Heterogeneous Firms Trading In Ideas: An Application to Energy Technologies

Innovation for climate change mitigation: a study of energy R&D, its uncertain effectiveness and Spillovers

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FEEM Seminar 11/11/10

0. Outline

1. Motivation
2. Literature Review
3. Our Contribution
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7. Empirical Strategy
8. Results
9. Conclusions/Future Research

1. Motivation: Technology and Development

- **Technology transfer (TT)** is an attractive options for countries with still limited innovative ability
- Both innovation and TT have received much attention in light of pressing **climate change issues** (change in perspectives in negotiation debates).
- Much remain to be understood with respect to how technologies move across countries and sectors
- In this paper, we focus on **technology transfer in energy technologies** as this sector is particularly relevant in the debate regarding Climate Change and Sustainable Development

2. Literature Review

- Induced innovation hypothesis points to both demand-push and technology-pull determinants (Popp 2002)
- Rich literature on innovation (both general and energy related)
- TT: most contributions focus on trade and FDI (economy-wide analyses)
- Limited evidence with respect to energy and climate change technologies, mostly due to lack of appropriate data
- Some evidence that CDM involved technology transfer (Dechezleprêtre et al. 2008)
- Notable exceptions: Dechezleprêtre et al (2009) Dekker et al (2009) but evidence is contradictory

2. Literature Review – Main Limitations

1. Focus on developed countries

- *relevant question is instead transfer from frontier innovators to laggards*

2. Empirical analysis of TT include variables that "make sense"

- *but do not necessarily have a framework of reference*

3. Only a few technologies are considered

- *mostly renewables*

3. Our Contribution

- Model inspired by recent trade literature that identifies the variables affecting the decision of innovating firms to protect a blueprint
- Test the model using data on power technologies
  - *strategic sector, relevant for development and with high mitigation potential*
- Focus on 47 countries
- **RESULTS:** (1) geographical distance hinders patenting; (2) Financial stability increases patenting; (3) environmental policy influences the probability of transfer; (4) sending and receiving knowledge stocks (proxies) play an important role

4. Patents: what they are

Patents are

1. *A set of exclusionary rights (territorial) granted by a state to a patentee*
2. *For a fixed period of time (usually 20 years)*
3. *In exchange for the disclosure of the details of the invention*

Granted on inventions (devices, processes, etc) that are:

1. *New (not known before the application of the patent)*
2. *Involve a non-obvious inventive step*
3. *Useful or industrially applicable*
4. *Patentee in US has the legal duty to cite prior art*

Imperfect but useful indicator of inventive activity

1. *Not all innovation are patented*
2. *Not all patented innovations have the same economic value*
3. *Propensity to patent may vary across countries and technological fields*

4. Patents: what they look like

Fluidized bed reactor having a furnace strip-air system and method for reducing heat content and increasing combustion efficiency of drained furnace solids

Bibliographic data | Description | Claims | Mosaics | Original document | INPADOC LEGAL status

Patent number:	US5390612 (A)
Publication date:	1995-02-21
Inventor(s):	TOTH STEPHEN J [US]
Applicant(s):	FOSTER WHEELER ENERGY CORP [US]
Classification:	
- international:	***F23C10/00; F23C10/24;* F23C10/00;** (IPC1-7): F23G7/00
- european:	F23C10/00D; F23C10/24
Application number:	US19930024041 19930301
Priority number(s):	US19930024041 19930301

View INPADOC patent family
View list of citing documents

Also published as:

- EP0614043 (A1)
- JP7004615 (A)
- PT614043 (T)
- ES2137321 (T3)
- CA2116283 (A1)

more >>

Cited documents:

- US3662719 (A)
- US4227488 (A)
- US4335661 (A)
- US4349969 (A)
- US4397102 (A)

more >>

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Abstract of **US 5390612 (A)**

A fluidized bed reactor having a furnace strip-air system and method for reducing heat content and increasing combustion efficiency of drained furnace solids in which a bed of particulate material is

4. Patents: why we use them

With respect to energy and environmental technologies

1. *Available at a high level of disaggregation*
2. *For a large number of countries*
3. *Patenting is likely a preferred means of protecting innovation in energy sector*
4. *Informs on "intended" (and unintended) knowledge flow*
5. *A set of exclusionary rights (territorial) granted by a state to a patentee*
6. *For a fixed period of time (usually 20 years)*
7. *In exchange for the disclosure of the details of the invention*

Good source of historical data for a sector in which private R&D, trade and human capital data are very scarce

