Firm and Labor Adjustments to FDI Liberalization*

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Abstract

This paper studies how liberalizing outward foreign direct investments (FDI) affects manufacturers' engagement in global production and their domestic workers' labor market outcomes. Focusing on a liberalization policy in 2001 by the government of Taiwan that allowed 122 electronic products to be produced in China, we estimate its effect on Taiwanese electronic manufacturers and their domestic workers. Employing a matched difference-in-differences strategy, we find that the manufacturers targeted by the policy were on average 16% more likely to invest in China relative to the non-targeted ones. Correspondingly, the domestic workers initially employed by the targeted manufacturers were on average more likely to change their jobs, stay employed for fewer years, and have lower wages in subsequent years relative to those employed by the non-targeted ones. The worker-level effects of the policy exhibited substantial heterogeneity across the initial wage distribution, with the top-decile workers benefiting and the other workers losing on average.

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1 Introduction

Foreign production activities by multinational enterprises (MNEs) play a crucial role in the global economy today. According to the OECD, the gross output of foreign affiliates increased from 7 to 20 trillion USD over 2000-2014, which accounted for 12% of global output overall (Cadestin et al., 2018). If the barrier to conducting foreign direct investments (FDI) gets lifted, how would the domestic manufacturers respond? What would happen to their workers in the home country? From a theoretical perspective, domestic manufacturers that are more productive could respond to such opportunities and set up foreign affiliates in order to utilize cheaper production factors abroad. However, the prediction regarding domestic workers is unclear: on the one hand, domestic workers could enjoy higher wages due to their employers' growth (Helpman, Itskhoki and Redding, 2010); on the other hand, they could be replaced by foreign workers as their employers shift production activities abroad. This paper examines these two questions empirically utilizing novel multinational production data and a liberalization policy in Taiwan that allows 122 electronic products to be produced in China.

To study the effect of outward FDI on firm and worker outcomes, two main challenges are present in the literature: data availability and identification. First, it is difficult to capture the extent of foreign production activities. Using trade data alone to study the impact of outward FDI would neglect a large chunk of foreign production activities if the major purpose of the FDI is to access the host country market (i.e. horizontal FDI, as in Helpman, Melitz and Yeaple, 2004) or to export to the world market (i.e. export-platform FDI, as in Tintelnot, 2017). These activities cannot be captured by import data but can still have an impact on workers in the home country. The ideal solution to this challenge would be to have a comprehensive dataset that tracks production activities for both the parent firms in the home country and their affiliates in the host country.

Even if firm production activities across locations are observed, the effect of FDI cannot be identified due to the endogenous nature of investment decisions. As theoretical papers on multinational production and FDI (Helpman, Melitz and Yeaple, 2004; Antràs and Yeaple, 2014) have already highlighted, firms self-select into FDI activities based on their unobserved

productivity in the face of fixed entry costs. As a result, comparing outcomes of FDI firms versus non-FDI firms reflects not only the causal effect of conducting FDI activities that we seek to capture but also unobserved productivity differences across firms. One ideal solution would be to randomly distribute licenses for firms to invest abroad, but it is probably not feasible in real life. A second-best solution then is to find a natural experiment that triggers some firms to conduct FDI but not others.

This paper deals with the challenge of data availability by utilizing novel data sources. At the firm level, we utilize a multinational production dataset that covers all Taiwanese-listed firms in the electronic manufacturing sector from 1998-2007. It contains balance-sheet information for both the Taiwanese parent firms and their Chinese affiliates, allowing us to examine the extent of outward FDI activities in the electronic manufacturing sector, where China is their major destination. At the worker level, we draw on the Taiwanese administrative matched employer-employee data to trace the domestic incumbent workers of the parent firms in our firm-level data over the sample period. These sources provide a complete picture of the multinational production activities and associated labor market outcomes for the electronic manufacturing sector in Taiwan.

Furthermore, this paper addresses the identification challenge by studying a rare policy change by the Taiwanese government in 2001 that permitted 122 electronic products to be produced in China. As we argue in detail in Section 2, this policy change is a great natural experiment, as its timing and content were exogenous from the perspective of Taiwanese electronic manufacturers at that time. In addition, during the studied period it significantly reduced the targeted firms' fixed costs to produce their products in China and thus increased their incentives to set up affiliates in China and shift their production there.

To estimate the causal effects of the policy change on firm investment behaviors, we employ a matched difference-in-differences (DID) strategy. We first define the "treatment firms" as the electronic manufacturers that produced products related to the 122 products before the policy change, then match these firms one-to-one with other electronic manufacturers that never produced related products before 2001 but nonetheless exhibited similar characteristics in 1998 (the "control firms"). Then we estimate a standard DID by compar-

ing their investment activities in China before and after the policy change. The underlying assumption of this strategy is that the treatment firms would have followed the same investment trend as the control firms in the absence of the policy change.[1] We find a quantitatively sizable and statistically significant response from the electronic manufacturers. At the extensive margin, the treatment firms were on average 16% more likely to start investing in China relative to the control firms. At the intensive margin, the treatment firms tended to hire more workers in China and fewer in Taiwan, paid higher wage bill per worker in China and lower in Taiwan, and enjoyed higher total and export sales in both locations.

Following the firm-level results, we then shift our attention to worker-level responses. In particular, we examine how home country workers employed by the treatment and control firms in 2001 (i.e. the "treated" and "untreated" workers) differed by their labor market outcomes in subsequent years after the policy change. The treated workers experienced significantly higher Job transition rates after 2001 relative to the untreated workers. They also tended to stay employed for fewer years and accumulated slightly lower wages on average, but these effects are not statistically significant. Nonetheless, we find that treated workers in the top decile of the wage distribution in 2001 enjoyed significantly better outcomes, while the negative effects were mainly found in the treated workers around the median of the distribution (25th-75th percentile in 2001). Overall, the worker-level results indicate an imprecise negative effect of the liberalization policy on average, but the distribution implication is clear: the effect of FDI liberalization was positive for the workers in the top wage decile, who were more likely to possess higher education and skill levels, but it was negative for the rest, who were likely to mostly be workers on the production line.

Our study contributes to two main strands of research in trade and globalization. The first one is about globalization and firm internal organizations. Many papers have found that global engagements of firms, either through imports, exports, or FDI, lead to more employment of domestic high-skilled workers and less employment of low-skilled workers (Burstein and Vogel, 2017; Hsieh and Woo, 2005; Hur, Yoon and Ahn, 2019; Bernard and

[1]The parallel trends assumption is supported by our event study estimates, as no significant pre-trends are detected. We further conduct a sensitivity analysis following Rambachan and Roth (2022) as a robustness check.

Jensen, 1997; Menezes-Filho and Muendler, 2011; Tsou et al., 2013; Alviarez et al., 2022) and adoption of new technologies in the home country (Lileeva and Trefler, 2010).[2] However, most of the papers do not actually observe the production activities abroad and could not study the intensive margin of FDI activities. In addition, most of them do not have plausibly exogenous variations to identify the firm responses. One rare exception is Alviarez et al. (2022), which exploits an FDI policy change in China that affects the set of "encouraged" FDI industries and uses confidential Japanese survey data to study firm-level structural transformation. Our paper complements their findings by utilizing an FDI liberalization episode in Taiwan that creates *within-industry* variation in FDI activities and further explores the extensive margin of firm response as well as the labor market effect for domestic incumbent workers.

We also contribute to another strand of literature on globalization and domestic labor market outcomes. Consistent results across developing and developed countries have shown that regions (Topalova, 2010; Autor, Dorn and Hanson, 2013; Kovak, 2013; Dix-Carneiro and Kovak, 2017) and individuals (Autor et al., 2014; Dix-Carneiro, 2014; Dix-Carneiro and Kovak, 2019) that are initially more exposed to trade liberalization episodes experience declining employment and lower wages in subsequent years. Most of these liberalization episodes are due to either productivity growth from foreign exporters, as the so-called "China shock" in the context of the United States, or policies that reduce import tariffs across sectors, as in the context of India and Brazil. Despite the extensive studies on trade liberalization, the liberalization of outward FDI is less covered in the literature. This paper fills in the gap by studying an FDI liberalization episode and confirms the large redistributive impact of such policy change on domestic workers.

The rest of the paper is organized as follows. Section 2 introduces the background of Taiwanese outward FDI since the 1990s as well as our firm- and worker-level data. Section 3 describes our empirical strategy and summarizes our firm and worker samples. Section 4 and Section 5 present the results of firm and worker responses to the liberalization policy respectively. Lastly, Section 6 concludes.

[2] A recent working paper by Branstetter et al. (2021) studies the same policy in Taiwan and finds that outward FDI into China actually decreases the innovation activities by Taiwanese electronic manufacturers.

2 Background and Data

2.1 Background on FDI Liberalization in Taiwan

Taiwanese investments in China began under strict regulations in the 1990s. Due to political tensions and national security concerns, the Taiwanese government was initially skeptical about investment opportunities following the Chinese economic reform. In 1996, Taiwanese President Lee Teng-Hui announced a series of regulations termed "no haste, be patient" to protect industries related to high technology and basic infrastructure from the instability in cross-strait relations. The regulations included the prohibition of 316 products from being produced in China, an investment cap of 50 million USD for any single investment project in China, and the requirement for the total investment amount per firm to be lower than 40 percent of its net worth. As a result, Taiwanese FDI activities in China accounted by the electronic manufacturing industry were rare in the 1990s.

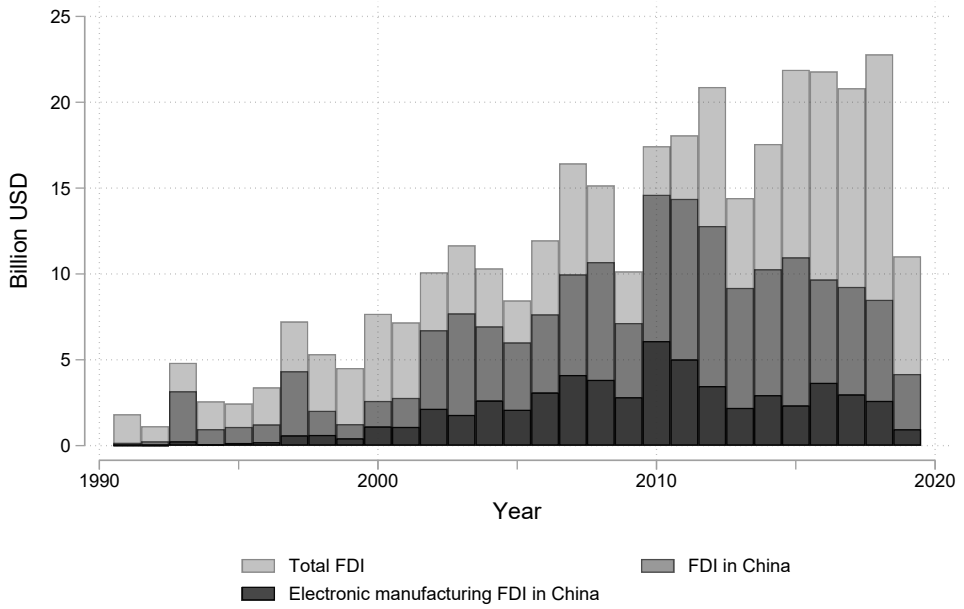
Following the global trend of trade liberalization, those restrictions on Taiwanese FDI activities in China started to ease in the 2000s. Chen Shui-Bian, the leader of the long-time opposition Democratic Progressive Party (DPP) in Taiwan, won the presidential election by a small margin in 2000. The DPP had no experience in office before and was previously known for its tougher stance toward China. With an urgent need to calm the opposition-controlled congress and the domestic business leaders, Chen moderated DPP's stance on Taiwanese nationalism and adopted a series of trade policies termed "active opening, effective management". Particularly, the 50 million USD investment cap was alleviated, and a list of 122 high-tech products, including laptops, mobile phones, digital optical drives, computer hardware and software, communication products, and consumer electronics, were allowed to be produced in China starting from 2001.[3] In Figure 1, we can see that the outward FDI amount into China substantially increased after 2001, with a major proportion coming from the electronic manufacturing industry.

The 2001 policy change is an excellent natural experiment to study the impact of FDI

[3]The complete list of products is provided in Appendix A.

liberalization. First, it only allowed a subset of high-tech products to be produced in China, granting us a well-defined treatment and control group. Second, it was adopted following the DPP's (who was more skeptical toward China) unexpected win in the presidential election. Based on these two reasons, this policy change is plausibly exogenous from the view of the electronic manufacturers in Taiwan.

Figure 1: Taiwanese yearly outward FDI (Billion USD)



NOTE: This figure illustrates Taiwanese outward FDI over 1991-2019, which further breaks down into total investment activities in China and electronic manufacturing activities in China. The statistics are from the Investment Commission, Ministry of Economic Affairs (MOEAIC) in Taiwan.

2.2 Firm-level Dataset

Focusing on Taiwanese electronic manufacturers who were the target of the 2001 policy, we recorded their production activities from 1998-2007 utilizing two main sources. Their production activities in Taiwan were collected from the Taiwan Economic Journal (TEJ) database, which contains balanced-sheet information for all publicly listed companies in Taiwan; on the other hand, their production activities in China were provided by the Chinese

Annual Survey of Industrial Firms (ASIF), which surveys state and non-state firms above 5 million RMB in annual sales (Brandt, Biesebroeck and Zhang, 2014). We have 533 Taiwanese electronic manufacturers in total. Before the policy change in 2001, each firm on average had 1.25 affiliates in China, employed 473 workers in Taiwan and 851 workers in China, paid annually 5.2K USD per worker in Taiwan and 1.4K USD per worker in China, and recorded annual sales of 54K USD in Taiwan and 49K USD in China.

2.3 Worker-level Dataset

The Fiscal Information Agency (FIA) under the Ministry of Finance in Taiwan provides yearly assembled taxation data starting from 2001. Our main data source for the worker-level analysis is the FIA data for individual income tax filing (equivalent to the IRS data in the US). We track the source of all taxable income of individuals in Taiwan and construct a matched employer-employee dataset. With the unique firm identifier, information from the firm-level dataset can be combined with the FIA dataset. For the purpose of this paper, we restrict our focus to salary/wage incomes. All workers that receive salary/wage income from a registered firm will be included in our analysis. If the workers become self-employed after leaving the initial firm, we can track their income if the newly established business is registered at the National Taxation Bureau. Otherwise, they will be considered unemployed.

