

A Lecture on International Technology Transfer and Intellectual Property – Preview of Ongoing Research

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The statistical analysis of firm level data on US multinational companies and their foreign affiliates was conducted at the Bureau of Economic Analysis, United States Department of Commerce, under arrangements that maintain legal confidentiality requirements. Views expressed in this paper are those of the authors and do not necessarily reflect the official positions of the US Department of Commerce.

* Joint, ongoing work with Olena Ivus and Kamal Saggi. I am solely responsible for any errors and/or omissions in this presentation.

Motivation

“Protection and enforcement of intellectual property rights should contribute...to the transfer and dissemination of technology.”

Article 7 of the Agreement on TRIPs

Intellectual Property Rights (IPR) can affect different modes of technology transfer: export, foreign direct investment (FDI), and licensing.

This study examines the impact of IPR protection on the **volume** and **composition** of international technology transfer, using U.S. multinational parent firm data.

- *Necessary to account for substitution/scale effects*
- *Significance: welfare, technological impacts vary by mode (e.g. employment, pricing and access, knowledge diffusion).*

Previous Contributions

- Entry Modes (Trade, FDI, or Licensing)
- Maskus & Penubarti (1995)
- Lee & Mansfield (1996)
- Smith (1999, 2002)
- Javorcik (2004)
- Branstetter et al. (2005)
- Park & Lippoldt (2005)
- Ivus (2009)
- Extensions
 - Analyze substitution vs. volume effects
 - More recent data, annual
 - Control for **Imitation Risk** (varies by industry; e.g. pharmaceuticals (easy to imitate) to transportation equipment (complex))
 - Focus on Manufacturing industries in the “South”

Conceptual Framework

Based on Ibus, Park, and Saggi (2013)

Overview

- Theory predicts:
 - Licensing occurs where imitation risk **low** (relatively safe)
 - Northern production (and export therefrom) where imitation risk is **high**
 - FDI occurs where imitation risk is **intermediate**
 - IPR expansion increases scale of technology transfer, but favors licensing over FDI

Conceptual Framework

Model Ingredients

Two countries: North (innovator) vs. South (imitator)

Continuum of industries $z \in [0, 1]$

<u>Choices</u>	<u>Pros/Cons</u>
Northern Production	No leakage / Higher Labor Costs
FDI	Lower Labor Costs / Imitation Risk, Costs of Establishment
Licensing	No Set-up costs / Greater Imitation Risk, and Rent Sharing

Conceptual Framework

Model Ingredients

For each z , $n(z)$ innovated products, $n^*(z)$ imitated

Imitation growth: $\dot{n}^*(z) = m(z)n(z)$

Suppose: $m(z) = \mu z$ for FDI

$m(z) = \iota \mu z$ for Licensing,

$$\iota > 1$$

μ = index of IPRs (inverse)

Higher $z \rightarrow$ greater imitation risk

Conceptual Framework

Other Assumptions

- Consumers spend equal share of their budget on all products
- Production function: Output = Labor

Pricing

North: $p = \alpha w$, $\alpha > 1$ (markup)

South: $p^* = \alpha w^*$, $\alpha > 1$ (markup), if no imitation
 $p^* = w^*$ if imitation

