

**How do Tax Incentives Affect Investment and Productivity?
Firm-Level Evidence from China**

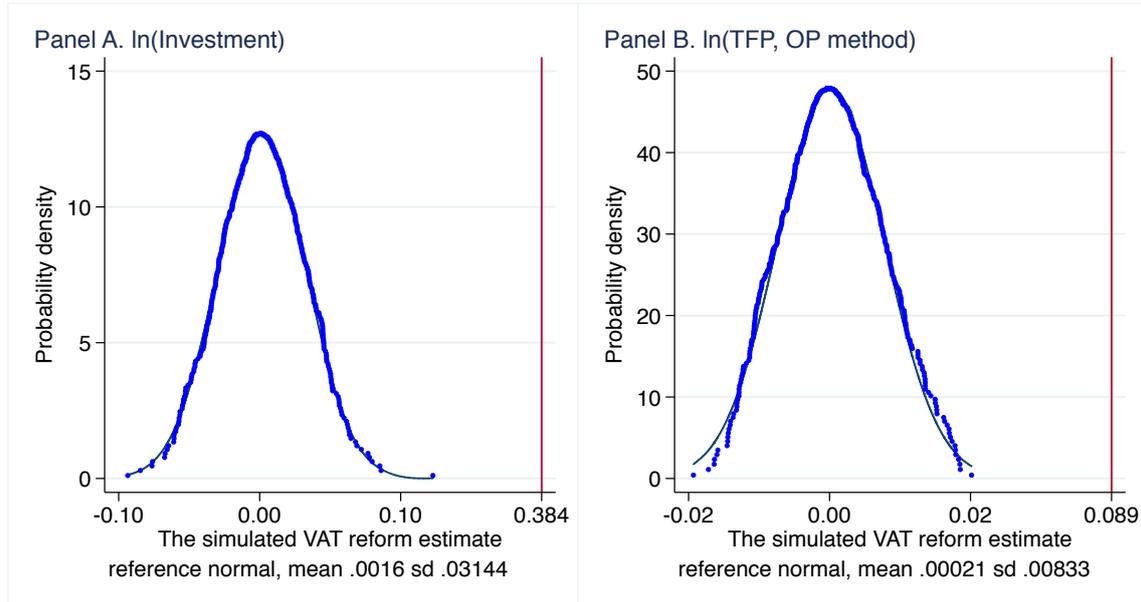
ONLINE APPENDIX

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Appendix A: Supplementary Figures and Tables

Figure A1: The Distribution of Estimates for the “False” VAT Reform Variable



Notes: The figure plots the density of the estimated coefficients of the “false” VAT reform variable from the 500 simulation tests using the specification in Column (3) of Table 2. The vertical red lines present the treatment effect estimates reported in Column (3) of Table 2.

Source: Authors’ calculations.