Some features of the FIA data are worth noting. The advantage of the FIA data is that we can combine datasets for different tax categories and demographic data from other administrative databases in Taiwan with the de-identified individual ID number. By accessing the household registration database, the basic demographic information of workers is also available, e.g. age, gender, and marital status of each worker. Despite its advantages, the FIA data do not record information unrelated to tax collection. For example, there is no data for the total working years and education level of workers. In addition, for each individual, we have no information about the working status prior to 2001. We also acknowledge that we cannot accurately determine the skill level of workers.

3 Empirical Strategy

As introduced in Section 2, the policy in 2001 opened up the possibility for Taiwanese electronic manufacturers to conduct FDI in China. Our goal is to exploit this liberalization policy that is unforeseen from the firms' perspective and study its effect on the firms and their domestic workers. To achieve this goal, we employ a matched difference-in-differences approach for the firm-level analysis and a cross-section regression approach for the worker-level analysis. In the rest of the section, we explain the empirical approach in detail and then present the summary statistics of the firm and worker samples respectively.

3.1 Research Design for the Firm-level Analysis

For the firm-level analysis, the main outcomes of interests include measures of outward FDI activities at both the extensive and intensive margins. The extensive margin outcomes include indicators of exiting the market, investing in China, and investing in the same three-digit industry in China. We make a distinction between the last two outcomes to specify whether the outward FDI into China is directly related to the Taiwanese electronic manufacturers' core production activities rather than other purposes, e.g. marketing or retail. The intensive margin outcomes include variables that cover the extent of production activities for the parent firms in Taiwan and the affiliate firms in China, including employment, wage bill per worker, total sales, and export sales for both the parents and affiliates respectively.

To study the causal effect of the liberalization policy in 2001, we employ a difference-in-differences design. In particular, we define the Taiwanese electronic manufacturers, who had been producing products related to the 122 permitted product categories before the policy change as the "treatment firms" and the other electronic manufacturers, that had never done so, as the "control firms". The key identification assumption here is the parallel trends of firm outcomes, the validity of which will be examined in Section 4.

The classification procedure for the electronic manufacturers is conducted by utilizing the product-level sales in the TEJ dataset and manually checking whether each firm had

produced any product that has the same keywords as the 122 electronic products in Appendix A. We end up with 190 treatment firms and 343 control firms, with the main outcomes over 1998-2000 summarized in Table 1. Treatment firms are significantly more engaged in FDI activities in China and have higher total and export sales than the control firms before the policy change. The ex-ante difference in firm characteristics poses a threat to the control firms as a proper control group and hence motivates our matching approach to obtain a sample that is balanced in observable characteristics across the treatment and control firms.

Table 1: Summary statistics of the full firm sample over 1998-2000

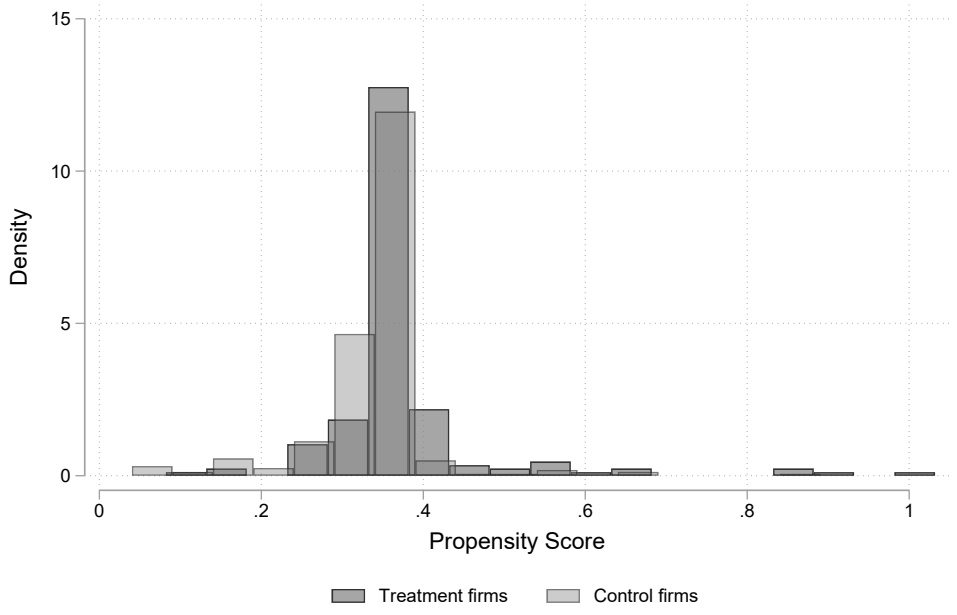
	All	Treatment firm	Control firm	T statistics
CN FDI	0.33	0.39	0.29	(2.61)**
CN FDI SIC3	0.06	0.09	0.04	(3.41)***
No. of affiliates in CN	1.25	1.28	1.23	(0.51)
Parent employment	472.64	474.15	471.78	(0.03)
Parent wage bill per worker	5.22	5.61	5.01	(0.60)
Parent total sales	53.67	71.89	43.30	(1.99)*
Parent export sales	39.47	58.44	28.68	(2.28)*
Affiliate employment	851.17	866.23	837.98	(0.09)
Affiliate wage bill per worker	1.43	1.53	1.35	(0.32)
Affiliate total sales	49.29	67.94	32.97	(1.20)
Affiliate export sales	34.41	43.65	26.32	(1.00)
Number of firms	533	190	343	

NOTE: This table shows the summary statistics of the full firm sample. "CN FDI" is an indicator of whether a Taiwanese electronic manufacturer conducts FDI in China, and "CN FDI SIC3" is an indicator of whether a Taiwanese electronic manufacturer conducts FDI in China in the same three-digit industry. "Parent" indicates the parent branch in Taiwan, and "affiliate" indicates the affiliate branch in China. The unit of sales and wages is 1,000 USD. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.2 Matching Procedure and Summary of Matched Firm Sample

To ensure that the control firms serve as a suitable counterfactual group for the treatment firms in the absence of the liberalization policy, we conduct one-to-one propensity score matching to obtain a firm sample that is balanced along pre-policy observable characteristics. Specifically, we match on parent firm characteristics over 1998-2000, including the number of workers, wage bill per worker, total sales, and export sales. We avoid matching on investment outcomes in China intentionally, as they are the main outcomes of interest. The propensity scores, i.e. predicted probabilities of being treated, are illustrated in Figure 2. The common support assumption seems to plausibly hold, as the treatment and control firms share overlapping support and have similar distributions.

Figure 2: Propensity scores for the treatment and control firms



The resulting matched sample is summarized for the years 1998-2000 in Table 2. It consists of 174 treatment and control firms each, and the outcomes are now balanced between the two groups, unlike the full sample in Table 1. The percentages of treatment and control firms conducting outward FDI into China are plotted in Figure 3a and Figure 3b. A common

rising trend of outward FDI into China exists for both groups, but it is noticeably higher for the treatment firms that conducted FDI in the same three-digit industry in China after the policy change in 2001. Our matching procedure seems to have achieved a well-balanced sample, as is reflected in the parallel trend before 2001. To ensure the robustness of our results to different matching methods, we also use the kernel matching method to construct another firm sample for robustness checks.

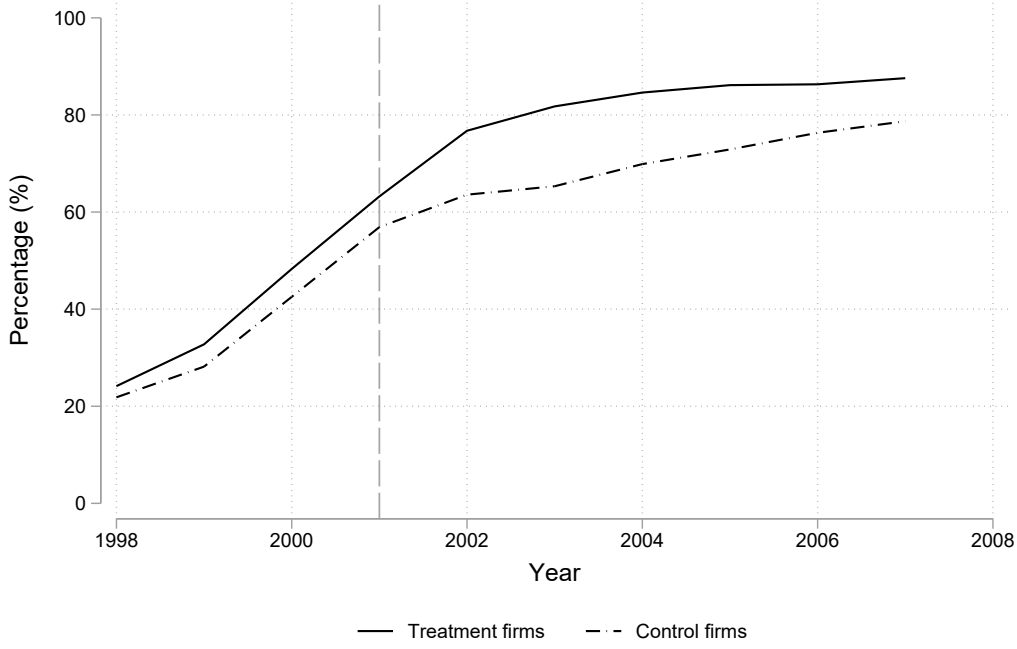
Table 2: Summary statistics of the matched firm sample over 1998-2000

	All	Treatment firm	Control firm	T statistics
CN FDI	0.33	0.35	0.31	(0.96)
CN FDI SIC3	0.03	0.04	0.02	(1.65)
No. of affiliates	1.22	1.28	1.14	(1.36)
Parent employment	394.73	440.70	348.76	(1.26)
Parent wage bill per worker	4.68	5.19	4.17	(0.95)
Parent total sales	51.82	64.14	39.49	(1.85)
Parent export sales	39.96	51.51	28.41	(1.89)
Affiliate employment	770.16	764.50	779.16	(0.05)
Affiliate wage bill per worker	1.36	1.35	1.38	(0.05)
Affiliate total sales	51.99	53.08	50.25	(0.07)
Affiliate export sales	32.61	28.94	38.44	(0.38)
Number of firms	348	174	174	

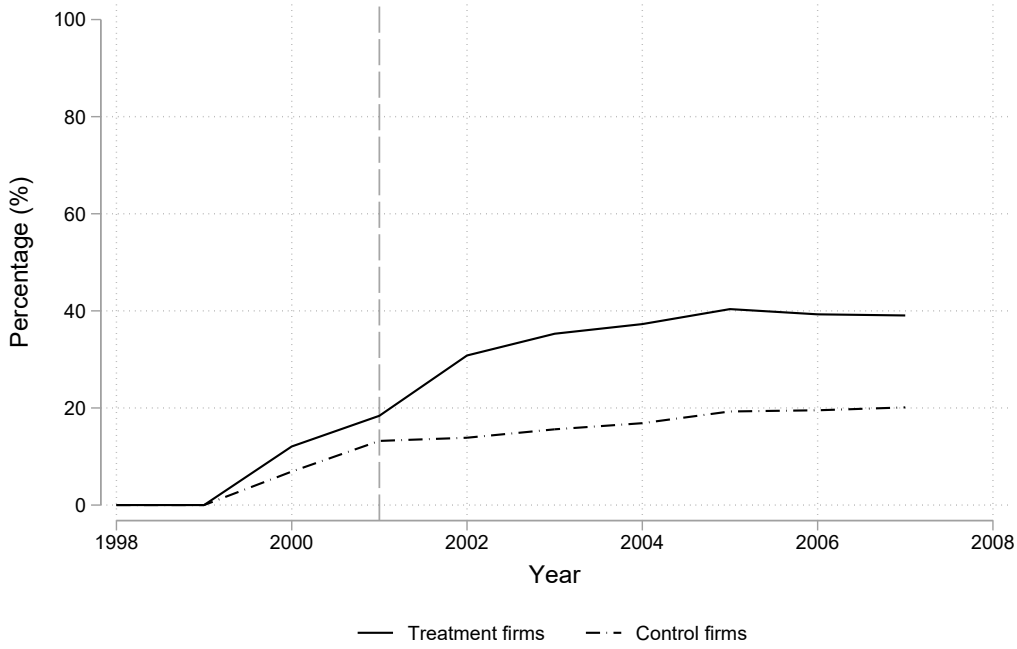
NOTE: This table shows the summary statistics for the firm sample constructed via one-to-one propensity score matching. "CN FDI" is an indicator of whether a Taiwanese electronic manufacturer conducted FDI in China during the studied period, and "CN FDI SIC3" is an indicator of whether a Taiwanese electronic manufacturer conducted FDI in China in the same three-digit industry. "Parent" indicates the parent branch in Taiwan, and "affiliate" indicates the affiliate branch in China. The unit of sales and wages is 1,000 USD. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 3: Percentage of FDI in China for treatment and control firms over 1998-2007

(a) Conducting FDI in China



(b) Conducting FDI in the same industry in China



NOTE: The figures show the percentages of treatment and control firms investing in China over 1998-2007. The firm sample is obtained via one-to-one propensity score matching.

3.3 Research Design for the Worker-level Analysis

To understand how the liberalization policy affected the local workers in Taiwan, a natural approach would be to follow the same strategy as the firm-level analysis and conduct a difference-in-differences analysis for the worker sample. Unfortunately, the FIA-matched employer-employee dataset only starts from 2001 (when the policy change happened), so the DID approach is not feasible. Instead, we opt for an approach similar to Autor et al. (2014) by following the incumbent workers' cumulative outcomes from 2001 onward.