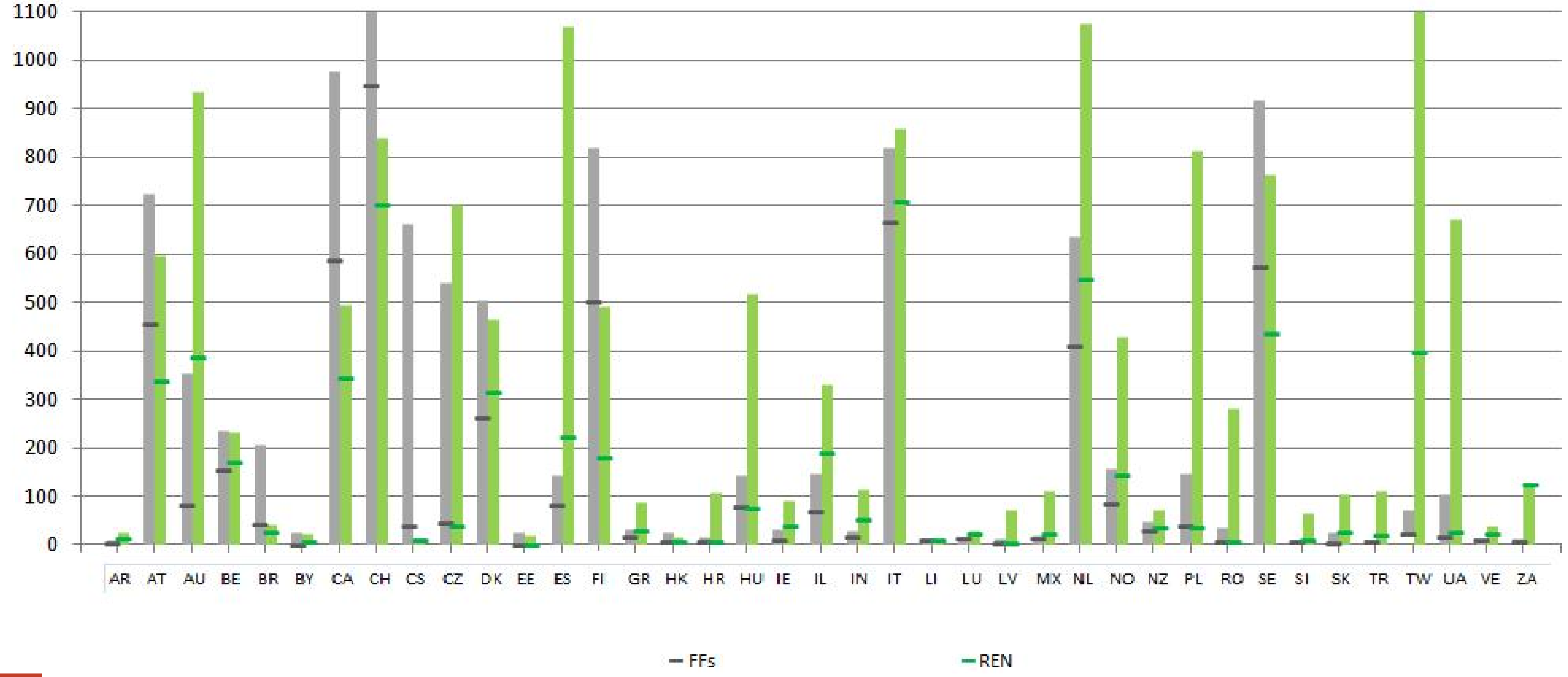
4. Patents: what we select

- Efficiency improving fossil techs for electricity production
    - Coal preparation technologies,Improved burners, Boilers, Gas turbines and steam engines, Fluidized beds, Super-heaters, Combined cycle, CHP and co-generation Traditional power plants and burners efficiency improvements
- Renewables
    - Solar, Wind, Hydro, Geothermal, Biomass, Ocean
- We distinguish between Singulars, Claimed Priorities and Duplicate patents
- We track in how many countries each innovation has been patented

