PATENT PROTECTION AND THE INDUSTRIAL COMPOSITION OF MULTINATIONAL ACTIVITY

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I. MOTIVATION

- Article 7 of the WTO TRIPS Agreement: "Protection and Enforcement of Intellectual Property Rights should contribute … to the transfer and dissemination of technology"

- The actual impact of strengthened IPRs on technology transfer depends on a complex interrelation of factors
  - Mode of transfer
  - Interdependency between various channels
  - Imitation Risk and IP-dependence in a sector

- Purpose of our research: to examine the impact of patent protection on the *mode*, *volume*, and *industry composition* of international technology transfer

II. SIGNIFICANCE

- IPR issues remain controversial – at the global level (North vs. South)

- Previous research focused:
  - primarily on national characteristics that condition the impacts of IPRs
  - on a specific mode of tech transfer

- Our contribution is to focus on
  - variation in imitation risk across industries
  - firm-level data in high-tech manufacturing
  - developing economies (as host countries)
  - choice of mode

- Mode and Industry Composition **matter**
  - for knowledge diffusion, access to technologies (medicines, digital goods, know-how, etc.), and economic development in the 'South'

III. Previous work

- Internalization aspects of MNCs
  - Markusen (1995, 2001), Ethier & Markusen (1996), Yang & Maskus(2001), Glass & Saggi (2002), Antras (2005), Nicholson (2007)

- Empirical Studies of Global IPR (Selected)
  - Trade: Maskus & Penubarti (1995), Smith (1999), Co (2005), Ivus (2010, 2011)
  - FDI: Ferrantino (1993), Javorcik (2004), Nunnenkamp & Spatz (2004), Branstetter, Fisman, Foley, & Saggi (2011), Berry (2014), Bilir (2014)
  - Licensing: Yang & Maskus (2001) , Park & Lippoldt (2005), Branstetter, Fisman, & Foley (2006)

- How the studies differ?
  - Sample period
  - Level of aggregation: country/industry/firm
  - Single mode vs. Multiple modes considered
  - Pooled sample vs. Developed/Developing Host Country breakdown
  - Controls for Industry Differences, or lack thereof

IV. Conceptual Background

- Consider two countries: North (innovator) and South (imitator)

- Continuum of industries $z \in [0, 1]$, in ascending order of imitation risk

- In each z: N(z) goods *(which grows with innovation).* Some produced by Northern firms, rest by Southern imitators:

$$N(z) = n(z) + n^*(z)$$

- Rate of imitation (i.e., fraction of n(z) imitated per *unit of time*)
  - 0   in a sector that produces in the North
  - μz in a sector that undertakes FDI
  - $\mu \iota z$ in a sector that licenses its technology externally ($\iota > 1$)

  where μ = index of IPR (inverse)

IV. Conceptual Background

Choices	Pros/Cons
Northern Production	Less Technology Leakage / Higher Labor Costs $(\omega = w/w^* > 1)$
FDI	Lower Labor Costs / Imitation Risk, Costs of Establishment
Arms Length Licensing	Lower Labor Costs, No Set-up Costs / Greater Imitation Risk and No Direct Control

- Innovating firm chooses the **mode** that maximizes **firm value** (i.e., PDV of the stream of profits): $V(z) = \max [V^N(z), V^F(z), V^\wedge(z)]$

  - FDI over Northern Production if $V^F(z) > V^N(z)$

  - Licensing over Northern Production if $V^\wedge(z) > V^N(z)$

  - Licensing over FDI if $V^\wedge(z) > V^F(z)$

CHOOSE LICENSING OVER FDI IF $V^\Lambda > V^F$

ω

Indifferent between FDI and Licensing

Licensing

FDI

z
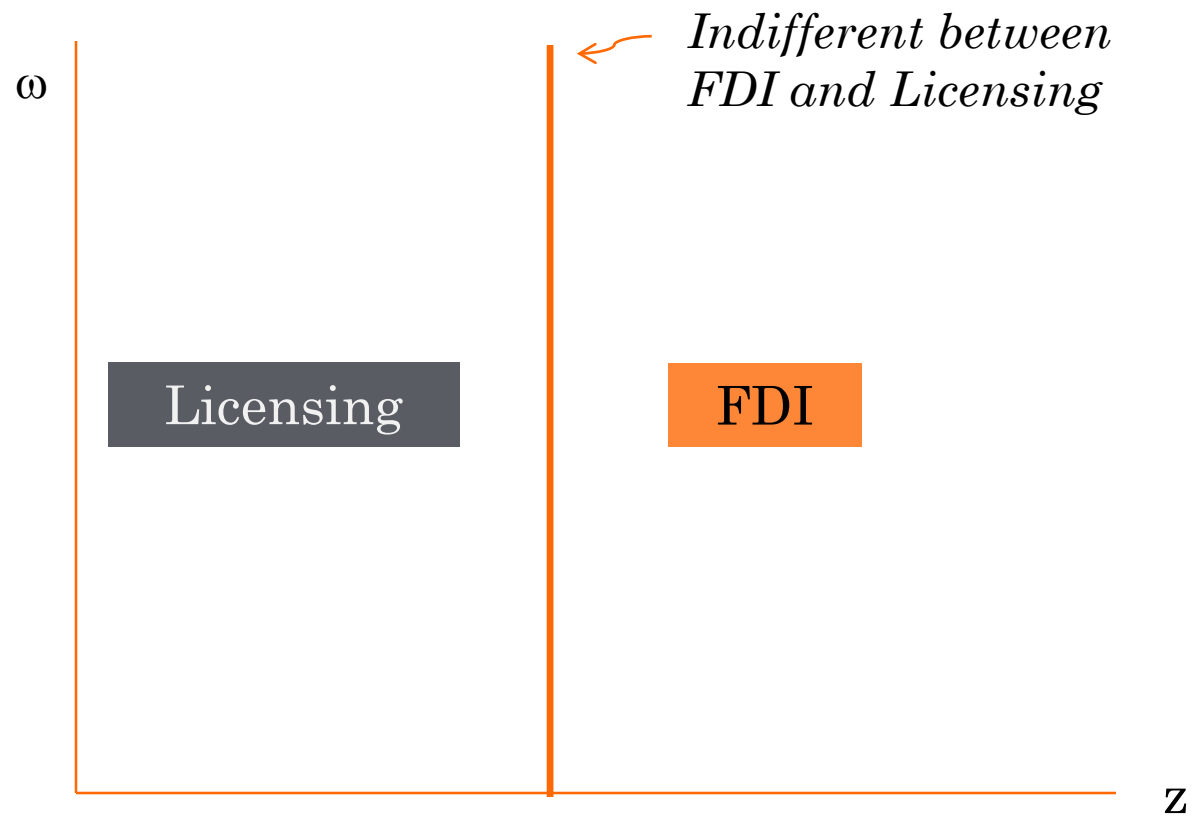
CHOOSE FDI OVER NORTHERN PRODUCTION IF $V^F > V^N$

