

The Local Technology Spillovers of Multinational Firms

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Abstract

This study investigates how the accumulation of patented technologies by multinational firms in the United States affects the productivity growth of the domestic firms co-located with their subsidiaries in China. Using firm-level data from both the United States and China, I match U.S. multinational firms with their manufacturing subsidiaries in China and use patent accumulation to measure multinational firms' innovation. To address potential endogeneity concerns, I adopt an instrumental variable strategy based on U.S. R&D tax credit policies. I find that the innovation of U.S. multinational firms causally improves the productivity of domestic firms in the same county as multinational subsidiaries, resulting in a local technology spillover effect. Moreover, domestic firms with high-quality human capital, innovation capacity, and private ownership are more capable of absorbing foreign technologies. Technology proximity also plays a crucial role in channeling multinational firms' technology spillovers, as domestic industries with closer technological ties to multinational firms benefit more from the local technology spillovers.

Keywords: FDI, technology spillovers, patents, productivity.

JEL codes: D2, F2, O1, O3

¹Email: rkgong@ust.hk. I thank Nicholas Bloom, Pete Klenow, Kyle Bagwell, and Hongbin Li for their thoughtful discussions and guidance. I also thank Caroline Hoxby, Pascaline Dupas, Bingjing Li, Isaac Sorkin, Daniel Xu, Matilde Bombardini, Heiwai Tang, and seminar participants in Stanford, SAIF, GWU, IMF, UArkansas, HKUST, CityU, HKU, NUS, Nanjing U, and the 5th PRN Conference in Tokyo for their detailed suggestions and comments. I thank two anonymous referees for providing insightful comments. I also thank Professor Jianghuai Zheng from Nanjing U for data support. Financial support from the Stanford Institute for Research in the Social Sciences Dissertation Fellowship and the Stanford Institute for Economic Policy Research Dixon and Carol Doll Graduate Fellowship is gratefully acknowledged. All mistakes are my own.

Table 1: Summary statistics

Panel A. Matched subsidiaries						
	Mean	Std. Dev.	25 Percentile	Median	75 Percentile	Observations
Gross output (millions RMB)	676.19	3832.23	66.44	162.86	393.32	1988
Value added (millions RMB)	200.97	1120.48	15.59	47.41	125.77	1988
Employment	512.33	1128.76	88.00	201.50	501.00	1988
Wage (thousands RMB)	53.47	217.83	22.31	37.64	63.25	1988
$TFP - LP$	-0.82	1.74	-1.15	-0.52	0.04	1988
Labor productivity	12.03	1.89	11.38	12.29	13.12	1988
Wholly foreign ownership (%)	0.90					1988
Panel B. Domestic firms in matched counties						
	Mean	Std. Dev.	25 Percentile	Median	75 Percentile	Observations
Gross output (millions RMB)	68.06	747.53	8.60	16.42	37.39	221923
Value added (millions RMB)	17.75	225.94	1.88	4.02	9.62	221923
Employment	200.93	640.86	45.00	86.00	175.00	221923
Wage (thousands RMB)	15.77	47.68	9.29	12.20	17.26	221923
$TFP - LP$	-1.16	1.38	-1.59	-1.01	-0.51	221923
Labor productivity	10.61	1.51	10.07	10.71	11.41	221923
State ownership (%)	0.21					221923
Collective ownership (%)	0.20					221923
Private ownership (%)	0.59					221923
Panel C. Patent stock measures						
	Mean	Std. Dev.	25 Percentile	Median	75 Percentile	Observations
$\ln(PatStock^{mnc})$	7.53	2.56	6.54	7.85	9.23	1988
$\ln(\widehat{PatStock}^{mnc})$	0.21	0.89	-0.11	0.51	0.82	1988
$\ln(PatStock^{loc})$	2.63	3.28	1.02	2.89	5.20	221923
$\ln(\widehat{PatStock}^{loc})$	-5.03	2.04	-6.09	-4.70	-3.50	221923
$\ln(PatStock^{prox})$	-3.10	3.44	-4.91	-2.75	-0.57	211221
$\ln(\widehat{PatStock}^{prox})$	-10.16	2.69	-11.52	-9.86	-8.19	211221

Notes: This table presents the summary statistics for the key variables in the analysis. Panel A shows the characteristics of the matched subsidiaries, panel B shows the characteristics of the domestic firms in the matched counties, and panel C shows the distribution of the multinational technology stock measures. The units are noted in the parentheses, if necessary.

