Creation and Diffusion of Knowledge in the Global Firm

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Motivation

- Knowledge creation and diffusion are main pillars of modern growth theory
- Multinational enterprises (MNEs) account for the vast majority of business expenditure on R&D and innovative activity
- We use **patent data to capture knowledge creation and diffusion**

Research Questions

- Is knowledge creation becoming more or less collaborative across borders?

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- What are the barriers to collaboration and knowledge diffusion?

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- What are the barriers to collaboration and knowledge diffusion?
- *Ongoing:* what role do inventor teams & their characteristics (gender) play?

Main Findings

1. Knowledge creation is increasingly conducted in **global collaborative teams of inventors**
   - Global collaborative patents are of higher quality
   - Large share of patents by inventors located in foreign affiliates

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   - Over and above the effect of physical distance
   - Affect both collaboration and citation patterns

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1. Knowledge creation is increasingly conducted in **global collaborative teams of inventors**
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   - Affect both collaboration and citation patterns

3. MNEs diffuse knowledge via **inventor mobility**
   - Overlap in business hours facilitates mobility, while distance does not deter it
   - Women inventors are less mobile

Data & Stylised Facts

- Patent data from EPO's PATSTAT and USPTO, 1980-2010
- We focus on triadic patent families ("inventions")
- For regressions: filed in 2000-2010 and granted by USPTO, EPO, and JPO

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 2. Global Ultimate Owner (GUO) information

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    1. Match between patents and *applicant* names
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- Define a firm as an MNE if it has affiliates in at least two countries
- Today: focus on MNEs.
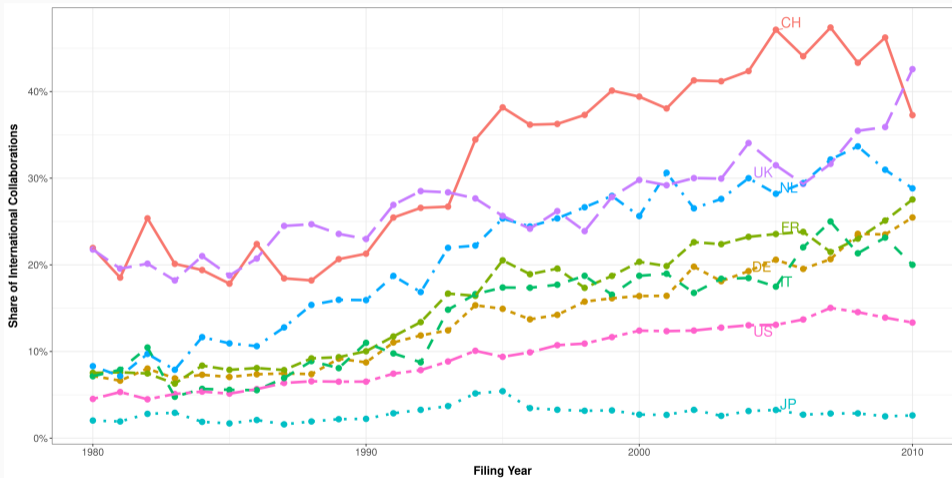
Fact 2: Global collaborative patents are of higher quality

Dependent Variable:	log(1+Citations)			
Model:	(1)	(2)	(3)	(4)
Variables				
Collaboration with HQ country	0.9411***	0.4357***	0.4023***	0.1784***
	(0.1278)	(0.0549)	(0.0532)	(0.0409)
log(Inventors)				0.5520***
				(0.0387)
Fixed-Effects				
Filing Year	Yes	Yes	Yes	Yes
Inventor	No	Yes	Yes	Yes
GUO	No	No	Yes	Yes
Country x Technology	No	No	Yes	Yes
Observations	589,609	589,609	589,609	589,609
R^2	0.25045	0.92168	0.93152	0.93957