The incumbent workers are assigned to treatment and control groups analogously to the firm sample. Specifically, the Taiwanese workers employed by the treatment firms in 2001 are defined as the "treated workers", and those employed by the control firms in 2001 are defined as the "untreated workers". We then compare their cumulative outcomes over 2001-2007 conditional on worker characteristics in 2001, including their age, gender, and marital status, as well as the industry fixed effect of their initial employer. The outcomes of interest are individual outcomes that evaluate their job security and earnings in the labor market, including whether a worker switches jobs, whether he or she is employed, and their wages received in a given year. The key identification assumption here is the conditional independence assumption, which is discussed in detail in Section 5.

Conceptually, the liberalization policy could have first- and second-order effects on the incumbent workers. First of all, the policy lowers the treatment firms' cost of investing in China and shifting their production activities. It would then affect the treated workers directly through higher job losses or lower wages due to decreasing labor demand in Taiwan, leading to fewer years employed and less wage accumulated in the initial firm. On the other hand, the policy may also have a second-order effect on workers separated from their initial employers, as being laid off could have adverse effects on re-employment probabilities in the future.

To distinguish the first-order effect from the second-order effect, we further decompose the employment status into four mutually exclusive outcomes: employment years in the initial firm, years outside the initial firm and same industry, years outside the initial firm

and different industries, and years unemployed. Similarly, cumulative wages are decomposed into wages earned in the initial firm, wages earned in the initial industry, and wages earned in different industries. Since the first-order effect is expected to be larger, the negative effect of the policy should be more salient, both on workers' employment years and their wages earned from the initial firm.

3.4 Summary of the Worker Sample

The average characteristics of the worker sample are presented in Table 3. Out of the 348 electronic manufacturers in the one-to-one matched firm sample, we are able to identify 324 of them in the FIA dataset (168 treatment firms and 156 control firms) and collect data for 111,426 workers who worked full time in those firms in 2001 and were within the age range of 22-65 over 2001-2007. The summary statistics indicate a large transition out of the original firms in subsequent years. 61% of the workers left their original firms by 2007, and the numbers for the treated and untreated workers are 68% and 54% respectively. The mean yearly wage of the treated workers was similar to that of the untreated workers at around 18K USD in 2001, but then it became significantly lower by 1.4K USD in 2007. The high separating rate and negative wage effect observed in the summary statistics are consistent with our empirical results in Section 5.

To investigate the heterogeneous treatment effect by initial wage levels, five wage groups are defined based on wage percentiles of the workers in 2001 and summarized in Table 4. In 2001, the average annual wage was 51K USD for workers in the top decile and 8K USD for workers in the bottom decile. In 2007, the average annual wage was 56K USD for workers in the top decile and 10K USD for workers in the bottom decile.

Table 3: Summary statistics of the worker samples

	All	Treated worker	Untreated worker	T statistics
Male (%)	53.5	54.2	52.7	(4.75)***
Age in 2001	32.4	32.7	32.0	(17.30)***
Wage in 2001	17.6	17.7	17.6	(0.97)
Wage in 2007	19.5	18.9	20.3	(8.74)***
Left initial firm by 2007 (%)	61.4	67.7	53.7	(48.11)***
Number of workers	111,426	61,468	49,958	

NOTE: The treated workers are workers employed by the treatment firms in 2001. The untreated workers are workers employed by the control firms in 2001. The unit of wage is 1,000 USD. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Summary statistics of mean wages by worker group

Group	Percentile in 2001	No. of workers	Wage in 2001	Wage in 2007
1	<p25	27,857	7.8	10.0
2	p25-p50	27,856	11.1	12.4
3	p50-p75	27,857	15.1	18.7
4	p75-p90	16,714	22.6	29.6
5	>p90	11,142	51.4	56.1

NOTE: The unit of wages is 1,000 USD.

4 Firm-level Responses to the Liberalization Policy

With the firm sample obtained via the matching procedure outlined in Section 3.2, we now present how Taiwanese electronic manufacturers responded to the liberalization policy in 2001. In the following, we first lay out the empirical specifications and identification assumption, then present the empirical results for extensive and intensive outcomes.

4.1 Empirical Specification

To estimate the effect of the liberalization policy on firm investment behavior, we compare Taiwanese electronic manufacturers who had produced related products before the policy change (i.e. the "treatment firms") versus those who had not (i.e. the "control firms"). This motivates the following difference-in-differences (DID) and event-study specifications:

$$Y_{jkt} = \alpha_0 + \alpha_1 Post_t \times Treatment_j + Year_t + Firm_j + \epsilon_{jkt} \tag{1}$$

$$Y_{jkt} = \alpha_0 + \sum_{t'=1998}^{2007} \alpha_{t'} \, Year_{t'} \times Treatment_j + Year_t + Firm_j + \epsilon_{jkt} \tag{2}$$

where j indexes firm, k indexes industry, and t indexes year ($t \in [1998, 2007]$). Y_{jkt} indicates the yearly firm outcome, $Post_t$ is an indicator of year t after 2001. $Treatment_j$ equals one for the treatment firms and zero for the control firms. $Year_t$ and $Firm_j$ are the year and firm fixed effects. Error terms ϵ_{jkt} are clustered at the three-digit industry level of the parent firms. The parameters of interest are α_1 in Equation (1) and $\{\alpha_{t'}\}$ in Equation (2).

4.2 Identification Assumption

For the parameters of interest to have a causal interpretation, the parallel trends assumption needs to hold; in other words, the treatment firms should follow the same time trend as the control firms in the absence of the policy. Under this assumption, α_1 and $\{\alpha_{t'}\}$ can be interpreted as the overall and period-specific average treatment effects on the treated (ATT)

for the liberalization policy.[4]

We assert that the parallel trends assumption is valid for the following reasons. First, the matching procedure outlined in Section 3 ensures similarity across observable characteristics between the treatment and control firms before the policy change. As the firms are similar ex-ante, it is plausible that the treatment firms would have exhibited the same time trend as the control firms if the policy change had not happened. As shown later in Figure 4, no pre-trend is spotted in the event study graphs. Second, our focus on the electronic manufacturers and the sole distinction by their products produced warrant that other major events during this time (e.g. Taiwan's accession to the WTO in 2001) would not affect the treatment and control firms differently.

With a recent method developed by Rambachan and Roth (2022), we can also allow for linear and non-linear time trends and examine to what extent our results would be affected. This sensitivity analysis is conducted in Section 4.5.2 following the firm-level results.

4.3 Extensive Margin Outcomes

We first look at the extensive margin outcomes, including whether firms exit the market, conduct FDI in China, and conduct FDI in the same three-digit industry in China. The corresponding DID estimates for Equation (1) are presented in Table 5. The treatment firms do not seem to be different in terms of the exit margin relative to the control firms. However, we do see that the treatment firms were on average 8.2% more likely to invest in China. In particular, the treatment firms were on average 16.3% more likely to invest in the *same* three-digit industry; this magnitude is six times bigger than the mean of the control firms before 2001. This result is consistent with the argument that the liberalization policy drove the firms that had produced related products to start investing in China and producing those related products after the policy change. The event study graphs following Equation (2) in Figure 4 convey a similar message, where higher propensities to invest in China, particularly in the same industry after 2001, are observed for the treatment firms.

[4] In the event-study graphs below, $\{\alpha_{t'}\}$ are adjusted with respect to the one before the policy, i.e. α_{2000}.

Table 5: Effect of the liberalization policy on firm extensive margin outcomes

	(1) Exit	(2) CN FDI	(3) CN FDI SIC3
Treatment*Post	0.002	0.082**	0.163**
	(0.004)	(0.037)	(0.070)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Pre-policy control mean	0	0.308	0.023
Observations	3480	3480	3480

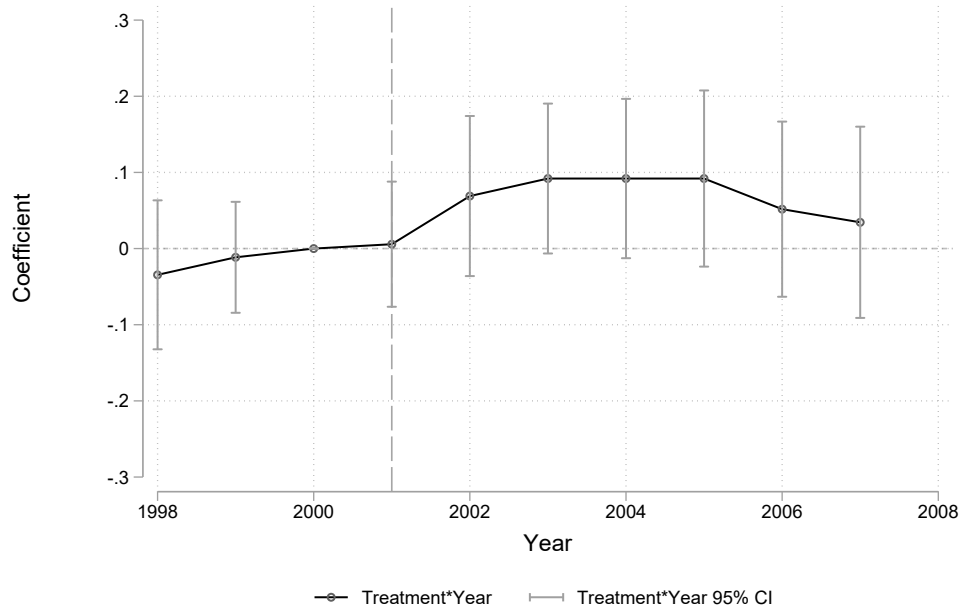
NOTE: This table shows the DID estimates α_1 in Equation (1) for firm extensive margin outcomes. Exit is an indicator of a firm that exists in the data in the previous year but disappears in the current year. CN FDI indicates a firm investing in China in a given year. CN FDI SIC3 indicates a firm investing in China in the same three-digit industry as the parent firm in a given year. Pre-policy control mean is the mean outcome for the control firms over 1998-2000. Standard errors are clustered at the three-digit industry level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.4 Intensive Margin Outcomes

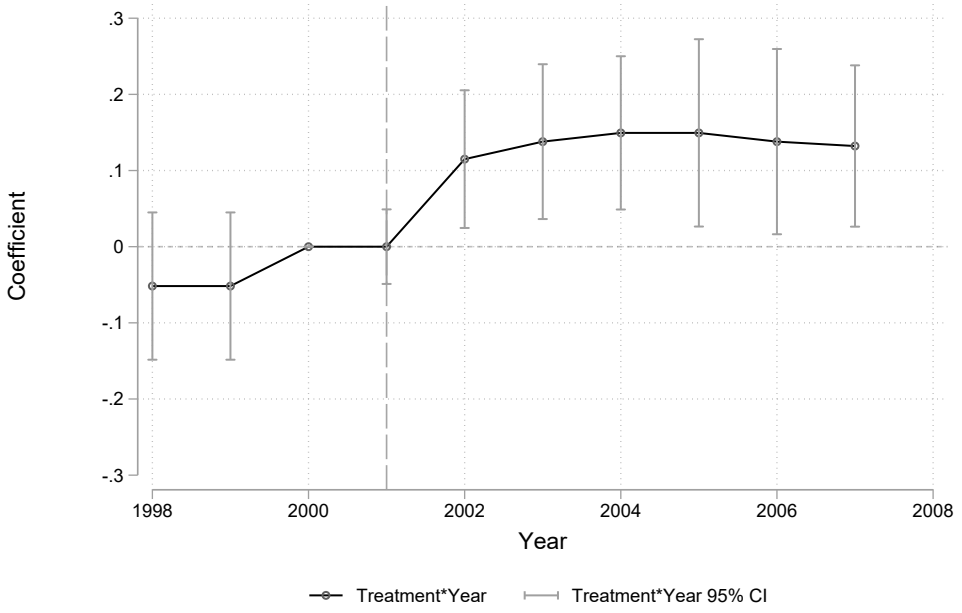
To understand how firms responded to the policy at the intensive margin, we restrict our sample to the firms with positive investments in China throughout the sample period (1998-2007) and study their outcomes including employment, wage bill per worker, total sales, and export sales for both the parent firms in Taiwan and their affiliates in China. The DID estimates for all outcomes in level with the pre-policy mean for the control firms are presented in Table 6. Despite lower statistical power due to fewer observations, the DID estimates for the parent firms show that on average, the treatment firms in Taiwan decreased their hiring and wage bill per worker by 65% and 57% relative to the control firms, while their affiliates in China nearly doubled their hiring and also raised the wage bill (although this did not reach statistical significance) relative to the counterparts. For the production outcomes, the treatment firms enjoyed a sizable increase in sales for both the parent and affiliate branches;

Figure 4: Event study graph for firm extensive margin outcomes

(a) Conducting FDI in China



(b) Conducting FDI in the same industry in China



NOTE: The figures illustrate the event-study estimates $\{\alpha_{t'}\}$ in Equation (2). The point estimates are adjusted with respect to one year before the policy change, such that α_{2000} equals zero.

in particular, export sales of the affiliates increased nearly nine-fold relative to the control mean, echoing the export-oriented feature of the new outward FDI induced by the policy.

Table 6: Effect of the liberalization policy on firm intensive margin outcomes

(a) Parent firms in Taiwan

	(1) Employment	(2) Wage bill per worker	(3) Total sales	(4) Export sales
Treatment*Post	-607.3	-7.1*	361.9	415.8
	(411.4)	(3.6)	(298.9)	(279.4)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Pre-policy control mean	934.8	12.4	87.9	70.9
Observations	298	298	298	298

(b) Affiliate firms in China

	(1) Employment	(2) Wage bill per worker	(3) Total sales	(4) Export sales
Treatment*Post	1856.5*	5.1	397.7*	376.4*
	(894.9)	(4.0)	(182.6)	(183.0)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Pre-policy control mean	988.7	1.5	52.7	42.3
Observations	298	298	298	298

NOTE: This table shows the DID estimates α_1 in Equation (1) for firm intensive margin outcomes. The sample is restricted to firms which have investments in China throughout the sample period (1998-2007). Firms that report missing values on the outcomes of interest are also excluded. Standard errors are clustered at the three-digit industry level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.5 Robustness of Firm-level Responses

4.5.1 Robustness to Different Matching Method

To test the robustness of our estimates of the firm-level response to the liberalization policy, we first conduct the same analysis on an alternative firm sample obtained via the kernel matching method. The summary of the kernel matching sample is in Table 16 of Apppendix C. The results analogous to Tables 5 and 6 using the kernel matching sample are provided in Tables 7 and 8. The estimates for the extensive margin outcomes align reasonably well; in particular, the DID estimate for investing in the same three-digit industry in China is also close to 16%. For the intensive margin outcomes, the estimates from the kernel matching sample reflect a consistent story: the treatment firms tend to reduce their employment and pay a smaller wage bill in Taiwan while raising their hiring and wage bill in China. Overall, our estimates are robust to different matching methods.