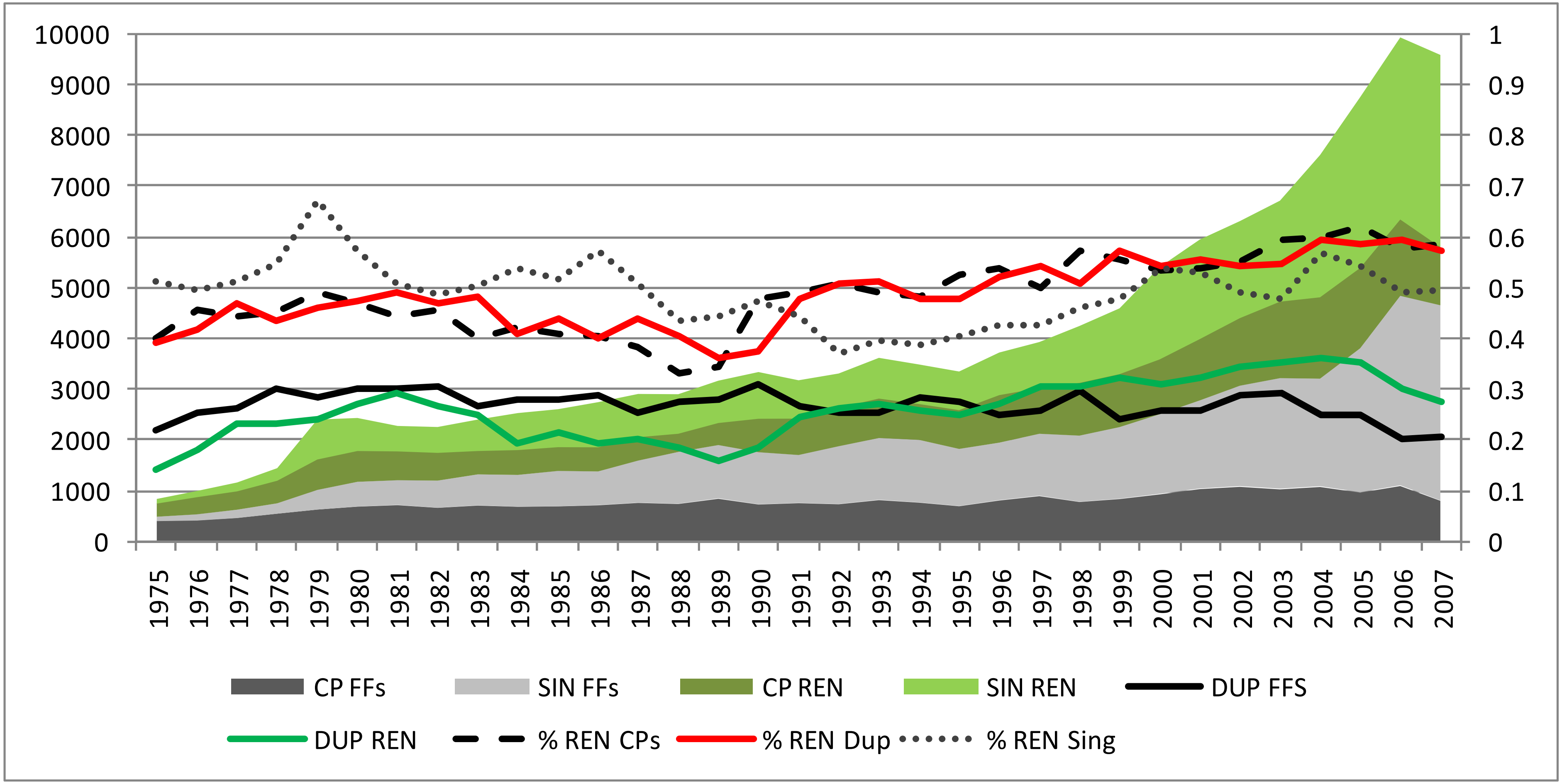
5. Stylized Facts

	FFS	REN	DUP FFS	DUP REN	% FFS cps	% REN cps	Dup/CP FFs	Dup/CP REN	Dup/patent FF	Dup/patent REN
Argentina,	11	27	6	56	36.4%	51.9%	1.500	4.000	0.545	2.074
Austria,	726	596	1427	1131	62.5%	56.9%	3.143	3.336	1.966	1.898
Australia,	354	934	327	1577	23.4%	41.5%	3.940	4.064	0.924	1.688
Belgium,	235	232	591	525	65.1%	73.7%	3.863	3.070	2.515	2.263
Brazil,	208	44	125	73	20.2%	56.8%	2.976	2.920	0.601	1.659
Belarus	25	22	1	7	4.0%	22.7%	1.000	1.400	0.040	0.318
Canada	976	495	1383	1066	60.2%	69.5%	2.352	3.099	1.417	2.154
Switzerland,	1487	840	3264	2660	63.8%	83.5%	3.443	3.795	2.195	3.167
China,	17697	263	154	139	0.6%	28.5%	1.525	1.853	0.009	0.529
Czechoslovakia,	663	14	122	35	5.9%	64.3%	3.128	3.889	0.184	2.500
Czech	540	703	86	51	8.1%	5.7%	1.955	1.275	0.159	0.073
Germany	18191	8414	19918	13070	36.7%	49.3%	2.987	3.154	1.095	1.553
Denmark,	504	465	1305	1280	51.8%	67.7%	5.000	4.063	2.589	2.753
Norway,	157	429	369	558	54.8%	33.3%	4.291	3.902	2.350	1.301
Spain,	143	1070	264	581	58.0%	20.7%	3.181	2.617	1.846	0.543
Finland,	821	492	2192	555	61.1%	36.4%	4.367	3.101	2.670	1.128
France,	2534	1557	8105	4074	84.5%	65.3%	3.786	4.010	3.199	2.617
United Kindom	1443	2803	4316	5066	73.3%	43.6%	4.083	4.142	2.991	1.807