Table A1: Evolution of the VAT Reform in China

Stage of the Reform (Starting Time)	Regions Covered	Industries Covered (Industry Classification Codes)
1 (July 2004)	The three North-eastern provinces: Liaoning (including Dalian city), Jilin and Heilongjiang.	Machine and equipment manufacturing (35, 36, 39, 40, 41, 42); Petroleum, chemical, and pharmaceutical manufacturing (25, 26, 27, 28, 29, 30); Ferrous and non-ferrous metallurgy (32, 33); Agricultural product processing (13, 14, 15, 17, 18, 19, 20, 21, 22); Shipbuilding (375); Automobile manufacturing (371, 372, 376, 379); Selected military and hi-tech products (a list of 249 firms, 62 of which are in our sample).
2 (July 2007)	26 cities of the six middle provinces: 4 (Taiyuan, Datong, Yangquan and Changzhi) in Shanxi province, 5 (Hefei, Maanshan, Bengbu, Wuhu and Huainan) in Anhui province, 4 (Nanchang, Pingxiang, Jingdezhen and Jiujiang) in Jiangxi province, 5 (Zhengzhou, Luoyang, Jiaozuo, Pingdingshan and Kaifeng) in Henan province, 4 (Wuhan, Huangshi, Xiangfan and Shiyan) in Hubei province, and 4 (Changsha, Zhuzhou, Xiangtan and Hengyang) in Hunan province.	Machine and equipment manufacturing (35, 36, 39, 40, 41, 42); Petroleum, chemical, and pharmaceutical manufacturing (25, 26, 27, 28, 29, 30); Ferrous and non-ferrous metallurgy (32, 33); Automobile manufacturing (371, 372, 376, 379); Agricultural product processing (13, 14, 15, 17, 18, 19, 20, 21, 22); Electric power (441, 442); Mining (6, 8, 9, 10, 11); Hi-tech (253, 2665, 271, 272, 274, 276, 368, 3761, 3762, 3769, 401, 402, 403, 4041, 4042, 4043, 405, 406, 407, 409, 411, 412, 4141, 4154, 4155, 419, 6211, 6212).
3 (July 2008)	(1) 5 cities of Inner Mongolia: Hulunbuir, Xingan, Tongliao, Chifeng and Xilingele. (2) 51 counties suffering from Wenchuan earthquake: 39 (Wenchuan, Beichuan, Mianzhu, Shifang, Qingchuan, Mao, An, Dujiangyan, Pingwu, Pengzhou, Li, Jiangyou, Lizhou district of Guangyuan city, Chaotian district of Guangyuancity, Yuanba district of Guangyuan city, Wangcang, Zitong, Youxiandistrict of Mianyang city, Fucheng district of Mianyang city, Jingyang district of Deyang city, Xiaojin, Luojiang, Heishui, Chongzhou, Jiange, Santai, Langzhong, Yanting, Songpan, Cangxi, Lushan, Zhongjiang, Dayi, Baoxing, Nanjiang, Guanghan, Hanyuan, Shimian, Jiuzhaigou) in Sichuan province, 8 (Wen, Wudu district of Longnan city, Kang, Cheng, Hui, Xihe, Liangdang, Zhouqu) in Gansu province, and 4 (Ningqiang, Lueyang, Mian, Chencang district of Baoji city) in Shaanxi province.	(1) 5 cities of Inner Mongolia: Machine and equipment manufacturing (35, 36, 39, 40, 41, 42); Petroleum, chemical, and pharmaceutical manufacturing (25, 26, 27, 28, 29, 30); Ferrous and non-ferrous metallurgy (32, 33); Agricultural product processing (13, 14, 15, 17, 18, 19, 20, 21, 22); Shipbuilding (375); Automobile manufacturing (371, 372, 376, 379); Military (2664, 3751, 4141); Hi-tech (253, 2665, 271, 272, 274, 276, 368, 3761, 3762, 3769, 401, 402, 403, 4041, 4042, 4043, 405, 406, 407, 409, 411, 412, 4141, 4154, 4155, 419, 6211, 6212). (2) 51 counties suffering from the <i>Wenchuan</i> earthquake: All the manufacturing sector (6-46), excepting coke processing (2520) and electrolytic aluminum producing (3316).
4 (January 2009)	Nation-wide	All the remaining general VAT taxpayers

Source: Authors' compilation from relevant official documents, including *File of the Ministry of Finance of China and the State Administration of Taxation of China No. 156 in 2004*, *File of the Ministry of Finance of China and the State Administration of Taxation of China No. 227 in 2004*, *File of the Ministry of Finance of China and the State Administration of Taxation of China No. 28 in 2005*, *File of the Ministry of Finance of China and the State Administration of Taxation of China No. 75 in 2007*, *File of the Ministry of Finance of China and the State Administration of Taxation of China No. 94 in 2008*, *File of the Ministry of Finance of China and the State Administration of Taxation of China No. 108 in 2008*, and *File of the Ministry of Finance of China and the State Administration of Taxation of China No. 170 in 2008*.

