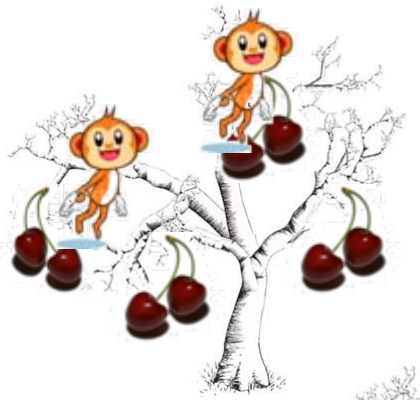
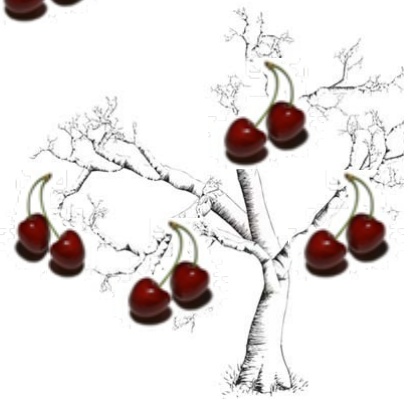
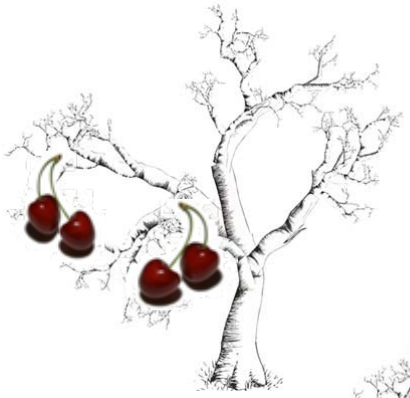
The Product Space and the Building Blocks of Economic Development

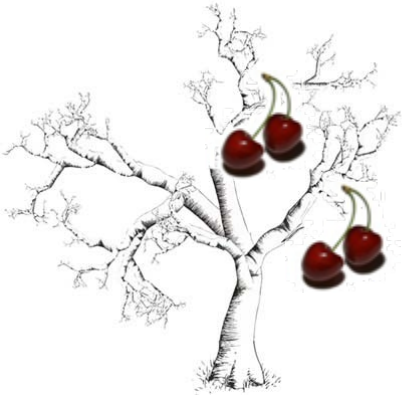
Cesar A. Hidalgo
Center for International Development,
and Harvard Kennedy School
Harvard University

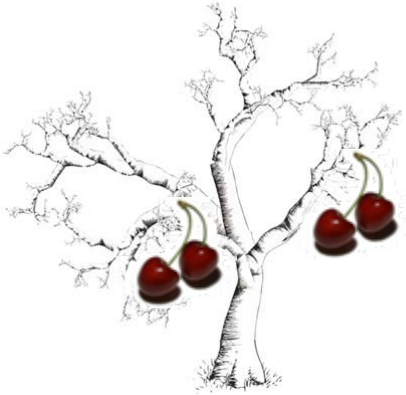
Hidalgo CA, Hausmann R, PNAS 2009
Hidalgo CA et al., Science, 2007