Table 7: Robustness check: Firm extensive margin outcomes (kernel-matching sample)

	(1) Exit	(2) CN FDI	(3) CN FDI SIC3
Treatment*Post	0.002	0.047	0.155*
	(0.004)	(0.031)	(0.076)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Pre-policy control mean	0	0.279	0.022
Observations	5110	5110	5110

NOTE: This table shows the DID estimates α_1 in Equation (1) for firm extensive margin outcomes. Exit is an indicator of a firm that exists in the data in the previous year but disappears in the current year. CN FDI indicates a firm investing in China in a given year. CN FDI SIC3 indicates a firm investing in China in the same three-digit industry as the parent firm in a given year. Pre-policy control mean is the mean outcome for the control firms over 1998-2000. Standard errors are clustered at the three-digit industry level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Robustness check: Firm intensive margin outcomes (kernel-matching sample)

(a) Parent firms in Taiwan

	(1)	(2)	(3)	(4)
	Employment	Wage bill per worker	Total sales	Export sales
Treatment*Post	-261.2	-2.9*	451.1	469.1
	(172.9)	(1.5)	(273.5)	(261.8)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Pre-policy control mean	696.7	8.6	55.0	40.2
Observations	456	456	456	456

(b) Affiliate firms in China

	(1)	(2)	(3)	(4)
	Employment	Wage bill per worker	Total sales	Export sales
Treatment*Post	2319.6**	7.1**	377.8*	361.3*
	(793.5)	(3.2)	(173.5)	(173.8)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Pre-policy control mean	780.6	1.3	32.3	26.1
Observations	456	456	456	456

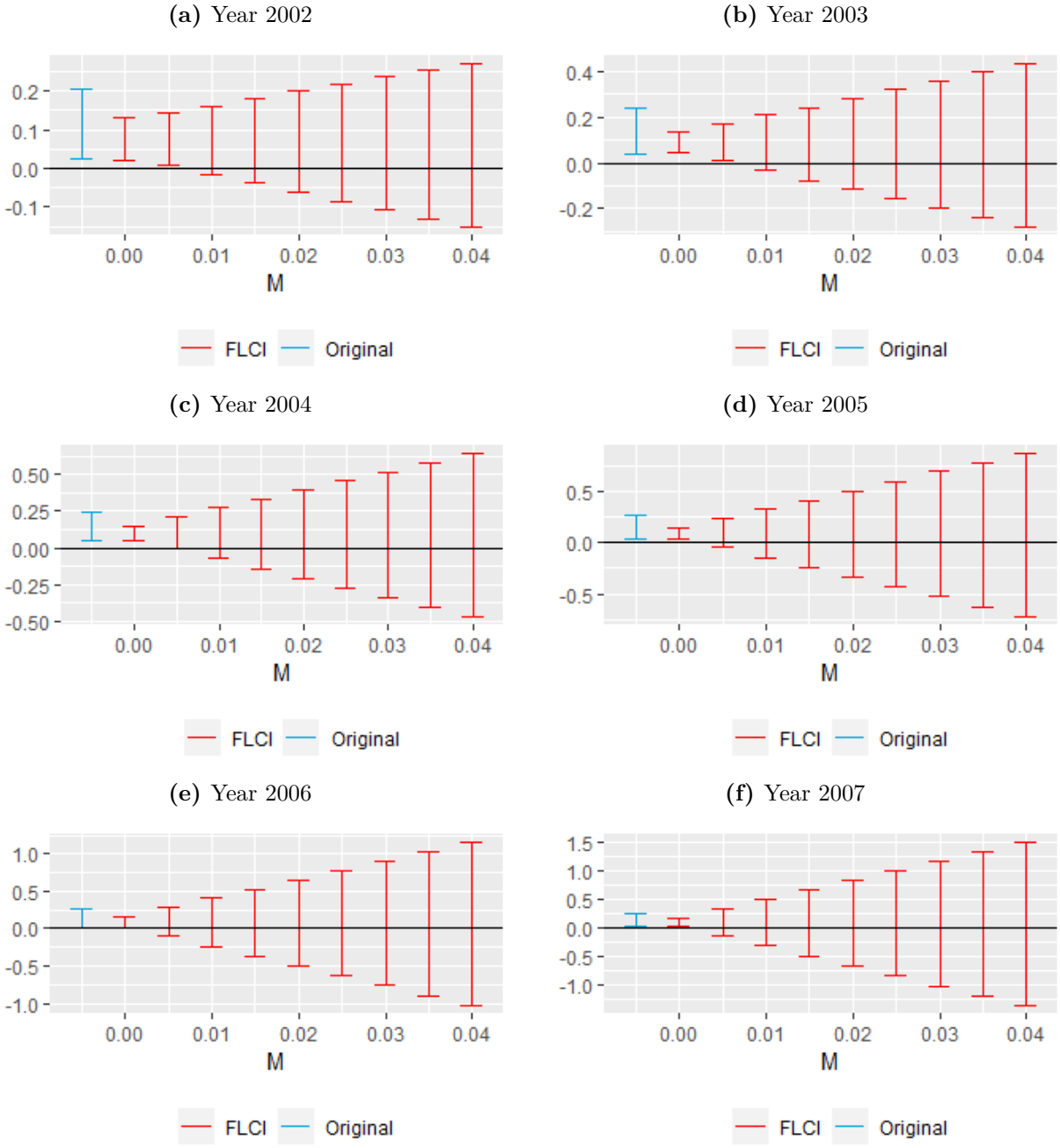
NOTE: This table shows the DID estimates α_1 in Equation (1) for firm intensive margin outcomes. The sample is restricted to firms that have investments in China throughout the sample period (1998-2007). Firms that report missing values in the outcome of interest are also excluded. Standard errors are clustered at the three-digit industry level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.5.2 Robustness to Relaxing Parallel Trends Assumption

The key identifying assumption of the DID and event-study estimates is the parallel trends assumption, i.e. the treatment firms would have followed the same time trend as the control firms if the policy change in 2001 had not happened. Although we could never directly test this assumption, it is not likely to hold if there is a significant pre-trend before the policy change takes place. For example, if we saw that the treatment firms already have a higher tendency to invest in China relative to the control firms before 2001, then it is hardly believable that the two groups would behave the same in the absence of the policy. As shown in Figure 4, there are no significant pre-trends associated with the two investment outcomes.

To provide a stricter examination, we conduct a sensitivity analysis using the *HonestDiD* package developed by Rambachan and Roth (2022). The main idea of this method is to relax the parallel trends assumption and allow for post-treatment differences in trends that are "close" to the estimated pre-trend, in linear or non-linear fashions. We apply the method to examine each event-study estimate after 2001 in Equation (2), i.e. $\{\alpha_t\}$. The results are shown in Figure 5. The coefficients in blue are the original estimates, and those in red are the estimated confidence sets allowing for trends, with M indicating the degree of non-linearity of the trends. It can be seen that all event-study estimates are robust to allowing for linear trends (i.e. the confidence sets when $M = 0$) but become less so as the trends get more and more non-linear. Nonetheless, most of the non-linear confidence sets cover our original estimates and thus are consistent with our main results. Overall, we are confident in concluding that our firm-level results are robust.

Figure 5: Sensitivity analysis: Relaxing parallel trends assumption



NOTE: The above figures show the sensitivity analysis following the method by Rambachan and Roth (2022) for each of the yearly estimates $\{\alpha_{t'}\}_{2002}^{2007}$ in Figure 4b. The intervals in blue are the confidence intervals of the original estimates, and the intervals in red are the confidence sets allowing for linear and non-linear time trends. When $M = 0$, the interval corresponds to the confidence set with a linear time trend. The time trend becomes more non-linear as M gets larger.

5 Worker-level Responses to the Liberalization Policy

After examining the firm-level response to the liberalization policy in Section 4, we move on to the worker sample to study the policy effect on the domestic incumbent workers, i.e. the Taiwanese workers employed by the electronic manufacturers in our firm sample at the onset of the policy in 2001. We first introduce the empirical specifications, then explain the identification assumptions needed to establish causal claims for the regression parameters, and finally present the results as well as the robustness checks.

5.1 Empirical Specification

As discussed in Section 3.3, the FIA matched employer-employee data starts from the year 2001 (i.e. the year when the policy change took place), so our empirical strategy is to compare the cumulative outcomes over 2001-2007 for the treated and untreated workers conditional on their demographic characteristics. This implies the following regression specification:

$$Y_{ijkt} = \alpha_t \, Treated_j + Industry_k + X_{ijk2001} + \zeta_{ijkt} \tag{3}$$

where i indexes incumbent workers, j indexes worker i's initial employer in 2001, k indexes worker i's initial industry in 2001, and t indexes years following the policy change ($t \in [2002-2007]$). Y_{ijkt} are the cumulative outcomes up to year t for worker i originally employed by firm j of industry k in 2001. $Treated_j$ indicates whether firm j is a treatment firm, $Industry_k$ is the four-digit industry fixed effects, and $X_{ijk2001}$ is a set of worker demographic characteristics in 2001, including their age, age squared, gender, and marital status. The statistical error ζ_{ijkt} is clustered at the level of three-digit industries. Following a similar approach by Dix-Carneiro and Kovak (2019), we estimate Equation (3) for each year t to obtain the coefficients of interests $\{\alpha_t\}$, which reveals the effect of the liberalization policy on the treated workers relative to the untreated workers up to year $t \in [2002, 2007]$.

To investigate the heterogeneous treatment effects of the policy by initial wage level and gender, we further run the following specifications:

$$Y_{ijk2007} = \alpha\, Treated_j + \sum_g \beta_g Treated_j \times WG_{ig2001} + \gamma WG_{ig2001} + Industry_k + X_{ijk2001} + \zeta_{ijk} \tag{4}$$

$$Y_{ijk2007} = \alpha\, Treated_j + \beta\, Treated_j \times Male_i + \gamma\, Male_i + Industry_k + X_{ijk2001} + \zeta_{ijk} \tag{5}$$

where $Y_{ijk2007}$ is the cumulative outcomes over 2001-2007, WG_{g2001} indicates whether worker i belongs to wage percentile group g in 2001 as defined in Table 4, and $Male_i$ is an indicator of whether worker i is male. The parameters of interest are α and $\{\beta_g\}$. The first parameter reflects the average effect of the policy for a reference group,[5] and the latter demonstrates the policy effect (for wage group g or male workers) relative to the reference group.

5.2 Identification Assumption

To identify the causal parameters $\{\alpha_t\}$ in Equation (3) as well as α and $\{\beta_g\}$ in Equations (4) and (5), the conditional independence assumption is needed. It requires that a worker's treatment status be independent of his or her potential outcomes conditional on the observable characteristics. In other words, whether a worker is employed by a treatment or control firm at the onset of the policy is "as if" random, conditional on their individual characteristics and industry fixed effects. Given this assumption, $\{\alpha_t\}$ can be interpreted as the per-period average treatment effects (ATE), and $\{\beta_g\}$ indicates the conditional average treatment effects (CATE) of the liberalization policy.

We argue that the conditional independence assumption is plausible for the following reasons. First, as we explained in Section 2, the policy change can be viewed as an exogenous event from the perspective of the electronic manufacturers. With the same reasoning, the workers employed by those firms in 2001 also cannot anticipate the policy change in advance.[6]

[5] The reference group for Equation (4) is the top-decile wage group, and the reference group for Equation (5) is female workers.

[6] The policy was officially announced in November 2001.

The matching procedure further strengthens the exogeneity of the policy, as the treatment and control firms are ex-ante similar from the perspective of the workers. In addition, the control variables including the four-digit industry fixed effects, and the worker characteristics account for the potential threat of selection on observables.

Nevertheless, it is a valid concern that workers might still self-select into the treatment and control firms based on some unobserved characteristics. For example, there may be systematic differences in their education levels or family resources, which are unobserved from the matched employer-employee data but could still affect their employment decisions and future labor outcomes. We deal with this concern by conducting two robustness checks. The first check is to use a different worker sample consisting of incumbent workers of the kernel-matching firm sample ("the kernel-matching worker sample"). For the second check, we control the financial assets of workers' parents by taking advantage of the kinship information provided by the FIA. This control variable serves as a proxy of the workers' education levels and family resources; however, it would be a bad proxy for older workers whose parents had already passed away by the year 2001. Therefore, this specification is provided as a robustness check rather than the main results.

5.3 Main Outcomes

The average effect of the liberalization policy on the worker cumulative outcomes over 2001-2007 is presented in Table 9. First of all, the estimate for job transitions is large and statistically significant. Specifically, the cumulative job transition rates of the treated workers were on average 24% higher than those of the untreated workers conditional on the industry fixed effects and individual characteristics. The estimate for total years of employment is small and insignificant. However, the employment years in the initial firm were 10% lower for the treated workers, indicating that they were more likely to leave their initial employers. The estimated effect on cumulative wages was negative on average but not statistically significant; nonetheless, wages earned in the initial firm were 12% lower for the treated workers.

Following Equation (3), we run the specification for each cumulative outcome from 2001

up to year $t \in [2002, 2007]$ and record the coefficients $\{\alpha_t\}$. The results for job transitions are presented in Figure 6a. Consistent with the estimated average policy effect in Table 9, the dynamic estimates indicate that the treated workers experienced higher job transition rates. In Figure 6b and Figure 6c, we examine the employment and wage outcomes by destination. As the two figures reveal, the treated workers were more likely to leave their initial employers and accumulate fewer wages from them over time relative to the untreated workers.

