

# Identifying FDI Spillovers

## Online Appendix

Yi Lu

Tsinghua University and National University of Singapore,

Zhigang Tao

University of Hong Kong

Lianming Zhu

Waseda University

This Version: December 2016

## 1 Appendix A: Determinants of Changes in FDI Regulations

To some extent, the changes in FDI *regulations* upon China's WTO accession in 2002 may not be randomly determined. This presents an identification issue that the treatment and control groups were not comparable before the changes in FDI regulations, which may potentially bias our DID estimation. Meanwhile, there is a reverse causality problem in that the productivity of China's domestic firms may affect the government's decision in modifying the FDI regulations, which may also cause estimation biases. In this appendix, we carefully examine the determinants of the changes in FDI regulations upon China's WTO accession in addressing these issues.

There are many reasons why the government decided to modify the Catalogue for the Guidance of Foreign Investment Industries in 2002. It is widely acknowledged that the central government of China was keen on making its domestic firms competitive in the era of globalization. According to the *Xinhua News* released on March 12, 2002, the government relaxed the FDI regulations for certain industries to promote industry upgrading and exports. Meanwhile, the government may protect infant industries in their early stages and encourage industrial clustering so as to boost development in those industries. Finally, the government also cares about how the relaxation of FDI regulations may impact labor market conditions, such as current employment and wages, which are critical for maintaining social stability in

the country.

To account for the above possible considerations of China’s government in relaxing its FDI regulations, we include seven variables: new product intensity (the ratio of new products in total output), export intensity (the ratio of exports to total output), number of firms, industrial clustering (the Ellison–Glaeser index), average age of firms, average employment, and average wage per worker.

The regression results are reported in column 1 in Table A2, in which the changes in FDI regulations (a dummy variable taking value 1 if FDI in an industry became more welcome, and 0 otherwise) are regressed on the aforementioned seven potential determinants in 1998, the initial year of the data available in our sample period. It is found that four variables are statistically significant: (1) new product intensity is found to have a positive effect; (2) export intensity is found to have a negative effect; (3) number of firms is found to have a positive effect; and (4) average age of firms is found to have a negative effect.

We further add a control of TFP in the regression to account for the potential reverse causality issue that the changes in FDI regulations may be reversely affected by TFP. As shown in column 2, the coefficient of TFP is not statistically significant, with magnitude close to zero. In column 3, we replace TFP level with the growth of TFP in the pre-WTO period (i.e., from 1998 to 2002). The estimated coefficient of the TFP growth rate is also insignificant. Combined, these result indicate that changes in FDI regulations are not reversely affected by TFP or the time trajectory of TFP.

## 2 Appendix B: Estimation of Firm TFP

Consider the following Cobb-Douglas production function in logs:

$$y_{ft} = \beta_l l_{ft} + \beta_k k_{ft} + \beta_m m_{ft} + \omega_{ft} + \epsilon_{ft}, \tag{A1}$$

where  $y_{ft}$  is the log of firm output, and  $l_{ft}$ ,  $k_{ft}$ , and  $m_{ft}$  are the inputs of log employment, log capital, and log materials, respectively.  $\omega_{ft}$  is firm productivity, and  $\epsilon_{ft}$  is measurement error and/or unanticipated shocks to output.

To obtain consistent production function estimates  $\beta = (\beta_l, \beta_k, \beta_m)$ , we need to control for unobserved productivity shocks potentially leading to simultaneity and selection biases. We use a control function based on a static input demand function to proxy for the unobserved productivity.

We follow the control function approach initiated by Olley and Pakes (1996), and extended by Levinsohn and Petrin (2003) and De Loecker and Warzynski (2012), and proxy for

the unobserved productivity using the following materials demand function:

$$m = m_t(\omega_{ft}, k_{ft}, EXP_{ft}). \quad (\text{A2})$$

where  $EXP_{ft}$  is firm's export status. Inverting (A2) yields the control function for productivity:

$$\omega_{ft} = h_t(k_{ft}, m_{ft}, EXP_{ft}).$$

In the first stage, we purge unanticipated shocks and/or measurement error  $\epsilon_{ft}$  by estimating the following equation:

$$y_{ft} = \phi_t(l_{ft}, k_{ft}, m_{ft}, EXP_{ft}) + \epsilon_{ft}, \quad (\text{A3})$$

which yields an estimate of predicted output ( $\hat{\phi}_{ft}$ ).