Let relative wage $\omega = w/w^* > 1$

Conceptual Framework

Multinational Firm's Choices

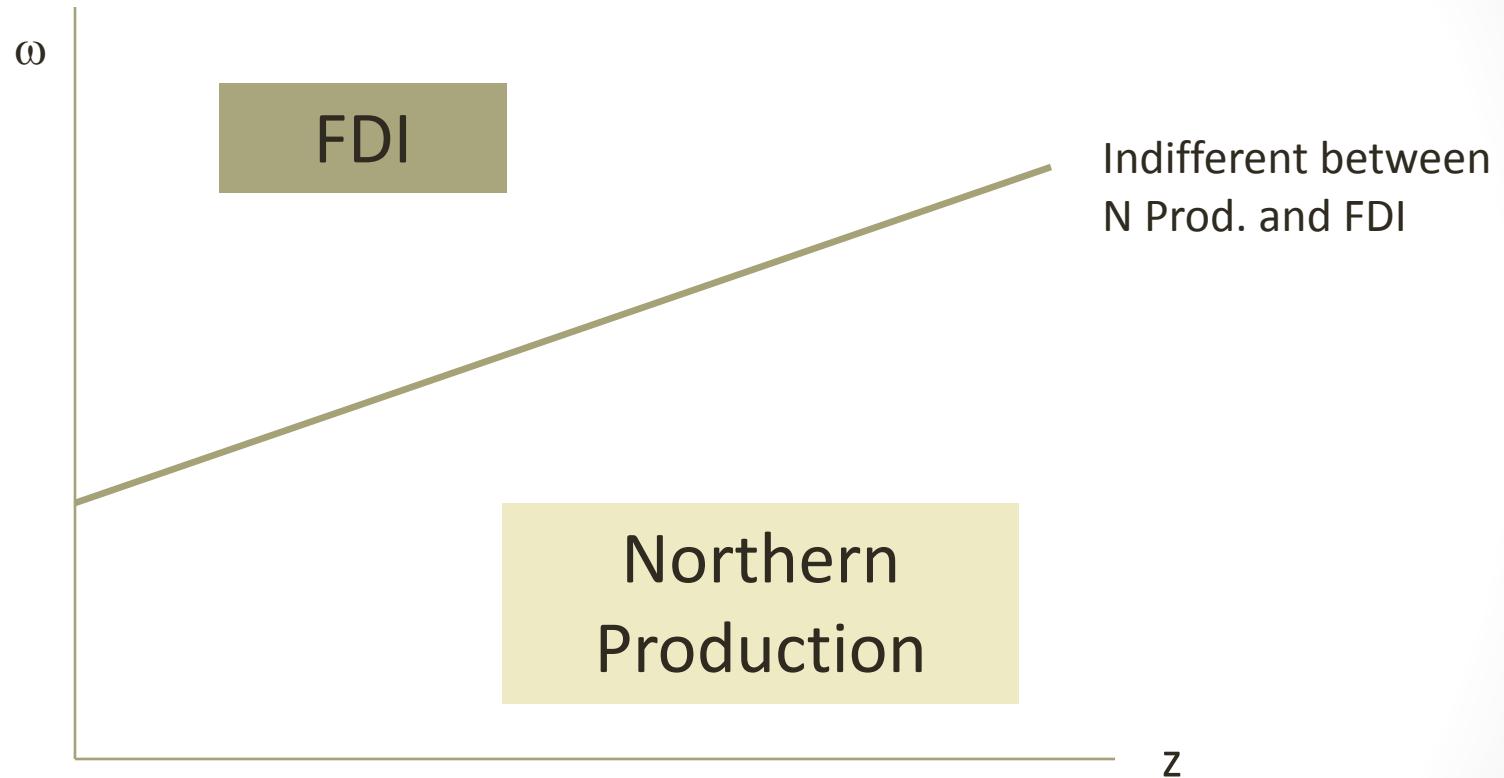
- $V(z) = \max[V^N(z), V^F(z), V^A(z)]$

$V^N = V^N(\omega, z)$ present discounted value of profits associated with Northern Production; $V_1^N < 0, V_2^N > 0$

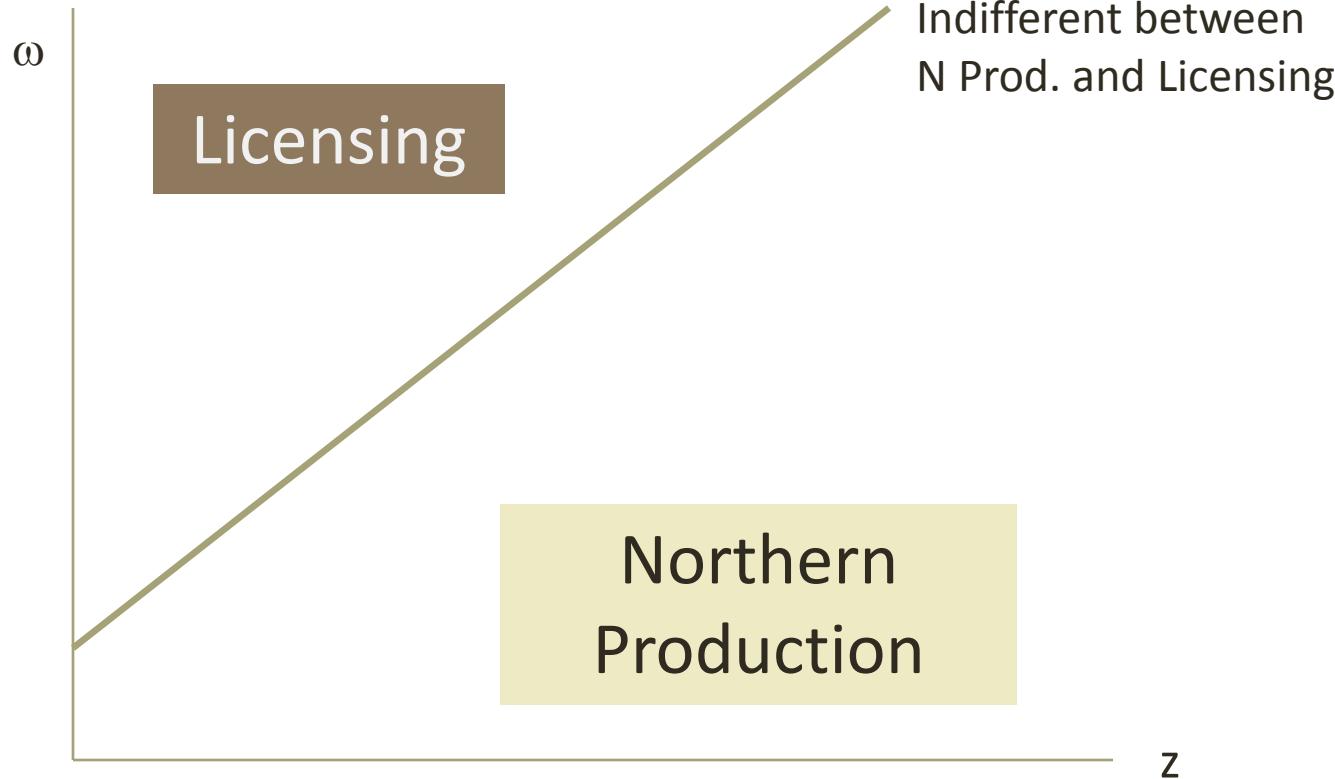
$V^F = V^F(\omega, z)$ present discounted value of profits associated with FDI; $V_1^F > 0, V_2^F < 0$

$V^A = V^A(\omega, z)$ present discounted value of profits associated with Licensing; $V_1^A > 0, V_2^A < 0$