ω

FDI

Indifferent between
N Prod. and FDI

Northern
Production

z

CHOOSE LICENSING OVER NORTHERN PRODUCTION IF $V^A > V^N$

ω

Licensing

Indifferent between N Prod. and Licensing

Northern Production

z
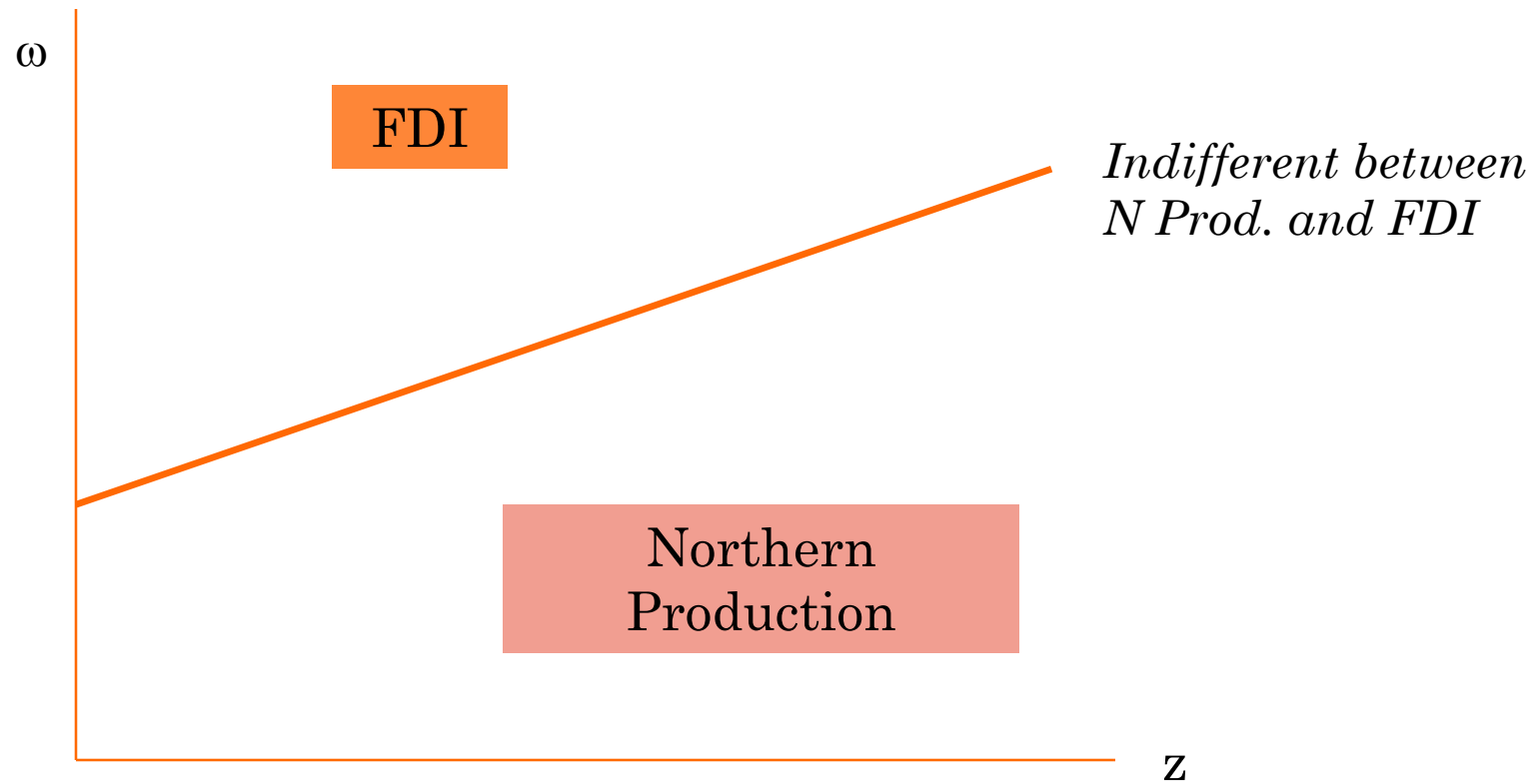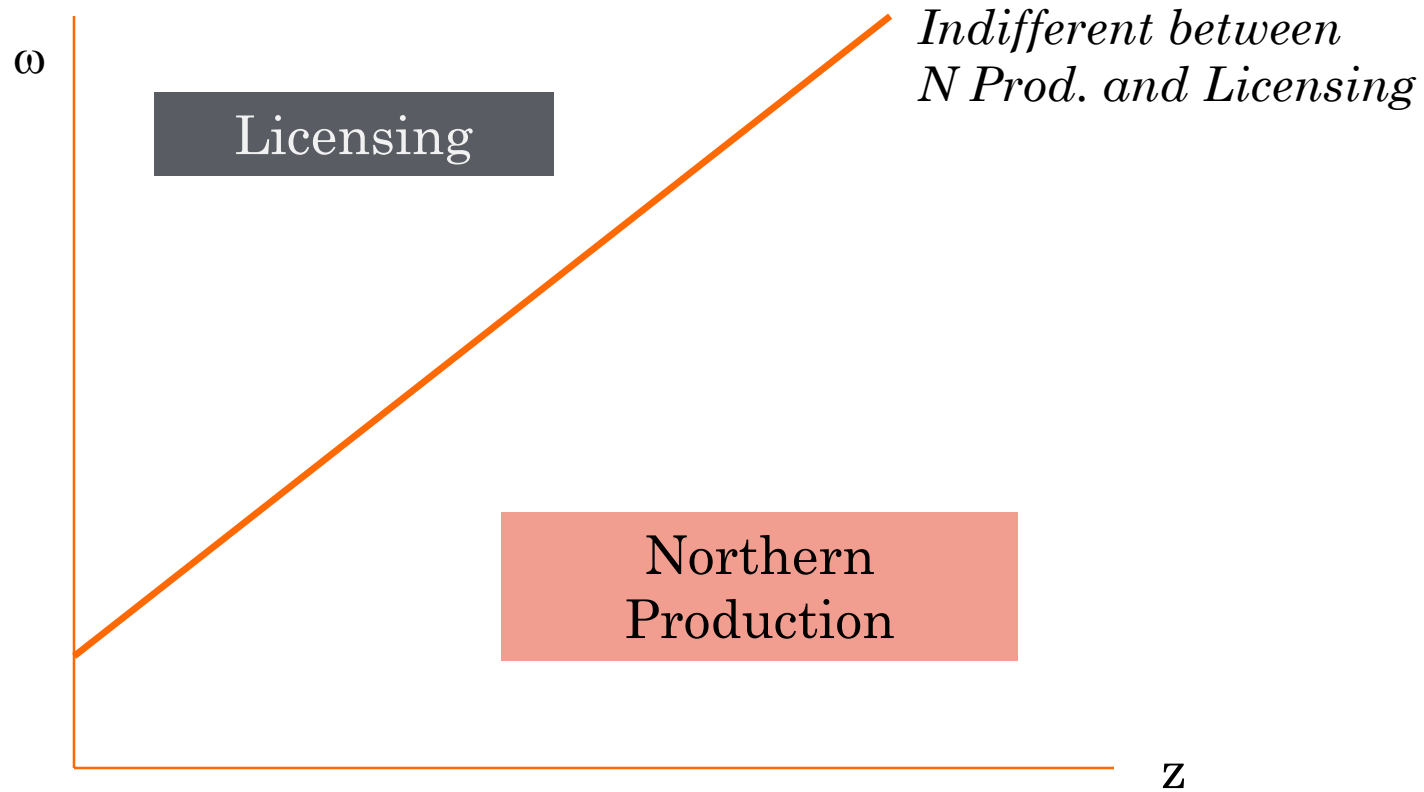
… COMBINED
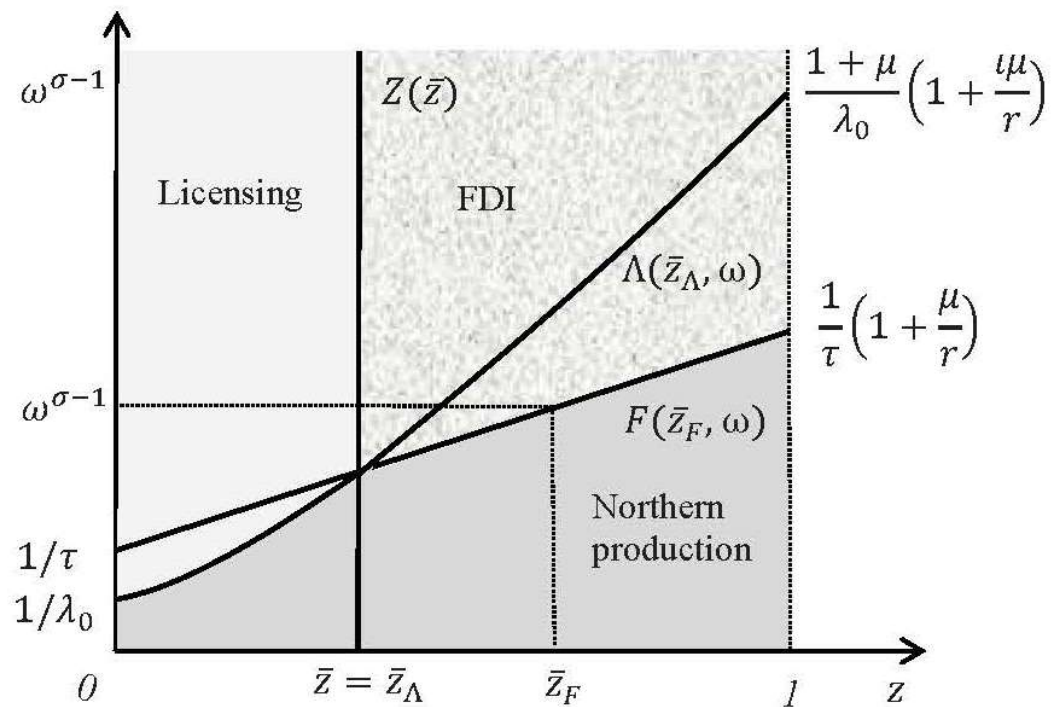
Figure 1: The equalized profit schedules