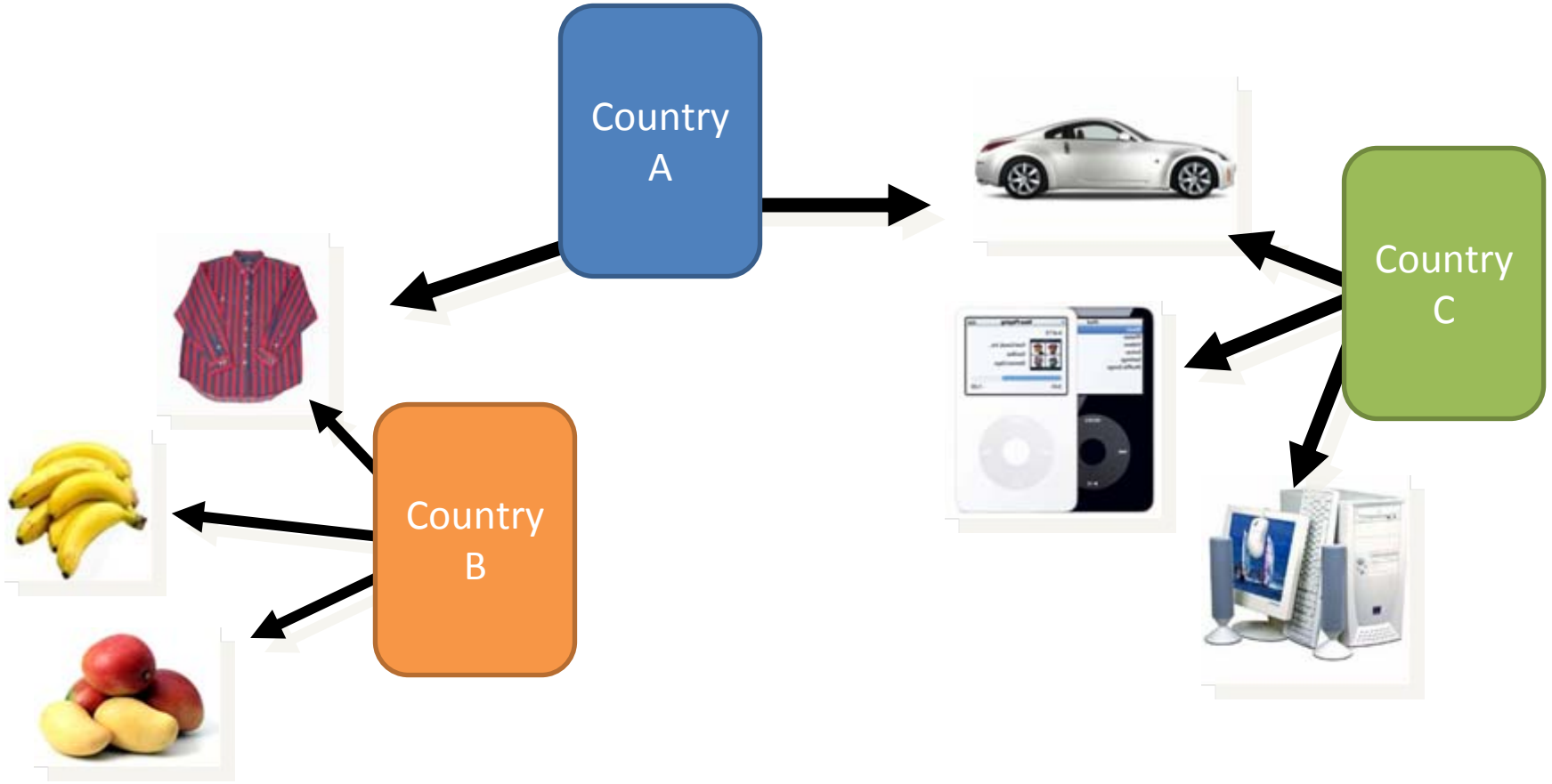


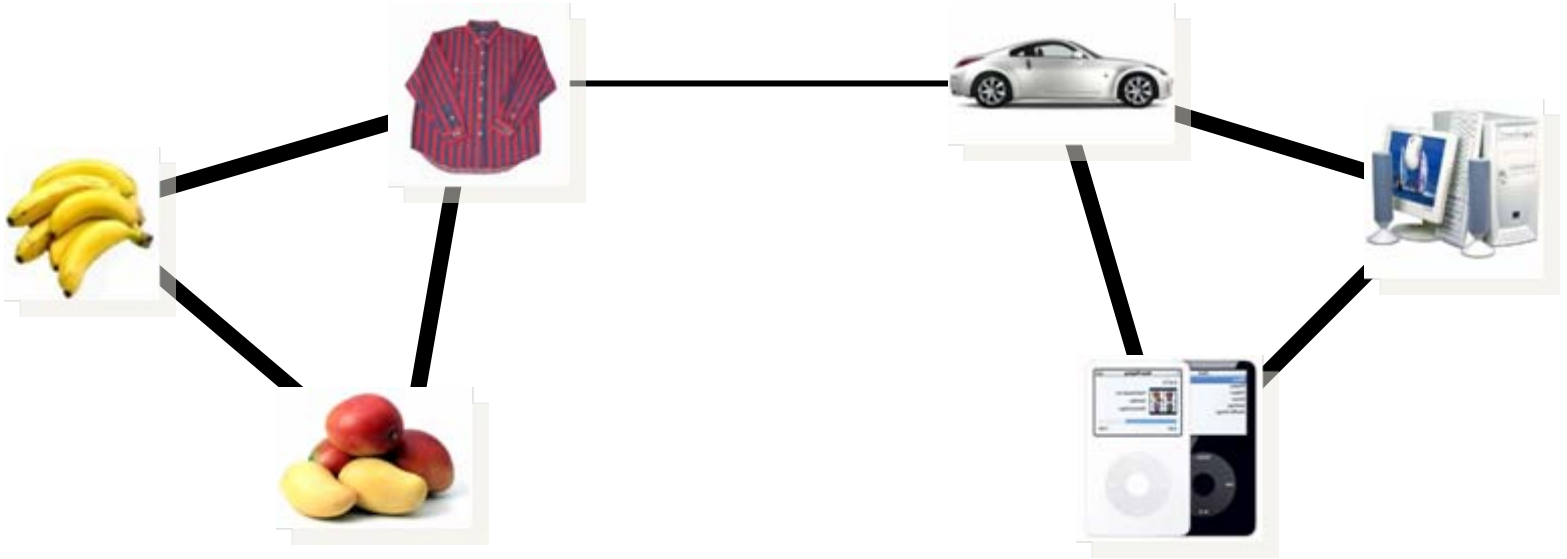


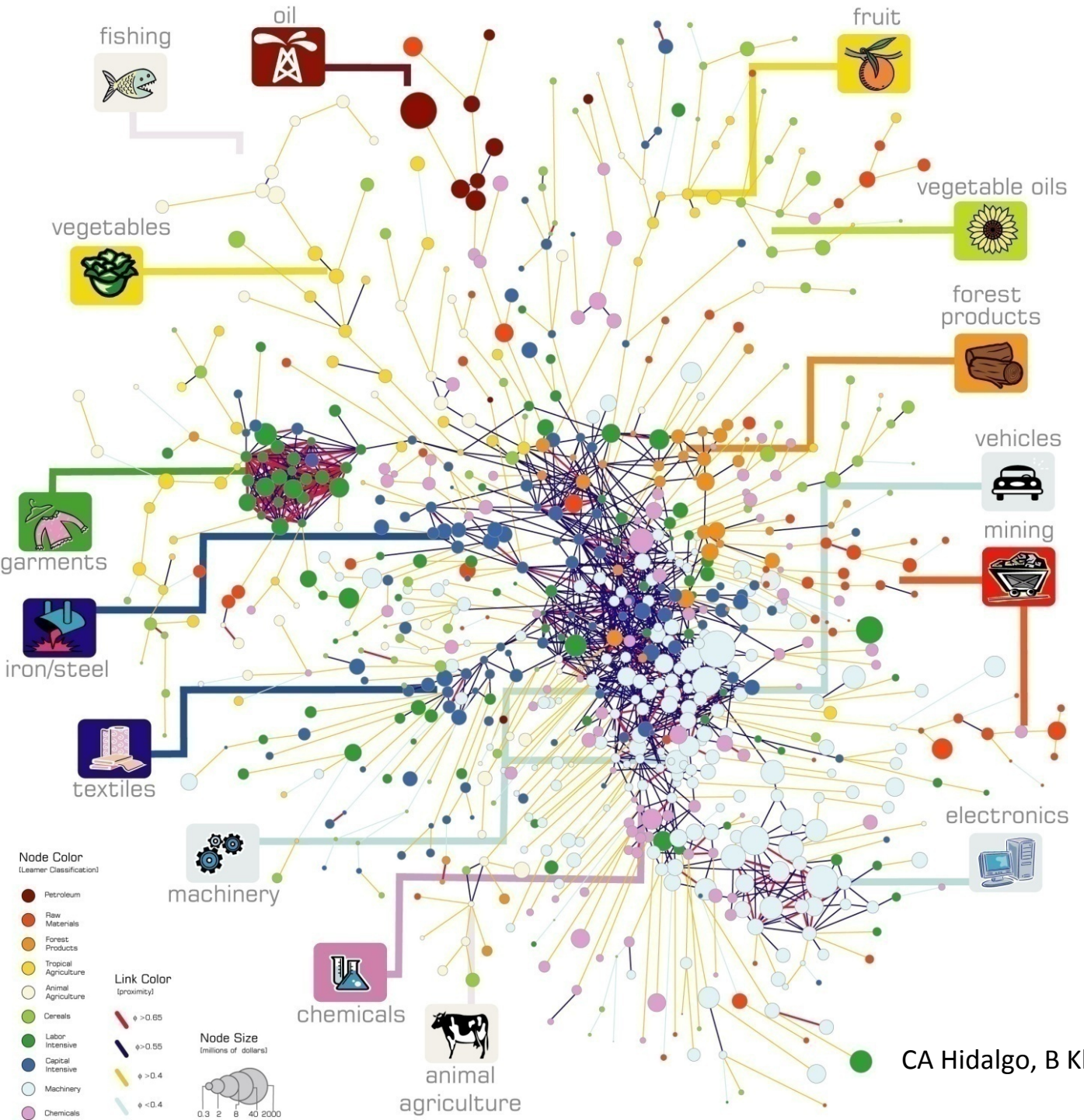





Building the Forest


