

Conference *The Transformation of Research in the South: policies and outcomes*
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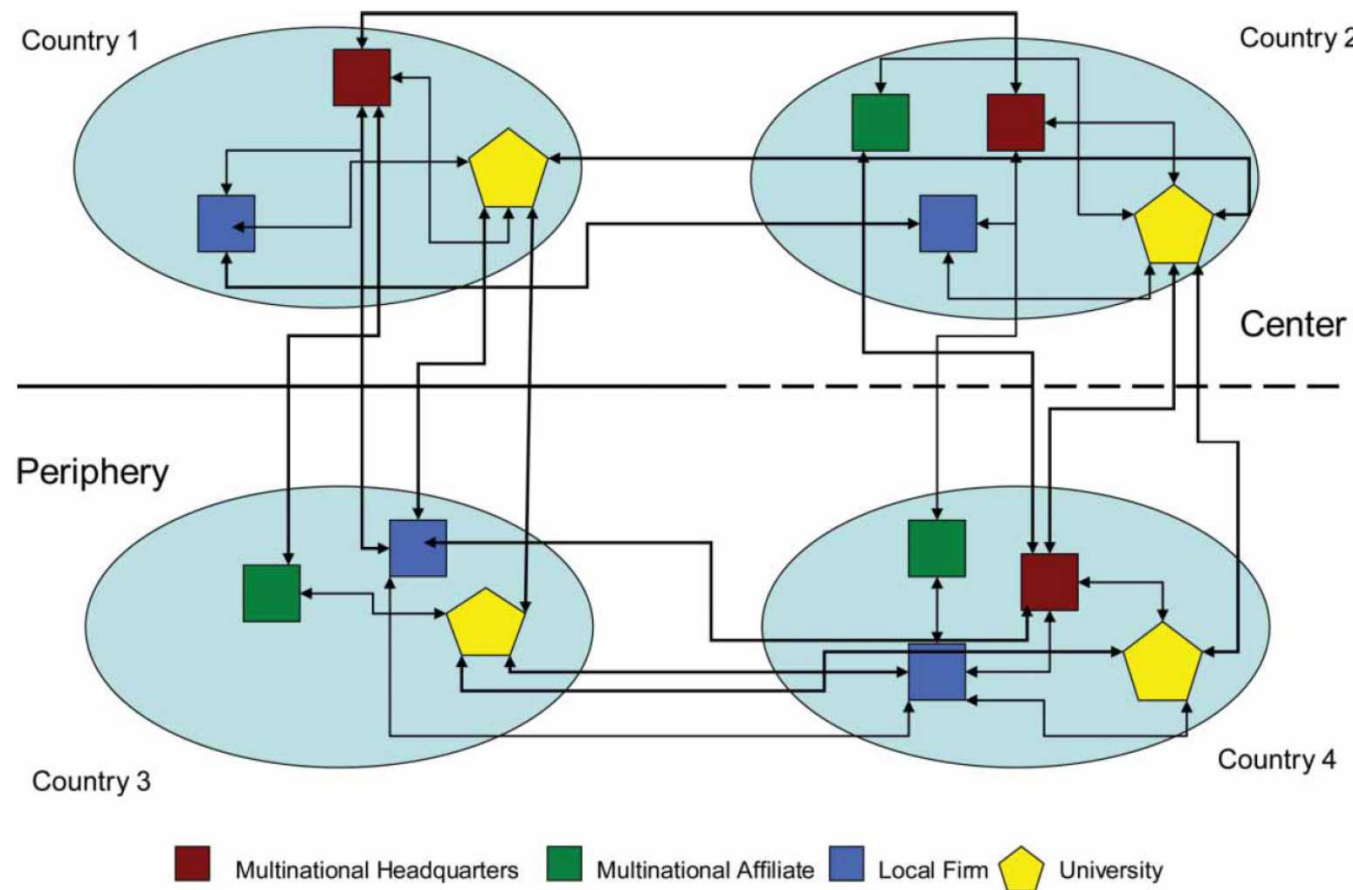
**MAPPING INTERNATIONAL KNOWLEDGE
FLOWS:
three dimensions for a framework to evaluate
transnational cooperation in research**

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Summary

- Introduction
- Literature review: internationalization, knowledge economy and a new phase of capitalism: an emerging global innovation system?
- First dimension: transnational corporations and their subsidiaries
- Second dimension: triadic patents as indicators of international flows
- Third dimension: ISI-indexed papers and TNCs in international flows of science
- A note on South-South international flows