Table A2: Variable Definitions

Variable	Definition
ln(Investment)	logarithm of (1+real investment)
Investment/lagged capital	real investment/lagged real capital stock, %
ln(Net investment)	logarithm of (the difference in the real capital stock between two consecutive years)
Net investment/lagged capital	(the difference in the real capital stock between two consecutive years)/lagged real capital stock, %
ln(Investment in buildings)	logarithm of (1+real investment in buildings)
ln(Investment in imported capital goods)	logarithm of (1+real value of purchases of imported capital goods)
ln(TFP, OP method)	logarithm of TFP, calculated by the OP method
ln(TFP, LP method)	logarithm of TFP, calculated by the LP method
ln(TFP, adjusted OP method)	logarithm of TFP, calculated by the adjusted OP method (see subsection III.E)
ln(TFP, adjusted LP method)	logarithm of TFP, calculated by the adjusted LP method (see subsection III.E)
VAT reform	dummy for the VAT reform (1 if the firm is eligible to the VAT reform incentives; 0 otherwise)
Markup	the ratio of the output elasticity for intermediate input to its corresponding expenditure shares in total revenue
Cash flows/lagged capital	(net profit after tax + current year depreciation)/lagged real capital stock, %
R&D expenditures/lagged capital	real R&D expenditures/lagged real capital stock, %
ln(Total assets)	logarithm of total assets (total assets are in real value)
ln(Total sales)	logarithm of total sales (total sales are in real value)
Profit margin	net profit/total sales, %
Age	firm's age

Table A3: Firms' Responses to the VAT Reform: Alternative Standard Errors

	ln(Investment)			ln(TFP, OP method)		
	(1)	(2)	(3)	(4)	(5)	(6)
VAT reform	0.384*** (0.139)	0.384*** (0.110)	0.384*** (0.136)	0.089** (0.041)	0.089*** (0.027)	0.089** (0.037)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry trends	Yes	Yes	Yes	Yes	Yes	Yes
VAT taxpayer trends	Yes	Yes	Yes	Yes	Yes	Yes
Cluster(province)	Yes	No	No	Yes	No	No
Cluster(industry)	No	Yes	No	No	Yes	No
Two-way clusters	No	No	Yes	No	No	Yes
Observations	249,803	249,803	147,902	280,348	280,352	170,879
R^2	0.022	0.022	0.022	0.185	0.185	0.185

Notes: In Columns (1)-(3) and Columns (4)-(6), the dependent variables are logarithm of investment and logarithm of OP method of TFP, respectively. Two-way clusters represent clustering at both the province and the industry levels. FE stands for “fixed effects”. Standard errors clustered at alternative levels are in parentheses.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

Table A4: Event Study Estimates: Firms' Responses to the VAT Reform

	ln(Investment)	Investment/ lagged capital	ln(TFP, OP method)	Cash flows/lagged capital	R&D Expenditures/ lagged capital
	(1)	(2)	(3)	(4)	(5)
4 year before	-0.200 (0.142)	-0.518 (0.694)	0.018 (0.037)	0.125 (0.088)	0.183 (0.586)
3 year before	-0.142 (0.111)	-0.006 (0.515)	-0.005 (0.029)	0.105 (0.066)	0.120 (0.437)
2 year before	0.039 (0.060)	-0.163 (0.339)	0.044*** (0.016)	0.017 (0.031)	0.270 (0.254)
Year of VAT reform	0.245* (0.128)	1.170* (0.609)	0.072** (0.031)	0.170** (0.078)	0.675 (0.532)
1 year after	0.470*** (0.131)	1.430** (0.613)	0.112*** (0.033)	0.263*** (0.081)	1.583*** (0.539)
2 year after	0.348*** (0.133)	0.901 (0.604)	0.119*** (0.034)	0.246*** (0.079)	1.379** (0.547)
≥ 3 year after	0.466*** (0.168)	1.239 (0.754)	0.125*** (0.042)	0.304*** (0.107)	0.878 (0.695)
Observations	249,803	243,411	280,352	208,055	240,374
R^2	0.023	0.017	0.185	0.010	0.019

Notes: This table reports the estimation results for event study using specification (2). The dependent variable for each estimation is indicated on the top of each column. These results are graphically presented in Figures 2 and 4, respectively. All regressions include firm fixed effects, year fixed effects, quadratic time trends and their interaction terms separately with two-digit industry dummies and types of VAT taxpayer dummy. Standard errors are clustered at firm level for all regressions.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table A5: Effect Heterogeneity: Robustness Checks