We use (A1) and (A3) from the first-stage estimation to express productivity:

$$\omega_{ft}(\boldsymbol{\beta}) = \hat{\phi}_{ft} - \beta_l l_{it} - \beta_k k_{it} - \beta_m m_{it}. \quad (\text{A4})$$

To estimate production function coefficients  $\boldsymbol{\beta}$ , we follow Akerberg, Caves, and Frazer (2015) and form moments based on innovation in the productivity shock  $\xi_{ft}$  in the law of motion for productivity:<sup>1</sup>

$$\omega_{ft} = g(\omega_{ft-1}, EXP_{ft}) + \xi_{ft}.$$

We use (A4) and nonparametrically regress  $\omega_{ft}(\boldsymbol{\beta})$  on  $g(\omega_{ft-1}, EXP_{ft})$  to obtain the innovation  $\xi_{ft}(\boldsymbol{\beta}) = \omega_{ft}(\boldsymbol{\beta}) - E(\omega_{ft}(\boldsymbol{\beta}) | \omega_{ft-1}(\boldsymbol{\beta}), EXP_{ft-1})$ .

The moment conditions used to estimate the production function coefficients are:

$$E(\xi_{ft}(\boldsymbol{\beta}) \mathbf{Y}_{ft}) = 0,$$

where  $\mathbf{Y}_{ft}$  contains lagged labor and materials, and current capital.<sup>2</sup>

Once the production function coefficients  $\hat{\boldsymbol{\beta}} = (\hat{\beta}_l, \hat{\beta}_k, \hat{\beta}_m)$  are estimated, we can compute firm productivity as follows:

$$\hat{\omega}_{ft} = \hat{\phi}_{ft} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it}.$$

---

<sup>1</sup>As in De Loecker (2013), we include firm's export status in the law of motion for productivity to account for the potential effect of exporting on productivity.

<sup>2</sup>Following the literature, we treat labor and materials as flexible inputs and their lagged values are used to construct moments. As capital is considered as a dynamic input that faces adjustment costs, its current value is used to form moments.

## References

- [1] Akerberg, Daniel A., Kevin Caves, and Garth Frazer, 2015. Identification properties of recent production function estimators. *Econometrica*. 83(6), 2411–2451.
- [2] De Loecker, Jan, 2013. Detecting learning by exporting. *American Economic Journal: Microeconomics*. 5(3), 1–21.
- [3] De Loecker, Jan, and Frederic Warzynski, 2012. Markups and firm-level export status. *American Economic Review*. 102(6), 2437–2471.
- [4] Levinsohn, James A., and Amil Petrin, 2003. Estimating production functions using inputs to control for unobservables. *Review of Economic Studies*. 70(2), 317–341.
- [5] Olley, Stephen G., and Ariel Pakes, 1996. The dynamics of productivity in the telecommunications equipment industry. *Econometrica*. 64(6), 1263–1297.

Table A1: Changes of FDI regulations (product level) between 1997 and 2002

		2002			
		(1)	(2)	(3)	(4)
		<i>Supported Category</i>	<i>Permitted Category</i>	<i>Restricted Category</i>	<i>Prohibited Category</i>
1997	(1) <i>Supported Category</i>	No change	Less welcome	Less welcome	Less welcome
	(2) <i>Permitted Category</i>	More welcome	No change	Less welcome	Less welcome
	(3) <i>Restricted Category</i>	More welcome	More welcome	No Change	Less welcome
	(4) <i>Prohibited Category</i>	More welcome	More welcome	More welcome	No Change

Table A2: Determinants of changes in FDI regulations (industry level)

Dependent variable: Changes in FDI regulations	(1)	(2)	(3)
New product intensity	1.571*** (0.253)	1.558*** (0.260)	1.593*** (0.256)
Export intensity	-0.257** (0.106)	-0.255** (0.106)	-0.257** (0.106)
(log) number of firms	0.032* (0.016)	0.032* (0.016)	0.031* (0.016)
Ellison-Glaeser index	0.742 (0.566)	0.732 (0.570)	0.749 (0.568)
Average age of firms	-0.009** (0.004)	-0.009** (0.004)	-0.008** (0.004)
(log) average employment	-0.009 (0.036)	-0.008 (0.036)	-0.011 (0.036)
(log) average wage per worker	0.086 (0.078)	0.087 (0.078)	0.082 (0.078)
(log) TFP		0.010 (0.051)	
TFP growth rate			-0.138 (0.335)
Observations	412	412	412
R-squared	0.130	0.130	0.130

Note: Observations are at the four-digit industry level. Robust standard errors are in parentheses. \*\*\*, \*\* and \* denote significance at the 1%, 5%, and 10% level, respectively.

