would differ if the firms with missing financial data had a TFP level equal to the 99th percentile in every post-TWI year in which their information is missing. These results indicate that even extreme scenarios are not able to undo the positive effects of the TWI program (fig. A3*G*, A3*H*). For example, when we impute the 99th percentile of TFP to firms with missing financial data, which implies that these firms would have had a TFP increase 137% higher than that of trained firms, the treatment effects become insignificant only in period 10.

Over time, trained firms undertook a number of structural changes that transformed them into larger and more complex organizations. Compared with nontrained firms, the number of plants of trained firms increased by 6.4% by period 10, the number of their employees by 13.5%, the number of their managers by 11.4%, and the number of their controlled subsidiaries by 5% (table A6). These findings are consistent with prior work that highlights the positive relationship between productivity and firm size (Syverson 2011).

From a financial perspective, the TWI training was a success. The direct costs of the program were $155 million (in 2020 USD), which implies that the direct costs per trained supervisor were $88.5.[22] Obviously, the highest costs were indirect, namely, the opportunity cost of the time dedicated to the program by the employees of participating firms. Trained employees had to spend 10 hours to receive the certification in one of the three TWI modules and possibly many more hours to implement the TWI concepts within their firms. Although we do not have data on the time the trained supervisors took to spread the TWI training within their firms, the available evidence suggests that the program was cost-effective for most firms. Assuming an hourly wage for managers and supervisors of $45, supervisors would have needed to dedicate at least 3,400 hours, or 21 months, of their time to the TWI training in order to make the program unprofitable for their firm by the tenth year after training.[23]

3. Managerial Practices

In the last portion of this section, we estimate the heterogeneous effects of different types of managerial training and their relationship with the adoption of specific managerial practices. Specifically, we replace the indicator TWI_i in equation (1) with a dummy variable for each of the three J-modules. As a reminder, supervisors learned how to break in new employees through the J-I module, how to manage human resources through the J-R module, and how to introduce improvements to business processes through the J-M module. The results indicate that all three trainings had positive and permanent effects on sales and TFP, while only J-R and J-M increased the ROA (fig. A6). Moreover, the J-R module had the largest effects on every outcome.

In order to explain the different effects of the J-modules on firm outcomes, we investigate what changes to managerial practices they induced. We start by analyzing data from the plant-level surveys the TWI administration conducted in each trained firm before the program, 3 months after the program, and then each year after training until 1945.[24] In general, the survey data show a clear relationship between the content of the J-modules

[22] The direct costs were the sum of $92.3 million of appropriations and $62.5 million from the US Office of Education to pay the TWI instructors (Dooley 1945, 122). Moreover, 1.75 million supervisors were trained through the TWI program.

[23] The hourly wage of $45 (2020 USD) comes from an annual wage of $5,000 (1940 USD) for "personnel workers" from the 1940 *Occupational Outlook Handbook* (https://babel.hathitrust.org/cgi/pt?id=osu.32435051428019&view=image&seq=7). Moreover, compared with nonapplicants, 6,056 trained applicant firms reported higher profits of $44.2 million by the tenth year after training. Therefore, ({[($45/h) × 3,400 hours] + $88.5}/6,056 firms) × 1.75 million trained supervisors ≃ $44.2 million in higher profits.

[24] The survey data were collected only for firms that eventually got treated. As a result, this analysis cannot include nontrained firms.

and changes in managerial practices (table A8). The J-I program highlighted the importance of having the workplace properly arranged and ensuring worker safety (Dooley 1945, 33). In the TWI surveys, firms that received the J-I training reported a drop in machine repairs and an increase in the probability of keeping a reliable record of breakdowns after the training, which can explain the increase in output and TFP.

In contrast, firms that received the J-R module became more likely to offer on-the-job training, performance-based bonus schemes, and a process for workers to submit suggestions to higher management. Moreover, they were more likely to formalize the tasks and responsibilities attached to different positions. These changes should have increased labor productivity, which in turn should have increased output and TFP.

Finally, firms that were trained in the J-M module found new ways to cut inefficiencies or increase revenues. They reported a drop in unused inputs as well as an increased reliance on production planning and marketing activities. The decreased inventory, in turn, reduced capital utilization, with positive effects on TFP. Furthermore, better production planning may have reduced bottlenecks, while a higher focus on marketing may have increased the customer base, leading to higher output.