	Investment/lagged capital	
	(1)	(2)
	Small	Large
VAT reform	4.222** (1.996)	0.863 (0.689)
Equality test	$P=0.112$	
Observations	66,657	75,335
R^2	0.012	0.022

Notes: The dependent variable is the ratio of investment to lagged capital stocks. We split the sample based on firm size, which is defined as the average value of firms' assets in the pre-reform period. The bottom three deciles are categorized as "small" firms, while the top three deciles are grouped as "large" firms. All regressions include firm fixed effects, year fixed effects, quadratic time trends and their interaction terms separately with two-digit industry dummies and types of VAT taxpayer dummy. Standard errors are clustered at firm level for all regressions.

**Significant at the 5 percent level.

Table A6: The Impacts of VAT Reform on R&D Expenditures and Cash Flows

	R&D expenditures/lagged capital			Cash flows/lagged capital		
	(1)	(2)	(3)	(4)	(5)	(6)
VAT reform	0.124** (0.059)	0.112* (0.059)	0.137** (0.060)	1.469*** (0.455)	0.698* (0.372)	1.336*** (0.459)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	No	Yes	No
Industry trends	No	No	Yes	No	No	Yes
VAT taxpayer trends	No	No	Yes	No	No	Yes
Observations	208,055	207,588	208,055	240,374	240,234	240,374
R^2	0.006	0.013	0.010	0.013	0.330	0.018

Notes: The dependent variable for Columns (1)-(3) is the ratio of R&D expenditures to lagged capital stock, and the dependent variable for Columns (4)-(6) is the ratio of cash flows to lagged capital stock. Controls indicate quartics in assets, sales, profit margin, and firm age. Industry trends indicate quadratic time trends interacted with two-digit industry dummies; and VAT taxpayer trends indicate quadratic time trends interacted with types of VAT taxpayers dummy. FE stands for “fixed effects”. Standard errors are clustered at firm level for all regressions.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table A7: Changes of Industry Markup Before and After 2009

Industry Code	Mean			Coefficient of Variation		
	05-08	09-12	Change (%)	05-08	09-12	Change (%)
13	1.20	1.08	-9.62	0.69	0.43	-37.28
14	1.26	1.19	-5.18	0.67	0.43	-34.82
15	1.52	1.38	-9.04	0.76	0.41	-46.50
17	1.13	1.11	-2.01	0.52	0.39	-24.28
18	1.25	1.21	-3.67	0.63	0.49	-22.40
19	1.18	1.18	-0.32	0.62	0.45	-27.83
20	1.18	1.11	-6.66	0.65	0.38	-40.87
21	1.21	1.18	-2.30	0.52	0.48	-8.36
22	1.16	1.17	1.39	0.45	0.31	-30.80
23	1.23	1.19	-3.20	0.59	0.56	-4.82
24	1.20	1.10	-7.87	0.65	0.48	-26.72
25	1.08	0.85	-21.14	0.50	0.22	-55.58
26	1.16	1.15	-0.59	0.57	0.38	-32.15
27	1.25	1.34	7.16	0.61	0.45	-26.13
28	1.13	1.14	0.81	0.30	0.21	-29.61
29	1.13	1.12	-0.81	0.50	0.43	-13.80
30	1.16	1.15	-0.82	0.49	0.38	-23.24
31	1.21	1.11	-7.79	0.62	0.45	-26.89
32	1.13	1.11	-1.88	0.45	0.27	-38.63
33	1.05	1.02	-2.98	0.45	0.24	-45.98
34	1.21	1.13	-6.49	0.57	0.37	-34.86
35	1.18	1.16	-1.30	0.51	0.38	-23.81
36	1.20	1.14	-4.64	0.57	0.37	-35.12
37	1.27	1.24	-2.21	0.59	0.46	-22.48
39	1.13	1.12	-0.66	0.48	0.33	-30.23
40	1.26	1.27	0.35	0.58	0.43	-25.38
41	1.22	1.28	4.81	0.56	0.50	-11.14
42	1.24	1.15	-7.58	0.60	0.56	-6.66
43	1.39	1.13	-19.10	0.78	0.41	-47.42