Country A
Country B
Country C





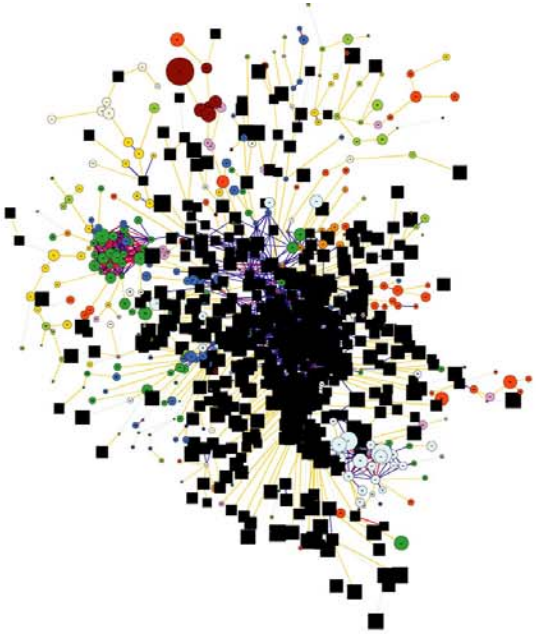
CA Hidalgo, B Klinger, A-L Barabasi, R Hausmann. *Science* (2007)


Where are the monkeys?

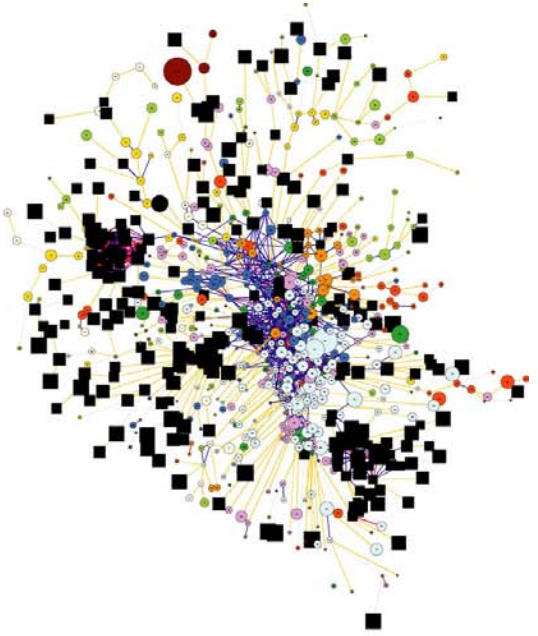
Patterns of Comparative Advantage

Hidalgo et a. *Science* (2007)