STRENGTHENING PATENT PROTECTION
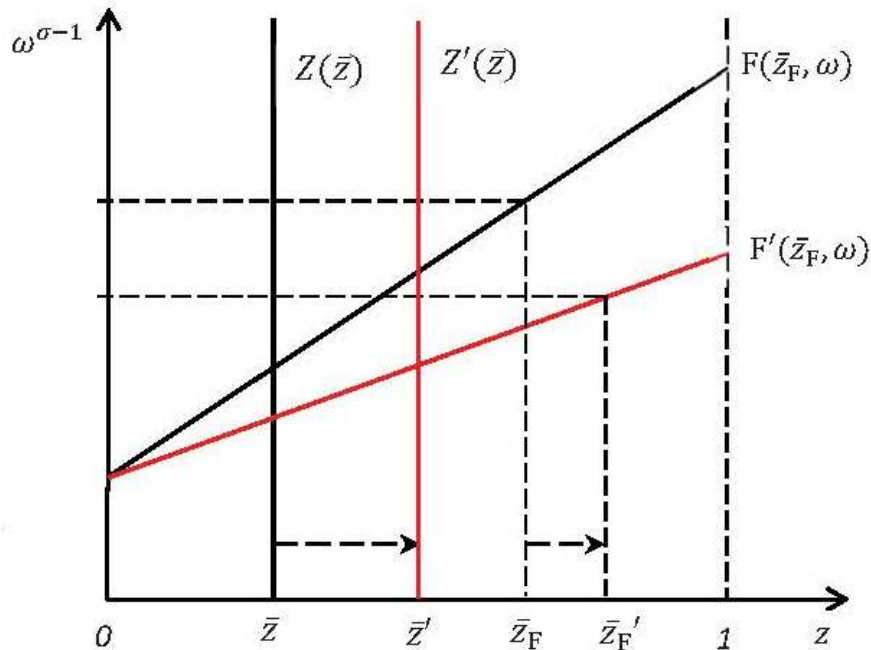
- Commentary
  - *Stronger IPR increases bargaining power of licensor (share of rents in contract)*
  - *Increased range of licensing industries, reduced profitability of Northern production*
    - *Switching from FDI to licensing; and from Northern Production to FDI*
  - *Stronger IPR reduces imitation risk in each z; market share of innovator in the South expands.*
    - *Reduces demand for Northern labor, lowering relative ω and mitigating expansion in FDI*
  - *Expect to observe: cross-industry shifts and within-industry shifts*

V. Empirical Framework

- Outcome Variable T_{ijt} denotes technology transfer: i indexes parent firm, j host country, and t year

$$T_{ijt} = \alpha_0 + \alpha_j + \alpha_t + \beta_0 \tau_{jt} + \beta_1 P_{jt} + \beta_2 X_{jt} + \beta_3 R_{it} + \beta_4 A_{it} + \beta_5 A_{it} \times P_{jt} + \beta_6 D_i^k + \varepsilon_{ijt}, \quad (1)$$

- P = index of patent protection; A = Patenting Rank
- {D} is set of industry dummies; {τ} vector of country-specific time trends
- R = parent R&D/Sales; {X} vector of host country controls
- {α} fixed/random effects; ε error term

- Augmented version

$$T_{ijt} = \alpha_0 + \alpha_j + \alpha_t + \beta_0 \tau_{jt} + \beta_1 P_{jt} + \beta_2 X_{jt} + \beta_3 R_{it} + \beta_4 A_{it} + \beta_5 A_{it} \times P_{jt}$$
$$+ \beta_6 D_i^k + \beta_7 Z_i + \beta_8 Z_i \times P_{jt} + \beta_9 D_i^k \times P_{jt} + \varepsilon_{ijt}, \quad (2)$$

- Z = complexity dummy

- Key Hypothesis: $\beta_8 < 0$ when T = ratio of unaffiliated/affiliated licensing

VI. DATA

- Overview
  - 1,185 U.S. Parent Firms from the High-tech Manufacturing Sector
    - 3000 < NAICS '02 Codes < 4000 (excluding Food/Beverages/Tobacco, Textiles, Wood)

  - Operating in 44 Developing Countries

Algeria	Dominican Rep	Mexico	Singapore
Angola	Ecuador	Morocco	Slovakia
Argentina	El Salvador	Nicaragua	South Africa
Brazil	Ghana	Nigeria	South Korea
Bulgaria	Guatemala	Panama	Sri Lanka
Chad	Hong Kong	Peru	Taiwan
Chile	Hungary	Philippines	Thailand
China	India	Poland	Trinidad & Tobago
Cote D'Ivoire	Jamaica	Romania	Venezuela
Cyprus	Kenya	Russia	Vietnam
Czech Rep	Malaysia	Saudi Arabia	Zimbabwe

  - Time period: 1994 – 2009 (annual)

SURVEYS

Variable	Source
Royalties & Licensing Receipts from UNAFFILIATED persons	BE-125* BE-93
Royalties & Licensing Receipts from AFFILIATED persons	BE-577 BE-125**
R&D Performed by Parent, Total Sales of Parent	BE-11
R&D Performed by Affiliate, Sales and Value Added of Affiliate***	BE-11
Income Taxes, Net Income of Foreign Affiliates***	BE-11

* BE-125 used for years after 2005; BE-93 for years before 2004. Interpolated 2004-5 linearly

** BE-577 used for years before 2006; BE-125 for years 2006 on

*** Data aggregated across affiliates of a parent firm in a host country

INDEX OF PATENT PROTECTION

- Based on Statutes and Case Laws
  - Measures right to exclude; length and scope of patent rights; protections available via domestic & global channels
  - Measures strength, not quality, of regime
- Score 0 – 5
  - Duration of Protection
  - Coverage
  - Enforcement Provisions
  - Membership in International Agreements
  - Restrictions on Exclusive Use
- Available by country and time