Table A3: Privatization of SOEs

Dependent variable:	Degree of state ownership	FDI sector
	(1)	(2)
FDI sector	-0.069 (0.045)	
Treatment $\times$ Post02		-0.001 (0.007)
Firm fixed effects	Y	Y
Year fixed effects	Y	Y
FDI determinants $\times$ Year dummies	Y	Y
Tariff reductions $\times$ Year dummies	Y	Y
Time-varying firm controls	Y	Y
Observations	1,153,661	176,941

Note: Determinants of changes in FDI regulations include new product intensity, export intensity, number of firms, and average age of firms at the four-digit industry level in 1998. Tariff reductions include output tariff, input tariff, and export tariff at the four-digit industry level in 2001. Time-varying firm controls include firm output, export status, and capital-labor ratio. Standard errors are clustered at the four-digit industry level in parentheses.

Table A4: Foreign multinationals before and after WTO accession

	(1)	(2)	(3)
	1998-2001	2002-2007	Diff (2)–(1)
Percentage of wholly-owned FIEs	0.442	0.659	–0.217***
	(0.002)	(0.001)	(0.002)

Note: The percentage of wholly-owned multinationals in all foreign firms is reported for the pre-WTO 1998-2001 period, post-WTO 2002-2007 period, and their differences. \*\*\* denotes significance at the 1% level.

Table A5: Expectation effect

Dependent variable: Log firm TFP	(1)	(2)	(3)
Fake treatment timing in 2001	-0.006 (0.004)		
Fake treatment timing in 2000		-0.007 (0.005)	
Fake treatment timing in 1999			-0.007 (0.006)
Firm fixed effects	Y	Y	Y
Year fixed effects	Y	Y	Y
FDI determinants $\times$ Year dummies	Y	Y	Y
Tariff reductions $\times$ Year dummies	Y	Y	Y
SOE privatization $\times$ Year dummies	Y	Y	Y
Time-varying firm controls	Y	Y	Y
Observations	402,552	402,552	402,552

Note: Determinants of changes in FDI regulations include new product intensity, export intensity, number of firms, and average age of firms at the four-digit industry level in 1998. Tariff reductions include output tariff, input tariff, and export tariff at the four-digit industry level in 2001. SOE privatization is a ratio of state-owned enterprises in the total number of firms at the four-digit industry level in 2001. Time-varying firm controls include firm output, export status, capital-labor ratio, and SOE dummy. Bootstrapped standard errors are clustered at the four-digit industry level in parentheses.