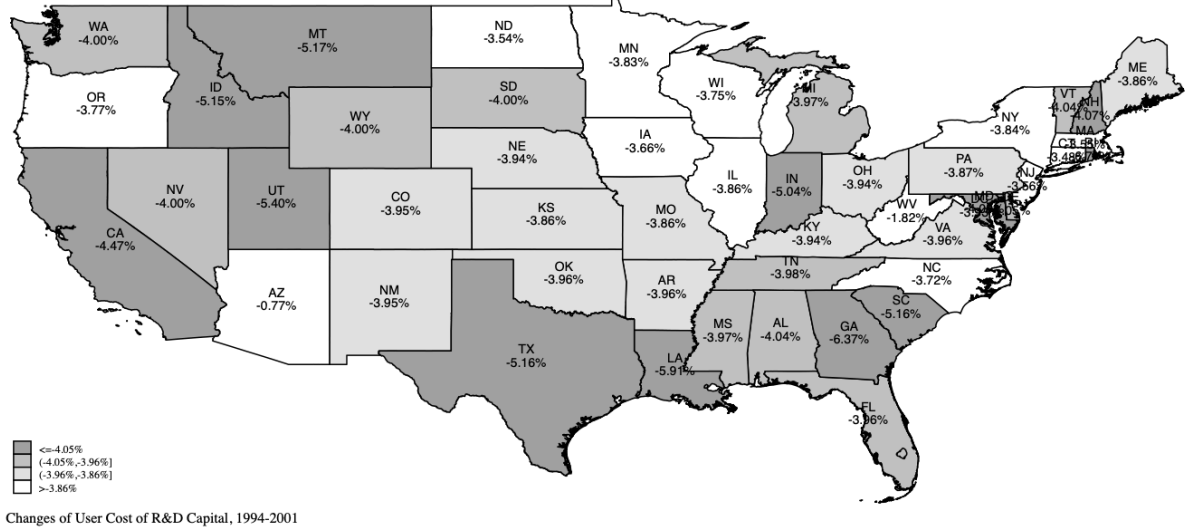
Figure 1: Geographic distribution of $\ln(PatStock^{loc})$ in 2000



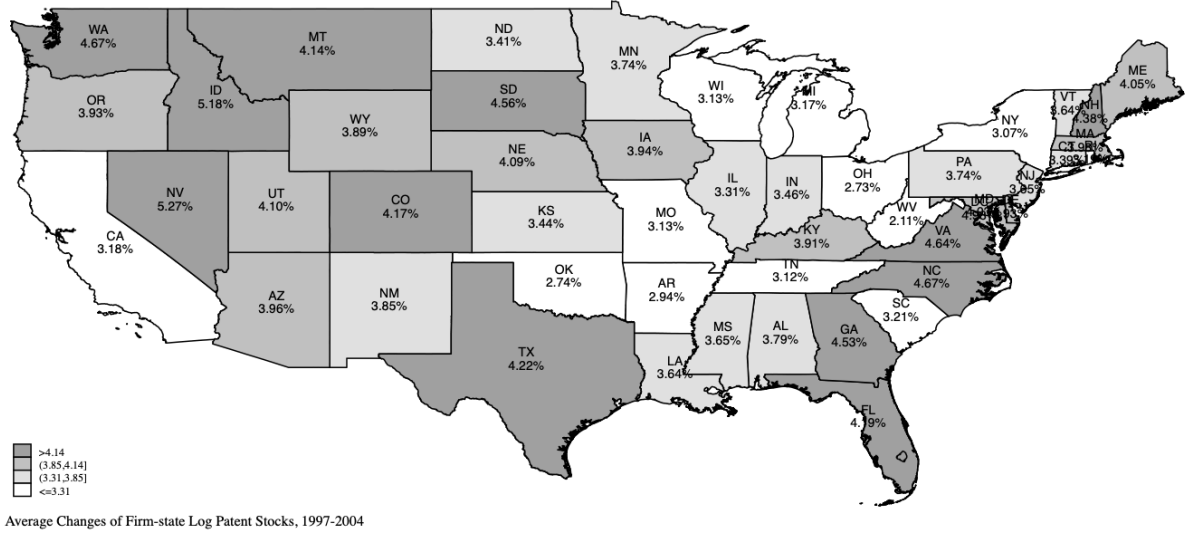
Notes: This figure shows the geographic distribution of the city-level patent stocks of U.S. multinational firms, which is the three-year lagged log weighted sum of the multinational firms' citation-weighted patent stocks. The subsidiaries are located in 121 counties out of 2,280 in total.