- A Patent Reform Dummy {0, 1} can also be derived based on Year of Major Reform

Index of Patent Rights for the 44 Developing Countries
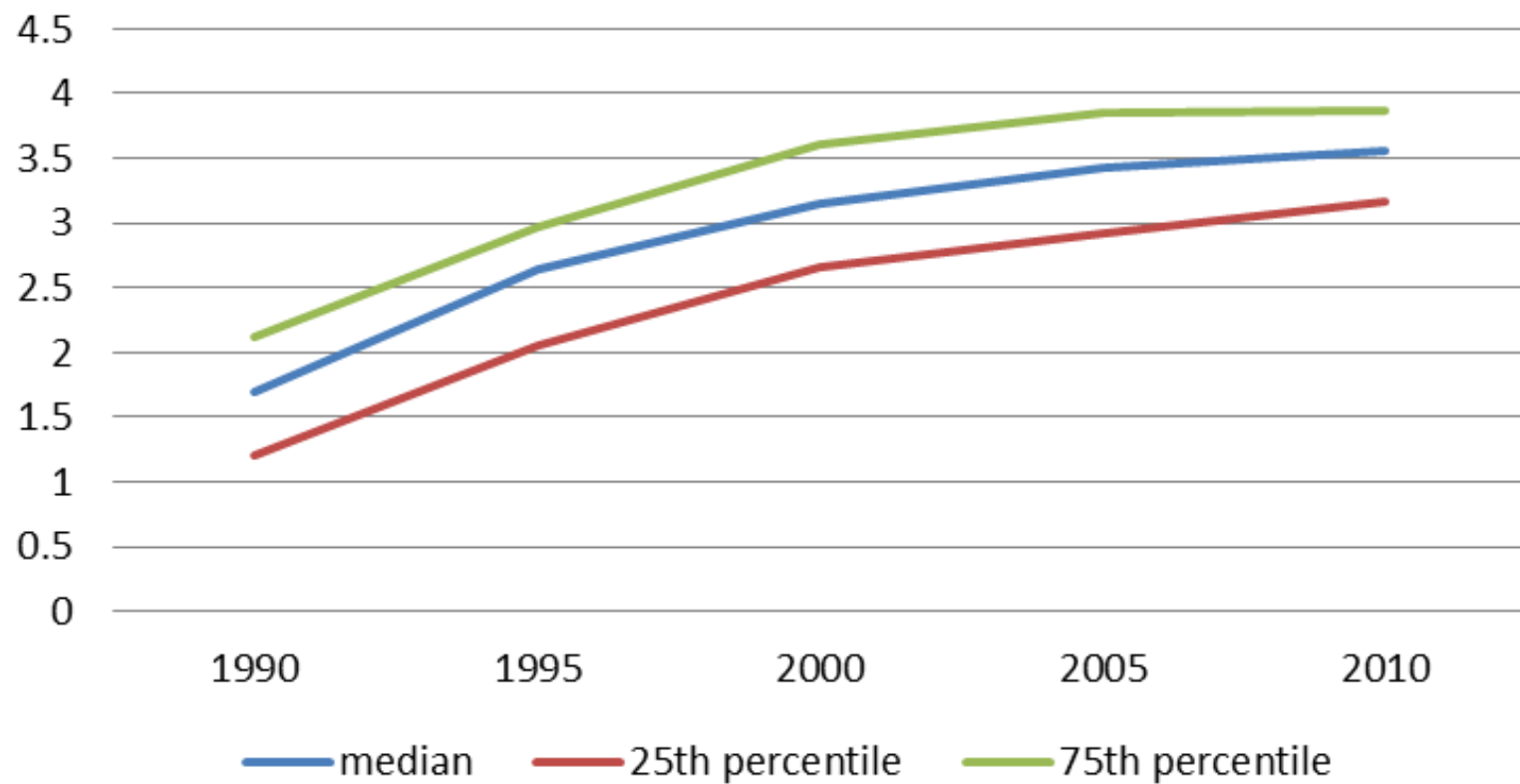
COMPLEXITY

Discrete Industries	Complex Industries

Discrete Industries

- Pharmaceuticals
- Non-pharm Chemicals
- Energy
- Metals

Complex Industries

- Transportation
- Machinery & Equipment
- Electronics & Components

Classification based on previous work: Rycroft and Kash (1999), Cohen et al. (2000), and Graevenitz et al. (2014)

Complexity is multidimensional: (i) inputs (number & diversity); (ii) integration of components; (iii) sociotechnical system of tasks in production …

Complex technologies & products "cannot be understood in detail by an individual expert and communicated precisely among experts across time and distance."
– *Rycroft and Kash, 1999*

Criteria were used to survey relevant experts to classify sectors.

COMPLEXITY: ALTERNATIVE

- Product Complexity
  - Task-Based Measure (Naghavi et al., 2015)
    - Interaction of three variables: Complexity of Occupation; Occupational Intensity in Industry; Share of Industry in Product

Industry	Product Complexity Rating
Chemicals	0.258
Energy	0.253
Metals	0.278
Transportation	0.281
Machinery & Equipment	0.370
Electronics & Components	0.401

- Results are qualitatively similar (Industry vs. Product)

OTHER DATA

Variable	Source
GDP, PPP Conversion Factor	World Bank WDI
Inward Capital Restrictions	IMF *International Financial Statistics*
Hourly Wages	*Occupational Wages around the World* (OWW) Database
Patent Family Filings (Worldwide)	PATSTAT
U.S. Patents Granted	NBER Patent Data Project
Institutional Quality	Kunčič (2014)

VII. DESCRIPTIVE STATISTICS

	Unaffiliated Licensing, % Share of Manufacturing	Affiliated Licensing, % Share of Manufacturing
Discrete		
Pharmaceuticals	1.01	8.35
Non-pharm Chemicals	6.84	39.29
Energy	3.39	0.64
Metals	0.17	1.11
Complex		
Transportation	**24.49**	18.65
Machinery & Equipment	**25.96**	13.95
Electronics & Components	**37.88**	13.30
Other Manufacturing*	0.24	4.52
Total	100	100

* Other Manufacturing consists of some complex and discrete products

Note: These shares were computed using sums of firms within sectors and are not restricted to firms with non-missing or non-zero affiliated licensing (see Patent Reform slide).