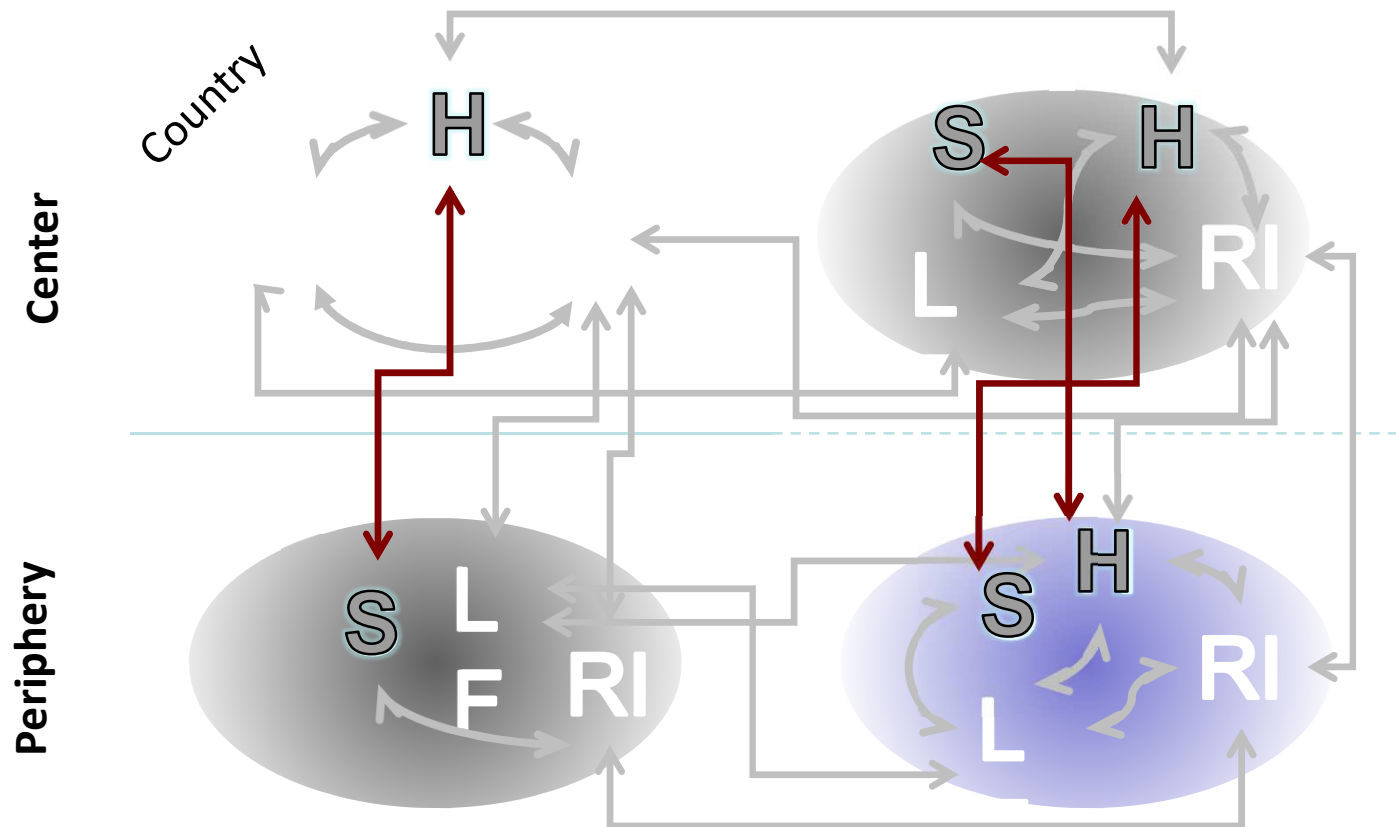
Literature review:
Multinationals, their R&D activities and scientific institutions as
connectors between different national systems of innovation
- a tentative framework (Figure 1)



Different Databases to Capture Different Kinds of Flows



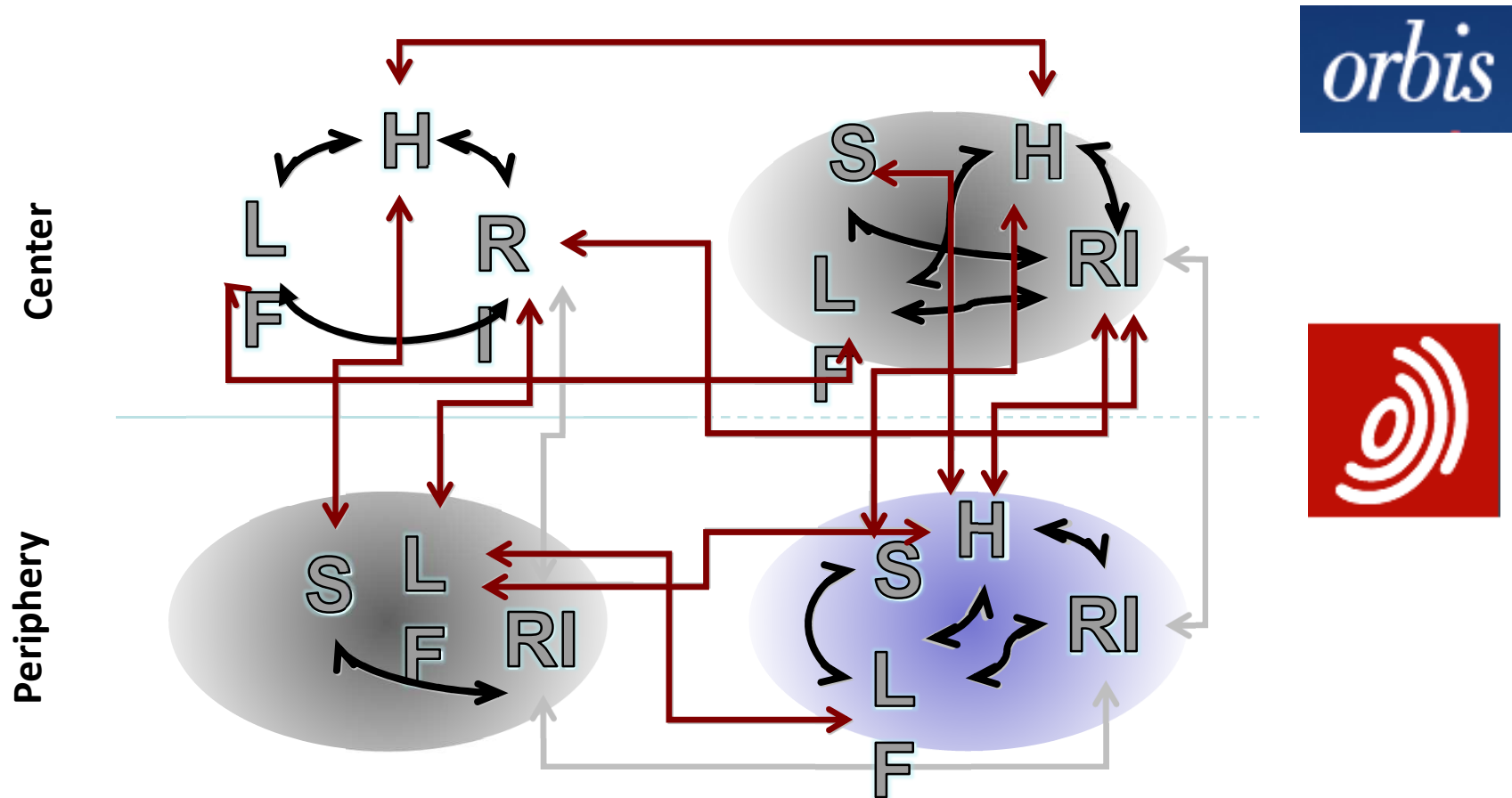
Tacit knowledge flow between
headquarter and its subsidiaries [1]