One caveat in the interpretation of these results is that the self-reported nature of the TWI surveys may have pushed firms to overstate the adoption of good managerial practices. To provide additional evidence on actual changes in spending, we can validate the survey data by using information from the firms' financial reports (table 3). Compared with nontrained firms, firms that received the J-I training started spending more for regular maintenance and less for machine repairs and worker injuries.[25] In contrast, firms trained in the J-R module became more likely to invest in performance-based bonus payments and on-the-job training programs. Moreover, they became less likely to experience worker strikes. Finally, firms that received the J-M training decreased their inventory, while they became more likely to increase the number of product lines and to invest in marketing activities. Remarkably, the only changes in the implementation of managerial practices that these firms documented in their financial statements were related to the specific training they had received, which highlights the critical role played by the TWI training.[26]

[25] The survey data indicate that firms that received the J-I module reported more injuries after the program, while the financial data show that the same firms spent less for worker injuries after the TWI. The two findings may signal that the J-I module induced trained firms to improve both their safety protocols and the reporting of injuries. As a result, trained firms may have started documenting more injury cases, including minor accidents, while experiencing a decrease in the severity of injuries. Although we cannot directly test it, this hypothesis is consistent with the historical reports on the effects of the J-I module published in the 1944 J-I manual for TWI instructors.

[26] These results, as well as the main findings in secs. V.B and VI.A, are robust to different clustering of the standard errors (table A9) and to corrections for multiple concurrent testing (table A10).

TABLE 3
ADOPTION OF MANAGERIAL PRACTICES

	Log Repairs (1)	Log Maintenance (2)	Log Injuries (3)	Log Bonus (4)	Log Strikes (5)	Prob. Training (6)	Log Inventory (7)	Log Product Lines (8)	Prob. Marketing (9)
J-I × Period 1	−.010***	.005***	−.020**	−.000	.000	−.001	−.010	.002	−.001
	(.000)	(.000)	(.010)	(.000)	(.001)	(.001)	(.011)	(.003)	(.001)
J-I × Period 5	−.033***	.014***	−.043***	−.000	.006***	−.051***	.007	−.002	−.028***
	(.001)	(.001)	(.010)	(.000)	(.002)	(.006)	(.010)	(.004)	(.005)
J-I × Period 10	−.057***	.025***	−.064***	.000	.030***	−.062***	.008	−.004	−.064***
	(.001)	(.001)	(.011)	(.000)	(.004)	(.006)	(.012)	(.005)	(.007)
J-R × Period 1	−.000	.000	.004	.414***	−.000	.043***	−.005	.002	.001*
	(.000)	(.000)	(.010)	(.000)	(.000)	(.010)	(.011)	(.002)	(.001)
J-R × Period 5	−.000	.000	.011	.431***	−.268***	.628***	.008	−.001	−.023***
	(.000)	(.000)	(.010)	(.000)	(.006)	(.025)	(.010)	(.004)	(.004)
J-R × Period 10	−.000	−.000	−.000	.459***	−.268***	.927***	.033***	−.000	−.061***
	(.000)	(.000)	(.009)	(.001)	(.006)	(.008)	(.010)	(.005)	(.006)
J-M × Period 1	.000	.000	−.001	.000	.000	.001	−.015***	.015***	.043***
	(.000)	(.000)	(.010)	(.000)	(.000)	(.001)	(.005)	(.004)	(.010)
J-M × Period 5	−.000	.000	.001	−.000	.007***	−.038***	−.071***	.538***	.661***
	(.000)	(.000)	(.009)	(.000)	(.002)	(.005)	(.006)	(.009)	(.024)
J-M × Period 10	−.000	.000	.006	−.000	.013***	−.062***	−.100***	.606***	.930***
	(.000)	(.000)	(.009)	(.000)	(.002)	(.006)	(.007)	(.009)	(.008)
Observations	67,472	67,472	67,472	67,472	67,472	67,472	67,472	67,472	67,472
R^2	.142	.131	.141	.170	.165	.559	.406	.445	.648

NOTE.—This table shows the coefficients of the interactions between the training variables and three selected period dummies (out of 15 period dummies included). The omitted period is the year before the TWI training (period −1). The distance from the TWI intervention for the nontreated firms is imputed, using the distance from the TWI intervention of the first participating firm in the same subdistrict and application window. All the dependent variables are logged, with the exception of two dummy variables that measure whether firms reported expenditures for on-the-job training (col. 6; mean = 0.06) or for marketing activities (col. 9; mean = 0.05). The regressions also include the treatment variables in isolation, as well as fixed effects for county-sector-period combinations, the application window, and the number of days between the opening of the window and the firm application. The sample includes applicant firms that received either only one TWI training or no training at all. Standard errors are clustered at the level of subdistricts and application windows.

* $p < .1$.
** $p < .05$.
*** $p < .01$.

In short, all trained firms experienced increases in productivity and profitability, but for different reasons. The fact that firms trained in the J-R module reported the largest treatment effects attests to the importance of human resource management in driving firm performance. This result is consistent with the idea that many management practices do not affect performance directly but do so only through the mediation of employees' effort (Bender et al. 2018). In this sense, it is not surprising that improving human resources generated the largest benefits of TWI training.