Figure 2: Changes of R&D Capital User Cost and Log Patent Stock

Panel A: Change of R&D Capital User Costs



Panel B: Average change of Log Patent Stock (Citation-weighted)



Notes: The figures show the geographic distribution of the changes in the R&D capital user cost and median log patent stock. The upper figure shows the change in the R&D capital user cost from 1994 to 2001. The lower figure shows the change in the median firm-state log patent stock from 1997 to 2004, corresponding to the years of my empirical analysis.

Table 2: First-stage Regressions

Panel A. U.S. firm-state level regressions				
Dependent variable	ln(SimpleCounts)		ln(CitationWeightedCounts)	
	(1a)	(2a)	(3a)	(4a)
ρ_{t-3}^h	-1.664*** (0.437)	-1.738*** (0.667)	-1.794** (0.830)	-3.491*** (1.318)
Firm-state fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Firm-specific year trends	No	Yes	No	Yes
State-specific year trends	No	Yes	No	Yes
Observations	494639	494639	494639	494639
Panel B. first stage regressions				
Dependent variable	$ln(PatStock^{mnc})$		$ln(PatStock^{loc})$	
	(1b)	(2b)	(3b)	(4b)
$ln(\widehat{PatStock}^{mnc})$	6.243*** (0.984)	6.238*** (0.977)		
$ln(\widehat{PatStock}^{loc})$			2.164*** (0.476)	2.158*** (0.478)
Firm fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes
Ownership-year fixed effects	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes
Observations	1988	1988	221923	221923

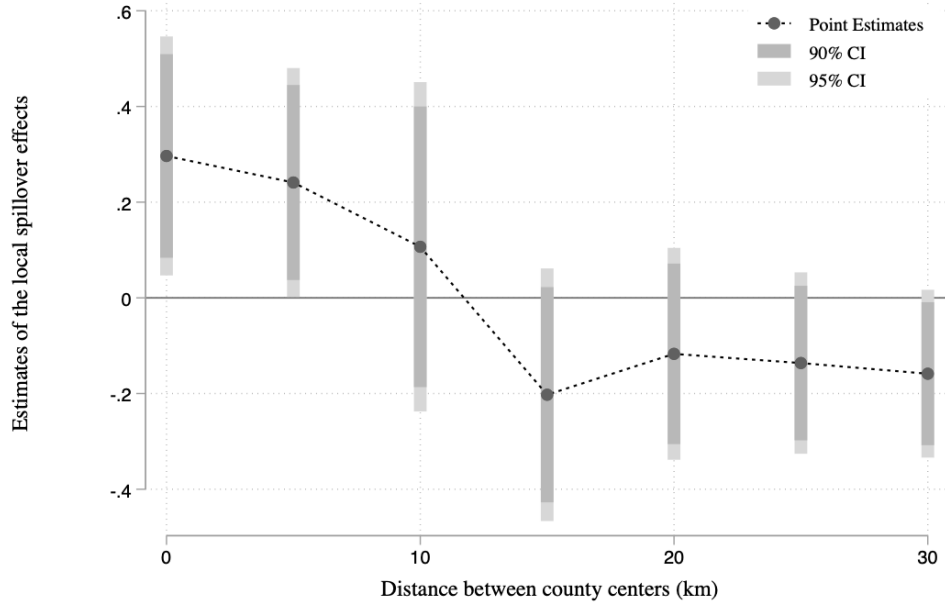
Notes: This table presents the first-stage regression results for Equation ?? and Equation ?. Regressions are weighted using the adjusted initial employment of the firms. Robust standard errors are clustered at the parent firm level in columns 1 and 2, and at the county level in columns 3 and 4. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

Table 3: The Effect of U.S. MNC Innovation on Local Firms' Productivity

Dependent variable	TFP-LP			Labor productivity		
Estimation method	OLS	IV	IV	OLS	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)
$ln(PatStock^{loc})$	0.106 (0.0955)	0.277** (0.138)	0.297** (0.127)	0.202** (0.0997)	0.428*** (0.157)	0.438*** (0.146)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Ownership type-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Initial conditions X year dummy	No	No	Yes	No	No	Yes
IV test		$F = 20.685$	$F = 20.376$		$F = 20.685$	$F = 20.376$
Observations	221923	221923	221923	221923	221923	221923