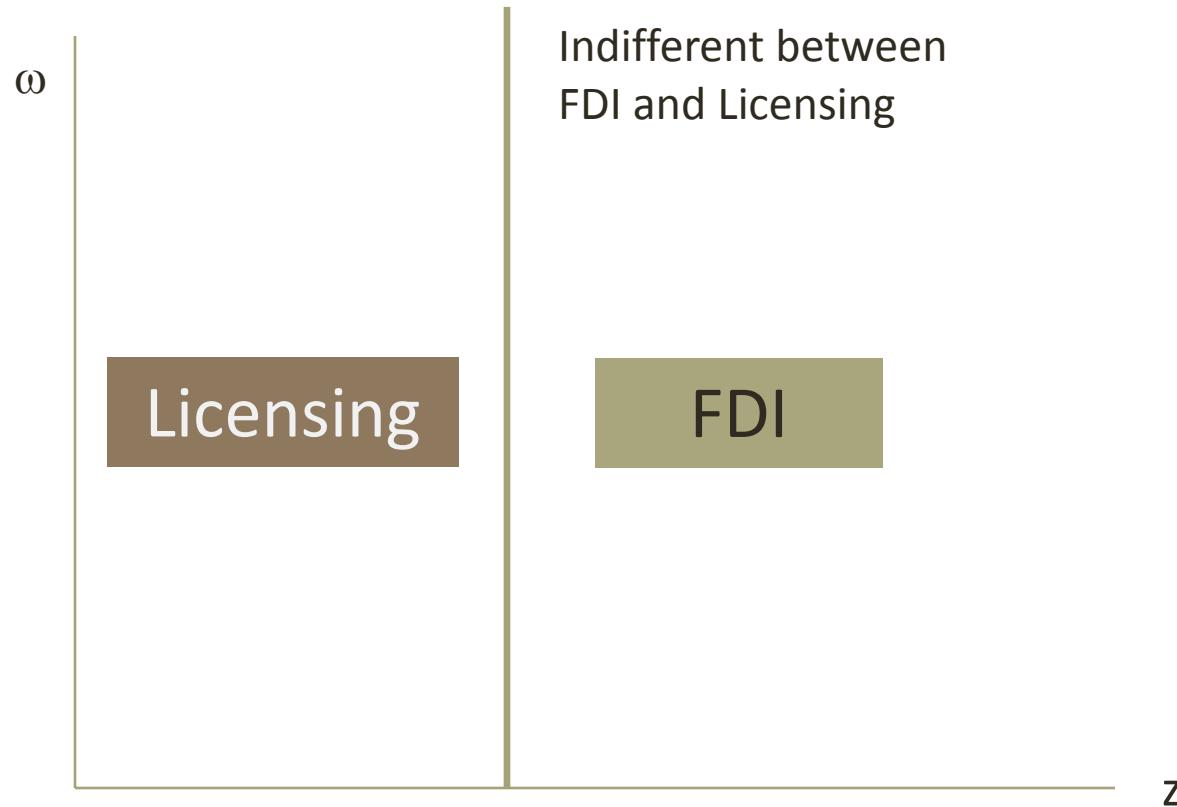
Choose FDI over Northern Production if $V^F > V^N$



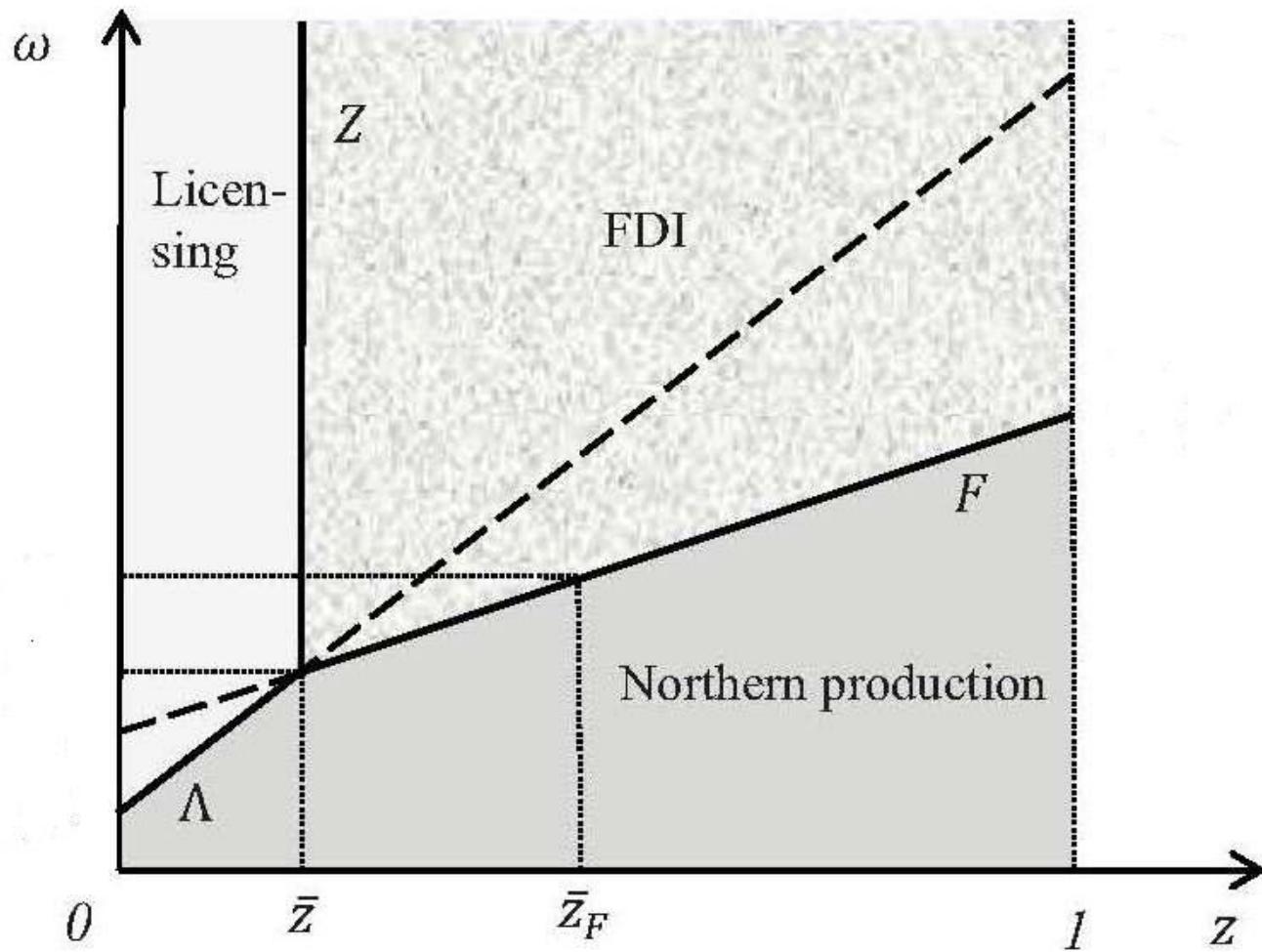
Choose Licensing over Northern Production if $V^A > V^N$