TRANSNATIONAL CORPORATIONS AND THEIR SUBSIDIARIES
ORBIS Database

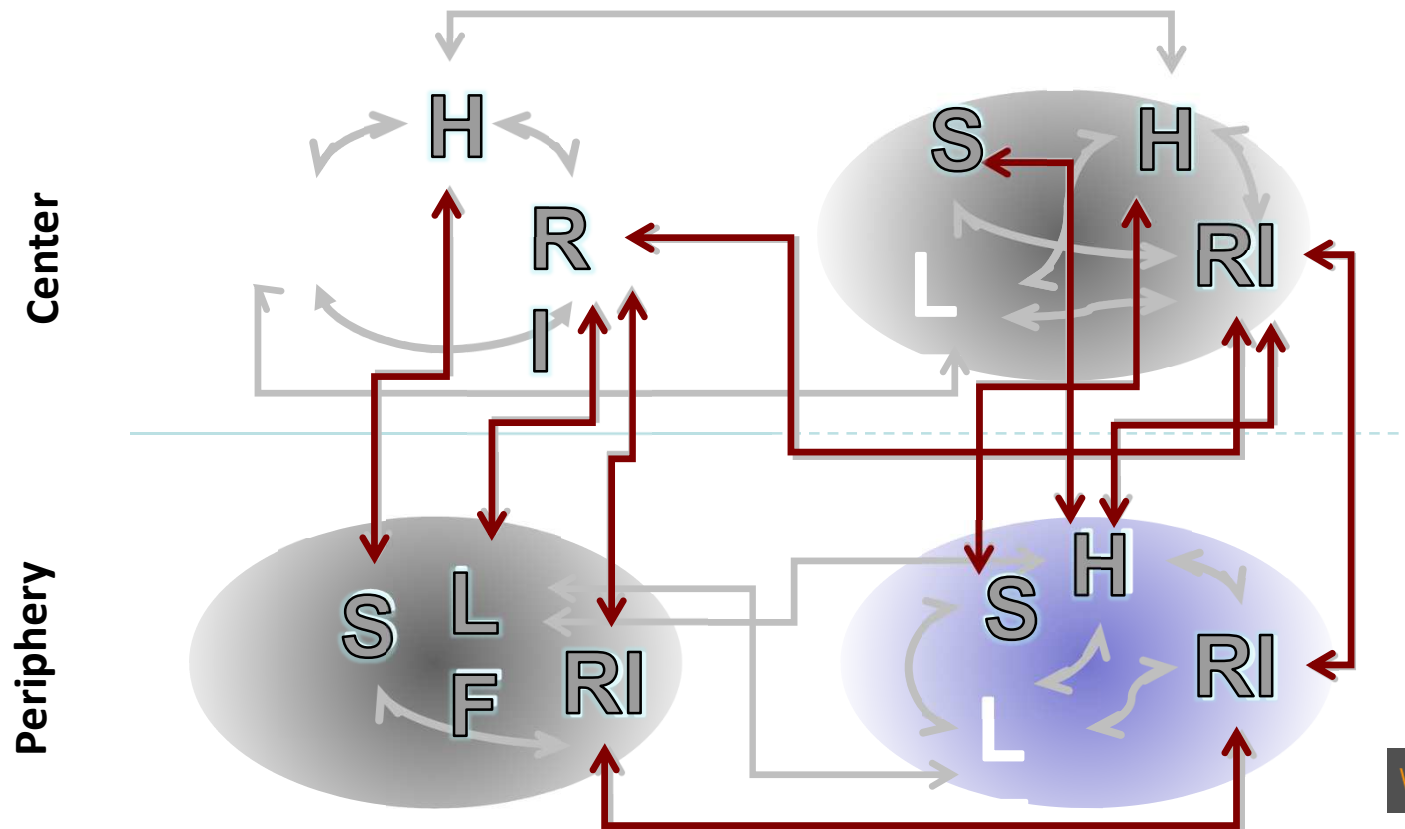
[1] D. J. Teece, The Economic Journal, Vol. 87, No. 346 (Jun., 1977), pp. 242-261

Different Databases to Capture Different Kinds of Flows



INTERNATIONAL FLOWS THROUGH PATENTS
Triadic Patents – PATSTAT Database

Different Databases to Capture Different Kinds of Flows



Interactions having as one of inductors the knowledge flow through Indexed papers

INTERNATIONAL FLOWS THROUGH PAPERS
ISI Indexed Papers – ISI Database

Three Huge Databases



Information on nearly 150 million companies worldwide, focus on private company.

- Company financials, Ratings, etc.
- **Detailed ownership structures**

Web Database

Web Query



Snapshot of EPO Database with worldwide coverage

- 67 million Patent information, **including bibliography**

Local Database



Information on nearly 10 million scientific publications,

- Fully data paper, **including citations and cited.**

Web Database

**Analyze Each One Separately
And Then Match Them**

First dimension: transnational corporations and their subsidiaries:
784 GUOs localized at 52 different countries having about 90 mil subsidiaries
abroad localized at 197 countries (Table 1)