Notes: This table presents the regression results of equation ?. The regression sample includes all local Chinese firms with domestic ownership. The regressions are weighted using the adjusted initial employment of the firms. $TECH^{loc}$ is the county-level aggregated patent stocks of U.S. multinational firms. Columns 1, 2, and 4 show the OLS estimates, and columns 3, 5, and 6 show the IV estimates. Column 1 controls for firm fixed effects and year fixed effects. Columns 2-6 control for firm fixed effects, 4-digit Chinese industry-year fixed effects, and ownership type-year fixed effects. Robust standard errors are clustered at the county level. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

Figure 3: Example of Name Matching Procedure



Notes: This figure shows an example of the matching procedure. In the first step (not shown here), I use text scraping tools to identify U.S. public firms operating in China during years around 2000. In the second step, I manually extract the names of the subsidiaries (if exist) from both Exhibit 21 and the main text of the 10-K files. In the third step, I search for the keywords of the names in Chinese, and find the exact names of those subsidiaries. In the last step, I search for the exact names in the ASIE data. I also double check the information in the ASIE data with the information in the 10K and the online searching results to ensure the matching accuracy.

Table 4: The Heterogeneous Effect of U.S. MNC Innovation

Dependent variable Sample	TFP-LP					
	$wage > median$ (1)	$wage \leq median$ (2)	$newproduct > 0$ (3)	$newproduct = 0$ (4)	$Private = 1$ (5)	$Private = 0$ (6)
$\ln(PatStock^{loc})$	0.470*** (0.157)	0.119 (0.161)	0.497*** (0.172)	0.123 (0.135)	0.274* (0.160)	0.162 (0.139)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Ownership type-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Initial conditions X year dummy	Yes	Yes	Yes	Yes	Yes	Yes
IV test	$F = 20.125$	$F = 23.851$	$F = 41.626$	$F = 29.606$	$F = 7.120$	$F = 13.488$
Observations	89537	132065	36219	185242	152850	68659

Notes: The regression sample includes all local Chinese firms with domestic ownership. The regressions are weighted using the adjusted initial employment of the firms. $TECH^{loc}$ is the county-level aggregated patent stocks of U.S. multinational firms. The IV estimates are reported in all columns. All columns control for firm fixed effects, 4-digit Chinese industry-year fixed effects, and ownership type-year fixed effects. Robust standard errors are clustered at the county level. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

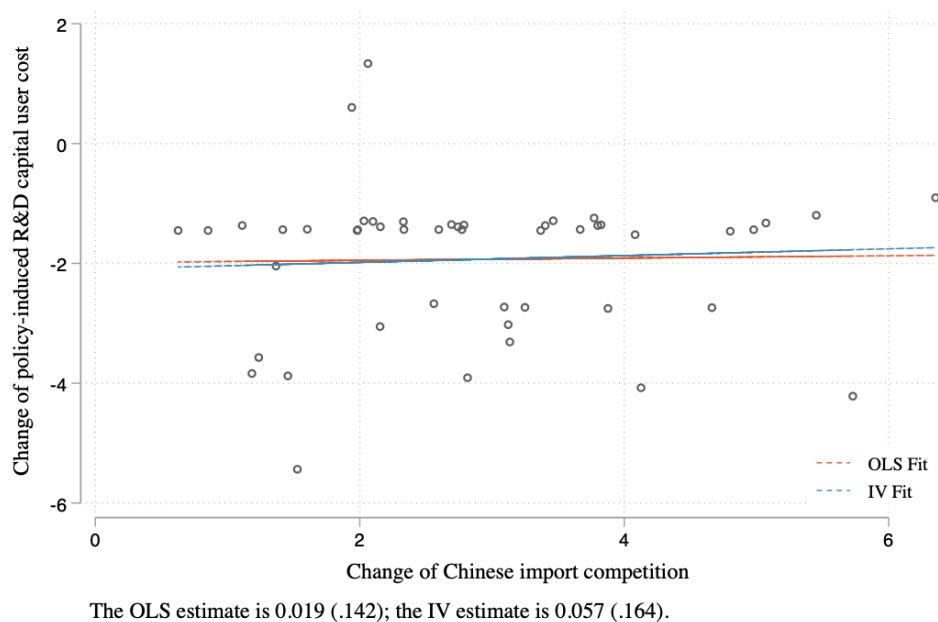
Table 5: The Effect of U.S. MNC Innovation through Technological Linkages