Notes: Based on firm-level markup, this table calculates the mean and coefficient of variation of markup for all two-digit manufacturing industries in each year, and takes their respective average values for the years before and after 2009. Industry names and codes are specified as follows: Agricultural & Sideline Foods Processing (13), Food Production (14), Beverage Production (15), Textile Industry (17), Clothes, Shoes & Hat Manufacture (18), Leather, Furs, Down & Related Products (19), Timber Processing, Bamboo, Cane, Palm Fiber & Straw Products (20), Furniture Manufacturing (21), Papermaking & Paper Products (22), Printing & Record Medium Reproduction (23), Cultural, Educational & Sports Articles Production (24), Petroleum Processing, Coking & Nuclear Fuel Processing (25), Raw Chemical Material & Chemical Products (26), Medical & Pharmaceutical Products (27), Chemical Fiber (28), Rubber Products (29), Plastic Products (30), Non-metal Mineral Products (31), Smelting & Pressing of Ferrous Metals (32), Smelting & Pressing of Non-ferrous Metals (33), Metal Products (34), Ordinary Machinery Manufacturing (35), Special Equipment Manufacturing (36), Transport Equipment Manufacturing (37), Electric Machines & Apparatuses Manufacturing (39), Communications Equipment, Computer & Other Electronic Equipment Manufacturing (40), Instruments, Meters, Cultural & Office Machinery Manufacture (41), Craftwork & Other Manufactures (42), Waste Resources and Old Material Recycling & Processing (43).

Appendix B: Calculating the Real Capital Stock

In their original accounting statements, firms only report the value of their fixed capital stock at original purchase prices, which means that these book values are simply the sum of the nominal values of their fixed capital stock still in use, measured in their respective purchasing years. Thus, the direct use of these nominal values runs the risk of introducing systematic biases related to a firm's age (Brandt et al., 2012).

Below, we follow Brandt et al.'s (2012) method to construct real values of firms' fixed capital stock that are comparable across firms and over time. The procedure begins with estimating the real value of the fixed capital stock for the first year in which the firm appears in our dataset. For the firms established in or after 2005, the first year of our panel, the real value of the fixed capital stock in this start-up year is obtained by deflating the book value in the same year by the industry-level fixed assets investment price deflator. The problem becomes complicated for those firms established before 2005 in our dataset, as we do not have information on a firm's past investments and initial stock of capital. We address this problem by making assumptions about the investment growth and depreciation rates of the firms. In particular, we use information from the China Statistical Yearbooks to construct estimates of the average rate of growth of total investment in fixed assets. We do this at the sector level by provinces, between 1996 and each year from 2005 to 2012.¹ We then use the obtained average growth rates of investment in fixed assets at the province–sector level as the average investment growth rates of the firms in the period between the year of establishment and the first year they appear in the dataset.

Thus, the nominal capital stock of a firm in 2005 or whichever year the firm initially appeared in the dataset is equal to the product of the firm's initial nominal capital stock and $(1 + r_{ps})^n$, where n is the number of years since the firm was established,² and r is the estimated rate of growth in fixed assets investment in province p in sector s . Using

¹Data on total investment in fixed assets by sectors and provinces are available from 1996 onwards.

²We consider 1978 as the start-up year for firms established before 1978. The assumption here is that the nominal capital stock before 1978, the year the open-door policy was adopted in China, has no significant impact on the firms' real capital stock in 2005 and later.

this equation, we then calculate the nominal capital stock in each year up to 2005 or the first year the firm appeared in the dataset. Annual investment is directly reported by the NTSD. The real capital stock for 2005 or whichever year the firm initially appeared in the dataset is calculated by the perpetual inventory method, assuming a depreciation rate of 9% and deflating annual investment using the industry-level fixed assets investment price deflator. For the years after 2005 or the first year the firm appeared in the dataset, we use the observed change in the firm's nominal capital stock at original purchase prices between years as the estimate of nominal fixed investment. The same rate of depreciation and investment deflator are applied to roll the calculation of firms' real capital stock estimates forward.