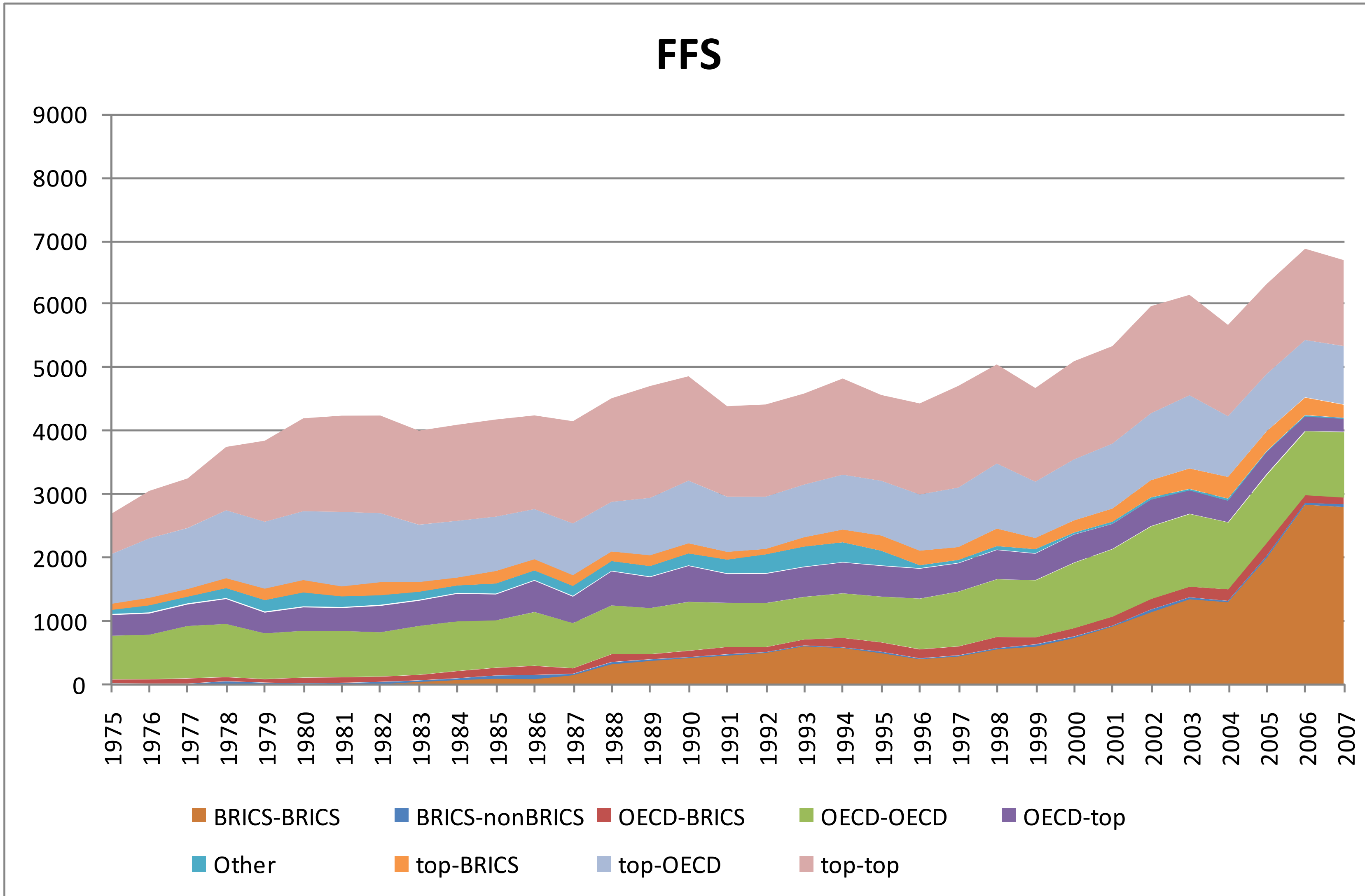
5. Stylized Facts