Finally, as pointed out by Bloom et al. (2020), one of the main reasons why management interventions do not always lead to permanent improvements is that beneficial practices are implemented in the short term but may be abandoned over time. In our case, however, the adoption of good managerial practices induced by the TWI training lasted throughout the period under consideration, which in turn sustained long-lasting effects on firm performance. In this sense, the evidence from the TWI training is consistent with the "Toyota Way" hypothesis that better management is able to start a "multiplier effect of ongoing further improvements" (Bloom et al. 2020, 217).

B. Complementarity among Managerial Practices

At the core of the "Toyota Way" hypothesis is the idea that managerial practices are complementary. According to this view, the costs of adding new managerial practices fall as others are adopted, allowing firms to continuously improve. This form of complementarity is therefore able to transform a single management intervention into a stream of improvements, the so-called *kaizen* approach.

So far, testing this hypothesis has proven to be quite challenging. In most papers that study management interventions, the firms studied received a service—either consulting or training—that improved a "bundle" of managerial practices at the same time. These settings prevent the analysis of complementarities, because all participating firms experienced contemporaneous improvements in multiple areas. However, because of the way it was implemented, the TWI program offers a unique opportunity to overcome these common challenges. As noted above, some firms received training in only one J-module, while others received training in multiple J-modules. We can therefore test whether receiving training in both areas x and y led to a higher adoption of beneficial practices associated with area x, compared with receiving training in area x exclusively.

In the empirical analysis, we replace the indicator TWI_i in equation (1) with a dummy variable for each of the three J-modules. Moreover, for each J-module, we add an indicator that equals 1 for firms that received that module along with another type of training, and we interact it with a post-TWI_{it} dummy. The coefficients of these new interactions measure the

additional effect that stems from receiving each module together with another training, compared with that of receiving each module by itself. If there are no complementarities, the coefficients of these interactions will be small and not statistically significant.

The data indicate that there were moderate complementarities for the J-R and J-M modules but none for the J-I module (table 4). Firms that received the J-M training with another module introduced 6.8% more product lines and were 2.7% more likely to report spending for marketing activities, compared with firms that received the J-M module alone. Firms that received the J-R training with another module experienced 9.6% fewer strikes and were 2.6% more likely to report spending for on-the-job training, compared with firms that received the J-R module by itself.[27]

Remarkably, after the TWI program was exported to Japan in the post-WWII period, the J-M training became the main inspiration for Toyota's *kaizen* approach (Dinero 2005, 48). It is therefore interesting to observe that the J-M module was one of the two modules that benefited from complementarities, one of the main features that characterize *kaizen*. Conversely, the lack of complementarities associated with the J-I module is most likely due to the nature of its content. Teaching how to use firm machinery safely and effectively did not seem to become easier with improvements in other areas, possibly because establishing the formal set of rules required by this module was all that was needed.

VI. Effects on Other Firms

One of the unusual features of the TWI program is the fact that it targeted many large-size firms that accounted for a substantial share of the US workforce in the 1940s. The large scale of the program offers a unique opportunity to study whether management training is able to generate spillover effects on other firms not directly targeted by the intervention. To the best of our knowledge, this is the first study that examines training spillovers across firms systematically.

A. Spillover and Selection Effects on Supply Chain

We started our analysis by examining whether the TWI training generated spillovers on firms in the supply chain of trained applicants. To do so, we first identified applicants' upstream and downstream firms by combining information on their products with information on applicants' products that are available in the replacement schedules.[28] Overall, we found data

[27] These findings are robust to two alternative specifications (tables A11, A12).
[28] More details are available in app. B.

TABLE 4
Complementarity Effects on Managerial Practices

	Log Repairs (1)	Log Maintenance (2)	Log Injuries (3)	Log Bonus (4)	Log Strikes (5)	Prob. Training (6)	Log Inventory (7)	Log Product Lines (8)	Prob. Marketing (9)
J-I × Post	−.038***	.014***	−.037***	−.002	.009***	−.035***	.009**	.001	−.026***
	(.003)	(.002)	(.005)	(.003)	(.002)	(.003)	(.004)	(.004)	(.003)
J-R × Post	−.001	−.001	−.004	.390***	−.194***	.543***	.011***	.004	−.027***
	(.003)	(.002)	(.005)	(.003)	(.005)	(.008)	(.004)	(.004)	(.003)
J-M × Post	−.004	−.002	.000	.001	.009***	−.034***	−.055***	.334***	.549***
	(.003)	(.002)	(.005)	(.003)	(.002)	(.003)	(.006)	(.006)	(.008)
J-I not alone × Post	.006*	−.013***	.007	.002	.107***	.015***	−.011**	.005	.014***
	(.003)	(.002)	(.005)	(.004)	(.003)	(.004)	(.005)	(.005)	(.004)
J-R not alone × Post	.000	−.007***	.004	−.012***	−.101***	.026***	−.006	−.006	.011***
	(.004)	(.002)	(.005)	(.004)	(.005)	(.009)	(.005)	(.005)	(.004)
J-M not alone × Post	.004	.006***	−.004	−.005*	.107***	.029***	−.007	.066***	.027***
	(.003)	(.002)	(.005)	(.003)	(.003)	(.004)	(.006)	(.006)	(.009)
Observations	134,288	134,288	134,288	134,288	134,288	134,288	134,288	134,288	134,288
R^2	.101	.098	.101	.210	.177	.615	.395	.552	.627