… FOR COMPARISON:

DEVELOPED COUNTRIES*	Unaffiliated Licensing, % Share of Manufacturing	Affiliated Licensing, % Share of Manufacturing
Discrete		
Pharmaceuticals	16.1	36.6
Non-pharm Chemicals	8.2	19.2
Energy	1.9	0.7
Metals	0.43	1.7
Complex		
Transportation	35.3	22.6
Machinery & Equipment	18.4	9.4
Electronics & Components	18.9	6.1
Other Manufacturing*	0.71	3.76
Total	100	100

* OECD (Europe, U.S., Japan, Australia, New Zealand, Canada, and Israel)

Key Differences: In richer economies (where IPRs are stronger), <u>discrete industries</u> perform a greater share of unaffiliated licensing in manufacturing, particularly by Pharmaceuticals. Drug companies also have a much greater share of affiliated licensing in the developed world.

VII. Descriptive statistics

Parent Firms:

Mean Values	Unrestricted				Restricted to Non-zero Affiliated Licensing*			
Industry	Lu	La	Lu/La	R&D/Sales	Lu	La	Lu/La	R&D/Sales
All	254.7	539.1	**0.47**	4.29%	459.9	2356.1	**0.20**	4.31%
Complex	471.9	526.1	**0.89**	5.14%	1124.1	2969.6	**0.38**	5.08%
Discrete	56.8	550.9	**0.10**	3.55%	68.6	1994.7	**0.034**	3.58%

- Lu ~ Unaffiliated Licensing (thousands of real 2005 PPP $)
- La ~ Affiliated Licensing (thousands of real 2005 PPP $)

- Computed over 44 developing countries, from 1994 – 2009

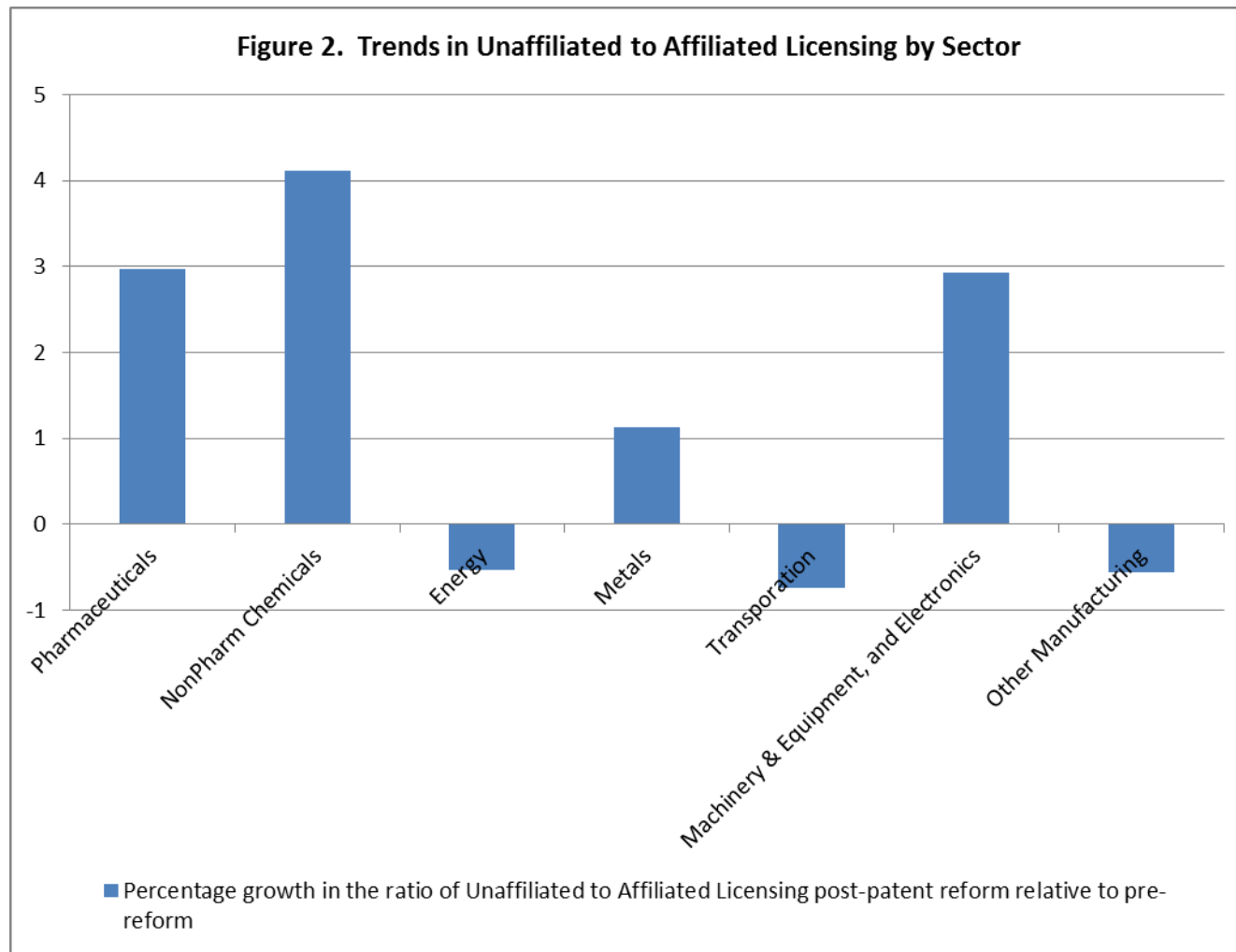*Restricted sample used to observe changes in intensive margin*

PATENT REFORM

Figure 1. Ratio of Unaffilated Licensing to Affiliated Licensing, by Complexity of Industry