Choose Licensing over FDI if $V^A > V^F$



....COMBINED

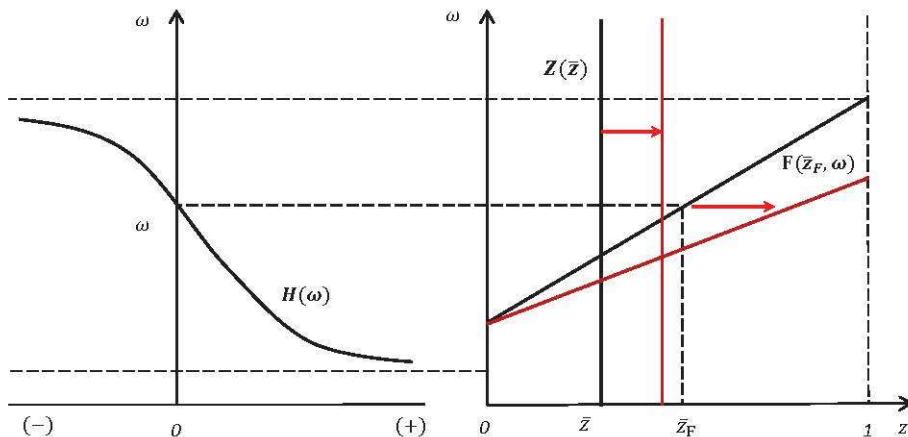


- See Ivus, Park, and Saggi (2013)

Effect of Strengthening IPRs

- Equivalent to a decrease in μ

Strengthening IPRs



- Overall technology transfers rise. Licensing increases; FDI may increase/decrease

Methodology

The main regression model is:

$$\ln Y_{ijt} = \alpha_i + \alpha_j + \alpha_t + H_{jt} + \beta X_{ijt} + \gamma_1 p_{jt} + \gamma_2 a_{it} + \gamma_3 p_{jt} * a_{it} + \varepsilon_{ijt}$$

where

i indexes the parent firm (which is the unit of analysis)

j indexes country

t indexes time

We ‘expect’ (hypothesize) that:

- for licensing (l), $\gamma_1 > 0$ $\gamma_2 > 0$ $\gamma_3 < 0$
- for FDI (f) $\gamma_1 > 0$ $\gamma_2 < 0$ $\gamma_3 > 0$

capturing both scale and substitution effects.

Data

- Source: U.S. Bureau of Economic Analysis
 - U.S. Direct Investment Abroad (BE-11 Survey)
 - FDI, Sales, Value Added, R&D
 - Quarterly Survey of Transactions in Selected Services and Intellectual Property with Foreign Persons (BE-125 Survey)
 - Licensing (Affiliated, Unaffiliated)
- Other
 - U.S. Patents Granted (National Bureau of Economic Research)
 - Wage (International Labor Office, Occupational Survey)
 - Country Risk (PRS Group Inc.)
 - Capital Restrictions (IMF Annual Report on Exchange Restrictions)
 - Patent Rights (Park (2008))
- Unit of Analysis:
 - U.S. Parent Firm investing/operating in 89 developing countries
 - 1989 - 2009

Data

- Measure of IPR
 - Park (2008) Research Policy
 - Index (Intensity of Reforms)
 - Dummy Variable (Major Reform = Yes, No)
- Measure of z
 - U.S. Patents Granted (inversely related to 'z')
 - Quintile Rank

$$a = \begin{cases} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{cases}$$

Sample Statistics

Patent Rank Quintile 'a'		Affiliated Licensing	Unaffiliated Licensing	Total Licensing
1	Mean	766.8	146.5	913.3
	S.D.	5554.8	1547.1	5761.7
2	Mean	284.7	204.8	499.0
	S.D.	3285.6	2622.5	4237.9
3	Mean	614.9	161.0	775.9
	S.D.	4262.6	2248.3	4836.9
4	Mean	474.5	212.7	687.8
	S.D.	2727.9	2025.5	3738.9
5	Mean	464.6	262.5	727.3
	S.D.	3074.0	3771.9	5196.5
Total	Mean	500.6	217.7	720.1
	S.D.	3523.4	2885.8	4770.3

Notes:

All are in real 2005 PPP adjusted US dollars

a' = rank in US patents granted (higher the more patents)