Note.—This table shows the coefficients of the interactions between the training variables and a post-TWI dummy (Post). All the dependent variables are logged, with the exception of two dummy variables that measure whether firms reported expenditures for on-the-job training (col. 6; mean = 0.18) or for marketing activities (col. 9; mean = 0.17). J-*x* is 1 for all firms that received the J-*x* training, while "J-*x* not alone" is 1 for firms that received the J-*x* module with another type of TWI training. The regressions also include the training variables in isolation, as well as fixed effects for county-sector-period combinations, the application window, and the number of days between the opening of the window and the firm application. The sample includes all applicant firms. Standard errors are clustered at the level of subdistricts and application windows.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

on 1,816 upstream and downstream firms linked to 1,572 firms that applied to the TWI program.

Next, we estimate equation (1), using as the dependent variable financial data from these upstream and downstream firms. Moreover, we replace the indicator TWI_i with a dummy variable for each of the three J-modules. This specification allows us to study whether the specific type of training received by an applicant had effects on the practices adopted by nontrained firms in its supply chain.

The results indicate that firms in the supply chain became more productive after trained firms received the TWI training, even though the sales of the former group did not increase (table 5, panel A). On the one hand, these results may be due to the fact that these firms were now working with companies that had themselves become more productive. On the other hand, they may indicate that upstream and downstream firms were exposed to the specific J-modules received by the applicant firm with which they had a business relationship.

To test whether there was indeed a spillover of managerial knowledge, we estimate whether firms in the supply chain started implementing the same managerial practices taught to trained companies. Remarkably, we find evidence that each J-module induced upstream and downstream firms to improve the managerial practices related to its content, following the same pattern that we described in section V.A. For example, firms in the supply chain of applicants that received the J-R training became less likely to experience worker strikes and more likely to report spending for on-the-job training. And firms in the supply chain of applicants that received the J-M training decreased the size of their inventory, increased the number of product lines, and became more likely to report spending for marketing activities.

There are four additional things to note about these findings. First, these results apply to both firms that were already in the supply chain of applicants at the time of the TWI training and firms that entered only after the TWI program (table 5, panel B). Second, with the exception of the decrease in inventory, the effect sizes tend to be smaller than the main treatment effects on applicant firms. This is not surprising, because spillovers are often smaller than direct effects. Third, the J-I module does not show any evidence of spillovers on the supply chain. This result could be due to its content—which involved basic tasks performed by lower-skilled workers and therefore less likely to be discussed by managers working for different firms—or to its smaller direct effects on applicant firms. Fourth, the spillovers associated with the J-M module tend to be larger when the trained firm was operating in the manufacturing sector (table A13, panel A).[29]

[29] The results do not depend on two other characteristics of trained firms, i.e., the size of the workforce at baseline and the location (table A13, panels B and C).

TABLE 5
Effects on Upstream and Downstream Firms

	Log Sales (1)	TFP (2)	Log Repairs (3)	Log Maintenance (4)	Log Injuries (5)	Log Bonus (6)	Log Strikes (7)	Prob. Training (8)	Log Inventory (9)	Log Product Lines (10)	Prob. Marketing (11)
	A. Baseline Results										
J-I × Post	.002	.043***	.029	−.021	.037	.032	.029	−.027	−.036**	−.004	.019
	(.006)	(.013)	(.027)	(.034)	(.028)	(.025)	(.021)	(.025)	(.014)	(.015)	(.023)
J-R × Post	−.001	.060***	.020	−.048	−.007	.015	−.113***	.426***	.007	−.002	−.027
	(.006)	(.011)	(.026)	(.038)	(.025)	(.024)	(.022)	(.037)	(.011)	(.014)	(.024)
J-M × Post	−.000	.071***	.020	.045	.009	−.007	.021	−.053**	−.269***	.020*	.321***
	(.006)	(.018)	(.022)	(.039)	(.023)	(.025)	(.018)	(.024)	(.052)	(.011)	(.042)
Observations	10,594	10,594	10,594	10,594	10,594	10,594	10,594	10,594	10,594	10,594	10,594
R^2	.855	.426	.232	.221	.221	.278	.208	.314	.301	.186	.278
	B. Differentiating between Old and New Firms										
J-I × Post	−.004	.024	−.021	.021	−.015	.060	.027	−.006	−.048***	−.005	.033
	(.005)	(.018)	(.036)	(.055)	(.039)	(.038)	(.031)	(.037)	(.010)	(.018)	(.037)
J-R × Post	.001	.057***	.018	−.078	−.012	.019	−.122***	.461***	.003	−.000	.029
	(.004)	(.017)	(.041)	(.066)	(.044)	(.036)	(.029)	(.059)	(.012)	(.020)	(.039)
J-M × Post	−.001	.083***	.016	.020	.004	−.010	.008	−.042	−.418***	.039**	.332***
	(.004)	(.029)	(.037)	(.065)	(.039)	(.032)	(.031)	(.032)	(.078)	(.018)	(.050)