PATENT REFORM

Figure 2. Trends in Unaffiliated to Affiliated Licensing by Sector
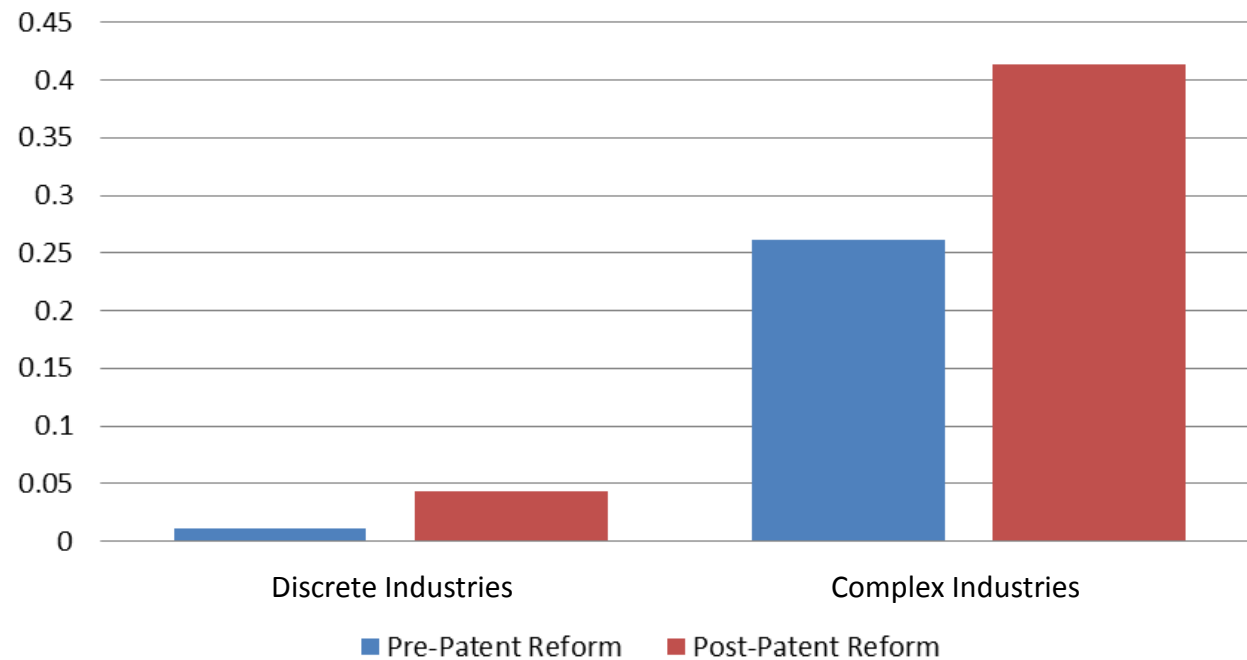
VII MAIN RESULTS

- Case 1: Omit Complexity Effects

	ln(Lu)	ln(La)	ln(Lu/La)	ln(Lu)	ln(La)	ln(Lu/La)
ln (PR)	0.182***	0.242***	-0.060	0.124**	0.214**	-0.069
A	0.116***	0.157***	-0.040	0.036*	0.125***	-0.068*
ln (PR) x A	-0.059***	-0.095***	0.036	-0.022	-0.058*	0.023
Industry Dummies	No	No	No	Yes	Yes	Yes
Other Controls	Parent R&D/Sales, Host GDP, Host Relative Wages, Capital Restrictions Dummy, Host Corporate Income Tax Rate – suppressed to conserve space (See Paper, Table 3)					
Notes:	# observations = 31,251. Fixed Effects by Year, Country, and Host-specific time trends included. ***, **, * are p-values 0.01, 0.05, 0.10 respectively; robust standard errors clustered by country x year. GLS Random Effects Estimation (id = Firm x Country)					

- Lu ~ Unaffiliated licensing receipts
- La ~ Affiliated licensing receipts
- PR ~ Index of Patent Rights
- A ~ Parent Patent Rank {0, 1}
- Industry Dummies ~ for Pharm, Non-Pharm Chem, Energy, Metals, Trans, Mach/Equip, Elec Comps;
  Other Manuf (dropped)

VII Main Results

○ Case 2: Control for Complexity Effects

	ln(Lu)	ln(La)	ln(Lu/La)	ln(Lu)	ln(La)	ln(Lu/La)
ln (PR)	0.108***	0.248***	-0.125	-0.026	0.245*	-0.247
A	0.031	0.154***	-0.103***	0.021	0.119***	-0.079**
ln (PR) x A	-0.025	-0.066**	0.028	-0.005	-0.052	0.034
Z	0.045	-0.518	0.554***	0.028	-1.150***	1.145***
ln (PR) x Z	0.036	-0.078	0.133	**-0.159***	**0.868****	**-0.980****
Interactions: ln(PR) x D	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies (D)	No	No	No	**Yes**	**Yes**	**Yes**
Other Controls	Parent R&D/Sales, Host GDP, Host Relative Wages, Capital Restrictions Dummy, Host Corporate Income Tax Rate – suppressed to conserve space (See Paper, Table 4)					
Notes:	# observations = 31,251. Fixed Effects by Year, Country, and Host-specific time trends included. ***, **, * are p-values 0.01, 0.05, 0.10 respectively; robust standard errors clustered by country x year. GLS Random Effects Estimation (id = Firm x Country)					

• **Z = 1 if complex industry, 0 otherwise**

VII Main Results

- Compare to Developed Country (North) Sample

	ln(Lu)	ln(La)	ln(Lu/La)	ln(Lu)	ln(La)	ln(Lu/La)
ln (PR)	-0.140	0.641*	-0.788*	-0.026	0.245*	-0.247
A	-0.338***	-0.222	-0.113	0.021	0.119***	-0.079**
ln (PR) x A	0.194***	0.327**	-0.136	0.186***	0.322**	-0.139
Z				1.180***	0.354	0.719
ln (PR) x Z				**-1.133***	0.629**	-0.383**
Other Controls	Parent R&D/Sales, Host GDP, Host Relative Wages, Capital Restrictions Dummy, Host Corporate Income Tax Rate – suppressed to conserve space (See Paper, Table 4)					
Notes:	# observations = 19,698. Fixed Effects by Year, Country, and Host-specific time trends included. ***, **, * are p-values 0.01, 0.05, 0.10 respectively; robust standard errors clustered by country x year. GLS Random Effects Estimation (id = Firm x Country)					