Sample Statistics

Meta-groups	Patents	Licen	FDI	Ratio of Licen/FDI x 1000
Chem (non-pharm)	32.11	163.32	24086	6.78
Pharm and medicines	33.54	49.00	33020	1.48
Rubber & Plastics	5.04	42.44	19473	2.18
Petroleum	46.46	71.39	167238	0.43
Aerospace products and parts manufacturing	38.53	1001.91	70807	14.15
Motor Vehicles	51.85	124.47	60193	2.07
Food, Beverages, Tobacco	6.09	110.65	34549	3.20
Machinery	38.05	235.41	37759	6.23
Equipment	26.15	522.15	34149	15.29
Textiles	6.74	78.10	12451	6.27
Wood	20.32	113.19	29113	3.89
Metals	7.80	17.88	24284	0.74
Total Manuf.	27.51	198.80	42937	4.63

Sample Statistics

LHS Variables	Mean	Std Dev
Total Licensing	713.9	5191.6
FDI	42936.9	391685.9
Parent's Value Added	3721366	6542542
Parent's Sales	1.21E+07	2.51E+07

RHS Variables	Mean	Std Dev
Parent's R&D/Sales	3.70%	11.10%
GDP destination	7.00E+11	1.05E+12
U.S./South wage ratio	6.59	5.44
Patent Index (0 - 5)	2.39	1.06
Patent Reform (0 - 1)	0.42	0.49
Country Risk (0 - 100)	70.4	9.86
Capital Restrictions (0 - 1)	0.75	0.43

Notes:

All manufacturing; LHS variables are in thousands of real 2005 PPP adjusted U.S. dollars

Sample Statistics

Activity Level	Mean Patent Rank Quintile 'a' of U.S. firm engaged in unaffiliated foreign licensing		Mean Patent Rank Quintile 'a' of U.S. firm engaged in total foreign licensing	Mean Patent Rank Quintile 'a' of U.S. firm engaged in FDI
	Low	Medium Low	3.54	2.97
Medium High	2.93		3.50	2.99
High	3.59		3.20	2.57
				3.11

Patent Rank Quintile 'a'	Pre- reform Licensing (I)	Post- Reform Licensing (I)	Pre- reform FDI Stock (f)	Post- Reform FDI Stock (f)	Pre-reform Parent Value Added (v)	Post- Reform Parent Value Added (v)
1	307.6	946.0	70021.5	108595.0	7247349	3419869
2	74.2	916.8	58647.9	137351.3	11400000	7678093
3	309.0	1030.9	18290.9	41842.4	2932387	3274322
4	480.0	893.1	20675.2	38522.8	3193264	3435980
5	509.9	960.0	29978.8	34904.9	3404314	2661049

Patent Rank Quintile 'a'	Pre- reform Ratio (I to f) x 100	Post- reform Ratio (I to f) x 100	Pre- reform Ratio (I to v) x 10000	Post- reform Ratio (I to v) x 10000	Pre- reform Ratio (f to v)	Post- reform Ratio (f to v)
1	0.439	0.871	0.424	2.766	0.966	3.175
2	0.127	0.667	0.065	1.194	0.514	1.789
3	1.689	2.464	1.054	3.148	0.624	1.278
4	2.322	2.318	1.503	2.599	0.647	1.121
5	1.701	2.750	1.498	3.608	0.881	1.312

Endogeneity of Wages

Dependent Variable: Manufacturing Wages in the Destination Countries (in natural logs)

Measure of Patent Protection: Index of IPR						
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	c1	c2	c3	c4	c5	c6
ke	0.166*** (0.044)	0.137*** (0.041)	0.168*** (0.044)	0.137*** (0.041)	0.168*** (0.044)	0.137*** (0.041)
h	0.230* (0.129)	0.163 (0.131)	0.226* (0.129)	0.163 (0.131)	0.224* (0.130)	0.161 (0.131)
p	0.039 (0.079)	0.042 (0.078)	0.038 (0.079)	0.042 (0.078)	0.304 (0.242)	0.262 (0.248)
a			0.124 (0.173)	-0.008 (0.183)	0.422 (0.357)	0.246 (0.386)
pa					-0.346 (0.327)	-0.286 (0.336)
I	0.059** (0.024)	0.032 (0.023)	0.059** (0.024)	0.032 (0.022)	0.057** (0.024)	0.031 (0.022)
f		0.127*** (0.039)		0.127*** (0.040)		0.126*** (0.040)
Constant	-1.168*** (0.427)	-2.529*** (0.687)	-1.268*** (0.440)	-2.523*** (0.686)	-1.457*** (0.534)	-2.678*** (0.777)
Observations	766	755	766	755	766	755
Number of id	55	55	55	55	55	55