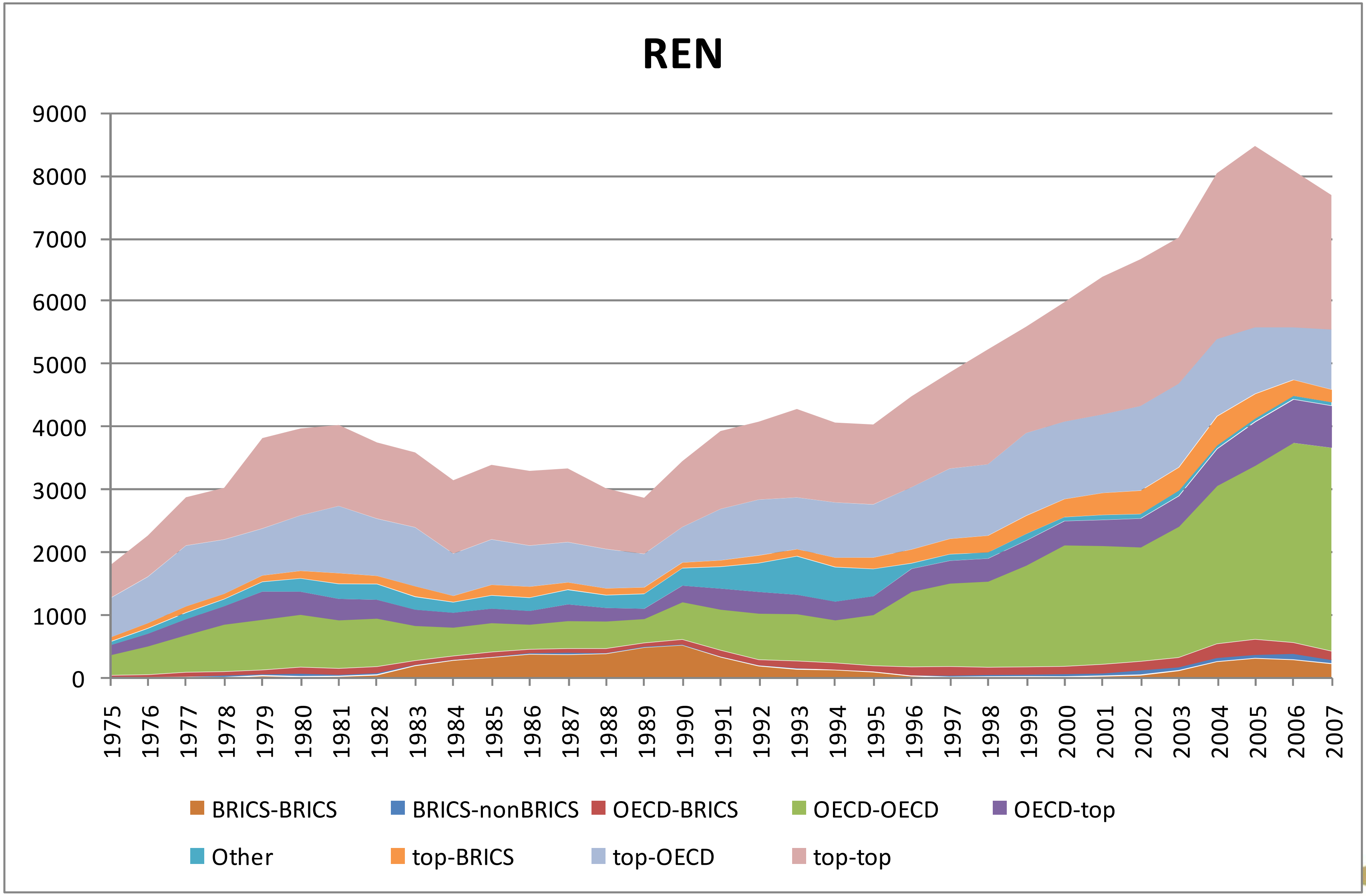
5. Stilyzed Facts (intertemporal trends)