J-I × Post × Pre-TWI firm	.005	.035	.083	−.079	.087	−.052	.002	−.035	.017	.001	−.032
	(.007)	(.024)	(.051)	(.073)	(.053)	(.048)	(.042)	(.046)	(.022)	(.025)	(.039)
J-R × Post × Pre-TWI firm	−.002	.006	.003	.051	.007	−.006	.016	−.056	.006	−.003	−.088
	(.007)	(.021)	(.050)	(.079)	(.050)	(.050)	(.043)	(.073)	(.017)	(.028)	(.059)
J-M × Post × Pre-TWI firm	.000	−.021	.005	.041	.007	.006	.020	−.021	.243***	−.030	−.020
	(.007)	(.034)	(.046)	(.084)	(.053)	(.044)	(.040)	(.049)	(.091)	(.023)	(.062)
Observations	10,594	10,594	10,594	10,594	10,594	10,594	10,594	10,594	10,594	10,594	10,594
R^2	.907	.433	.235	.224	.224	.280	.210	.317	.312	.187	.295

NOTE.—The sample used for this table includes 1,816 upstream and downstream firms linked to 1,572 firms that applied to the TWI program. Out of 1,816 upstream and downstream firms, 1,102 firms are in the supply chain of applicant firms that received at most one training. We use these 1,102 firms to obtain the results included in this table. The training variables are as follows: J-I is 1 for firms linked to applicants that received the J-I training; J-R is 1 for firms linked to applicants that received the J-R training; J-M is 1 for firms linked to applicants that received the J-M training. The distance from the TWI intervention is imputed, using the distance from the TWI program of the applicant firm with which the upstream/downstream firm has a contractual relationship. If an upstream/downstream firm joins the supply chain of an applicant firm after the latter received the TWI program, period 0 identifies the year of entry in the supply chain. Pre-TWI firm is 1 for firms that were in the supply chain of applicants before the start of the TWI program. In panel A, the regressions also include the training variables by themselves, the Pre-TWI firm dummy by itself, and a dummy for firms that are upstream with respect to the trained firm, as well as fixed effects for county-sector-period combinations, the application window of the applicant firm, and the number of days between the opening of the window and the firm application. Panel B shows the results of triple-difference specifications. These regressions also include the interaction between the training variable and the Pre-TWI firm dummy, the interaction between the period fixed effects and the Pre-TWI firm dummy, the training variables by themselves, the Pre-TWI firm dummy by itself, and a dummy for firms that are upstream with respect to the trained firm, as well as fixed effects for county-sector-period combinations, the application window of the applicant firm, and the number of days between the opening of the window and the firm application. Standard errors are clustered at the level of subdistricts and application windows.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

Finally, we study whether trained applicants became more likely to have better upstream and downstream firms. To do so, we focus exclusively on firms that entered the supply chain of applicants after the TWI program. Then, we regress their characteristics observed in the year before their entry into the supply chain of an applicant on the TWI_i indicator, which is 1 if the applicant received a form of TWI training.[30] The coefficients of TWI_i indicate that, after experiencing the TWI program, trained applicants were more likely than nontrained applicants to enter into a business relationship with more productive and larger upstream and downstream firms (table A14).

Overall, these findings indicate another channel through which the TWI training could have had long-lasting effects on trained firms. After fixing their own internal processes, trained applicants could experience additional improvements by transmitting the key concepts of the TWI program to firms in their supply chain. Interestingly, the TWI program itself emphasized the importance of spreading the J-modules both within and outside the firm in order to maximize the so-called multiplier principle of training (Dooley 1945, 6). Consistent with this finding, using modern data from the Census Bureau's Management and Organizational Practices Survey, Bloom et al. (2013a) find that 76% of respondents mentioned the supply chain (customers and suppliers) as a source of new management ideas.