Table 9: Effect of the liberalization policy on worker cumulative outcomes (2001-2007)

(a) Job transitions and years employed by destination

	Job transitions	Years employed				Years unemployed
		Overall	Initial firm	Initial industry	Other industries	
Treated	0.225**	-0.094	-0.482*	0.254*	0.134	0.094
	(0.080)	(0.052)	(0.179)	(0.118)	(0.126)	(0.052)
Control mean in 2007	0.950	6.385	4.755	0.474	1.157	0.615
Observations	111,426	111,426	111,426	111,426	111,426	111,426

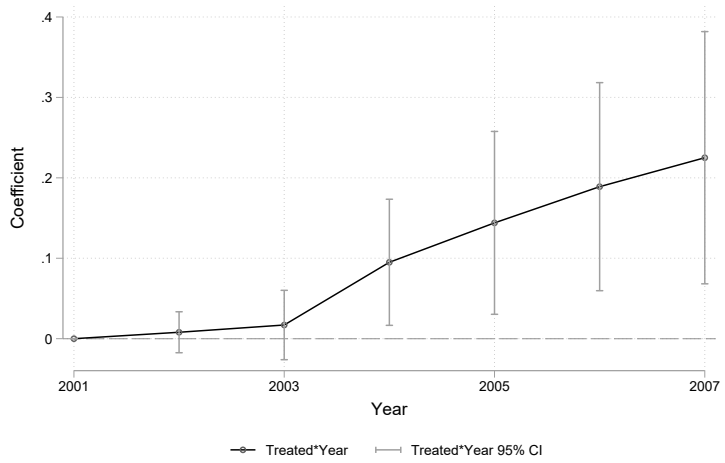
(b) Normalized wages by destination

	Wages earned			
	Overall	Initial firm	Initial industry	Other industries
Treated	-0.161	-0.618*	0.354	0.104
	(0.223)	(0.251)	(0.200)	(0.208)
Control mean in 2007	7.136	5.304	0.583	1.249
Observations	111,426	111,426	111,426	111,426

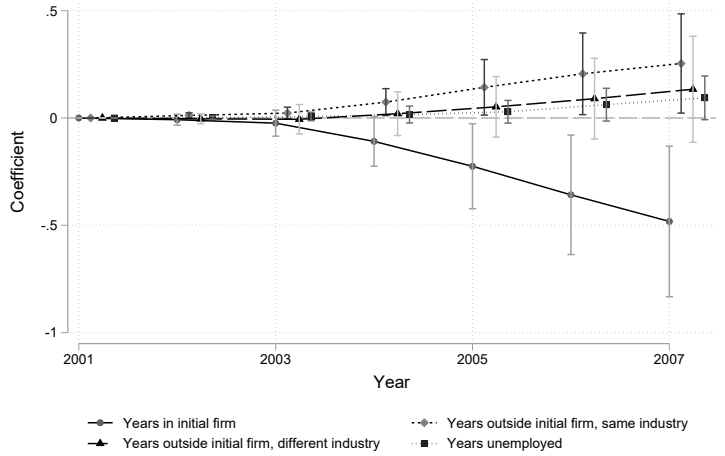
NOTE: Job transitions, years employed, years unemployed, and wages earned are cumulative outcomes from 2001 to 2007. Job transitions are the total number of job changes from 2001 to 2007. The cumulative wage is normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, and marital status. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 6: Worker cumulative outcome by year

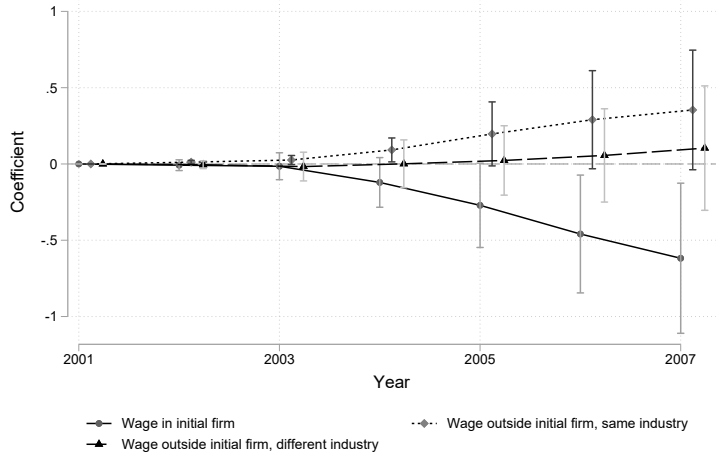
(a) Job transitions



(b) Employment years by destination



(c) Wage by destination



NOTE: The figures show the yearly estimates $\{\alpha_t\}_{2001}^{2007}$ in Equation (3) for worker cumulative outcomes.

5.4 Heterogeneity

After examining the main results, we now look into the heterogeneous treatment effects for the incumbent workers. We first investigate the heterogeneity by workers' initial wage level, separated into five wage percentile groups. The regression estimates of treatment-wage interaction terms following Equation (4) are presented in Table 10, with the treated workers in the top wage decile as the reference group. Panel (a) of Table 10 shows that the treated workers in the 1st to 3rd wage quartiles experienced higher job transition rates and stayed employed for fewer years relative to the untreated workers. The effects were particularly large for the treated workers in the 2nd and 3rd wage quartiles: they each experienced 37% and 29% higher job transition rates than the untreated workers; furthermore, they each stayed 18% and 12% fewer years in the initial firm relative to the untreated workers. Consistent with the main results, the negative effect on employment status is most evident in years employed in the initial firm. On the other hand, the policy effects on job transitions and years employed in the initial firm are not significant for treated workers in the top decile.

The substantial heterogeneity across initial wage levels is also observed for workers' cumulative wages, demonstrated in Panel (b) of Table 10. For the treated workers in the 25th-50th, 50th-75th, and 75th-90th percentile groups, their cumulative wages over 2001-2007 were 4%, 6%, and 4% lower than those of the untreated workers, respectively. In contrast, the treated workers initially in the top wage decile experienced a positive wage increase of 10% relative to the untreated workers.

Apart from the initial wage level, we also explore the heterogeneity by worker gender following Equation (5). Table 11 shows that female workers in the treatment group experienced more negative effects than male workers. While the treated male workers experienced a 14% higher job transition rate, stayed 5% fewer years, and earned 7% less in the initial firm, treated female workers experienced a 34% higher job transition rate, stayed employed 16% fewer years in the initial firm, and earned 17% lower wages earned in the initial firm compared to untreated workers.

Table 10: Heterogeneous effect of the liberalization policy: Initial wage level

(a) Job transitions and years employed by destination

	Job transitions	Years employed				Years unemployed
		Overall	Initial firm	Initial industry	Other industries	
Treated*<p25	0.251**	-0.098	-0.687**	0.182*	0.408*	0.098
	(0.079)	(0.059)	(0.224)	(0.072)	(0.182)	(0.059)
Treated*p25-p50	0.305***	-0.226***	-0.802***	0.198*	0.379*	0.226***
	(0.073)	(0.061)	(0.172)	(0.091)	(0.144)	(0.061)
Treated*p50-p75	0.229***	-0.250***	-0.544***	0.053	0.241**	0.250***
	(0.053)	(0.070)	(0.125)	(0.062)	(0.082)	(0.070)
Treated*p75-p90	0.000	-0.069	0.046	-0.106	-0.010	0.069
	(0.074)	(0.043)	(0.151)	(0.071)	(0.100)	(0.043)
Treated	0.051	0.019	-0.040	0.154*	-0.096	-0.019
	(0.072)	(0.046)	(0.182)	(0.062)	(0.193)	(0.046)
Control mean in 2007	0.950	6.385	4.755	0.474	1.157	0.615
Observations	111,426	111,426	111,426	111,426	111,426	111,426

(b) Normalized wages by destination

	Wages earned			
	Overall	Initial firm	Initial industry	Other industries
Treated*<p25	-0.692*	-1.317***	0.106	0.519**
	(0.276)	(0.260)	(0.165)	(0.188)
Treated*p25-p50	-0.974***	-1.463***	0.148	0.341*
	(0.240)	(0.273)	(0.145)	(0.141)
Treated*p50-p75	-1.138***	-1.248***	-0.054	0.164
	(0.235)	(0.253)	(0.101)	(0.098)
Treated*p75-p90	-0.986***	-0.656*	-0.226	-0.104
	(0.213)	(0.255)	(0.141)	(0.108)
Treated	0.707*	0.455	0.341**	-0.089
	(0.314)	(0.250)	(0.107)	(0.280)
Control mean in 2007	7.136	5.304	0.583	1.249
Observations	111,426	111,426	111,426	111,426

NOTE: Job transitions, years employed, years unemployed, and wages earned are cumulative outcomes from 2001 to 2007. Job transitions are the total number of job changes from 2001 to 2007. Self-employed individuals are treated as unemployed. The cumulative wage is normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, and marital status. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Heterogeneous effect of the liberalization policy: Worker gender

(a) Job transitions and years employed by destination

	Job transitions	Years employed				Years unemployed
		Overall	Initial firm	Initial industry	Other industries	
Treated*Male	-0.186***	0.182***	0.547***	-0.190*	-0.175*	-0.182***
	(0.037)	(0.045)	(0.091)	(0.081)	(0.076)	(0.045)
Treated	0.320***	-0.187	-0.763***	0.352**	0.224*	0.187*
	(0.084)	(0.072)	(0.197)	(0.129)	(0.110)	(0.072)
Control mean in 2007	0.950	6.385	4.755	0.474	1.157	0.615
Observations	111,426	111,426	111,426	111,426	111,426	111,426

(b) Normalized wage by destination

	Wage earned			
	Overall	Initial firm	Initial industry	Other industries
Treated*Male	0.259*	0.523***	-0.205	-0.058
	(0.120)	(0.138)	(0.110)	(0.103)
Treated	-0.294	-0.887**	0.459*	0.134
	(0.247)	(0.255)	(0.210)	(0.168)
Control mean in 2007	7.136	5.304	0.583	1.249
Observations	111,426	111,426	111,426	111,426

NOTE: Job transitions, years employed, years unemployed, and wages earned are cumulative outcomes from 2001 to 2007. Job transitions are the total number of job changes from 2001 to 2007. Self-employed individuals are treated as unemployed. The cumulative wage is normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, and marital status. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Two other approaches are adopted to address worker heterogeneity. First, we present the wage effect for workers who stayed in the initial firm throughout our sample period (i.e. the "stayers") and workers who left the initial firm (i.e. the "leavers") separately in Table 12. Among the stayers, treated workers in the 50th-90th initial wage percentiles earned less than the untreated workers. In stark contrast, treated workers in the top decile earned 10% more than the untreated workers. For the leavers, we can observe a similar negative wage effect concentrated among workers in the 50th-90th initial wage percentiles. Second, we utilize the causal forests method (Wager and Athey, 2018) to estimate the conditional average treatment effect (CATE) of the policy. Similarly, the estimates imply large heterogeneity along worker initial wage and gender. The description of the method and related results are provided in Appendix B.

The results presented above convey stark differences in the policy effect on domestic incumbent workers. On the one hand, the treated workers from the top decile benefited from the liberalization policy in terms of job security and earnings. These workers are likely well educated, highly skilled, and in occupations (e.g. researchers or managers) that are less subject to competition from workers in the Chinese affiliates. On the other hand, the liberalization policy led to higher job transitions, fewer years employed, and lower cumulative wages for the treated workers in the medium income percentiles. The workers in the bottom wage decile also faced more job transitions and stayed employed for fewer years in the initial firm. However, there was no significant negative wage effect, possibly due to lower labor market attachment.

5.5 Robustness of Worker-level Response

5.5.1 Robustness to Different Worker Sample

Analogous to the firm analysis, we create another worker sample with workers employed by the firms from the kernel-matching sample for robustness checks. Their average characteristics are summarized in Table 17 of Appendix C. We then run the same regressions in Equation (3) and Equation (4) using this alternative sample. The results are presented

Table 12: Effect of the liberalization policy: Stayers v.s. Leavers

(a) Main results

	Wages for stayers	Wages for leavers			
	Overall	Overall	Initial firm	Initial industry	Other industries
Treated	0.022	0.169	0.026	0.260	-0.117
	(0.193)	(0.282)	(0.081)	(0.173)	(0.270)
Control mean in 2007	8.168	6.332	3.072	1.037	2.223
Observations	40,303	71,123	71,123	71,123	71,123

(b) Heterogeneity by initial wage

	Wages for stayers	Wages for leavers			
	Overall	Overall	Initial firm	Initial industry	Other industries
Treated*<p25	-0.149	-0.279	-0.471***	0.011	0.182
	(0.350)	(0.270)	(0.101)	(0.168)	(0.226)
Treated*p25-p50	-0.509	-0.557*	-0.571***	0.014	0.001
	(0.272)	(0.215)	(0.144)	(0.148)	(0.140)
Treated*p50-p75	-0.816***	-0.901**	-0.434***	-0.316*	-0.150
	(0.191)	(0.259)	(0.113)	(0.125)	(0.109)
Treated*p75-p90	-1.135***	-0.845**	-0.227**	-0.420	-0.198*
	(0.172)	(0.259)	(0.082)	(0.211)	(0.084)
Treated	0.786**	0.726	0.433**	0.376***	-0.083
	(0.289)	(0.418)	(0.137)	(0.083)	(0.371)
Control mean in 2007	8.168	6.332	3.072	1.037	2.223
Observations	40,303	71,123	71,123	71,123	71,123

NOTE: Workers that stayed working in the initial firm from 2001-2007 are defined as "stayers" and the others are defined as "leavers". Wages are cumulative outcomes from 2001 to 2007 and are normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, and marital status. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

in Tables 13, 18, and 19. The robustness check generates similar results. Treated workers experienced more job transitions and on average stayed employed for fewer years both overall and in the initial firm. The negative wage effects are concentrated among workers with initial wages ranked in the 25th-90th percentiles, while the treated workers from the top decile are better off.