Group ¹	Countries	GUO			Subsidiaries			Countries (Home/Host)	
		(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
		Total	MNE ²	Hosted ³	Total	Abroad	Hosted ⁴	Internalized ⁵	Hosted ⁶
A	United States (US)	262	232	412	47,695	25,036	9,161	160	42
A	Japan (JP)	111	104	252	16,421	8,875	862	136	29
A	United Kingdom (GB)	58	54	511	12,000	7,187	9,417	163	46
A	Germany (DE)	44	36	428	12,754	8,588	4,496	152	38
A	France (FR)	40	38	360	12,654	9,416	2,801	158	36
B	China (CN)	37	24	406	1,578	278	4,436	52	36
A	Canada (CA)	27	23	448	1,350	935	2,452	61	35
B	India (IN)	24	23	308	992	628	1,062	75	32
B	Taiwan (TW)	23	23	194	730	619	412	48	20
B	South Korea (KR)	22	22	244	1,050	799	549	75	22
A	Switzerland (CH)	19	19	334	5,682	5,176	1,355	150	39
A	Netherlands (NL)	15	15	506	3,112	2,248	4,661	93	45
A	Sweden (SE)	14	14	248	3,267	2,438	1,188	108	28
A	Spain (ES)	12	11	388	2,202	1,341	2,192	75	34
B	South Africa (ZA)	12	11	246	1,030	648	859	75	33
A	Australia (AU)	11	11	350	1,633	939	3,153	86	33
A	Italy (IT)	11	10	360	1,981	1,654	1,651	88	36
B	Brazil (BR)	10	9	380	645	475	1,679	37	35
A	Bermuda (BM)	9	9	164	1,246	1,182	557	67	30
B	Mexico (MX)	8	7	364	796	550	1,946	52	30
B	Russia (RU)	8	7	298	583	112	1,482	29	33
B	Cayman Islands (KY)	7	7	166	243	240	749	24	32
A	Ireland (IE)	5	5	289	1,571	1,512	1,301	85	32
B	Hong Kong (HK)	5	5	353	211	145	1,315	36	32
B	United Arab Emirates (AE)	5	5	160	52	23	319	14	28
B	Malaysia (MY)	5	4	278	275	148	856	26	34
B	Indonesia (ID)	5	3	216	26	8	692	5	29

Second dimension: triadic patents as indicators of international flows

Triadic Patent Definition and some Conventions:

- PCT application on USPTO, EPC and JP (same international ID)
- Granted date is the first of triplet
- Assignee, Authors and citations to Patents and other references (NPRs) are got from first USPTO grant

International Flows assessed:

- Assignee – Author
- GUO-Assignee
- Co-authoring
- Co-Assignee
- Patent Citation
- Article Citation
- Total International Flow: At least one of previous flows

Second dimension: triadic patents as indicators of international flows

(Table 2)

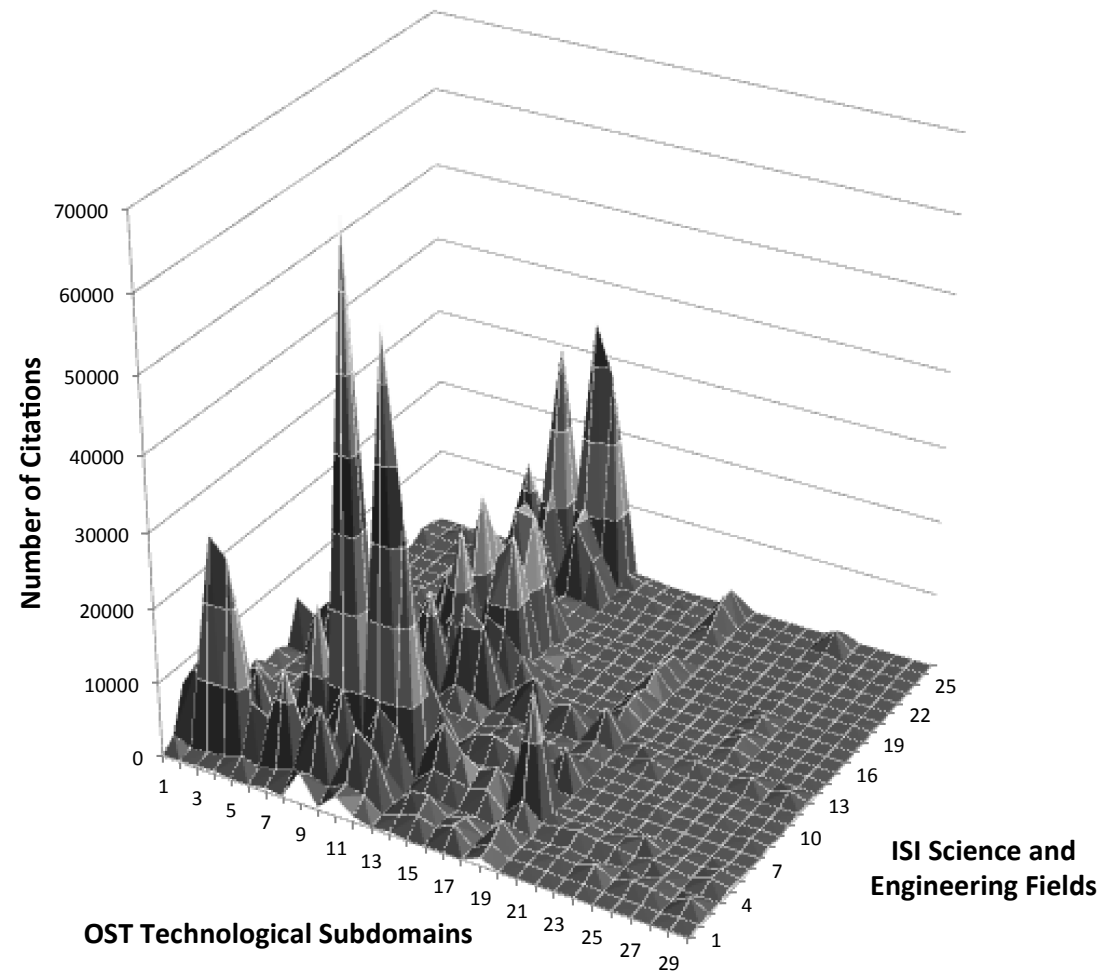
Granted Year	International Flows - Fully Granted Triadic Patents										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Granted Triadic Patentes	2881 (53.7%)	21696 (45.1%)	20109 (44.7%)	19466 (46.3%)	18142 (47%)	16373 (50.9%)	18387 (55.1%)	16273 (58.1%)	15116 (62.3%)	12631 (66.3%)	10455 (69.5%)
Inter. Flow - Assignee - Author	235 (62.1%)	2111 (52.8%)	1902 (50.1%)	2058 (53.8%)	1998 (52.5%)	1555 (53.8%)	1926 (60.7%)	1757 (62.3%)	1726 (68.8%)	1388 (73.2%)	1148 (73.1%)
%	8%	10%	9%	11%	11%	9%	10%	11%	11%	11%	11%
Inter. Flow - GUO-Assignee*	0 (0%)	27 (48.1%)	151 (53.6%)	300 (46.7%)	461 (46.4%)	490 (51.6%)	698 (59.6%)	641 (60.1%)	708 (63.6%)	526 (62.4%)	466 (70.4%)
%	0%	0%	1%	2%	3%	3%	4%	4%	5%	4%	4%
Inter. Flow - Co-authoring	135 (64.4%)	1258 (57.4%)	1172 (58.9%)	1255 (60.8%)	1212 (62.3%)	1034 (63.4%)	1337 (70.3%)	1105 (71.4%)	1148 (73.5%)	974 (78.3%)	755 (79.5%)
%	5%	6%	6%	6%	7%	6%	7%	7%	8%	8%	7%
Inter. Flow - Co-Assgnee	32 (53.1%)	214 (56.1%)	171 (57.9%)	174 (72.4%)	163 (58.3%)	179 (52.5%)	142 (69%)	130 (72.3%)	126 (69%)	114 (81.6%)	109 (79.8%)
%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Inter. Flow - Patent Citation	2545 (54.7%)	19036 (45.5%)	17683 (45.5%)	17380 (46.9%)	16209 (47.7%)	14862 (51.3%)	16300 (55.8%)	14613 (58.8%)	13546 (63%)	11406 (67%)	9435 (70.4%)
%	88%	88%	88%	89%	89%	91%	89%	90%	90%	90%	90%
Inter. Flow - Article Citation	44 (100%)	349 (100%)	276 (100%)	287 (100%)	278 (100%)	330 (100%)	502 (100%)	396 (100%)	365 (100%)	309 (100%)	259 (100%)
%	1.5%	1.6%	1.4%	1.5%	1.5%	2.0%	2.7%	2.4%	2.4%	2.4%	2.5%
Total Internationla Flow	2570 (54.6%)	19272 (45.6%)	17905 (45.6%)	17580 (47%)	16365 (47.8%)	15025 (51.5%)	16551 (56.1%)	14792 (59%)	13688 (63.1%)	11503 (67.1%)	9517 (70.3%)
%	89%	89%	89%	90%	90%	92%	90%	91%	91%	91%	91%