B. Spillover Effects on Nonapplicant Firms

The TWI program was open to all US war contractors, but only 46% of them applied. Compared with applicants, nonapplicant firms, on average, were less productive, had fewer plants and employees, and reported lower sales in 1939, the year before the beginning of the TWI program (table A15). In spite of these differences, applicants and nonapplicants were operating in the same sectors, had workforces with similar gender and racial composition, and were equally affected by the war. For example, comparable shares of their employees (23% for applicants vs. 20% for nonapplicants) were drafted during WWII.

In this section, we use data on nonapplicant firms to answer two questions. First, we investigate whether the TWI training had spillover effects on the nonapplicants located near trained firms. On the one hand, nonapplicant firms could have benefited from spillovers of managerial knowledge. On the other hand, these firms could have been harmed by the improved performance of trained firms. To estimate these effects, we divided

[30] These regressions also include fixed effects for district-sector combinations, the application window, and the number of days between the opening of the window and the firm application.

the 364 subdistricts into 52 groups of adjacent subdistricts. For each nonapplicant firm, we computed the number of applicant firms located in the same cluster of subdistricts and their average distance from the nonapplicant firm. Next, we regress nonapplicants' economic outcomes on one of these two measures of indirect exposure to the TWI program interacted with period dummies, in which period 0 identifies the modal treatment year within each of the 52 groups of subdistricts.[31]

The results of these regressions indicate the lack of spillovers (fig. A7; table A16). Specifically, having a greater number of trained firms nearby had no correlation with the performance of nonapplicants or with their adoption of managerial practices. It is important to note that these findings do not necessarily rule out the possibility that trained firms drew business away from nonapplicants. Given that the US economy was growing after WWII, trained firms might have gained market share at the expense of nonapplicants even without poaching their existing customers.

Second, we investigate what the effects of the TWI program would have been had it been implemented with a group of firms with characteristics more similar to those of nonapplicants. To do so, we replicate the estimation of equation (1) on a smaller sample of applicant firms that we matched to nonapplicants on the basis of their features in 1939. Specifically, the matching process was based on propensity scores and used a nearest-neighbor algorithm without replacement. The matching variables were the number of plants and employees in 1939, TFP in 1939, distance from the nearest port and railroad station, sector, and fixed effects for the 22 TWI districts. The result is a group of 2,223 applicant firms with features that more closely mirror those of nonapplicants (table A15, col. 6). Estimating the main specification on this sample reveals similar effects on sales and TFP and smaller effects on ROA (fig. A8), which nevertheless remain significant and persistent.

In short, the baseline treatment effect that we estimated in section V.A measures the consequences of training on the average firm that was willing to participate in the TWI program. This result, which is unbiased for voluntary participants, is the one that is more common in the literature on management interventions. In fact, in most cases it is not possible to force firms to open their plants to consultants or trainers. In order to keep attrition low, especially when the sample size is small, many studies need to preselect a group of firms that have shown interest in receiving the intervention. The estimates using the smaller sample of matched applicants provide a better description of the effects of the TWI program on the average war contractor, rather than the more productive and larger average applicant firm. The two sets of estimates remain very close, suggesting

[31] The regressions also include firm and period fixed effects.

that the effect of the TWI program did not significantly depend on the level of firm performance at baseline.[32]

In addition to turning down free training during WWII, there is no evidence that the nonapplicants attempted to implement the TWI concepts during the post-WWII years, even though the program was proving effective among trained firms. This fact might be even more surprising if we consider that, after the end of the war, the TWI Foundation (now a private entity) successfully exported the J-modules to 27 countries, including Japan, where they inspired the implementation of lean production (Dinero 2005, 42). Two main reasons could explain low interest in the TWI training in the United States (Dinero 2005, 15).

First, in the post-WWII period, US firms might have perceived external trainers as potentially interfering with their processes and limiting their agency, instead of as a source of help (Breen 2002, 264). All US firms were facing a large increase in domestic demand. Moreover, they were expanding their market share in foreign countries, because many foreign factories had been damaged or destroyed during WWII. In this period of economic bonanza, low-productivity firms might have been short-sighted enough to consider training a nuisance. This possible explanation is consistent with the fact that we did not find negative horizontal spillovers and with the fact that US firms refocused on training only when their worldwide dominance was threatened by Japanese products in the late 1970s (Cusumano 1985).

Second, although the TWI printed materials were available for purchase after the war, US firms that wanted to implement the J-modules could not rely on the TWI administration. The lack of carefully vetted and highly prepared TWI instructors, as well as the absence of any follow-up, were possibly important enough reasons for making a self-taught TWI training likely to be less successful than the original program had been.