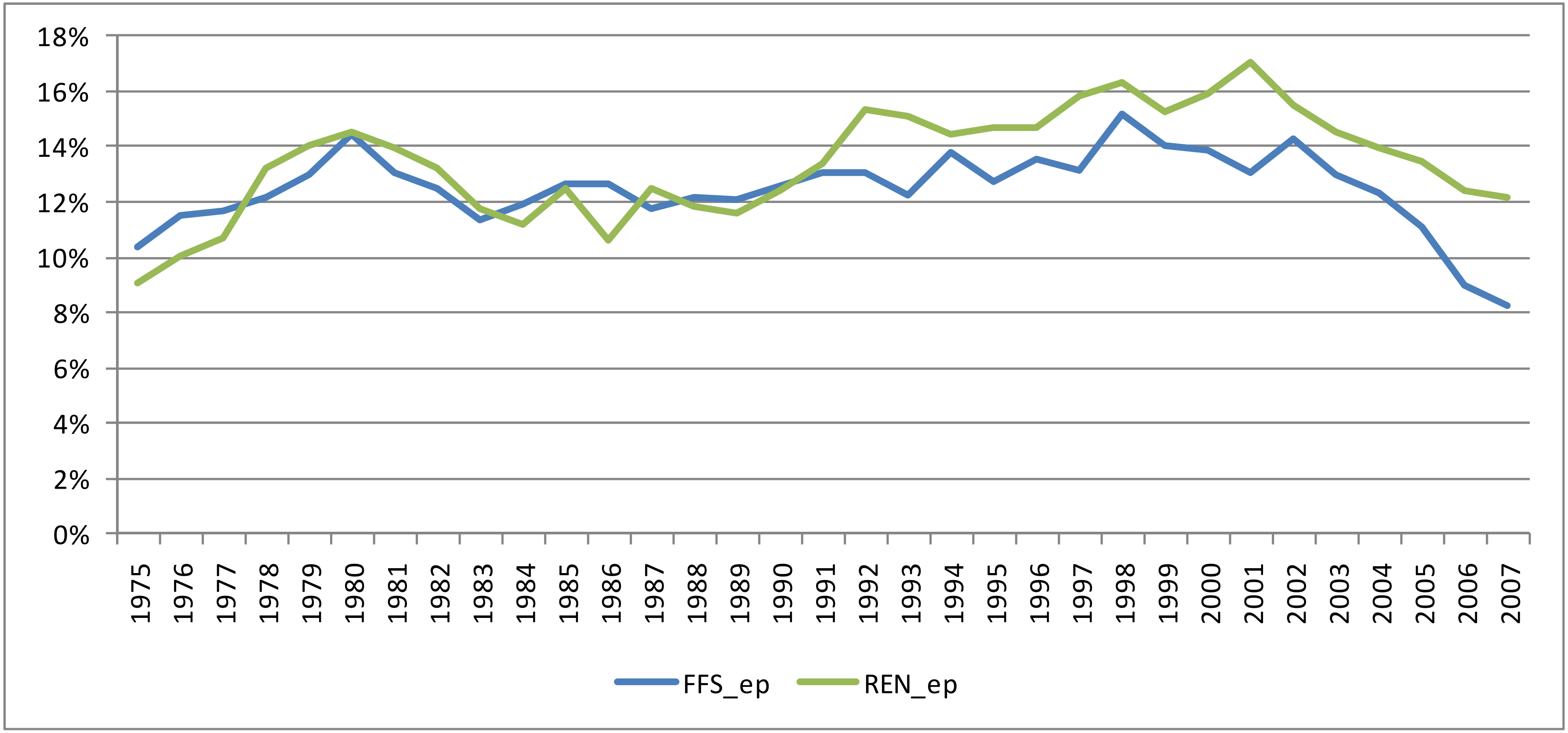
5. Stilyzed Facts (FFS geographical distribution)



5. Stilyzed Facts (REN geographical distribution)



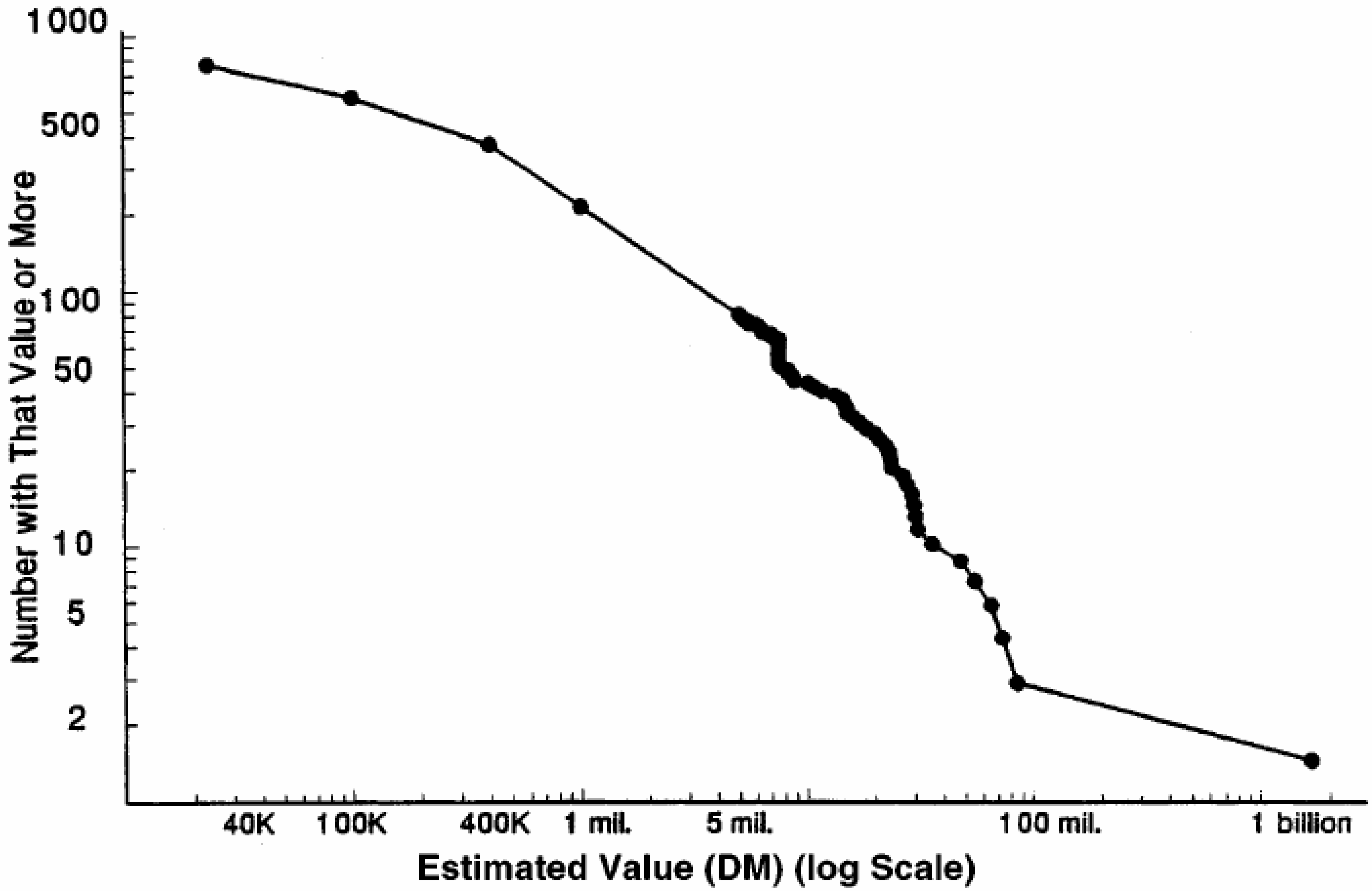
5. Stilyzed Facts (% of innovation “trading” partners)