5.5.2 Robustness to Additional Controls

To address unobserved worker characteristics that could affect both their employment decisions and future outcomes, we control for the total assets of workers' parents utilizing the individual wealth data from FIA. Parents' wealth can serve as a proxy for the resources of a worker's family and positively correlate with the worker's education level. We did not add this control variable to our main empirical specification, since it requires both parents to be alive in order to measure their wealth, which causes us to lose 48,457 observations. The results with parents' wealth controlled are presented in Table 14 and 20. Again, the estimates are all similar in sign and magnitude to our main results.

Overall, our results are consistent with the idea that FDI liberalization would trigger manufacturing firms to move their production to low-cost countries and reduce their employment in the home country, hurting in particular the incumbent workers with lower initial wages, who are likely low-skilled or less educated. The workers in the top wage decile who are mostly in charge of management and R&D activities would benefit because their employers now enjoy higher profits from cost reductions and increasing sales; thus, they have larger demands for headquarter services in the home country.

Table 13: Robustness check: Worker average effect (kernel-matching sample)

(a) Job transitions and years employed by destination

	Job transitions	Years employed				Years unemployed
		Overall	Initial firm	Initial industry	Other industries	
Treated	0.223***	-0.091	-0.450**	0.205*	0.154	0.091
	(0.060)	(0.052)	(0.139)	(0.089)	(0.093)	(0.052)
Control mean in 2007	0.907	6.391	4.825	0.507	1.059	0.609
Observations	195,302	195,302	195,302	195,302	195,302	195,302

(b) Normalized wage by destination

	Wages earned			
	Overall	Initial firm	Initial industry	Other industries
Treated	-0.264	-0.579**	0.262	0.052
	(0.169)	(0.200)	(0.155)	(0.148)
Control mean in 2007	7.246	5.425	0.642	1.179
Observations	195,302	195,302	195,302	195,302

NOTE: Job transitions, years employed, years unemployed, and wage earned are cumulative outcomes from 2001 to 2007. Job transitions are the total number of job changes from 2001 to 2007. Self-employed individuals are treated as unemployed. The cumulative wage is normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, and marital status. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Robustness check: Worker average effect with parents' wealth controlled

(a) Job transitions and years employed by destination

	Job transitions	Years employed				Years unemployed
		Overall	Initial firm	Initial industry	Other industries	
Treated	0.220*	-0.060	-0.461*	0.304*	0.097	0.060
	(0.091)	(0.030)	(0.203)	(0.141)	(0.127)	(0.030)
Control mean in 2007	0.950	6.488	4.716	0.548	1.224	0.512
Observations	62,969	62,969	62,969	62,969	62,969	62,969

(b) Normalized wage by destination

	Wages earned			
	Overall	Initial firm	Initial industry	Other industries
Treated	-0.086	-0.601*	0.440	0.075
	(0.199)	(0.273)	(0.250)	(0.206)
Control mean in 2007	7.475	5.394	0.699	1.382
Observations	62,969	62,969	62,969	62,969

NOTE: The cumulative wage is normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, marital status in 2001 and parents' wealth in 2003 (which is the earliest wealth data we have access to). The sample is restricted to individuals with both parents alive in 2008, which is the earliest household registration data we have access to. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6 Conclusion

FDI activities are a crucial component of global trade. However, episodes of FDI liberalization are much less studied compared to other trade liberalization episodes such as import competition. The theoretical prediction for the causal effect of such liberalization policies on worker outcomes is unclear due to competing forces of firm growth and worker replacement. Taking advantage of novel data sources that cover Taiwanese electronic manufacturers and their affiliates in China as well as their workers in Taiwan, our paper studies a policy change in 2001 by the Taiwanese government that provides a subset of Taiwanese electronic manufacturers with extra incentives to conduct FDI in China.

The DID estimates at the firm level confirm a large treatment effect for the treatment firms, which reallocated their production resources to China both at the extensive and intensive margins. Moreover, the worker-level analysis indicates substantial heterogeneous effects of the policy, where the incumbent workers in the top decile of initial wages benefited and the other workers lost out following the implementation of the policy. This result echoes the theoretical predictions from classic trade models that trade liberalization creates winners and losers. From an aggregate perspective, a large-scale FDI liberalization episode such as the one experienced in Taiwan since the 2000s could substantially affect the overall income distribution and inequality of the society as a whole.

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Appendices

A Original List of the 122 Products

C.C.C.Code	Category in English	Category in Chinese
95421090	Fiber distributed data interface (FDDI), synchronous optical networking (SONET), ISDN equipment and IC related products	光纖分散數據介面、同步光纖網路系統、整體服務數位網路設備及其相關IC
85179092108	Thermal printhead (printer component)	熱感應印字頭
85252010102	All types of mobile phones, wireless communication system, digital wireless switches, satellite communications systems	行動電話、數位行動電話、GSM 行動電話機、泛歐無線電話 (DECT)、展頻數位無線電話、第二代數位無線 CT2 基台及手機、無線通信系統、數位式無線交換機與電話機、網際網路電腦通訊器及國際海事衛星通信 M/B 型移動系統
84213910	Filtering or purifying machinery for gase	電動空氣過濾器及電動空氣清潔器
84219910	Cartridges for filter/purifying machines	過濾芯子（供立即使用者）
84709010	Postage machine	郵資機
84709090	Other 8470 machines	其他第 8470 節所屬之機器
84710000	Advanced CAD/CAM system	高級 CAD/CAM 系統
84711000	Analog or hybrid automatic data processing machine	類比或混合自動資料處理機
84713000	Portable automatic data-processing machines, weighing not more than 10 kg, consisting of at least a central processing unit, a keyboard and a display	攜帶式數位自動資料處理機，其重量不超過 10 公斤並至少包含有一中央處理單元，一鍵盤及一顯示器者

C.C.C.Code	Category in English	Category in Chinese
84713000EX	Portable automatic data-processing machines, weighing not more than 10 kg, consisting of at least a central processing unit, a keyboard and a display (for work processing stations and related to: RISC CHIPS, multiprocessor systems, medical optical cards, interface card, medical records system, multimedia systems- hardware, software and applications, back servers, high-performance networks and controllers)	攜帶式數位自動資料處理機，其重量不超過 10 公斤並至少包含有一中央處理單元，一鍵盤及一顯示器者（高級工作站及相關 RICS CHIPS、多處理機系統、醫療光卡、光卡閱讀機個人電腦介面卡及光卡醫療記錄寫作系統、多媒體電腦系統－硬體、軟體及應用系統、後置服務器、高性能跨越網路之控制器）
84714100	Other digital automatic data processing machines comprising at least a central processing unit and an input and output unit	其他數位式自動資料處理機同一機殼內至少包含有一中央處理單元及一輸入、輸出單元，不論是否組合者
84714100EX	Other digital automatic data processing machines- Comprising in the same housing at least a central processing unit and an input and output unit, whether or not combined (for work processing stations and related to: RISC CHIPS, multiprocessor systems, medical optical cards, interface card, medical records system, multimedia systems- hardware, software and applications, back servers, high-performance networks and controllers)	其他數位式自動資料處理機同一機殼內至少包含有一中央處理單元及一輸入、輸出單元，不論是否組合者（高級工作站及相關 RICS CHIPS、多處理機系統、醫療光卡、光卡閱讀機個人電腦介面卡及光卡醫療記錄寫作系統、多媒體電腦系統－硬體、軟體及應用系統、後置服務器、高性能跨越縛路之控制器）
84714900	Other digital automatic data processing machines- Other, presented in the form of systems	其他數位式自動資料處理機，具系統形式者

C.C.C.Code	Category in English	Category in Chinese
84714900EX	Other digital automatic data processing machines- Other, presented in the form of systems	其他數位式自動資料處理機，具系統形式者（高級工作站及相關 RICS CHIPS、多處理機系統、醫療光卡、光卡閱讀機個人電腦介面卡及光卡醫療記錄寫作系統、多媒體電腦系統－硬體、軟體及應用系統、後置服務器、高性能跨越網路之控制器）
84715000EX	Digital processing units other than those of sub-headings 8471.41 and 8471.49, whether or not containing in the same housing one or two of the following types of unit : storage units, input units, output units	第 8471.41 及 8471.49 等目除外之數位式處理單元，在同一機殼內不論其是否含有一個或兩個下列形式之單元: 儲存單元、輸人單元、輸出單元（電子音樂合成系統）
84716020	Printers	列表機
84716020EX	Laser printers, optical printers, high resolution printers	雷射印表機、光電成像印表機、高解析度頁印機
84716090	Input or output units, whether or not containing storage units in the same housing	其他輸入或輸出單元，在同一機殼內不論其是否含有儲存單元者
84716090EX	High performance scanner	高性能文件掃瞄器
84717010EX	Hard disk drives, micro hard drives, micro drives	硬式磁碟機、微小型硬式磁碟機、微小型磁碟機
84717090	Other storage units	其他儲存單元
84717090EX	Solid-state storage, medical optical cards, PC-linked smart card readers, IC cards	固態記憶系統、醫療光卡、光卡閱讀機個人電腦介面卡及光卡醫療記錄寫作系統、IC 記憶卡
84718000	Other automatic data processors- magnetic or optical readers	其他自動資料處理機單元
84719030	Magnetic or optical readers	磁性或光學閱讀機
84719030EX	Barcode readers, catalytic converters, medical optical cards, optical card reader PC interface card and the optical card medical record writing system	條碼閱讀機、觸媒轉化器、醫療光卡、光卡閱讀機個人電腦介面卡及光卡醫療記錄寫作系統

C.C.C.Code	Category in English	Category in Chinese
84719090	Other automatic data processing machines under the heading 8471	其他第 8471 節所屬之自動資料處理機（其中電子音樂合成系統及固態記憶系統為禁止類）
84719090EX	Electronic music synthesis system and a solid-state memory system	電子音樂合成系統及固態記憶系統
84731000	Parts and accessories of the machines of heading 84.69	第 8469 節機器之零件及附件
84732900	Other parts and accessories of the machines of heading 84.70	其他第 8470 節所屬機器之零件及附件
84733010	Other parts and accessories of the machines of subheading 8471.10, 8471.30, 8471.41, 8471.49, 8471.50, 8471.60 and 8471.70	第 8471.10、8471.30、8471.41、8471.49、8471.50、8471.60、8471.70 目下機械之零件及附件
84733010EX	Photocopying machine toners, heat sensitive printing head servo writer, fiber-optic network with a waveguide coupler, high-resolution laser printer engine, drives head	影印機用墨粉、熱感應印字頭伺服寫入器、光纖網路用波導藕合器、高解析度雷射印表引擎、磁碟機讀寫頭
84733021	Parts and accessories of the machines of division 8471.90.10	第 847190.10 款下機械之零件及附件
84733029	Parts and accessories of the machines of subheadings 8471.80 and 8471.90	第 8471.80、第 8471.90 目下機械之零件及附件
84734010	Parts and accessories of perforating (punching), stapling, and pencil-sharpening machines	打孔機、裝訂機及削鉛筆機之零件及附件
84735010	Parts and accessories equally suitable for use with machines of subheadings 8471.80 and 8471.90	同時適用於第 8471.80、8471.90 目下機械之零件及附件
84735020	Parts and accessories equally suitable for use with machines of subheading 8471.10, 8471.30, 8471.41, 8471.49, 8471.50, 8471.60 and 8471.70	同時適用於第 8471.10、8471.30、8471.41、8471.49、8471.50、8471.60、8471.70 目下機械之零件及附件

C.C.C.Code	Category in English	Category in Chinese
84735020EX	photocopying machine toners, heat sensitive printing head servo writer, fiber-optic network with a waveguide coupler, high-resolution laser printer engine	影印機用墨粉、熱感應印字頭伺服寫入器、光纖網路用波導藕合器、高解析度雷射印表引擎
85011090EX	Precision small motors	精密微小馬達
85041100	Widescreen desktop CRT	大尺寸／寬螢幕映像管 (16：9 CRT)
85044011EX	Switched mode power supplies	交換式電源供應器（高功率密度、高頻電源供應器）
85044012EX	UPS power supplies (high power density, high-frequency power supply)	不斷電式電源供應器（高功率密度、高頻電源供應器）
85044019EX	Other power supplies (high power density, high frequency power supply)	其他電源供應器（高功率密度、高頻電源供應器）
85044090EX	Other electrostatic converters	其他靜電式變流器（微電腦控制交流感應馬達變頻器等相關變頻器）
85171 lOOEX	Wireless and wired phones	附無線手機之有線電話機（整體服務數位網路用戶端設備）
85171910	Video phone	影像電話機
85171990EX	Other phones (ISDN CPE)	其他電話機（整體服務數位網路用戶端設備）
85172100EX	fax machine, ISDN	G4 傳真機、整體服務數位網路用戶端設備
85173011	Central office telephone exchange	局用電話交換機
85173011EX	Central office telephone exchange (integrated services digital network CPE)	局用電話交換機（整體服務數網路用戶端設備）
8517301990	Other telephone exchange	其他電話交換機
85173019EX	Other telephone exchange (integrated services digital network CPE)	其他電話交換機（整體服務數網路用戶端設備）
85175010EX	Modem (integrated services digital network CPE)	數據機（整體服務數網路用戶端設備）+ E5878
85175090	Other carrier or digital line systems with appliances	其他載波電流線路系統用或數位線路系統用器具