Fact 3: Large share of patenting takes place in foreign affiliates

HQ Country	Patent families	HQ inventors (in %)	Affiliate inventors (in %)	HQ-affiliate collaboration (in %)
JP	111606	90.75	4.24	5.01
US	75528	64.41	14.41	21.18
DE	38738	64.56	10.58	24.86
FR	18330	52.17	23.05	24.78
UK	8653	34.59	30.20	35.21
CH	6390	16.07	49.20	34.73
NL	5880	11.36	52.02	36.62
SE	5800	49.72	23.14	27.14
KR	5203	78.47	8.38	13.15
IT	4909	60.87	11.96	27.17

- Similar picture emerges for inventor locations ▸ View inventors
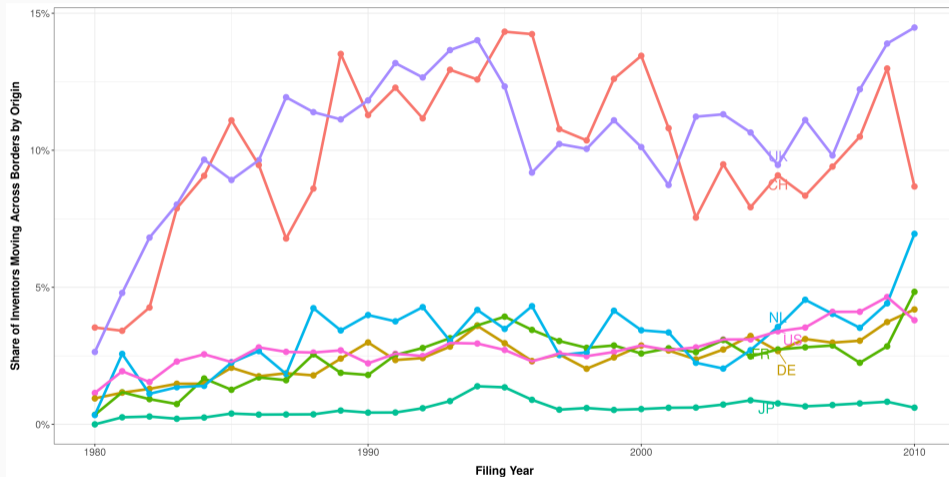
Empirical Findings on Knowledge Diffusion

1. Global collaboration
2. Citations
3. Inventor mobility
4. *Ongoing:* Women inventors & gender norms

Global collaboration: Two alternative approaches

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$$Collaboration_{pijfct} = \alpha Overlap_{ict} + \beta Distance_{ict} + \gamma_f + \delta_{cj} + \eta_i + \varepsilon_{pijfct}$$

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- γ_f GUO FE, δ_{cj} country-technology class FE, η_i inventor FE

Collaboration at the patent-inventor level

Dependent Variable:			Collaboration		
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
log(1+hours overlap)	0.1072***	0.0516**	0.0341***	0.0532***	0.0510***
	(0.0124)	(0.0220)	(0.0118)	(0.0156)	(0.0158)
log(distance)		-0.0512***	-0.0702***	-0.0736***	-0.0732***
		(0.0181)	(0.0107)	(0.0173)	(0.0178)
log(Inventors)					0.1102***
					(0.0116)
Both EN-speaking					0.0721***
					(0.0265)
log(1+hours overlap) × Woman					0.0199
					(0.0163)
log(distance) × Woman					0.0078
					(0.0122)
Fixed-Effects					
Country × Technology	No	No	Yes	Yes	Yes
GUO	No	No	Yes	Yes	Yes
Inventor	No	No	No	Yes	Yes
Observations	607,304	607,304	607,304	607,304	607,304
R^2	0.04121	0.04689	0.47931	0.72588	0.73059

Collaboration at the establishment level - 1

Dependent Variable:	Collaboration			
Model:	(1)	(2)	(3)	(4)
Variables				
log(1+hours overlap)	0.1047***	0.0268**	0.0359***	0.0352***
	(0.0095)	(0.0132)	(0.0129)	(0.0130)
log(distance)		-0.0715***	-0.0655***	-0.0606***
		(0.0079)	(0.0094)	(0.0095)
Both EN-speaking				0.0688***
				(0.0229)
Fixed-Effects				
Country x Technology	No	No	Yes	Yes
GUO	No	No	Yes	Yes
Fit statistics				
Observations	84,028	84,028	84,028	84,028
R^2	0.03594	0.0456	0.52778	0.52823