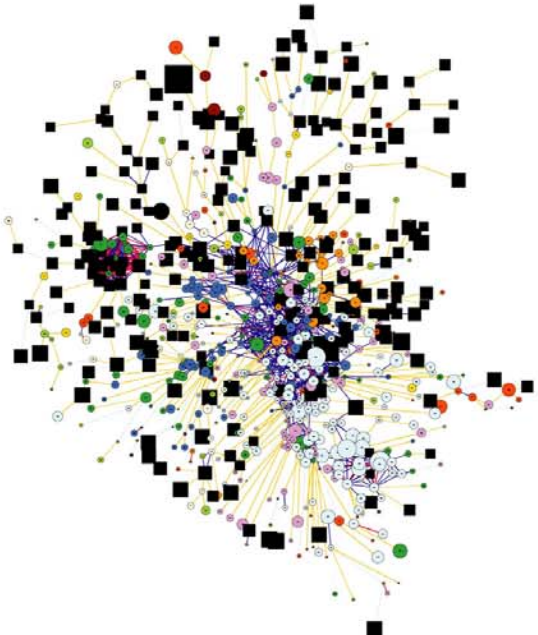
Industrialized Countries



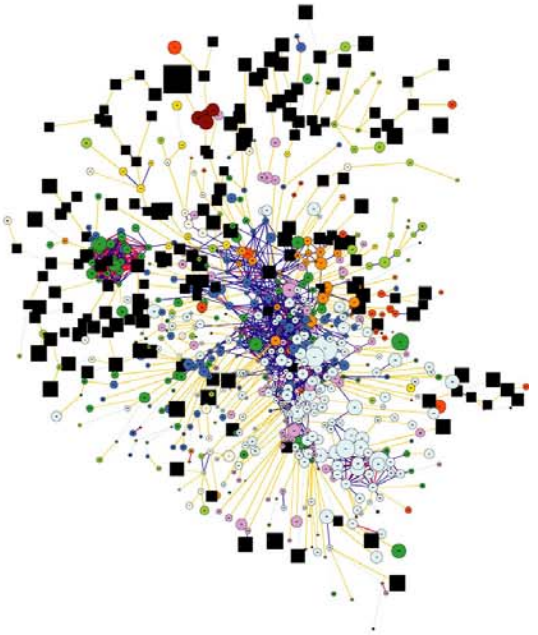