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Pooled Sectors

		Patent Index (measure of p)							
Fitted W	VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		c1	c2	c3	c4	c5	c6	c7	c8
		host		host		host		host	
rs		0.032*** (0.006)	0.029*** (0.006)	0.030*** (0.006)	0.028*** (0.006)	0.032*** (0.006)	0.029*** (0.006)	0.030*** (0.006)	0.028*** (0.006)
y		0.952*** (0.155)	1.028*** (0.171)	1.195*** (0.177)	1.347*** (0.236)	0.955*** (0.155)	1.026*** (0.168)	1.194*** (0.177)	1.347*** (0.236)
p		0.287*** (0.077)	0.191** (0.074)	0.293*** (0.077)	0.207*** (0.073)	0.286*** (0.076)	0.191** (0.074)	0.292*** (0.077)	0.207*** (0.073)
a		0.055*** (0.017)	0.056*** (0.017)	0.047*** (0.017)	0.047*** (0.018)	0.055*** (0.017)	0.056*** (0.017)	0.047*** (0.017)	0.047*** (0.018)
pa		-0.029** (0.015)	-0.029* (0.015)	-0.028* (0.015)	-0.027* (0.016)	-0.029** (0.015)	-0.029* (0.015)	-0.028* (0.015)	-0.027* (0.016)
cr			0.734*** (0.229)	0.265 (0.220)			0.740*** (0.228)	0.267 (0.222)	
wer		0.697** (0.291)	0.501* (0.289)	0.587* (0.313)	0.384 (0.278)	0.713** (0.292)	0.501* (0.281)	0.590* (0.312)	0.385 (0.279)
imf					0.001 (0.059)	-0.005 (0.063)	0.014 (0.044)	0.005 (0.043)	
Constant		-15.989*** (2.805)	-15.728*** (3.440)	-23.283*** (3.033)	-22.553*** (4.151)	*	*	*	*
Observations		42,346	42,346	39,939	39,939	42,320	42,320	39,939	39,939
Number of id		6,402	6,402	5,339	5,339	6,397	6,397	5,339	5,339

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Year and Country effects included; Host refers to the inclusion of host specific trend effects

Pooled Sectors

		Patent Index (measure of p)							
Fitted W	VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		c1 f	c2 f	c3 f	c4 f	c5 f	c6 f	c7 f	c8 f
rs			<i>host</i>		<i>host</i>		<i>host</i>		<i>host</i>
		0.041*** (0.006)	0.039*** (0.006)	0.037*** (0.006)	0.035*** (0.006)	0.041*** (0.006)	0.039*** (0.006)	0.037*** (0.006)	0.035*** (0.006)
y									
		1.508*** (0.191)	0.986*** (0.204)	1.835** (0.220)	1.200*** (0.303)	1.509*** (0.189)	0.978*** (0.205)	1.825*** (0.221)	1.197*** (0.303)
p									
		0.232*** (0.076)	0.308*** (0.099)	0.236*** (0.072)	0.254** (0.100)	0.223*** (0.075)	0.309*** (0.099)	0.230*** (0.072)	0.252** (0.100)
a									
		-0.055*** (0.016)	-0.054*** (0.016)	-0.060*** (0.016)	-0.059*** (0.016)	-0.054*** (0.017)	-0.054*** (0.016)	-0.059*** (0.016)	-0.059*** (0.016)
pa									
		0.076*** (0.015)	0.073*** (0.014)	0.079** (0.015)	0.076*** (0.014)	0.076*** (0.015)	0.073*** (0.014)	0.078*** (0.015)	0.076*** (0.014)
cr									
		-0.066 (0.285)	0.461* (0.261)				-0.024 (0.293)	0.487* (0.264)	
wer									
		3.455*** (0.436)	3.655*** (0.490)	3.611*** (0.457)	2.877*** (0.458)	3.509*** (0.434)	3.662*** (0.493)	3.636*** (0.455)	2.894*** (0.457)
imf									
					0.104 (0.081)	-0.001 (0.070)	0.080 (0.064)	0.058 (0.054)	
Constant									
		-21.660*** (3.535)	-13.281*** (3.861)	-27.444*** (4.080)	-17.949*** (5.380)	*	*	*	*
Observations		46,484	46,484	44,179	44,179	46,450	46,450	44,179	44,179
Number of id		6,635	6,635	5,748	5,748	6,631	6,631	5,748	5,748

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Year and Country effects included; Host refers to the inclusion of host specific trend effects

Pooled Sectors

	Patent Index (measure of p)					
Fitted W	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	c1	c2	c3	c4	c5	c6
	If	If	lp	lp	fp	fp
rs		<i>host</i>		<i>host</i>		<i>host</i>
	0.008 (0.008)	0.010 (0.008)	0.027*** (0.007)	0.025*** (0.007)	0.019*** (0.007)	0.014** (0.007)
y	-0.642*** (0.222)	0.051 (0.293)	1.355*** (0.188)	1.341*** (0.247)	1.901*** (0.213)	1.004*** (0.355)
p	0.182* (0.098)	-0.042 (0.112)	0.371*** (0.083)	0.231*** (0.075)	0.302*** (0.072)	0.274*** (0.100)
a	0.079*** (0.021)	0.077*** (0.022)	0.035* (0.018)	0.033* (0.019)	-0.080*** (0.017)	-0.077*** (0.017)
pa	-0.078*** (0.018)	-0.076*** (0.018)	-0.035** (0.016)	-0.031* (0.017)	0.071*** (0.015)	0.068*** (0.015)
cr	0.014 (0.315)	-1.126*** (0.321)	0.726*** (0.250)	0.423* (0.229)	0.101 (0.310)	0.757** (0.309)
wer	-1.730*** (0.443)	-1.063** (0.432)	0.380 (0.333)	0.166 (0.305)	3.415*** (0.444)	2.633*** (0.455)
imf	-0.005 (0.063)	-0.022 (0.059)	0.034 (0.046)	0.009 (0.044)	0.052 (0.062)	0.059 (0.054)
Constant	5.537 (3.867)	-3.220 (5.447)	-39.814*** (3.217)	-36.137*** (4.393)	-43.156*** (3.845)	-27.249*** (6.139)
Observations	35,493	35,493	38,711	38,711	38,696	38,696
Number of id	5,173	5,173	5,293	5,293	5,391	5,391

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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Pooled Sectors