* Only Granted Triadic TOOP500 Ranking

Second dimension: triadic patents as indicators of international flows

(Figure 2)

Leading peaks:
ORGANIC CHEMISTRY
PHARMACEUTICAL
BIOTECHNOLOGY



Second dimension: triadic patents as indicators of international flows

(Table 3)

Ranking Triadic Patent Country					
All Triadics			Triadics with International Flow		
Rank	Country	Patents	Rank	Country	Patents
1	JP	75644	1	JP	65383
2	US	32644	2	US	28925
3	DE	20913	3	DE	19867
4	FR	8132	4	FR	7819
5	GB	6179	5	GB	6004
6	KR	4369	6	KR	4151
7	CH	3439	7	CH	3335
8	SE	3027	8	SE	2954
9	NL	2643	9	NL	2584
10	IT	2577	10	IT	2431
11	CA	1672	11	CA	1605
12	BE	1377	12	BE	1348
13	FI	1314	13	FI	1294
14	AU	1234	14	AU	1171
15	DK	1107	15	DK	1044
16	AT	1051	16	AT	980
17	IL	846	17	IL	819
18	CN	491	18	CN	432
19	ES	418	19	ES	385
20	NO	389	20	NO	359
21	RU	200	21	RU	184
22	IE	182	22	IE	175
23	IN	178	23	IN	160
24	SG	159	24	SG	153
25	NZ	153	25	NZ	151
26	TW	144	26	TW	134
27	HU	124	27	BR	107
28	BR	113	28	HU	106
29	ZA	112	29	ZA	97
30	HK	58	30	HK	55

Third dimension: ISI-indexed papers and TNCs in international flows of science (Table 4)

Total Articles
2019563
Articles With Inter flow
329190
16.3%

Ranking ISI 2012 Articles Country					
All Articles			Articles with International Flow		
Rank	Country	Article	Rank	Country	Patents
1	USA	461853	1	USA	61146
2	Peoples R China	247166	2	Peoples R China	26129
3	Germany	92272	3	Germany	22491
4	England	90439	4	England	21409
5	Japan	86948	5	France	15019
6	Canada	60179	6	Canada	13336
7	France	59574	7	Italy	12723
8	Italy	58484	8	Spain	11338
9	India	54137	9	Australia	10120
10	Spain	52585	10	Japan	9368
11	South Korea	51051	11	Netherlands	8861
12	Australia	46127	12	South Korea	6911
13	Brazil	39307	13	Switzerland	6837
14	Netherlands	30786	14	Sweden	5478
15	Taiwan	30043	15	Brazil	5268
16	Turkey	27901	16	Belgium	5152
17	Iran	26351	17	India	5055
18	Russia	22791	18	Scotland	3598
19	Poland	22232	19	Austria	3587
20	Switzerland	19120	20	Denmark	3474
21	Sweden	18513	21	Russia	3303
22	Belgium	15758	22	Taiwan	3279
23	Portugal	12471	23	Portugal	3181
24	Denmark	11760	24	Poland	2999
25	Israel	11735	25	Iran	2914
26	Scotland	11433	26	Israel	2783
27	Czech Republic	11409	27	Norway	2679
28	Austria	11287	28	Finland	2616
29	Malaysia	11174	29	Singapore	2570
30	Greece	10748	30	Turkey	2410

Third dimension: ISI-indexed papers and TNCs in international flows of science

(Table 5)