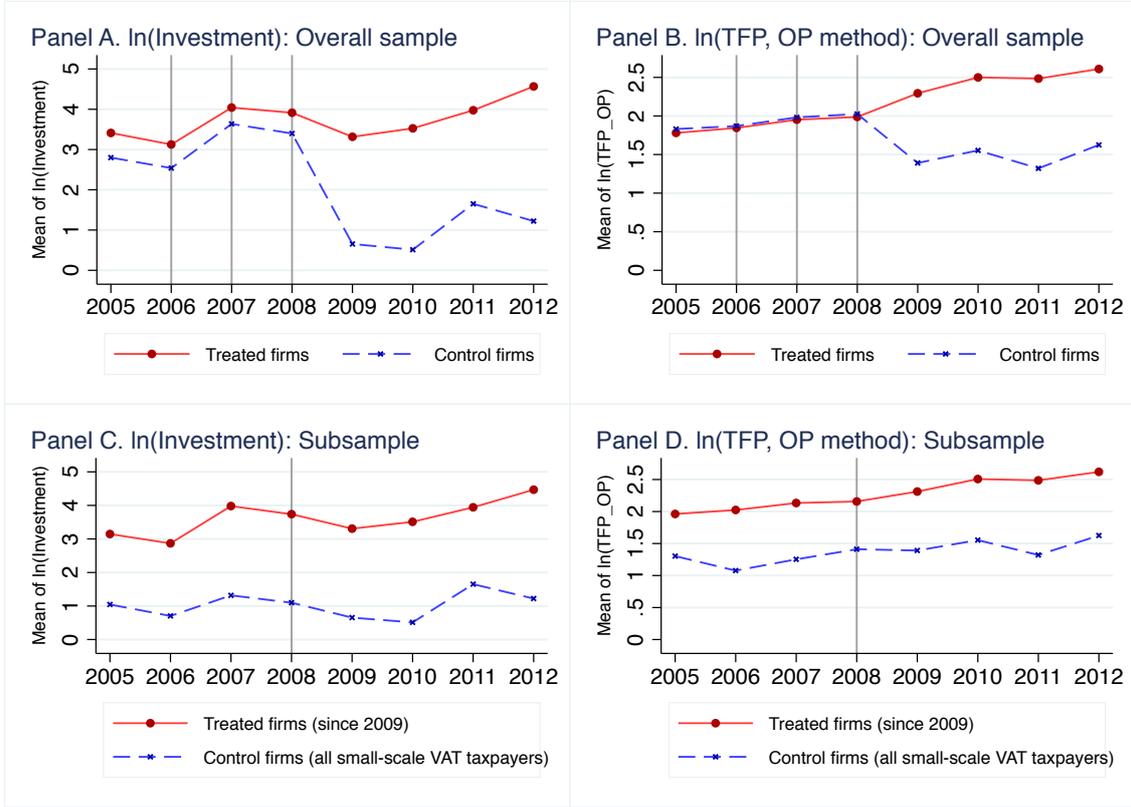
Appendix C: Descriptive Evidence

The validity of our identification strategy and main results are visually presented in Figure C1, which depicts the evolution of logarithmic investment and TFP for the treated and control firms. In Panels A and B of Figure C1, we utilize the overall manufacturing sample, covering all firms with different treatment status over years. In particular, the red solid lines represent weighted average values of the logarithm of investment and TFP for firms that have experienced the VAT incentives treatment over years, while the blue dashed lines denote the corresponding weighted average values for firms ineligible for the tax incentives in the same years.³ In the years before (and including) 2008, a year before the start of the nation-wide implementation of the VAT reform (i.e., final stage of the reform), the investment and TFP of the treated firms increased slightly at rates similar to those of the control firms. However, after 2008, the investment and TFP of the treated firms experienced a moderate increase, while the control firms saw a decrease in investment and TFP. Although these patterns in Panels A and B of Figure C1 shed light on the common trend experienced by the two groups of firms in the pre-treatment period, and reflect the treatment effects of the VAT reform, they should be interpreted with caution. This is because the red solid lines do not contain any pre-treatment information for the treated firms, though a significant difference exists for the treated firms before and after 2008.⁴ Similarly, the gaps between the treated and control firms after 2008 may not result from the pure treatment effects of the VAT reform; in particular, the blue dashed lines in the years before 2008 contain *both* the general VAT taxpayers that are not yet eligible for tax incentives treatment and the small-scale VAT taxpayers that are not eligible to the tax incentives throughout the entire period. However, in the years