Dependent variable	TFP-LP				
Estimation method	OLS	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)
$\ln(PatStock^{prox})$	0.0430*** (0.0136)	0.0680*** (0.0220)	0.0662*** (0.0218)	0.0491** (0.0220)	0.0521** (0.0216)
$\ln(PatStock^{loc})$				0.242 (0.165)	
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes
Ownership type-year fixed effects	Yes	Yes	Yes	Yes	Yes
County-year fixed effects	No	No	No	No	Yes
Initial conditions X year dummy	No	No	Yes	Yes	No
IV test		$F = 869.585$	$F = 886.679$	$F = 384.441$	$F = 1331.000$
Observations	211028	211028	211028	211028	211028

Notes: This table shows the effects of local multinational technology shocks on local domestic firms' performance through technological proximity. The regressions are weighted using the adjusted initial employment of the firms. $TECH^{prox}$ is the county-level patent stocks of U.S. multinational firms aggregated by technological proximity. All columns report the IV estimates. Columns 1, 3, and 5 control for firm fixed effects, 4-digit Chinese industry-year fixed effects, and ownership type-year fixed effects. Columns 2 and 4 control for county-year fixed effects in addition. Columns 6, 7, and 8 control for firm fixed effects, IO sector-year fixed effects, and ownership-year fixed effects. Robust standard errors are clustered at county by industry level. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

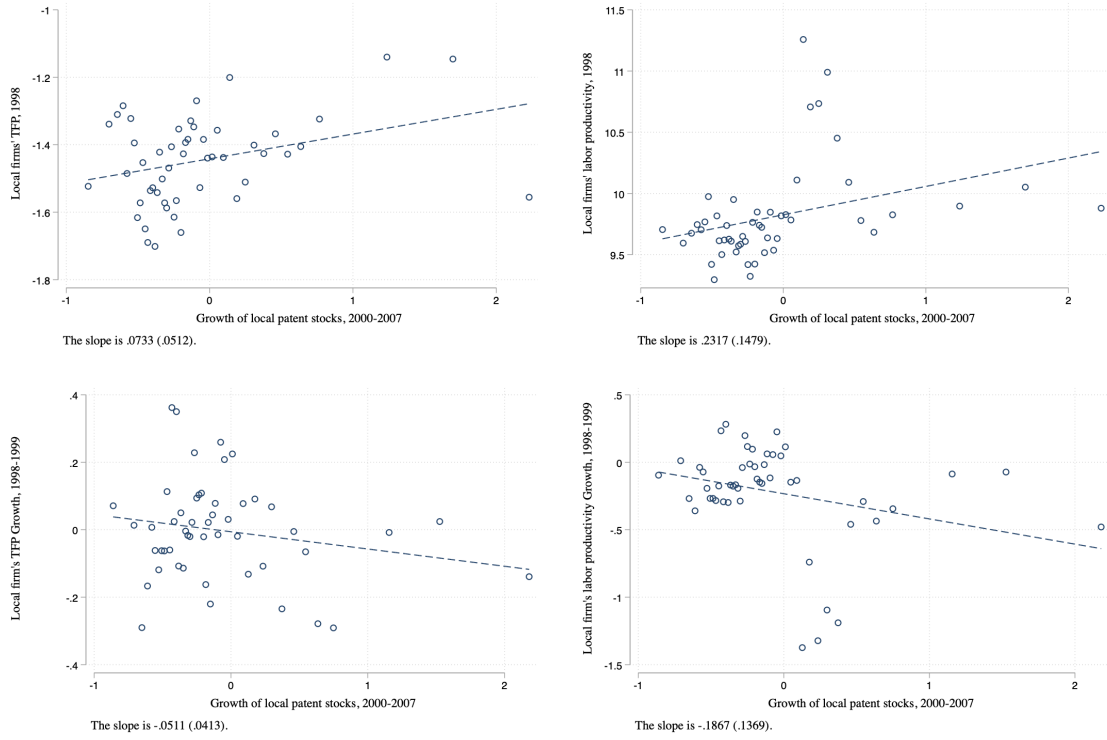
Appendix A Additional Figures and Tables