Patent Reform (0, 1) as a measure of p								
Fitted W	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	c9	c10	c11	c12	c13	c14	c15	c16
rs								
	<i>host</i>		<i>host</i>		<i>host</i>		<i>host</i>	
rs	0.032*** (0.006)	0.028*** (0.006)	0.030*** (0.006)	0.027*** (0.006)	0.032*** (0.006)	0.028*** (0.006)	0.030*** (0.006)	0.027*** (0.006)
y	0.899*** (0.152)	1.011*** (0.164)	1.079*** (0.177)	1.172*** (0.221)	0.908*** (0.151)	1.016*** (0.161)	1.075*** (0.177)	1.170*** (0.221)
p	0.337*** (0.050)	0.306*** (0.050)	0.343*** (0.050)	0.323*** (0.050)	0.338*** (0.050)	0.307*** (0.050)	0.344*** (0.050)	0.323*** (0.050)
a	0.056*** (0.014)	0.060*** (0.014)	0.050*** (0.014)	0.054*** (0.014)	0.057*** (0.014)	0.060*** (0.014)	0.050*** (0.014)	0.054*** (0.014)
pa	-0.042*** (0.013)	-0.046*** (0.013)	-0.042*** (0.013)	-0.047*** (0.013)	-0.042*** (0.013)	-0.046*** (0.013)	-0.042*** (0.013)	-0.047*** (0.013)
cr								
	0.967*** (0.219)	0.543*** (0.206)				0.997*** (0.220)	0.558*** (0.210)	
wer	0.885*** (0.285)	0.679** (0.281)	0.685** (0.307)	0.469* (0.265)	0.931*** (0.286)	0.690** (0.273)	0.700** (0.306)	0.477* (0.265)
imf								
					0.052 (0.058)	0.018 (0.059)	0.064 (0.045)	0.031 (0.042)
Constant	-15.270*** (2.707)	-15.685*** (3.287)	-22.317*** (2.975)	-20.680*** (3.897)	*	*	*	*
					15.552** (2.691)	15.821** (3.211)	22.457** (2.981)	20.751** (3.896)
Observations	43,087	43,087	40,648	40,648	43,058	43,058	40,648	40,648
Number of id	6,467	6,467	5,387	5,387	6,459	6,459	5,387	5,387

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Year and Country effects included; Host refers to the inclusion of host specific trend effects

Pooled Sectors

Patent Reform (0, 1) as a measure of p								
Fitted W	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
VARIABLES	c9	c10	c11	c12	c13	c14	c15	c16
	f	f	f	f	f	f	f	f
	host		host		host		host	
rs	0.042*** (0.006)	0.040*** (0.006)	0.038*** (0.006)	0.035*** (0.006)	0.042*** (0.006)	0.040*** (0.006)	0.038*** (0.006)	0.035*** (0.006)
y	1.449*** (0.191)	0.939*** (0.211)	1.751*** (0.222)	1.053*** (0.300)	1.454*** (0.189)	0.941*** (0.211)	1.735*** (0.223)	1.047*** (0.300)
p	0.054 (0.064)	0.055 (0.066)	0.035 (0.063)	0.051 (0.064)	0.055 (0.064)	0.054 (0.066)	0.039 (0.062)	0.052 (0.063)
a	-0.015 (0.013)	-0.014 (0.013)	-0.017 (0.013)	-0.016 (0.013)	-0.014 (0.013)	-0.014 (0.013)	-0.016 (0.013)	-0.016 (0.013)
pa	0.047*** (0.013)	0.042*** (0.013)	0.048*** (0.013)	0.043*** (0.013)	0.047*** (0.013)	0.043*** (0.013)	0.047*** (0.013)	0.043*** (0.013)
cr		-0.027 (0.283)	0.618** (0.257)			0.044 (0.290)	0.661** (0.260)	
wer	3.497*** (0.435)	3.753*** (0.484)	3.626*** (0.456)	2.985*** (0.448)	3.582*** (0.432)	3.779*** (0.486)	3.668*** (0.454)	3.012*** (0.445)
imf					0.150* (0.081)	0.030 (0.069)	0.127** (0.064)	0.091* (0.052)
Constant	-20.410*** (3.529)	-12.431*** (3.974)	-25.839*** (4.113)	-15.994*** (5.346)	*	*	*	*
					20.754** (3.454)	12.533** (3.981)	26.026** (4.118)	16.204** (5.357)
Observations	47,245	47,245	44,911	44,911	47,208	47,208	44,910	44,910
Number of id	6,703	6,703	5,803	5,803	6,697	6,697	5,803	5,803

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Year and Country effects included; Host refers to the inclusion of host specific trend effects

Pooled Sectors

Patent Reform (0, 1) as a measure of p						
Fitted W	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	c1	c2	c3	c4	c5	c6
	lf	lf	lp	lp	fp	fp
		host		host		host
rs	0.009 (0.008)	0.012 (0.008)	0.027*** (0.007)	0.024*** (0.007)	0.020*** (0.007)	0.014** (0.007)
y	-0.685*** (0.224)	-0.094 (0.307)	1.218*** (0.189)	1.197*** (0.232)	1.795*** (0.219)	0.935*** (0.353)
p	0.363*** (0.061)	0.335*** (0.060)	0.366*** (0.053)	0.329*** (0.051)	0.030 (0.062)	0.013 (0.063)
a	0.042** (0.018)	0.043** (0.018)	0.034** (0.015)	0.037** (0.015)	-0.040*** (0.013)	-0.037*** (0.013)
pa	-0.053*** (0.017)	-0.057*** (0.017)	-0.046*** (0.014)	-0.050*** (0.014)	0.041*** (0.013)	0.035*** (0.012)
cr	0.201 (0.304)	-0.945*** (0.307)	1.024*** (0.240)	0.701*** (0.220)	0.200 (0.309)	0.888*** (0.304)
wer	-1.500*** (0.422)	-0.942** (0.387)	0.501 (0.329)	0.305 (0.292)	3.331*** (0.445)	2.623*** (0.442)
imf	-0.000 (0.058)	-0.036 (0.057)	0.087* (0.046)	0.040 (0.043)	0.103* (0.061)	0.084 (0.053)
Constant	5.024 (3.832)	-1.609 (5.745)	-38.760*** (3.160)	-34.939*** (4.150)	-41.241*** (3.949)	-26.443*** (6.155)
Observations	36,054	36,054	39,410	39,410	39,332	39,332
Number of id	5,214	5,214	5,341	5,341	5,438	5,438