³Note that in the calculation of Figure C1, to ensure comparison of the distribution of firms over years, we non-parametrically reweight the distribution of firms over years by ten size bins based on total assets crossed with ten size bins based on total sales. Specifically, as a reference base, we set the bins based on the distribution of total assets and total sales and compute bin counts and total counts separately for each group of (two-digit) industry-province for 2005 (i.e., the first year of our covered period). For all other years, we set weights at bin-level equal to the base-year fraction of firms in a bin divided by the corresponding year fraction of firms in a bin. This reweighting procedure was initially proposed by DiNardo et al. (1996) and was recently employed by Zwick and Mahon (2017).

⁴In the years before and including 2008, the treated firms only include a small fraction of firms in selected industries located in certain areas that had initiated the VAT reform. These are listed in Table A1 in the Appendix. After 2008, the treated firms include all general VAT taxpayers in the nation.

Figure C1: Trend Comparison of Firms' Investment and Productivity



Notes: Figure C1 illustrates the time trends of weighted average values of the logarithm of investment and TFP for the treated and control firms. In Panels A and B, we utilize the overall sample of manufacturing firms, where the treated firms are those firms that are eligible for the VAT incentives in *every* corresponding year and the control firms are those firms that are not eligible to the VAT incentives in the same years. Vertical lines on years 2006, 2007, and 2008 represent one year before the treatment years for different stages of the VAT reform in the overall manufacturing sample. In Panels C and D, we look at a subsample of the manufacturing firms, where the treated firms are those that became eligible for the tax incentives *only* after 2008 (i.e., due to the final stage of the VAT reform). The control firms are all small-scale VAT taxpayers that were ineligible for the VAT incentives during the whole sample period. Vertical line on year 2008 represents the year before the final stage of the reform. To ensure comparison of the distribution of firms over years, we non-parametrically reweight the distribution of firms over years by ten size bins based on total assets crossed with ten size bins based on total sales. Specifically, as a reference base, we set the bins based on the distribution of total assets and total sales and compute bin counts and total counts separately for each group of (two-digit) industry-province for 2005 (i.e., the first year of our covered period). For all other years, we set weights at bin-level equal to the base-year fraction of firms in a bin divided by the corresponding year fraction of firms in a bin. This reweighting procedure was initially proposed by DiNardo et al. (1996) and was recently employed by Zwick and Mahon (2017).

Source: Authors' calculations.

after 2008, these lines *only* contain the small-scale VAT taxpayers (recall that in the last stage of the reform, all general VAT taxpayers became eligible to the tax incentives), and thus, the gaps after 2008 may also be confounded with the original systematic difference between the general VAT taxpayers and small-scale taxpayers.

To illustrate the validity of common trend condition of the two groups of firms and the treatment effects of the VAT reform in a clearer manner, in Panels C and D of Figure C1 we look at a subsample of the manufacturing firms, consisting *only* treated firms due to the final stage of the reform (denoted by the red solid lines) and all small-scale VAT taxpayers that were ineligible for the tax incentives during the whole sample period (represented by the blue dashed lines). As shown, the eventually treated firms (general VAT taxpayers) and control firms (small-scale VAT taxpayers) show systematic difference but similar trends in the pre-treatment period (before the final stage of the VAT reform in 2009). However, they diverge a bit after 2008, when investment and TFP of the treated firms increased faster than the corresponding values for the control firms. As we shall show, this timing is commensurate with the timing of the nation-wide implementation of the VAT reform.

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- [3] Zwick, Eric, and James Mahon, 2017, Tax policy and heterogeneous investment behaviour, *American Economic Review* 107(1), 217-248.