East Asia Pacific



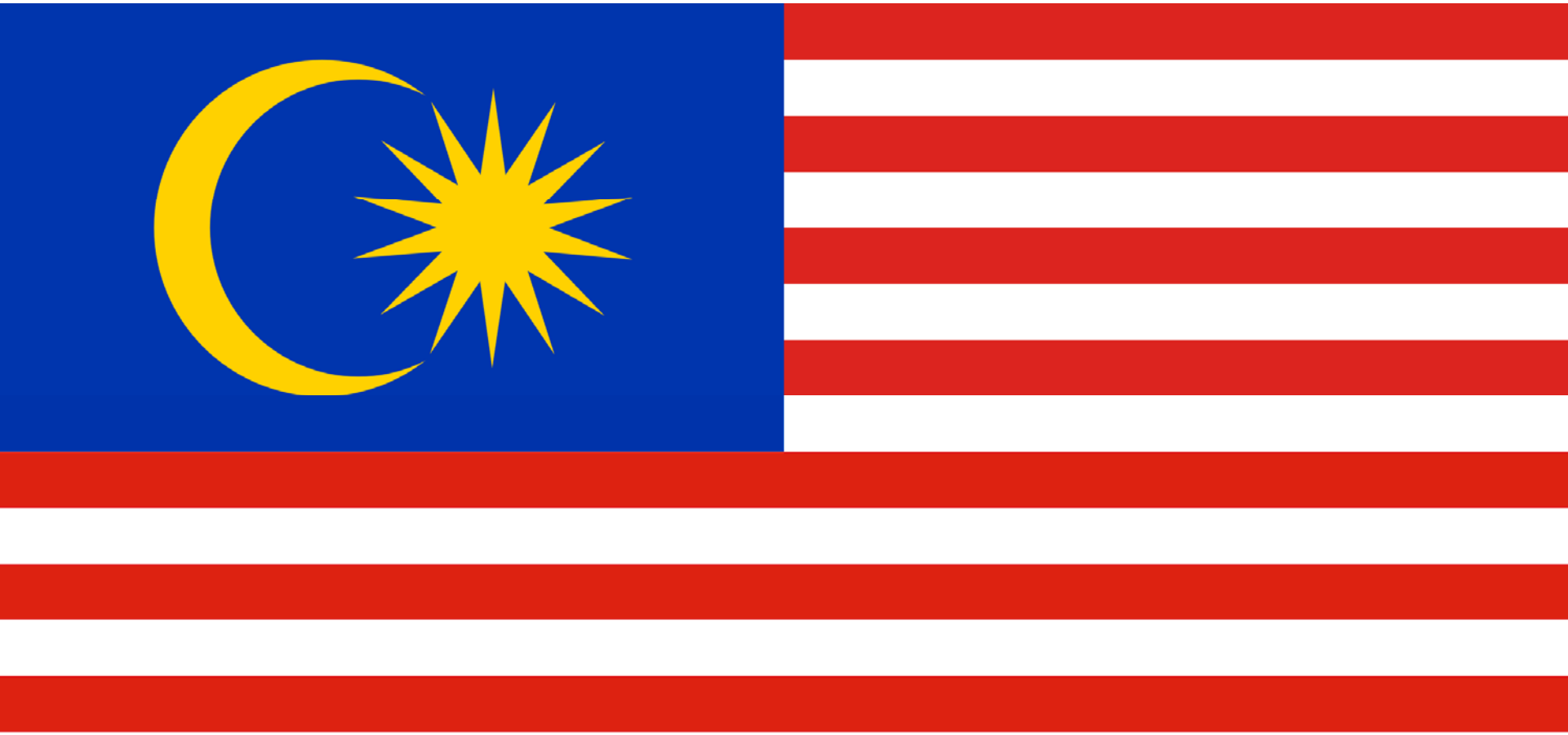
Latin America and the Caribbean