VII. War-Related Events and Other Heterogeneities

In this section, we perform several heterogeneity analyses to show how firms with different characteristics responded to the TWI program. As a general caveat, we cannot usually leverage exogenous variation along the dimensions used for these heterogeneity tests. Therefore, these results should be interpreted not as causal estimates but as correlations between firm variables and the baseline treatment effects.

A. Switching to War Production

So far, we have explored mechanisms that are consistent with the "Toyota Way" hypothesis. Complementarities in management practices, as well as

[32] We test this hypothesis directly in sec. VII.

vertical spillovers, can explain why the TWI training was able to generate long-lasting results. Here, we test whether the disruptions generated by WWII might have contributed to diminishing the efficacy of the TWI program over time.

We start this analysis by considering the fact that many US war contractors had to change their product lines to produce war items (sec. III.C). This change in production might have made the TWI training less effective. During the TWI in-plant training, workers might have applied the J-modules to solve the challenges they were facing while producing a given war item. After switching to a very different peacetime good, these workers might have faced a new set of problems. Although the J-modules were designed to be widely applicable to different situations, it might have been difficult to implement them for different production processes.

To test this hypothesis, we estimate equation (1) separately for firms that did and did not produce war items in different 2-digit SIC codes (fig. A9). As expected, firms that had to switch to different products during the war benefited less from the TWI training. However, the data also indicate that changing to wartime production was not enough to totally erase the effect of the program. Firms that produced items in different 2-digit SIC codes reported significant increases in their sales, TFP, and ROA.

B. Loss of Human Capital

The draft represented another major war-related disruption to firm processes. More than half of the male population aged 18–45 in 1940 (50 million people) served during WWII (Jaworski 2014). Data from the replacement schedules indicate that all war contractors in our sample lost workers as a result of the draft, experiencing mobilization rates of their workforce between 13% and 33%. Losing experienced workers to the war might have slowed down the application of the TWI concepts within trained firms, because of the higher influx of untrained and inexperienced new hires. We test this hypothesis by estimating equation (1) separately for firms in different tertiles of the distribution of drafted workers (table A10, panels A–C).

Firms in the highest tertile, and therefore those with the highest number of drafted employees, experienced a lower increase in sales, TFP, and ROA, but the gap between those and firms in lower tertiles is small. In short, there is no evidence that the draft substantially interfered with the efficacy of the TWI training. This result is not necessarily surprising when we recall that the TWI program was introduced to teach firms how to deal with the challenges raised by the draft.

Relatedly, we can test whether the loss of human capital after the war was responsible for smaller treatment effects. Specifically, we use the names of the top executives who are included in the firms' financial reports to

measure the share of top managers leaving the firm between the end of the training and 1955, the last year available in our sample. Between 4% and 73% of top executives left their firms in the years after the program. We then estimate equation (1) separately for firms in different tertiles of the distribution of top-management turnover (table A10, panels D–F).

The results on sales and TFP indicate that the effect sizes of the program are larger for firms in which more managers stayed within the firm over the first 10 posttraining years. However, even for firms in the top tertile of management turnover, the treatment effects are positive, large, and persistent. For ROA, there is not a clear pattern correlated with the turnover of top managers. Moreover, there is no differential implementation of managerial practices between firms with a low share and those with a high share of managers leaving (table A17).

These results are relevant because they inform the ongoing debate about whether improvements in management accrue to the firm or to individual managers. The fact that our results are only slightly lower among firms with higher turnover of managers indicates that the TWI training was able to create firm-specific "managerial capital" (Bruhn, Karlan, and Schoar 2010) that remained within the trained firms, even after trained managers left. These findings are different from the ones reported by Bloom et al. (2020), who document a drop in the implementation of good managerial practices when managers leave the firm, and by Huber, Lindenthal, and Waldinger (2021), who find that the loss of managers can harm a firm's profitability.

However, it is possible to reconcile our findings with this prior work. In the TWI context, trained firms were growing after the end of the war, significantly increasing the number of managers in their ranks (table A6). Therefore, these firms may have been able to retain the benefits of the TWI program by training the large number of newly hired managers on the importance of the J-modules, even if many top executives who were at the firm at the time of the TWI program were leaving. Consistent with this hypothesis is the fact that the TWI program promoted the diffusion of its principles to nontrained workers within the trained firms (the "multiplier effect" discussed in sec. V.A). Moreover, Friedrich (2020) shows that more productive firms are more likely to use internal promotions to hire managers. If this tendency applied to our sample, trained firms would have started relying more heavily on internal talent, already exposed to the TWI training, to replace departing managers.

C. Relations with the US Government

Here, we test whether the relationship of trained firms with the federal government strengthened after the TWI training. For example, it is plausible to assume that the Department of War might have preferred to assign

war contracts to firms that had been trained in at least one J-module. After all, one of the main goals of the program was to make these firms more productive in order to meet the Allies' military needs.