6. The Model

- N countries, j
- Final output: $$Y_j = \left[Y_{j,c}^{\frac{\varepsilon-1}{\varepsilon}} + Y_{j,d}^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}$$
- For each j=c,d input: $$Y_{j,t} = \left[\int_0^{A_{j,t}} y_{j,t}^{\frac{\sigma_t-1}{\sigma_t}} ds_t \right]^{\frac{\sigma_t}{\sigma_t-1}}$$
- Technical progress increases number of varieties $A_{j,t}$
- Monopolistic competition: producing firms each using a specific idea/blueprint. Heterogeneous innovating firms differ along parameter a, or recipe quality (Pareto)
- Ideas or high quality a_H are patented, ideas of low quality a_L are not

Plot of German renewed patent values on Pareto coordinates



Uncertainty and the size distribution of rewards from innovation
F. M. Scherer, Dietmar Harhoff and Jörg Kukies
Evo.lutionary Economics Vol 10

6. The Model

First solve the lower nest: optimal demand of $y_{j,t}$ given $Y_{j,t}$

then find optimal leves of $Y_{j,t}$ given total spending M_j

$$Y_{j,t} = M_j \left(\frac{P_{j,t}}{P_j} \right)^{-\varepsilon}$$

Which allows to find demand for $y_{i.t}$

$$y_{j,t} = \left(\frac{p_{j,t}}{P_{j,t}} \right)^{-\sigma} M_j \left(\frac{P_{j,t}}{P_j} \right)^{-\varepsilon}$$

Where:

$$P_j = \left(P_{j,d}^{1-\varepsilon} + P_{j,c}^{1-\varepsilon} \right)^{\frac{1}{(1-\varepsilon)}}$$

$$P_{j,t} = \left[\int_0^{A_{j,t}} p_{j,t}{}^{1-\sigma_t} ds_t \right]^{\frac{1}{1-\sigma_t}}$$

6. The Model

- Producing one unit of $y_{j,t}$ costs $\tau_{ij} c_{j,t} / a_{ij}$

- Firms will price

$$p_{j,t} = \frac{\tau_{ij} c_{j,t}}{\beta_t \, a_{ij}}$$

- Profit for each firm in j will be

$$\Pi_{ij,t}(a) = [1 - \beta_t] \left(\frac{\tau_{ij} c_{j,t}}{\beta \, a_{ij}} \right)^{1-\sigma_t} M_j P_{j,t}^{\sigma - \varepsilon} P_j^{\varepsilon} - F_j$$

- Firms will produce if

$$[1 - \beta_t] \left(\frac{\tau_{ij} c_{j,t}}{\beta_t \, a_{ij}} \right)^{1-\sigma_t} M_j P_{j,t}^{\sigma - \varepsilon} P_j^{\varepsilon} > F_j$$

6. The Model

- Assumption on distribution of ***a*** means that the fraction of country-*i* ideas with quality higher than a_{ij} is $G_{ij}(a) = \bar{a}_{ij}^{-\theta}$
- Morever, $\tau_{ij}^{\theta} = D_{ij}^{\gamma} e^{-u_{ij}}$

$$G_{ij,t} = \begin{cases} [D_{ij}^{-\gamma}] (F_j)^{-\frac{\theta}{\sigma_t - 1}} [c_{j,t}]^{-\theta} [M_j]^{\frac{\theta}{\sigma_t - 1}} \left[P_{j,t}^{\varepsilon-\sigma} P_j^{-\varepsilon}\right]^{\frac{\theta}{\sigma_t - 1}} \left[\beta (1-\beta)^{\frac{1}{\sigma_t - 1}}\right]^{\theta} e^{u_{ij}} & if \quad a_{i,t} > \bar{a}_{ij,t} \\ 0 & otherwise \end{cases}$$