Figure A.1: Chinese Import Competition and R&D Tax Credit



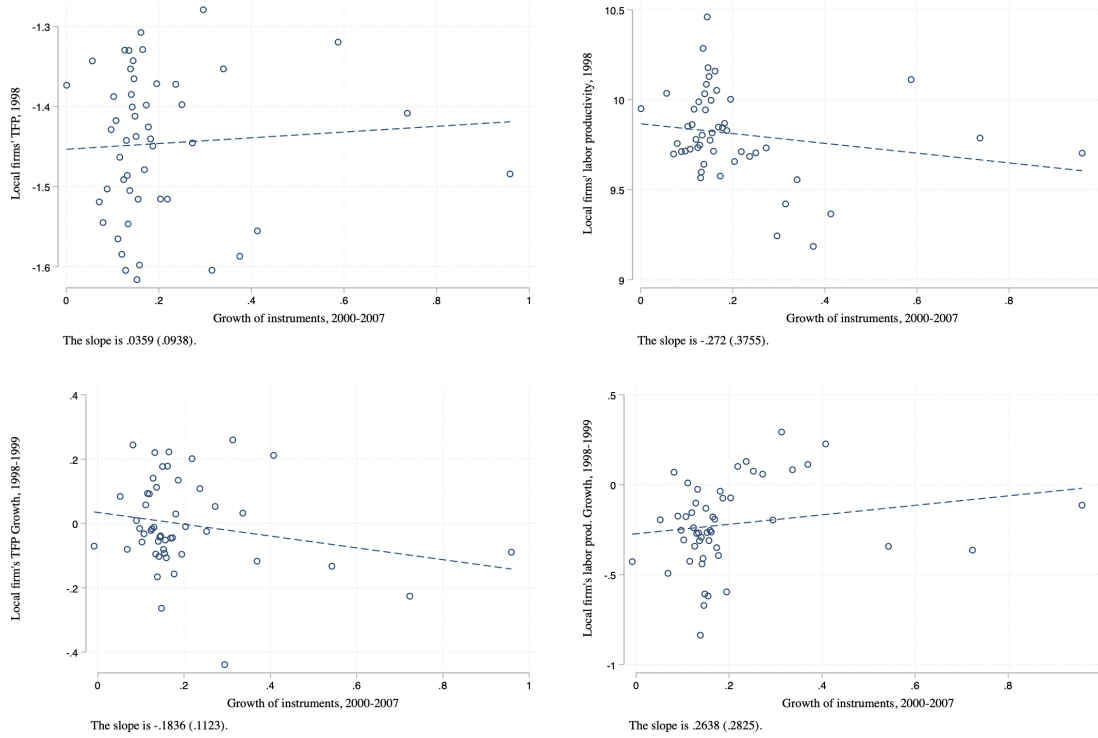
Note: The figure shows the scatter plot of the state R&D tax credit-induced changes in the user cost of R&D capital from 2000 to 2007 versus state-level import competition changes from 2000 to 2007 based on ?. The red dot line shows the OLS fit, and the blue dot line shows the IV fit, using import competition to other high-income countries as the instrument. Robust standard errors are reported.

Figure A.2: Ex-ante economic outcomes and ex-post patent stock changes



Note: The figures show the relationship between the ex-ante economic outcomes and the ex-post changes of U.S. multinational firms' local technology stocks. Each figure presents a binscatter plot (and a linear fit) that represents the correlation between an ex-ante outcome variable of local firms and the ex-post changes of the local technology stocks, after controlling for an industry fixed effects. The first row of figures show the correlation between the levels of local firms' value-added output, TFP, and labor productivity in 1998 and the changes of the local technology stocks between 2000 and 2007; the second row of figures show the correlation between the changes of local firms' value-added output, TFP, and labor productivity from 1998 to 2000 and the changes of the local technology stocks between 2000 and 2007.

Figure A.3: Ex-ante economic outcomes and ex-post instrument changes



Note: The figures show the relationship between the ex-ante economic outcomes and the ex-post changes of U.S. multinational firms' local technology stocks. Each figure presents a binscatter plot (and a linear fit) that represents the correlation between an ex-ante outcome variable of local firms and the ex-post changes of the local technology stocks, after controlling for an industry fixed effects. The first row of figures show the correlation between the levels of local firms' value-added output, TFP, and labor productivity in 1998 and the changes of the local technology stocks between 2000 and 2007; the second row of figures show the correlation between the changes of local firms' value-added output, TFP, and labor productivity from 1998 to 2000 and the changes of the local technology stocks between 2000 and 2007.