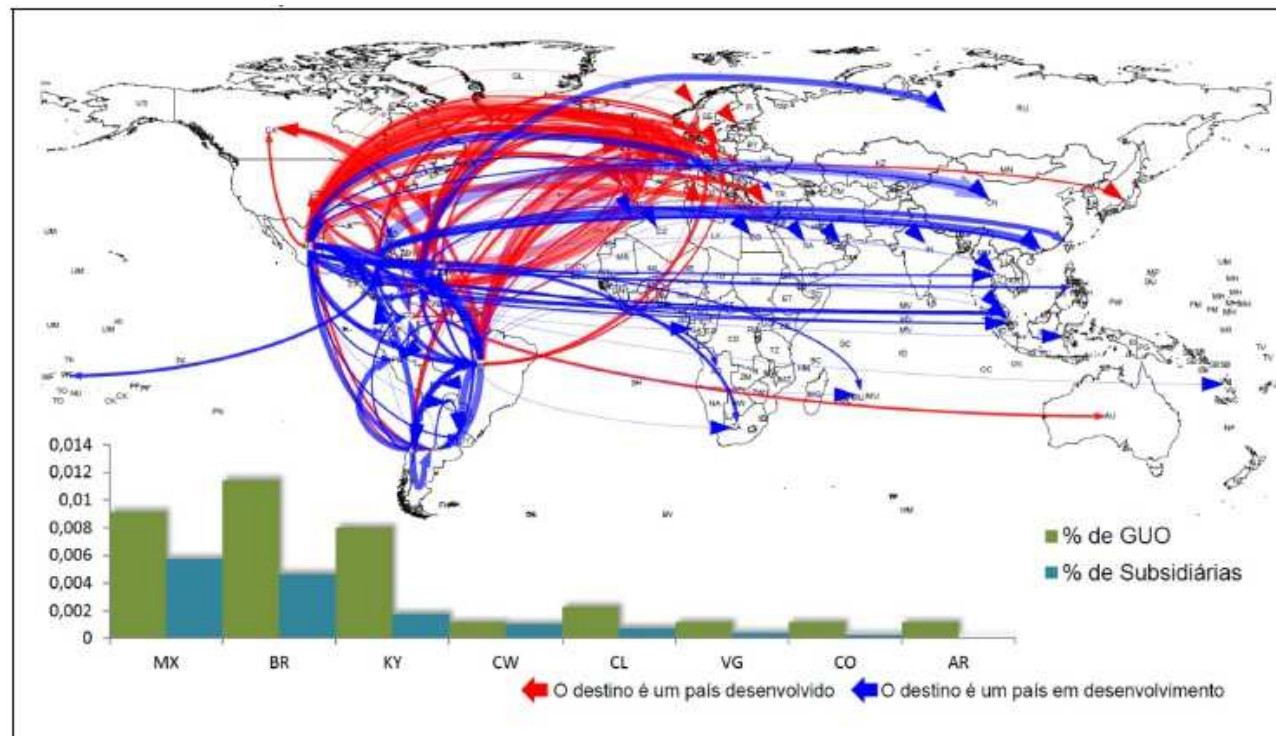
Ranking ISI 2012 Coauthoring Institutions			Ranking ISI 2012 Coauthoring Institutions		
RI - RI Interaction			Firm - Firm Interaction		
Rank	Country	Article	Rank	Country	Article
1	Harvard Univ (USA);Univ Toronto (Canada)	438	1	Novartis Pharma AG (Switzerland);Novartis Pharmaceut (USA)	131
2	Harvard Univ (USA);Univ Oxford (England)	378	2	Abbott GmbH e Co KG (Germany);Abbott Labs (USA)	34
3	Harvard Univ (USA);McGill Univ (Canada)	371	3	F Hoffmann La Roche e Co Ltd (Switzerland);Genentech Inc (USA)	24
4	Univ Edinburgh (Scotland);Univ Oxford (England)	367	4	Genentech Inc (USA);Roche Prod Ltd (England)	20
5	Univ Cambridge (England);Univ Edinburgh (Scotland)	366	4	Pfizer Inc (USA);Pfizer Ltd (England)	20
6	Ohio State Univ (USA);Univ Roma La Sapienza (Italy)	331	5	Ingelheim Pharma GmbH e Co KG (Germany);Boehringer Ingelheim Pharmace	16
6	Harvard Univ (USA);UCL (England)	331	6	Genentech Inc (USA);Roche (England)	14
7	Univ Pisa (Italy);Univ Wisconsin (USA)	321	6	F Hoffmann La Roche e Co Ltd (Switzerland);Roche Prod Ltd (England)	14
8	Ohio State Univ (USA);Univ Pisa (Italy)	319	7	Pfizer Global Res e Dev (France);Pfizer Inc (USA)	13
9	Univ Roma La Sapienza (Italy);Univ Wisconsin (USA)	317	8	Novartis Horsham Res Ctr (England);Novartis Pharmaceut (USA)	12
10	MIT (USA);Univ Pisa (Italy)	314	8	Ingelheim Pharma GmbH e Co KG (Germany);Boehringer Ingelheim Pharmaceut I	12
11	Univ Glasgow (Scotland);Univ Oxford (England)	313	9	F Hoffmann La Roche Ltd (Switzerland);Genentech Inc (USA)	11
12	Univ Penn (USA);Univ Toronto (Canada)	311	10	Janssen Res e Dev (Belgium);Janssen Res e Dev LLC (USA)	10
13	Univ Edinburgh (Scotland);Univ Manchester (England)	309	11	Novartis Healthcare Pvt Ltd (India);Novartis Pharmaceut (USA)	9
14	Ohio State Univ (USA);Univ Bologna (Italy)	308	11	Bayer HealthCare Pharmaceut (USA);Bayer Pharma AG (Germany)	9
15	Ohio State Univ (USA);Univ Athens (Greece)	305	12	F Hoffmann La Roche Ltd (Switzerland);Roche Prod Ltd (England)	8
16	MIT (USA);Univ Roma La Sapienza (Italy)	304	12	Novartis Healthcare Pvt Ltd (India);Novartis Pharma AG (Switzerland)	8
17	Harvard Univ (USA);Univ Cambridge (England)	303	12	Eli Lilly Japan KK (Japan);Eli Lilly e Co (USA)	8
18	Univ Athens (Greece);Univ Bologna (Italy)	299	12	CSL Behring AG (Switzerland);CSL Behring LLC (USA)	8
19	Univ Oxford (England);Univ Toronto (Canada)	295	12	IBM Deutschland Res e Dev GmbH (Germany);IBM Syst e Technol Grp (USA)	8