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Year and Country effects included; Host refers to the inclusion of host specific trend effects

Chemicals

	Ratio among Modes							
	(1) c1 	(2) c2 	(3) c3 lp	(4) c4 lp	(5) c5 ls	(6) c6 ls	(7) c7 lf	(8) c8 lf
VARIABLES								
rs	0.054*** (0.017)	0.051*** (0.017)	0.055*** (0.017)	0.059*** (0.017)	0.088*** (0.020)	0.090*** (0.020)	0.009 (0.019)	0.013 (0.019)
y	1.452*** (0.276)	2.116*** (0.299)	1.560*** (0.280)	2.299*** (0.315)	1.507*** (0.276)	2.171*** (0.309)	0.061 (0.339)	0.522 (0.400)
p	0.790*** (0.306)	0.858*** (0.235)	0.767** (0.333)	0.957*** (0.260)	0.761** (0.325)	0.884*** (0.247)	0.731** (0.330)	0.572* (0.333)
a	0.799*** (0.158)	0.772*** (0.131)	0.669*** (0.173)	0.785*** (0.158)	1.038*** (0.142)	0.898*** (0.142)	1.575*** (0.143)	1.600*** (0.153)
pa	-0.112* (0.065)	-0.128** (0.051)	-0.098 (0.072)	-0.138** (0.058)	-0.105 (0.069)	-0.132** (0.053)	-0.136* (0.073)	-0.101 (0.074)
cr		0.658** (0.333)		0.455 (0.356)		0.563* (0.339)		0.200 (0.458)
wer	1.018** (0.431)	0.752 (0.474)	1.163** (0.451)	0.931* (0.506)	1.063** (0.434)	0.789 (0.484)	-0.531 (0.653)	-1.270** (0.642)
Constant	-26.110*** (4.951)	-40.297*** (5.049)	-42.013*** (5.020)	-56.945*** (5.339)	-42.368*** (4.966)	-56.051*** (5.242)	-10.220* (6.092)	-17.922*** (6.661)
Observations	14,182	13,372	13,864	13,056	14,182	13,372	12,817	12,035
Number of id	1,878	1,570	1,870	1,560	1,878	1,570	1,843	1,542

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Year, Country Effects included

Machinery & Equipment

	Ratio among Modes							
	(1) c1 I	(2) c2 I	(3) c3 Ip	(4) c4 Ip	(5) c5 Is	(6) c6 Is	(7) c7 If	(8) c8 If
VARIABLES								
rs	0.034*** (0.009)	0.032*** (0.009)	0.019* (0.011)	0.018 (0.011)	0.052*** (0.012)	0.050*** (0.012)	0.023** (0.011)	0.022** (0.011)
y	1.124*** (0.262)	1.325*** (0.276)	1.441*** (0.303)	1.726*** (0.320)	1.294*** (0.291)	1.587*** (0.300)	-0.764** (0.329)	-0.816** (0.346)
p	0.810*** (0.125)	0.886*** (0.120)	0.751*** (0.136)	0.807*** (0.131)	0.676*** (0.133)	0.745*** (0.128)	0.638*** (0.172)	0.760*** (0.161)
a	0.162*** (0.032)	0.187*** (0.032)	0.085** (0.035)	0.109*** (0.035)	0.101*** (0.033)	0.128*** (0.033)	0.151*** (0.042)	0.179*** (0.041)
pa	-0.182*** (0.026)	-0.198*** (0.026)	-0.144*** (0.030)	-0.155*** (0.029)	-0.152*** (0.027)	-0.166*** (0.026)	-0.195*** (0.033)	-0.212*** (0.031)
cr		0.398 (0.352)		0.552 (0.359)		0.509 (0.359)		-0.526 (0.498)
wer	0.141 (0.463)	0.055 (0.483)	-0.032 (0.490)	-0.009 (0.509)	-0.191 (0.493)	-0.224 (0.520)	-2.532*** (0.665)	-2.585*** (0.698)
Constant	-19.909*** (4.613)	-25.213*** (4.694)	-38.603*** (5.320)	-46.189*** (5.499)	-36.706*** (5.118)	-44.195*** (5.125)	7.870 (6.024)	10.988* (6.192)
Observations	11,082	10,589	10,721	10,230	11,082	10,589	9,795	9,320
R-squared	0.018	0.019	0.020	0.022	0.026	0.028	0.073	0.074
Number of id	1,791	1,526	1,781	1,517	1,791	1,526	1,736	1,477

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Year, Country Effects included

Review

- Empirical Results thus far are supportive of the theory
- Licensing occurs in low imitation risk industries (e.g. **Machinery and Equipment**) and less in higher risk industries (e.g. **Chemicals**).
- IPR affects the **scale** of technology transfer
- IPR induces **substitution effects** (switching between FDI and licensing, and between licensing/FDI and Northern production (and potentially exports)).
- Major IPR **reforms** favor licensing over FDI, at the margin.