We test this hypothesis by estimating equation (1) with dependent variables that describe the relationship of trained firms with the federal government. We find that the probability of having war supply contracts and their number and value, as well as the value of subsidies given to war contractors after WWII, were not different between firms with and firms without training (table A18; fig. A11). These results show that improved outcomes are not automatically tied to trained firms having tighter economic relationships with the US government. Moreover, the TWI training does not predict higher war-related government spending in a county, reinforcing the idea that the federal government did not use the TWI program as a tool to assign more resources (table A18, panel D).

Overall, the data reject the hypothesis that the documented improvements in firm performance stemmed from closer ties with the federal government. First, in section IV.B, we established that the value and number of war supply contracts before the TWI were not correlated with the probability of receiving training (table 2, panel B). Therefore, closer government ties before the program cannot explain selection into treatment. Second, in this section, we found that the value and number of war supply contracts did not increase disproportionately among trained firms after the TWI program. Therefore, closer government ties after the program cannot explain differences in sales and productivity between trained and nontrained firms.

D. Other Heterogeneities

The TWI program is one of the few management interventions that targeted firms operating in different sectors, namely, manufacturing, transportation, services, and agriculture. Therefore, it is interesting to ask whether the benefits of the program differed across fields. The results indicate that firms operating in all sectors experienced significant increases in productivity after training, but manufacturing and services firms saw the largest increase (fig. A12*A*). This finding is consistent with the fact the J-modules were designed with the manufacturing sector in mind.

In the next set of results, we test whether firms in different US Census Bureau regions benefited differently from the TWI training (fig. A12*B*). We find that firms in every region experienced similar long-lasting increases in productivity. This finding indicates that our results do not crucially depend on the local economic conditions that firms may have faced during and after WWII.

Next, we test whether the year in which firms received the training affected the efficacy of the program. The overall pattern of treatment effects

is similar among all firms that participated in the program, but firms trained earlier experienced more benefits (fig. A12*C*). This finding can be explained by the fact that such firms received more follow-ups from the TWI service before it permanently shut down in 1945.

In addition, we estimate equation (1) separately for firms in different quartiles of the distribution of workforce size in the year before receiving the TWI training (fig. A12*D*). The results do not indicate any clear pattern that is correlated with the size of trained firms at baseline. Moreover, we estimate the treatment effects for firms in different quartiles of the distribution of TFP in the year before receiving the TWI training (fig. A12*E*). The results indicate that the program was more beneficial for firms that were less productive at baseline. However, all firms, including those in the top quartile of preexisting productivity, experienced large, significant, and long-lasting increases in TFP.

Finally, we show that the effects of the program did not significantly change among firms that received more instructors with experience in the private sector (fig. A12*F*). These findings suggest that our results are not driven by the specific instructors who provided the training to war contractors. We can conclude that, in line with the goal of the program, the TWI administration was able to standardize the content of the TWI training and to guarantee the same level of quality among all trained companies.

VIII. Conclusions

This paper studies the long-term and spillover effects of management training on firm performance and the adoption of managerial practices, using evidence from the Training Within Industry (TWI) program. To perform this analysis, we linked newly digitized information on the participation of 11,575 firms in the TWI program to data from 20 years of those firms' balance sheets and income statements. We compare applicant firms that received the training to applicant firms that did not receive any intervention, both of which groups were statistically indistinguishable before the start of the program, and control for nonlinear trends correlated with the application date, sector, and county.

We find that the TWI training had a positive and long-lasting impact on firm performance until at least 10 years after its implementation. Moreover, we establish a direct link between the content of the training and the adoption of managerial practices by trained firms. There are several channels that can explain a long-term effect of training on firm outcomes. First, we document the existence of complementarities among different types of training, which implies that receiving more training decreases the costs of improvements in new areas. Second, we find positive spillovers on firms in the supply chain of trained applicants. Third, we document the fact that trained firms were able to retain most of the benefits of the

TWI training even after a large share of their trained executives had left the company. Overall, our findings are consistent with the so-called Toyota Way hypothesis, which states that management interventions can generate a virtuous cycle of growth within firms.

We argue that these findings are relevant for both firms and policy makers. Firms routinely use internal training to improve the productivity of their workforce (Acemoglu and Pischke 1998; Konigs and Vanormelingen 2015). However, the effectiveness of these policies is usually evaluated over a limited time period and on small samples, usually without randomizing the content of the training and without evaluating spillovers outside the trained firm (McKenzie and Woodruff 2014). Our research addresses these open issues by showing that management training can have long-lasting effects, that the content of training matters, and that positive spillovers can take place along the supply chain. Therefore, these factors should be taken into account to ensure the success of management training interventions.

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