A note on South-South international flows

(Figure 3)

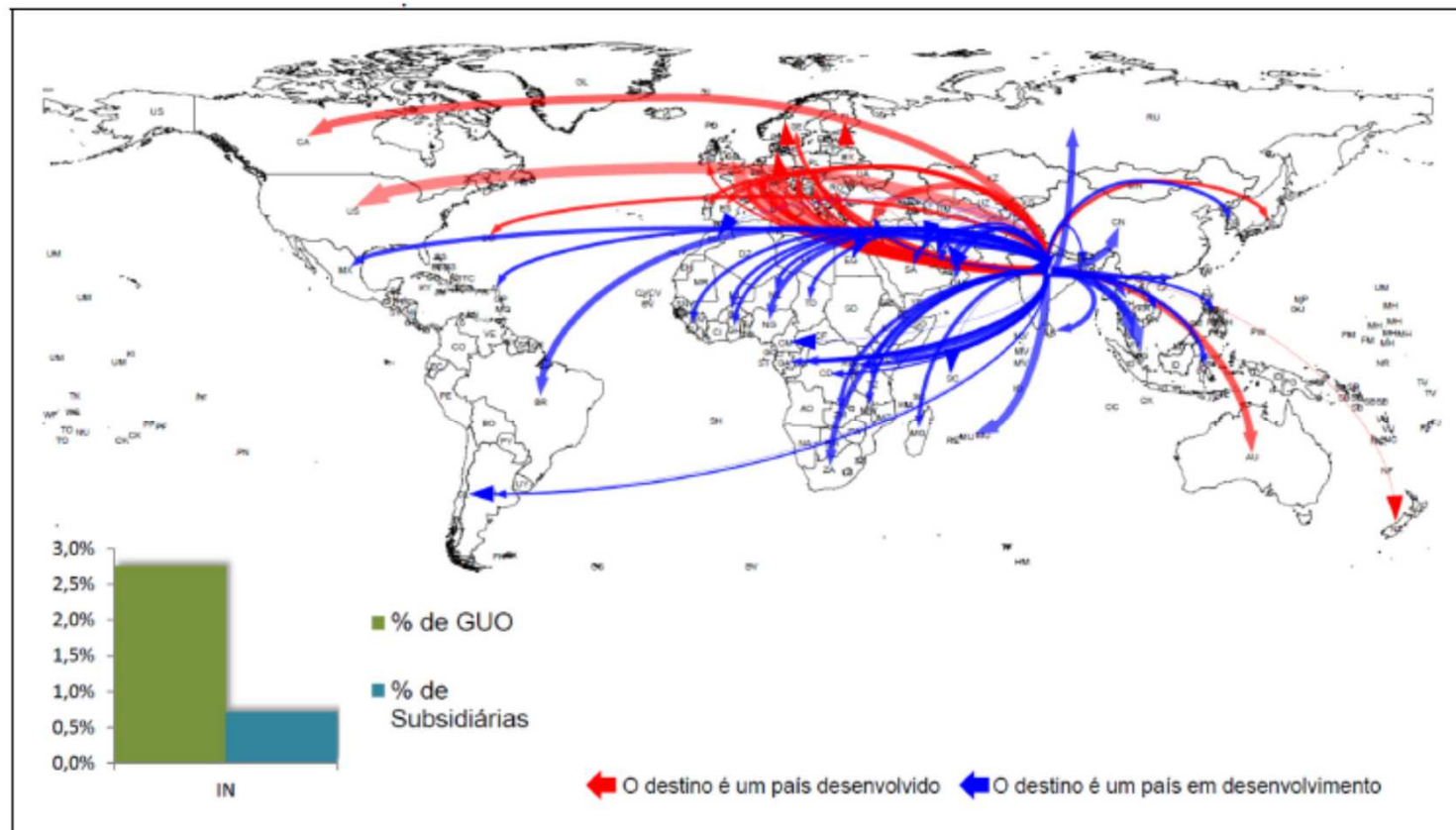
148 TNCs have headquarter and subsidiaries located at the periphery – a total of 2,766 subsidiaries located at the periphery