C.C.C.Code	Category in English	Category in Chinese
85175090EX	ADM150 synchronous optical network systems, optical digital subscriber loop carrier equipment, network access equipment, fiber distributed data interface, integrated services digital network CPE, multimedia, multi-protocol network hub, Ethernet to ATM smart hub, high speed digital subscriber loop equipment, ISDN router, high-speed Ethernet LAN chipset (speed of 100Mbps and above), regional control network products, high-capacity fiber-optic subscriber loop systems, digital wireless subscriber loop transmission equipment, fast Ethernet-speed B set line to network (speed of 100Mbps and above), the full range of network technology	同步光纖網路 ADM150 系統、光纖迴路數位用戶載波機、網路存取設備、光纖分散式數據界面、整體服務數位網路用戶端設備、多媒體、多重協定網路中樞、Ethernet to ATM Smart Hub、高速數位用戶迴路設備、ISDN 路由器、高速乙太區域網路晶片組（速率 100Mbps 以上）、區域性控制網路系列產品、大容量光纖用戶迴路系統、數位式無線用戶迴路傳輸設備、高速乙太網路（速率 100Mbps 及以上）、全方位網路技術之集線路
85203210	Digital tape recorders or digital casette tape players	數位錄放音帶機或數位卡帶錄放音機
85203290	Other digital sound recording apparatus	其他數位錄放音器具
85209000EX	Other sound recording apparatus (digital tape players)	其他錄放音器具（數位錄放音機）
85211019EX	Other tape-style VCRs (digital video recorders)	其他磁帶式錄放影機（數位錄放影機）
85219010	Laser optical system disc video player	雷射光學系統碟式放影機
85219010EX	Laser video disk players	雷射影音碟機
85219010EX	Digital DVD player	數位影音光碟機
85219090	Other VCRs	其他錄放影機
85219090EX	Digital VCR	數位錄放影機
85229020EX	Parts and accessories of tape players (digital tape players)	錄放音機之零件及附件（數位錄放音機機構體）
85232010	Blank audio CDs	空白音碟

C.C.C.Code	Category in English	Category in Chinese
85232020	Blank DVDs	空白影碟
85232030	Blank disc automatic data processing systems	自動資料處理系統之空白磁碟
85232030EX	CD and floppy drives	硬碟機薄膜磁片
85232090	Multimedia systems	多媒體系統
85232090	Multimedia computer system- hardware, software, applications	多媒體電腦系統—硬體、軟體、及應用系統
85232090	Multimedia computer systems and software	多媒體電腦系統及其軟體
85232090	Systems and instrumental software	系統及工具性軟體
85232090	Multimedia database management system	多媒體資料庫管理系統
85232090	System software	系統軟體
85232090	Family information systems	家庭資訊系統
85232090	High-tech application software systems	高科技應用軟體系統
85232090	Electrical systems auxiliary systems engineering tools	電統輔助系統工程工具
85232090	Other blank discs	其他空白磁碟
85232090	Rewritable CDs/DVDs	可重複讀寫光碟片 (DVD-RAM, PD)
85232090EX	Floppy disks	磁片碟片
85233000EX	Equipped with a card magnetic strip (multimedia computer systems and software, multimedia computer systems- hardware, software and applications, systems and tools of software, multimedia systems)	裝有磁條之卡片（多媒體電腦系統及其軟體、多媒體電腦系統－硬體、軟體及應用系統、系統及工具性軟體、多媒體系統）
85239090EX	Other recording media, blank or recorded (multimedia computer systems and software, multimedia computer systems- hardware, software and applications, systems and tools of software, multimedia systems)	其他錄音或錄製其他類似現象用之空白媒體（多媒體電腦系統及其軟體、多媒體電腦系統－硬體、軟體及應用系統、系統及工具性軟體、多媒體系統）
85241010	Language teaching records	語言教學唱片
85241020	Recorded music	音樂唱片

C.C.C.Code	Category in English	Category in Chinese
85241090	Other records	其他唱片
85243100	Recorded discs for reproducing phenomena other than sound or image	已錄製供重放聲音或影像以外現象之碟片
85243211	Educational, news, and audio CDs	教育性、新聞性音碟
85243219	Other recorded audio CDs	其他已錄製音碟
85243910	Educational and news DVDs	教育性、新聞性影碟
85243990	Discs for laser reading systems- Other	其他已錄製供雷射閱讀系統用碟片
85244030	Recorded tapes for reproducing phenomena other than sound or image- of a width exceeding 6.5mm	已錄製供重放聲音或影像以外現象之磁帶，寬度超過 6.5 毫米者
85245111	Educational and news audio tapes, width no more than 4mm	教育性、新聞性錄音帶，寬度未超過 4 毫米者
85245121	Educational and news videos, width no more than 4mm	教育性、新聞胜錄影帶，寬度未超過 4 毫米者
85245211	Educational and news audio tapes, width between 4 and 6.5mm	教育性、新聞性錄音帶，寬度超過 4 毫米，但未超過 6.5 毫米者
85245221	Educational and news videos, width between 4 and 6.5mm	教育性、新聞性錄影帶，寬度超過 4 毫米，但未超過 6.5 毫米者
85245311	Educational and news audio tapes, width over 6.5mm	教育性、新聞性錄音帶，寬度超過 6.5 毫米者
85245321	Educational and news videos, width over 6.5mm	教育性、新聞性錄影帶，寬度超過 6.5 毫米者
85245329	Other recorded videos, width over 6.5mm	其他已錄製錄影帶，寬度超過 6.5 毫米者
85245390	Other recorded tapes, width over 6.5mm	其他已錄製磁帶，寬度超過 6.5 毫米者
85246000	Recorded cards with a magnetic strip	裝有已錄製磁條之卡片
85249100	Recorded media for reproducing phenomena other than sound or image	已錄製供重放聲音或影像以外現象之媒體
85249300	Medical optical cards, optical card reader PC interface, and optical card medical record	醫療光卡、光卡閱讀機個人電腦介面及光卡醫療記錄寫作系統
85249900	Other music recordings or other similar media recordings	其他已錄音或已錄製其他類似現象之媒體

C.C.C.Code	Category in English	Category in Chinese
85251020	Radio transmission apparatus	無線電廣播傳輸器具
85251030	TV transmission apparatus	電視傳輸器具
85251090	Other radio transmission machines	其他無線電傳輸機器
85252010	Radio phone	無線電話機
85252090	Other radio transmission receivers	其他具有接收器具之無線電傳輸器具
85254010	Static camcorder	靜相攝影機
85254010EX	Static photography	電子靜相照像機
85279000EX	Other wireless telephone or wireless telegraphy receivers	其他無線電話或無線電報接收機（全球定位系統接收器、全球定位系統接收器及引擎、國際海事衛星通信 M/B 型移動系統及網際網路口袋型電腦通訊器）
85281200EX	Color TV reception apparatus, whether or not incorporating radio broadcast receivers or sound, video recording or reproducing apparatus by TV (resolution of more than 1000)	彩色電視接收器具，不論是否裝有無線電廣播接收機或音、影錄或放器具者［高級數位電視機、高畫質電視機（水平解析度在 1000 條以上）］
85282110	Color CCTV system A	彩色閉路電視系統
85282190EX	17-inch or more color video monitors	17 吋以上彩色影像監視器
85283010	Color projector	彩色影像投射機
85283010EX	Color projector (TV projector, LCD projector)	彩色影像投射機（投影式電視機、液晶投影電視機）
85283020EX	Black and white monochrome video projectors (digital type)	黑白或其他單色影像投射機（數位式）
85371010EX	Computer numerical control (CNC)	電腦數值控制器，PC 級電腦數值控制器
90065900EX	Static camera	電子靜相照像機
90079100EX	Digital camcorders	數位攝錄放影機
90139000	HS code 9013, parts and accessories	第 9013 節所屬物品之零件及附件

B Estimate CATE Using Causal Forests

B.1 Outline of the Method

We apply the causal forests method (or generalized random forests, GRF) developed by Wager and Athey (2018); Athey, Tibshirani and Wager (2019) to our incumbent worker sample and estimate the conditional average treatment effect (CATE) of the 2001 liberalization policy.[7] The method utilizes the algorithm of random forests to estimate the CATE. Similar to random forests, subsamples are randomly drawn from the main sample to train decision trees. However, rather than splitting the tree to minimize the sum of squared residuals in the outcome within each node, the splits are chosen so as to maximize the differences of treatment effects between nodes. Once the training is done, the prediction of CATE for a test example can be made by "pushing down" the test example from top to bottom for each tree and calculating the weighted treatment effects with weights given by the share of times that the test example falls into the same leaf as the training samples.

B.2 Results

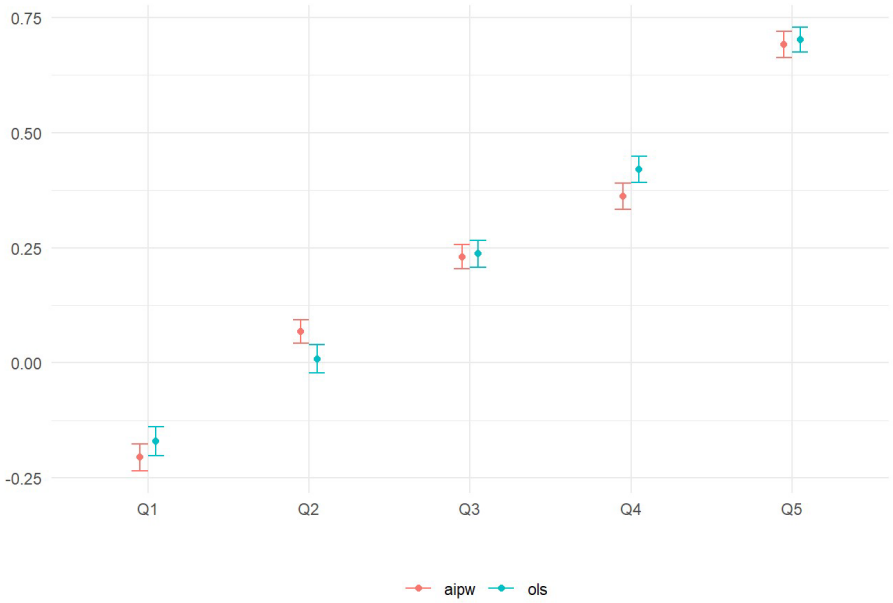
We implement the GRF package in R using our incumbent worker sample. Three cumulative outcomes over 2001-2007 are our focus: job transitions, employment years, and normalized wages. Worker characteristics of interest include their initial wages in 2001, gender, marital status, and age. Four-digit industry dummies (for their initial employers in 2001) are also added into the model to control for industry fixed effects.

The individual CATE estimates for each outcome are predicted and summarized in quintiles from the smallest to the largest in Figures 7, 8, and 9. Large heterogeneity is spotted in panel A for all three outcomes, as the estimates go from significantly negative to significantly positive. The average worker characteristics for each CATE quintile are presented in panel B. Echoing our regression-based heterogeneity analysis in Section 5, male workers and workers with higher initial wages tended to have fewer job transitions, more employment years, and higher cumulative wage.

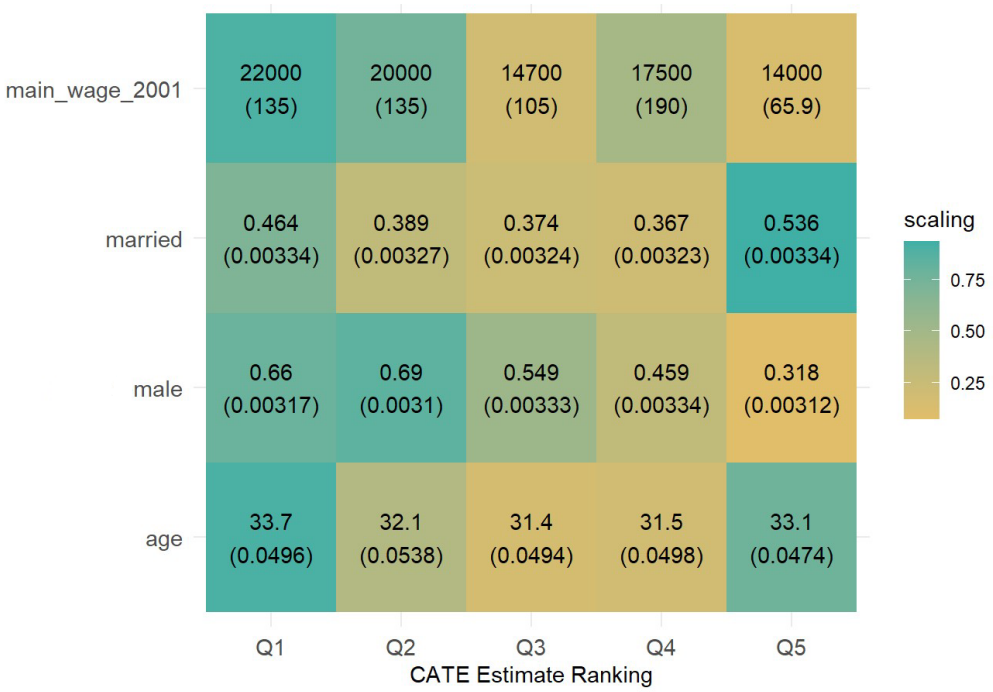
[7] Readers who are interested in the details of the method can read the original papers and refer to the package codebook online: https://grf-labs.github.io/grf/REFERENCE.html#general-algorithm.