Table A6: First-stage estimation results

	(1)	(2)	(3)
Panel A. Horizontal vs. vertical FDI			
Dependent variable	Horizontal FDI	Backward FDI	Forward FDI
Treatment $\times$ Post02	0.017** (0.007)	-0.002 (0.003)	0.002 (0.002)
$\alpha \times$ Treatment $\times$ Post02	0.044** (0.020)	0.145*** (0.015)	-0.011*** (0.004)
$\beta \times$ Treatment $\times$ Post02	0.030* (0.016)	-0.019 (0.014)	0.052*** (0.006)
Weak instrument test			
Anderson-Rubin Wald test	(32.32)***		
Stock-Wright LM S statistic	(109.08)***		
Panel B. Local vs. non-local FDI			
Dependent variable	FDI sector (local)	FDI sector (non-local)	
Treatment $\times$ Post02 $\times$ Local share	0.043** (0.021)	0.006 (0.021)	
Treatment $\times$ Post02 $\times$ Non-local share	0.831*** (0.193)	1.770*** (0.388)	
Weak instrument test			
Anderson-Rubin Wald test	(54.87)***		
Stock-Wright LM S statistic	(34.55)***		
Panel C. Developed vs. developing FDI			
Dependent variable	FDI sector (developed)	FDI sector (developing)	
Treatment $\times$ Post02	-0.002 (0.004)	0.018*** (0.006)	
Treatment $\times$ Indicator $\times$ Post02	0.008 (0.006)	-0.014* (0.008)	
Weak instrument test			
Anderson-Rubin Wald test	(6.52)**		
Stock-Wright LM S statistic	(10.69)***		
Panel D. TFP growth			
Dependent variable	FDI sector		
Treatment $\times$ Post02	0.013** (0.006)		
Weak instrument test			
Anderson-Rubin Wald test	(1.19)		
Stock-Wright LM S statistic	(3.28)*		
Panel E. Interaction with R&D intensity in 2001			
Dependent variable	FDI sector	FDI sector $\times$ R&D intensity in 2001	
Treatment $\times$ Post02	0.012* (0.007)	-0.000036 (0.000025)	
Treatment $\times$ Post02 $\times$ R&D intensity in 2001	0.017 (0.022)	0.034*** (0.009)	
Weak instrument test			
Anderson-Rubin Wald test	(7.95)**		
Stock-Wright LM S statistic	(11.54)***		
Panel F. Interaction with SOE dummy in 2001			
Dependent variable	FDI sector	FDI sector $\times$ SOE dummy in 2001	
Treatment $\times$ Post02	0.014** (0.007)	-0.003*** (0.001)	
Treatment $\times$ Post02 $\times$ SOE dummy in 2001	-0.006** (0.003)	0.015*** (0.005)	
Weak instrument test			
Anderson-Rubin Wald test	(13.20)***		
Stock-Wright LM S statistic	(26.39)***		

Note: First-stage estimation results of the IV estimation are reported in panels A-F. \*\*\*, \*\* and \* denote significance at the 1%, 5%, and 10% level, respectively.

Table A7: Dynamic effect

Dependent variable	TFP growth ( $t, t-1$ )	TFP growth ( $t, t+3$ )
	(1)	(2)
Lagged FDI sector	0.945*** (0.230)	
FDI sector		1.440*** (0.203)
Firm fixed effects	Y	Y
Year fixed effects	Y	Y
FDI determinants $\times$ Year dummies	Y	Y
Tariff reductions $\times$ Year dummies	Y	Y
SOE privatization $\times$ Year dummies	Y	Y
Time-varying firm controls	Y	Y
Observations	938,305	640,863

Note: Determinants of changes in FDI regulations include new product intensity, export intensity, number of firms, and average age of firms at the four-digit industry level in 1998. Tariff reductions include output tariff, input tariff, and export tariff at the four-digit industry level in 2001. SOE privatization is a ratio of state-owned enterprises in the total number of firms at the four-digit industry level in 2001. Time-varying firm controls include firm output, export status, capital-labor ratio, and SOE dummy. Bootstrapped standard errors are clustered at the four-digit industry level in parentheses. \*\*\* and \*\* denote significance at the 1% and 5% level, respectively.

Table A8: Different lags of FDI presence

Dependent variable: Log firm TFP	
FDI sector	-2.602*** (0.370)
One-year lagged FDI sector	-1.956* (1.079)
Two-year lagged FDI sector	-1.111** (0.504)
Three-year lagged FDI sector	-1.113 (1.174)
Firm fixed effects	Y
Year fixed effects	Y
FDI determinants $\times$ Year dummies	Y
Tariff reductions $\times$ Year dummies	Y
SOE privatization $\times$ Year dummies	Y
Time-varying firm controls	Y
Observations	441,320

Note: Determinants of changes in FDI regulations include new product intensity, export intensity, number of firms, and average age of firms at the four-digit industry level in 1998. Tariff reductions include output tariff, input tariff, and export tariff at the four-digit industry level in 2001. SOE privatization is the ratio of state-owned enterprises in the total number of firms at the four-digit industry level in 2001. Time-varying firm controls include firm output, export status, capital-labor ratio, and SOE dummy. Bootstrapped standard errors are clustered at the four-digit industry level in parentheses. \*\*\*, \*\* and \* denote significance at the 1%, 5%, and 10% level, respectively.

Table A9: Ratio of skilled labor

Dependent variable: Ratio of skilled labor	(1)	(2)
Indicator for foreign firms	0.022***	0.037***
	(0.001)	(0.001)
Industry fixed effects	N	Y
City fixed effects	N	Y
Observations	214,723	214,723

Note: Robust standard errors are in parentheses. \*\*\* denotes significance at the 1% level.