Illustration of Latin America and Caribbean TNCs



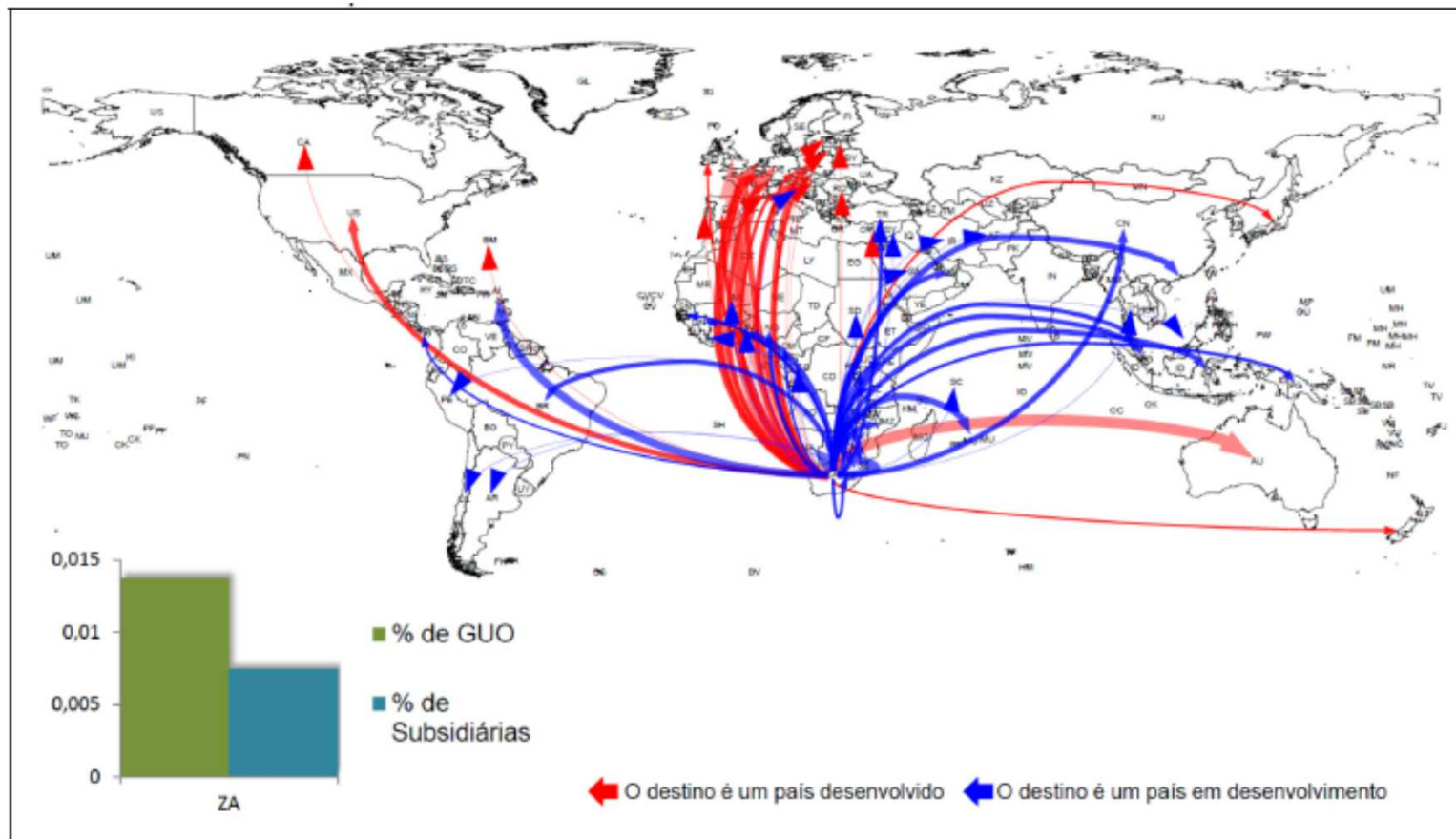
A note on South-South international flows (Figure 4)

Connections between TNCs with GUO in South Asia and their subsidiaries in developed and developing countries



A note on South-South international flows (Figure 5)

Connections between TNCs with GUO in Sub-Saharan Africa and their subsidiaries in developed and developing countries



A note on South-South international flows (Table 6)

- The first pair from Global South is in the 80th position: South Korea and Taiwan. Other pairs are China and South Korea (87th position).
- Countries from the Global South form pairs with developed countries in better positions (South Africa and USA, 127th position; Brazil and USA, 149th position; India and USA, 83rd position).

Country Interaction - Triadics with Patente Citation International Flow - 2010		
Rank	Country	Patents
1	JP;US	4666
2	DE;JP	2168
3	DE;US	1845
4	FR;US	937
5	JP;KR	911
6	GB;US	864
7	FR;JP	824
8	KR;US	664
9	CH;US	614
10	SE;US	612
11	GB;JP	554
12	CA;US	545
13	NL;US	520
14	JP;SE	468
15	JP;NL	464
16	DE;FR	460
17	CH;JP	441
18	CA;JP	359
19	IT;US	338
20	CH;DE	323

A note on South-South international flows (Table 7)

- Table 7 shows that among the 40 first positions, there are 8 pairs with one country from the Global South. China's pair with USA leads the ranking.
- Pairs between countries from the Global South begin at the position 68th (China and South Korea, with 2,056 papers).
- Other examples of South-South pairs are Egypt and Saudi Arabia (122nd position), Brazil and Argentina (233rd), India and China (237th), Brazil and China (252nd), Iran and Malaysia (347th), Brazil and Mexico (348th), Brazil and India (387th position, with 376 papers), and Brazil and South Africa (459th, with 285 papers).

International flows through co-authorship of ISI-indexed articles, by countries

Ranking ISI 2012 Coauthoring Countries		
All Interactions		
Rank	Country	Articles
1	Peoples R China;USA	21310
2	Germany;USA	17013
3	England;USA	16934
4	Canada;USA	16118
5	France;USA	11189
6	Italy;USA	9899
7	England;Germany	8711
8	Japan;USA	8466
9	Australia;USA	8158
10	South Korea;USA	7598
11	Spain;USA	7458
12	Netherlands;USA	7274
13	France;Germany	7188
14	England;France	6332
15	Switzerland;USA	6308
16	Germany;Switzerland	6099
17	Germany;Italy	5927
18	France;Italy	5603
19	Germany;Netherlands	5592
20	England;Italy	5582
21	England;Netherlands	5193
22	Australia;England	4956
23	England;Scotland	4872
24	Germany;Spain	4665
25	England;Spain	4622
26	Brazil;USA	4526
27	Sweden;USA	4474
28	France;Spain	4391
29	Canada;England	4303
30	Italy;Spain	4219
31	Japan;Peoples R China	4141
32	Austria;Germany	3991
33	England;Peoples R China	3954
34	Australia;Peoples R China	3948
35	India;USA	3604
36	England;Switzerland	3559
37	Belgium;USA	3550
38	Canada;Germany	3546
39	Israel;USA	3526
40	Germany;Peoples R China	3517

Conclusions

- Those data might suggest that the Global South has identified links with the ongoing process of internationalization of science and technology, smaller than the links between developed and richer countries.
- But the identified links, in the three dimensions evaluated in this manuscript, show that Global South have at least important starting points for a broader internationalization process - a key component of the emerging global knowledge economy.