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Collaboration at the establishment level - 2

Dependent Variable:	Share of Collaborations with HQ							
	No Zeros	No Zeros	No Zeros	No Zeros	With Zeros	With Zeros	With Zeros	With Zeros
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables								
log(1+hours overlap)	0.0617***	0.0203***	0.0215***	0.0213***	0.0374***	0.0128***	0.0085**	0.0085**
	(0.0041)	(0.0063)	(0.0062)	(0.0062)	(0.0029)	(0.0042)	(0.0037)	(0.0037)
log(distance)		-0.0377***	-0.0102*	-0.0081		-0.0225***	-0.0112***	-0.0107***
		(0.0047)	(0.0053)	(0.0056)		(0.0031)	(0.0035)	(0.0036)
Both EN-speaking				0.0249*				0.0073
				(0.0130)				(0.0078)
Fixed-Effects								
Country x Technology	No	No	Yes	Yes	No	No	Yes	Yes
GUO	No	No	Yes	Yes	No	No	Yes	Yes
Fit statistics								
Observations	47,621	47,621	47,621	47,621	84,028	84,028	84,028	84,028
R²	0.04422	0.05434	0.61576	0.61593	0.02431	0.02941	0.518	0.51802

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- $Citation > 0$: indicates whether a patent filed at a foreign affiliate cites at least one patent previously filed by inventors located in HQ

Citations at the patent-inventor level

Dependent Variable:	Citation Count > 0				
Model:	(1)	(2)	(3)	(4)	(5)
Variables					
log(1+hours overlap)	0.0067	0.0062	0.0225**	0.0263	0.0236
	(0.0086)	(0.0087)	(0.0089)	(0.0195)	(0.0195)
log(distance)		-0.0009	-0.1439***	-0.1377***	-0.1395***
		(0.0142)	(0.0415)	(0.0512)	(0.0512)
Both EN-speaking					0.0746
					(0.0632)
log(1+hours overlap) × Woman					0.0224
					(0.0151)
log(distance) × Woman					0.0110
					(0.0210)
Fixed-Effects					
Citing GUO	No	No	Yes	Yes	Yes
Country × Technology	No	No	Yes	Yes	Yes
Inventor	No	No	No	Yes	Yes
Fit statistics					
Observations	241,436	241,436	241,436	241,436	241,436
R^2	0.00035	0.00035	0.28995	0.63465	0.63472

Citations at the establishment level

Dependent Variable:	Citation Count > 0			
Model:	(1)	(2)	(3)	(4)
Variables				
log(1+hours overlap)	0.0169**	0.0115	0.0249***	0.0253***
	(0.0078)	(0.0076)	(0.0096)	(0.0096)
log(distance)		-0.0103	-0.2166***	-0.2158***
		(0.0142)	(0.0546)	(0.0545)
Both EN-speaking				-0.0107
				(0.0272)
Fixed-Effects				
Citing GUO	No	No	Yes	Yes
Country x Technology	No	No	Yes	Yes
Fit statistics				
Observations	28,735	28,735	28,735	28,735
R^2	0.00168	0.00197	0.38796	0.38797

Inventor mobility: Testing for within-firm moves

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$$Move_{fc} = \alpha Overlap_{fct} + \beta Distance_{fct} + \gamma_f + \delta_c + \varepsilon_{fct}$$

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$$Move_{fc} = \alpha Overlap_{fct} + \beta Distance_{fct} + \gamma_f + \delta_c + \varepsilon_{fct}$$

- $Move_{fct} = 1$ if there is at least one inventor patenting at affiliate (headquarters) who has previously patented at headquarters (affiliate), 0 otherwise