- **Z = 1 if complex industry, 0 otherwise**

'Complexity' has weak effects on composition of Tech Transfer in the North

VIII. Robustness checks

○ Stock of Licensing & Patent Reform Dummy

	ln(Lu)	ln(La)	ln(Lu/La)	(Lu)	ln(La)	ln(Lu/La)
Measure of Patent Protection (PP)	ln (Patent Rights)			Patent Reform {0, 1}		
PP	-0.024	0.663***	-0.664***	-0.145***	0.671***	-0.849***
Z	-0.106	-1.750***	1.932***	-0.232*	-1.067***	0.972***
PP x Z	**-0.142**	**1.223*****	**-1.643*****	**-0.014**	**0.808****	**-1.001****
Interactions: PP x D	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies (D)	Yes	Yes	Yes	Yes	Yes	Yes
Other Controls	Patent Rank & Interaction with PP, Parent R&D/Sales, Host GDP, Host Relative Wages, Capital Restrictions Dummy, Host Corporate Income Tax Rate – suppressed to conserve space (See Paper, Table 6)					
Notes:	# observations = 38,522. Fixed Effects by Year, Country, and Host-specific time trends included. ***, **, * are p-values .01, .05, .10 respectively; robust standard errors clustered by country x year. GLS Random Effects Estimation (id = Firm x Country)					

VIII. ROBUSTNESS CHECKS

- Additional Controls

	ln(Lu)	ln(La)	ln(Lu/La)
ln (PR)	-0.018	0.232*	-0.234
Z	0.014	-1.314***	1.294***
ln (PR) x Z	**-0.158**	**1.009***	**-1.124***
Product Life	-0.193***	0.138***	-0.338***
Product Life x ln (PR)	0.147***	-0.040	0.191**
Interactions: ln (PR) x D	Yes	Yes	Yes
Industry Dummies (D)	Yes	Yes	Yes
Other Controls	Institutional (Legal) Quality, Patent Rank & Interaction with PR, Parent R&D/Sales, Host GDP, Host Relative Wages, Capital Restrictions Dummy, Host Corporate Income Tax Rate – suppressed to conserve space (See Paper, Table 7)		
Notes:	Product Life from Bilir (2014) = mean patent citation lag by industry. See also notes to Main Results, Cases 1 and 2.		

VIII. ROBUSTNESS CHECKS

- ## Selection Bias
  - ### Two Stage Selection Model
    - Stage 1: Patenting Cost used as Exclusion Restriction (significantly associated with probability of licensing)
    - Stage 2: Inverse Mills Ratio <u>not</u> statistically significantly associated with volume of licensing (hence, no evidence of bias)

- ## Endogeneity Test
  - ### Colonial origin as Instrumental Variable (IV)
    - TRIPS Agreement as an exogenous shock to patent systems of non-UK & non-French colonies
    - Colonial origin in turn should not directly affect changes in the composition of licensing
    - First-stage: IV passes tests (reject null of weak identification & under-identification)
    - Second-stage: cannot reject the null that shifts in patent rights are exogenous

IX. Impacts of technology Transfers

- Impact on Affiliate R&D

Industry:	Discrete	Complex	Discrete	Complex
ln (Parent's Affiliated Licensing)	0.020**	0.049***		
ln (Parent's Unaffiliated Licensing)	-0.004	0.032		
L3. ln (Parent's Affiliated Licensing)			0.050***	0.032**
L3. ln (Parent's Unaffiliated Licensing)			0.010	0.032
Other Controls	Affiliate Sales, Parent R&D/Sales, Host GDP, Host Relative Wages, Capital Restrictions Dummy, Host Corporate Income Tax Rate, Patent Rights – suppressed to conserve space (See Paper, Table 9)			
Number of Observations	14,384	13,889	9,573	8,868
Notes:	Dependent Variable is the natural log of Affiliate Sales. L3 denotes three-year lag. See also Notes to Main Results, Cases 1 and 2.			

IX. Impacts of technology Transfers

○ Impact on Local Innovation

Measure of Innovation	Priority Patents	Priority Patents	Trilateral Patents	Trilateral Patents
ln (Parent's Affiliated Licensing)	0.003		-0.019	
ln (Parent's Unaffiliated Licensing)	0.043**		0.029***	
ln (Parent's Affiliated Licensing, Discrete)		-0.015		-0.022
ln (Parent's Affiliated Licensing, Complex)		-0.003		-0.013
ln (Parent's Unaffiliated Licensing, Discrete)		0.054***		0.043***
ln (Parent's Unaffiliated Licensing, Complex)		0.014		0.001
Other Controls	Host GDP, Host Relative Wages, Capital Restrictions Dummy, Host Corporate Income Tax Rate, Patent Rights – suppressed to conserve space (See Paper, Table 10)			
Number of Observations	748	743	748	743
Notes:	Dependent Variables are in natural logs.			

X. HIGHLIGHTS

- The effect of IPRs on the internalization motives of MNCs is one of the foundational questions in the literature.
- Impact of Patent Rights on Technology Transfer via Licensing varies by industry:
  - Risk of Imitation greater in discrete industries; hence, arms-length licensing is more prevalent in complex industries.
  - Increased patent protection and patent reforms have a greater impact on the unaffiliated licensing of firms in discrete industries.
- Important to consider not only the volume of technology transfer, but also the composition (between intra-firm and arms-length)
- This choice is relevant from an economic development perspective. External licensing facilitates the spread of knowledge and know-how, beyond the boundaries of the MNC network, to *indigenous* agents.
  - While intra-firm technology transfers positively affect affiliate R&D and value added, external transfers are shown to contribute to indigenous innovation.