Which we implement empirically as follows:

$$g_{ij} = \beta_0 + \beta_1 d_{ij} + \beta_2 f_j + \beta_3 c_j + \beta_4 m_j + \chi_j + \chi_i + u_{ij}$$

- Log(G_{ij}) is observed only for a subsample: control for sample selection in the transfer relationship (Heckman)

7. Empirical Strategy: Distance

Geographical distance

- Dummy =1 if $i=j$
- Dummy =1 if contiguous
- Dummy =1 if common language
- Dummy =1 if colonial relationship
- Distance

Mij

- Market Stock, per capita
- Energy use per capita
- GDP per capita

7. Empirical Strategy: Costs and M_{ij}

Fixed costs

- Ginarte and Park Index: 5 years index. Interpolated
- Financial Risk Ratio: monthly by ICRG

Exclusion restrictions

- Stock of efficiency and renewable policies (sum)
- Knowledge stock in selection equation

$$K_{i,s,t} = PAT_{i,s,t} + (1-\delta)K_{i,s,t-1}$$

$$K_{i,s,t_0} = \frac{PAT_{i,s,t_0}}{(\bar{g}_{i,s} + \delta)}$$

	Outcome Equation					
	Energy Efficient			Renewables		
Same	3.6437***	2.9812***	3.0319***	4.4458***	3.5260***	3.6022***
	(0.317)	(0.313)	(0.320)	(0.343)	(0.287)	(0.290)
Distance	-0.0373	-0.1274**	-0.1232*	0.0918	-0.0565	-0.0469
	(0.055)	(0.065)	(0.065)	(0.069)	(0.068)	(0.069)
Colonial Relationship	0.5388***	0.4648***	0.4585***	0.7372***	0.5401***	0.5458***
	(0.159)	(0.157)	(0.159)	(0.198)	(0.179)	(0.182)
Contiguous	0.4383***	0.2905*	0.2818*	0.5626***	0.2781*	0.2836**
	(0.145)	(0.156)	(0.157)	(0.163)	(0.144)	(0.144)
Common Language	0.4684***	0.1758	0.2086*	0.6856***	0.3594***	0.3940***
	(0.126)	(0.121)	(0.120)	(0.124)	(0.110)	(0.109)
Financial Security (Risk Ratio Index)	0.6166***	0.4142***	0.4553***	0.7226***	0.4122***	0.4602***
	(0.123)	(0.132)	(0.144)	(0.152)	(0.154)	(0.165)
Market Stock PC	0.2027***	0.2588***	0.4082***	0.2487***	0.2897***	0.4127***
	(0.029)	(0.042)	(0.072)	(0.034)	(0.054)	(0.063)
Consumer Price Index			-0.0210*			-0.0381***
			(0.013)			(0.012)
Selection Equation						
Sending Knowledge Stock Fossil	0.2839***	0.2456***	0.2479***	0.1376***	0.1141***	0.1109***
	(0.017)	(0.023)	(0.023)	(0.015)	(0.019)	(0.019)
Sending Knowledge Stock Renewable	-0.0062	0.0697**	0.0837***	0.1237***	0.2120***	0.2237***
	(0.017)	(0.028)	(0.028)	(0.017)	(0.026)	(0.026)
Ratio Policy Stocks		-0.0339***	-0.0278***		-0.0165**	-0.0125*
		(0.010)	(0.009)		(0.007)	(0.007)
Financial Security (Risk Ratio Index)	0.4858***	-0.0417	0.2920**	0.5845***	0.1855	0.4487***
	(0.087)	(0.119)	(0.129)	(0.088)	(0.118)	(0.129)
Market Stock PC	0.0881***	0.1832***	0.1970***	0.0746***	0.1326***	0.1401***
	(0.012)	(0.019)	(0.018)	(0.010)	(0.012)	(0.012)
Consumer Price Index			-0.0961***			-0.0771***
			(0.012)			(0.009)
Observations	41466	20154	19832	42189	20124	19807
Log-Likelihood	-23725	-14862	-14348	-26273	-15900	-15485

6. Empirical Results

- Model: identifies the variables affecting the decision of heterogeneous firms to protect blueprints abroad
- Geographical distance hinders patent duplication (TT)
- Financial stability has a positive effect on TT. Now exploring whether this effect is differentiated by country/level of development
- Innovative ability in the sending country associated with higher probability of TT
- Environmental policy is positively correlated with the probability of transfer

6. Future Research Avenues

Short term:

- Better index for environmental policy
- Better index for fixed costs
- Price indexes

Longer term:

- What drives the Pareto distribution?
- What is the role of IPR and transfer on domestic innovation in developing countries?
- Using trade data to look at the issue of embededd technology transfers

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Thanks

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