Inventor mobility: bidirectional results

Dependent Variables:	Move from HQ to Affiliate			Move from Affiliate to HQ		
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
log(1+hours overlap)	0.0265**	0.1357***	0.1227***	0.0423***	0.1226***	0.1079***
	(0.0123)	(0.0286)	(0.0272)	(0.0161)	(0.0285)	(0.0283)
log(distance)		-0.1260	-0.1419		0.0135	-0.0044
		(0.0876)	(0.0888)		(0.0655)	(0.0658)
Both EN-Speaking			0.1500*			0.1697
			(0.0898)			(0.1078)
Fixed-Effects						
GUO	No	Yes	Yes	No	Yes	Yes
Host Country	No	Yes	Yes	No	Yes	Yes
Fit statistics						
Observations	12,611	12,611	12,611	12,611	12,611	12,611
R^2	0.00032	0.1989	0.19925	0.00105	0.18127	0.18185

Robustness checks

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  - Robust to dropping GUOs from US or dropping inventors located in the US
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- Can unobserved bilateral variables drive the results?
  - Robust to inclusion of HQ-host country bilateral FE
- Are results driven by certain countries?
  - Robust to dropping GUOs from US or dropping inventors located in the US
  - Robust to dropping GUOs with multiple home establishments
- Clustering at different combinations of GUO, host country, technology class

Are women inventors less mobile?

$$Move_{ifct} = \eta\,Woman_i + \theta\,Tenure_{ift} + \delta_c + \gamma_f + \varepsilon_{ifct}$$

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Dependent Variable:			Move between HQ and Affiliate			
	Full Sample	Full Sample	Full Sample	Full Sample	Full Sample	4th patent or more
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Woman	-0.0014	-0.0045***	-0.0047***	-0.0046***	-0.0042***	-0.0052***
	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0018)
log(Previous Filings)			-0.0015***			
			(0.0002)			
log(Citations Received)				-0.0004***		
				(0.0001)		
Fixed-Effects						
GUO	No	Yes	Yes	Yes	Yes	Yes
Host Country	No	Yes	Yes	Yes	Yes	Yes
Origin Year	No	No	No	No	Yes	No
Destination Year	No	No	No	No	Yes	No
Fit statistics						
Observations	279,909	279,909	279,909	279,909	279,909	96,211
R^2	1e-05	0.12195	0.12211	0.12203	0.12327	0.09604

Gender norms at HQ and host countries

$$WomanShare_{ct} = \alpha GenderGap_c + \beta MathGap_c + \eta HQWShare_{ft} + \gamma_{fj} + \delta_{cj} + \varepsilon_{ct}$$

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Dependent Variable:	Affiliate Woman Share						
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables							
Overall Gender Gap Host	0.0142***	0.0173***					0.0123***
	(0.0041)	(0.0056)					(0.0039)
Math Gender Gap Host			-0.0164***	-0.0167**			-0.0160***
			(0.0055)	(0.0081)			(0.0058)
HQ Woman Share					0.2001***	0.0881***	0.0849***
					(0.0265)	(0.0301)	(0.0300)
Fixed-Effects							
GUO×Technology	No	Yes	No	Yes	No	No	No
GUO Country×Technology	No	No	No	No	No	Yes	Yes
Fit statistics							
Observations	48,191	48,191	48,191	48,191	48,191	48,191	48,191
R²	0.00159	0.54657	0.00181	0.54636	0.00967	0.13997	0.14312

Concluding Remarks

- Cross-country evidence on where and how innovative activity takes place inside MNEs
- Document barriers to MNEs' ability to diffuse knowledge across borders
- **Working across time zones** $\implies$ communication costs, monitoring, and repeated interaction matter
- *In progress:* role of inventor teams, **gender**, and country-level gender norms

Appendix

Fact 3: Many inventors are located in foreign affiliates

HQ Country	Inventors	HQ inventors (in %)	Affiliate inventors (in %)
JP	296603	91.47	8.53
US	255277	79.48	20.52
DE	98278	73.98	26.02
FR	39714	57.85	42.15
UK	27794	46.33	53.67
CH	17812	20.93	79.07
KR	15467	83.06	16.94
NL	14643	22.64	77.36
SE	13641	59.09	40.91
IT	9752	64.05	35.95