Figure 7: CATE estimates using causal forests: Cumulative job transitions

(a) Average CATE quintiles by ranking



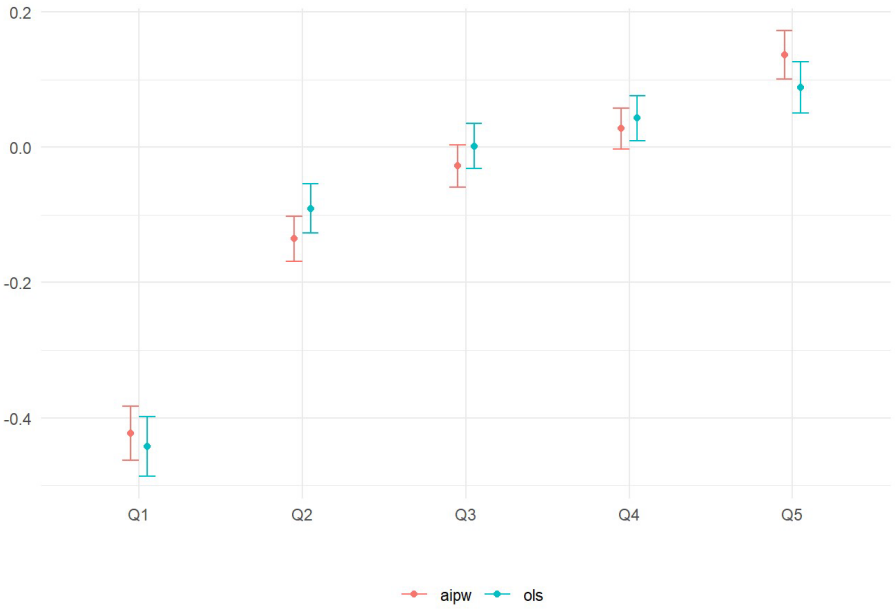
(b) Average covariate values by CATE quintile



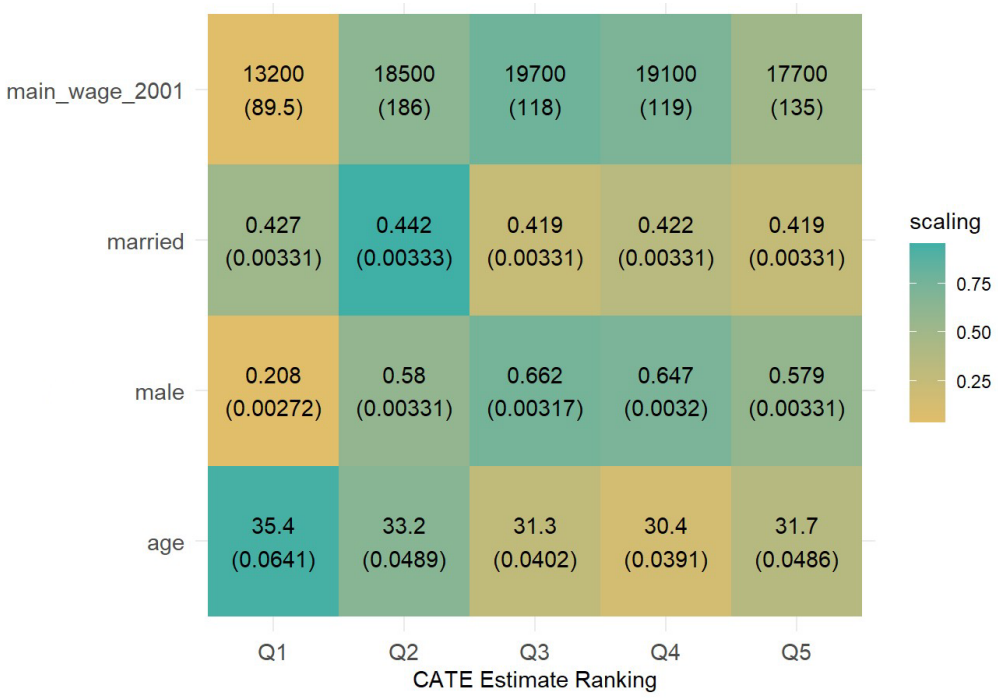
NOTE: The individual CATE estimates are summarized in quintiles and ranked from smallest to largest. Two methods to predict CATE are presented in Panel a: the out-of-bag predictions following the procedure of Chernozhukov et al. (2016) and the predictions using augmented inverse-propensity weighting (AIPW) following Athey, Tibshirani and Wager (2019). In Panel b, the average worker characteristics are shown, with their standard deviations in parentheses. The unit of worker's initial wage is USD.

Figure 8: CATE estimates using causal forests: Employment years

(a) Average CATE quintiles by ranking



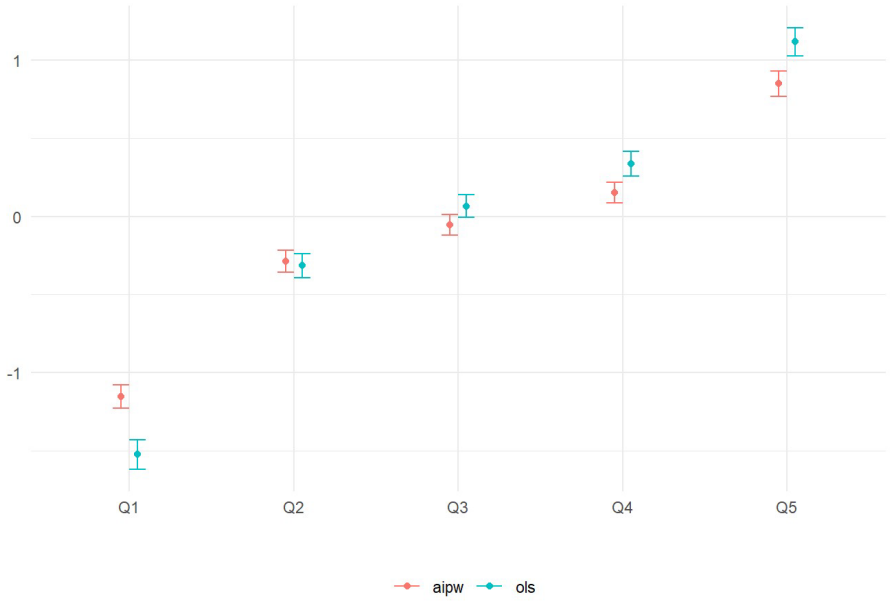
(b) Average covariate values by CATE quintile



NOTE: The individual CATE estimates are summarized in quintiles and ranked from smallest to largest. Two methods to predict CATE are presented in Panel a: the out-of-bag predictions following the procedure of Chernozhukov et al. (2016) and the predictions using augmented inverse-propensity weighting (AIPW) following Athey, Tibshirani and Wager (2019). In Panel b, the average worker characteristics are shown, with their standard deviations in parentheses. The unit of worker's initial wage is USD.

Figure 9: CATE estimates using causal forests: Normalized wage

(a) Average CATE quintiles by ranking



(b) Average covariate values by CATE quintile

NOTE: The individual CATE estimates are summarized in quintiles and ranked from smallest to largest. Two methods to predict CATE are presented in Panel a: the out-of-bag predictions following the procedure of Chernozhukov et al. (2016) and the predictions using augmented inverse-propensity weighting (AIPW) following Athey, Tibshirani and Wager (2019). In Panel b, the average worker characteristics are shown, with their standard deviations in parentheses. The unit of worker's initial wage is USD.

C Additional Robustness Results

Table 16: Summary statistics of the kernel-matching firm sample over 1998-2000

	All	Treatment firm	Control firm	T statistics
CNFDI	0.30	0.35	0.28	(1.84)
CNFDI SIC3	0.03	0.04	0.02	(1.94)
No. of affiliates	1.22	1.28	1.19	(0.94)
Parent employment	462.38	440.70	474.10	(0.44)
Parent wage bill per worker	5.04	5.17	4.97	(0.20)
Parent total sales	47.31	63.89	38.43	(2.03)*
Parent export sales	33.68	51.26	24.27	(2.38)*
Affiliate employment	698.66	764.50	647.46	(-0.51)
Affiliate wage bill per worker	1.23	1.35	1.13	(0.40)
Affiliate total sales	40.88	53.08	31.38	(0.68)
Affiliate export sales	26.34	28.94	24.31	(0.28)
Number of firms	511	175	336	

NOTE: This table shows the summary statistics for the firm sample constructed using the kernel matching method. "CN FDI" is an indicator of whether a Taiwanese electronic manufacturer conducted FDI in China, and "CN FDI SIC3" is an indicator of whether a Taiwanese electronic manufacturer conducted FDI in China in the same three-digit industry. "Parent" indicates the parent branch in Taiwan, and "affiliate" indicates the affiliate branch in China. The unit of sales and wages is 1,000 USD. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 17: Summary statistics of the kernel-matching worker sample

	All	Treated worker	Untreated worker	T statistics
Male (%)	51.7	54.2	50.6	(14.43)***
Age in 2001	31.9	32.7	31.5	(35.86)***
Wage in 2001	18.0	17.7	18.1	(4.40)***
Wage in 2007	20.7	18.9	21.5	(20.27)***
Left initial firm by 2007 (%)	56.3	67.6	51.0	(69.63)***
Number of workers	195,302	61,578	133,724	

NOTE: The treated workers are workers employed by the treatment firms in 2001. The untreated workers are workers employed by the control firms in 2001. The unit of wage is 1,000 USD. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 18: Robustness check: Worker heterogeneous effect by initial wage (kernel-matching sample)

(a) Job transitions and years employed by destination

	Job transitions	Years employed				Years unemployed
		Overall	Initial firm	Initial industry	Other industries	
Treated*<p25	0.218***	-0.151**	-0.572***	0.006	0.415**	0.151**
	(0.055)	(0.052)	(0.140)	(0.085)	(0.120)	(0.052)
	0.289***	-0.329***	-0.729***	0.056	0.345**	0.329***
	(0.067)	(0.065)	(0.146)	(0.081)	(0.121)	(0.065)
Treated*p50-p75	0.232***	-0.317***	-0.547***	-0.001	0.231**	0.317***
	(0.042)	(0.066)	(0.096)	(0.043)	(0.075)	(0.066)
Treated*p75-p90	0.044	-0.117***	-0.047	-0.121*	0.052	0.117***
	(0.069)	(0.030)	(0.133)	(0.046)	(0.096)	(0.030)
Treated	0.066	0.073	-0.076	0.213***	-0.064	-0.073
	(0.068)	(0.063)	(0.165)	(0.056)	(0.160)	(0.063)
Control mean in 2007	0.907	6.391	4.825	0.507	1.059	0.609
Observations	195,302	195,302	195,302	195,302	195,302	195,302

(b) Normalized wage by destination

	Wages earned			
	Overall	Initial firm	Initial industry	Other industries
Treated*<p25	-0.885*	-1.243***	-0.179	0.537***
	(0.401)	(0.279)	(0.217)	(0.117)
Treated*p25-p50	-1.227***	-1.454***	-0.078	0.305**
	(0.255)	(0.250)	(0.137)	(0.109)
Treated*p50-p75	-1.243***	-1.256***	-0.148	0.161*
	(0.197)	(0.209)	(0.085)	(0.080)
Treated*p75-p90	-0.964***	-0.694***	-0.254**	-0.015
	(0.105)	(0.177)	(0.091)	(0.109)
Treated	0.766**	0.463	0.430**	-0.127
	(0.284)	(0.285)	(0.132)	(0.217)
Control mean in 2007	7.246	5.425	0.642	1.179
Observations	195,302	195,302	195,302	195,302

NOTE: Job transitions, years employed, years unemployed, and wage earned are cumulative outcomes from 2001 to 2007. Job transitions are the total number of job changes from 2001 to 2007. Self-employed individuals are treated as unemployed. The cumulative wage is normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, and marital status. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 19: Robustness check: Worker heterogeneous effect by gender (kernel-matching sample)

(a) Job transitions and years employed by destination

	Job transitions	Years employed				Years unemployed
		Overall	Initial firm	Initial industry	Other industries	
Treated*Male	-0.193***	0.162***	0.553***	-0.209*	-0.182**	-0.162***
	(0.035)	(0.043)	(0.084)	(0.090)	(0.061)	(0.043)
Treated	0.324***	-0.176*	-0.740***	0.315**	0.250**	0.176*
	(0.070)	(0.070)	(0.170)	(0.101)	(0.080)	(0.070)
Control mean in 2007	0.907	6.391	4.825	0.507	1.059	0.609
Observations	195,302	195,302	195,302	195,302	195,302	195,302

(b) Normalized wage by destination

	Wages earned			
	Overall	Initial firm	Initial industry	Other industries
Treated*Male	0.109	0.483***	-0.270	-0.104
	(0.134)	(0.087)	(0.147)	(0.075)
Treated	-0.322	-0.832	0.404*	0.107
	(0.203)	(0.217)	(0.163)	(0.131)
Control mean in 2007	7.246	5.425	0.642	1.179
Observations	195,302	195,302	195,302	195,302

NOTE: The cumulative wage is normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, and marital status. We set gender = 1 for males and gender = 0 for females. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 20: Robustness check: Worker heterogeneous effect by initial wage with parents' wealth controlled

(a) Job transitions and years employed by destination

	Job transitions	Years employed				Years unemployed
		Overall	Initial firm	Initial industry	Other industries	
Treated*<p25	0.217**	-0.079	-0.638**	0.131	0.428**	0.079
	(0.074)	(0.066)	(0.205)	(0.081)	(0.135)	(0.066)
Treated*p25-p50	0.292***	-0.174***	-0.733***	0.162	0.397**	0.174***
	(0.080)	(0.048)	(0.194)	(0.100)	(0.141)	(0.048)
Treated*p50-p75	0.197**	-0.191***	-0.459***	0.033	0.235*	0.191***
	(0.056)	(0.042)	(0.124)	(0.076)	(0.092)	(0.042)
Treated*p75-p90	-0.010	-0.057	0.042	-0.135	0.034	0.057
	(0.073)	(0.030)	(0.157)	(0.095)	(0.114)	(0.030)
Treated	0.063	0.028	-0.058	0.235**	-0.150	-0.028
	(0.072)	(0.027)	(0.183)	(0.069)	(0.156)	(0.027)
Control mean in 2007	0.950	6.488	4.716	0.548	1.224	0.512
Observations	62,969	62,969	62,969	62,969	62,969	62,969

(b) Normalized wage by destination

	Wages earned			
	Overall	Initial firm	Initial industry	Other industries
Treated*<p25	-0.856**	-1.395***	0.013	0.526***
	(0.290)	(0.280)	(0.213)	(0.136)
Treated*p25-p50	-1.169***	-1.562***	0.069	0.323*
	(0.222)	(0.299)	(0.170)	(0.153)
Treated*p50-p75	-1.332***	-1.327***	-0.125	0.121
	(0.190)	(0.249)	(0.131)	(0.127)
Treated*p75-p90	-1.192***	-0.788**	-0.323	-0.081
	(0.189)	(0.276)	(0.176)	(0.138)
Treated	0.994***	0.589*	0.508***	-0.104
	(0.276)	(0.238)	(0.142)	(0.236)
Control mean in 2007	7.475	5.394	0.699	1.382
Observations	62,969	62,969	62,969	62,969

NOTE: Job transitions, years employed, years unemployed, and wage earned are cumulative outcomes from 2001 to 2007. Job transitions are the total number of job changes from 2001 to 2007. Self-employed individuals are treated as unemployed. The cumulative wage is normalized by wage in 2001. Control variables include the four-digit industry fixed effects, worker age, age squared, gender, and marital status. Standard errors are clustered at the three-digit industry level. The control mean is the mean outcome for untreated workers. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$