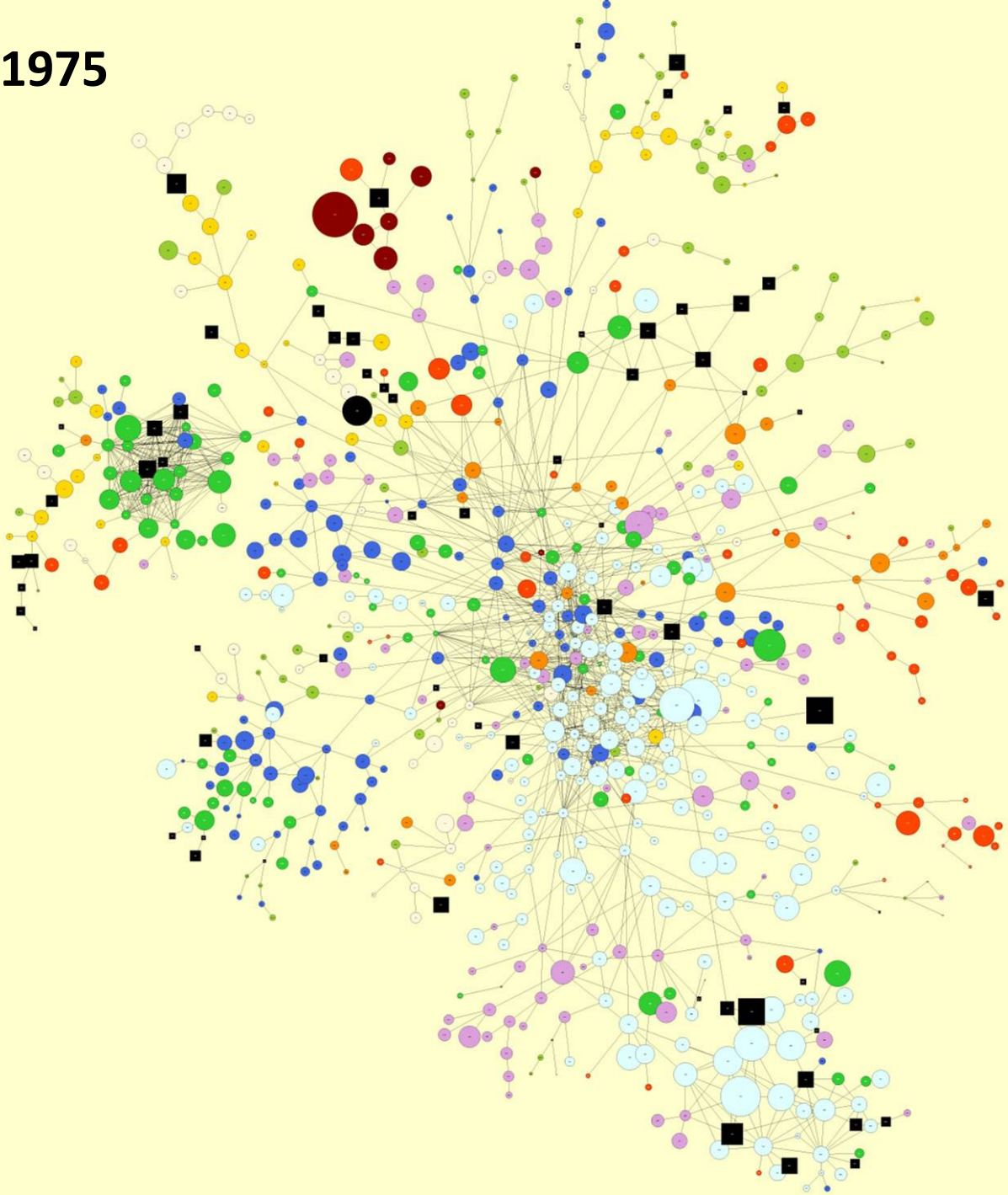
Sub-Saharan Africa



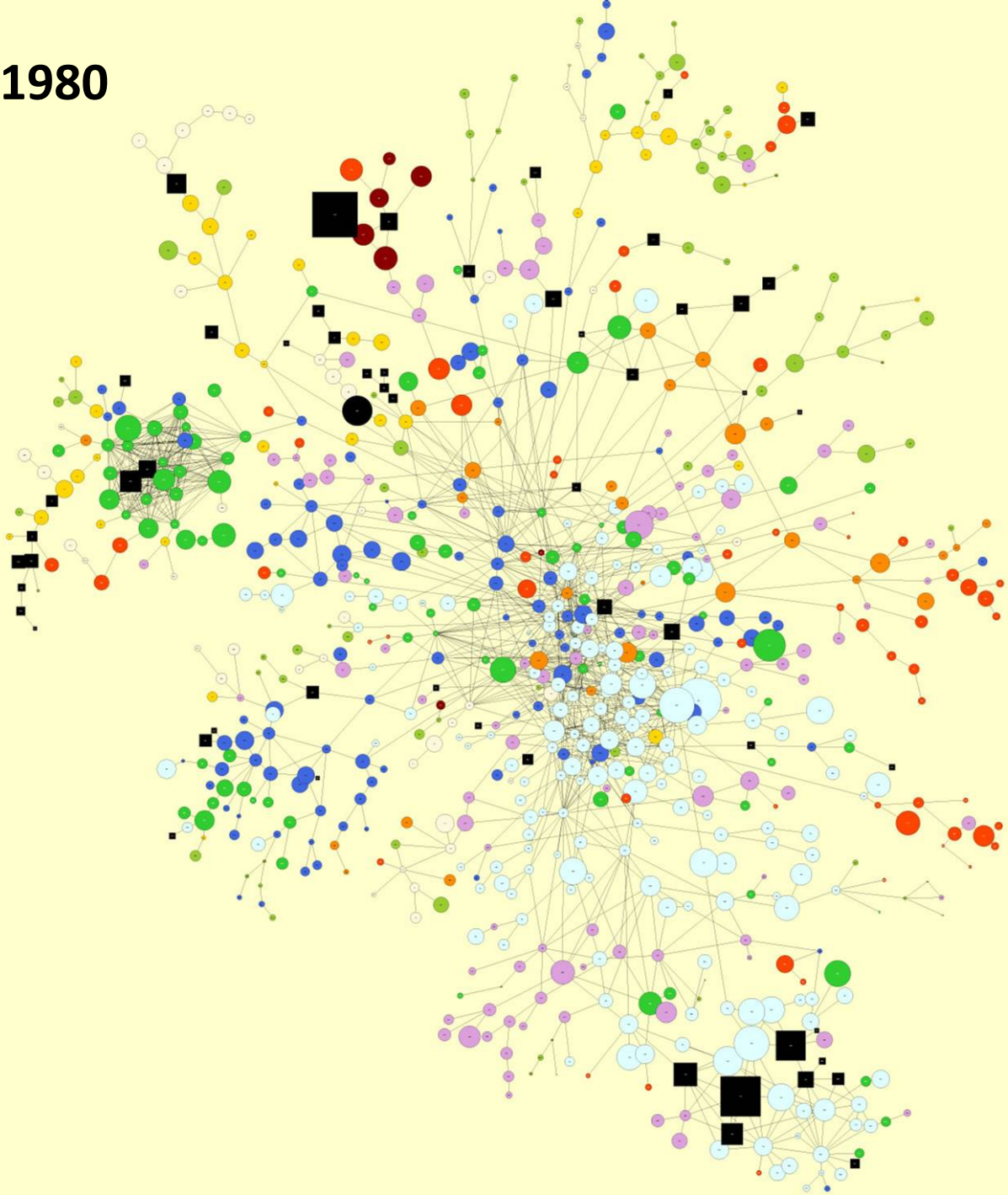
How do monkeys jump?



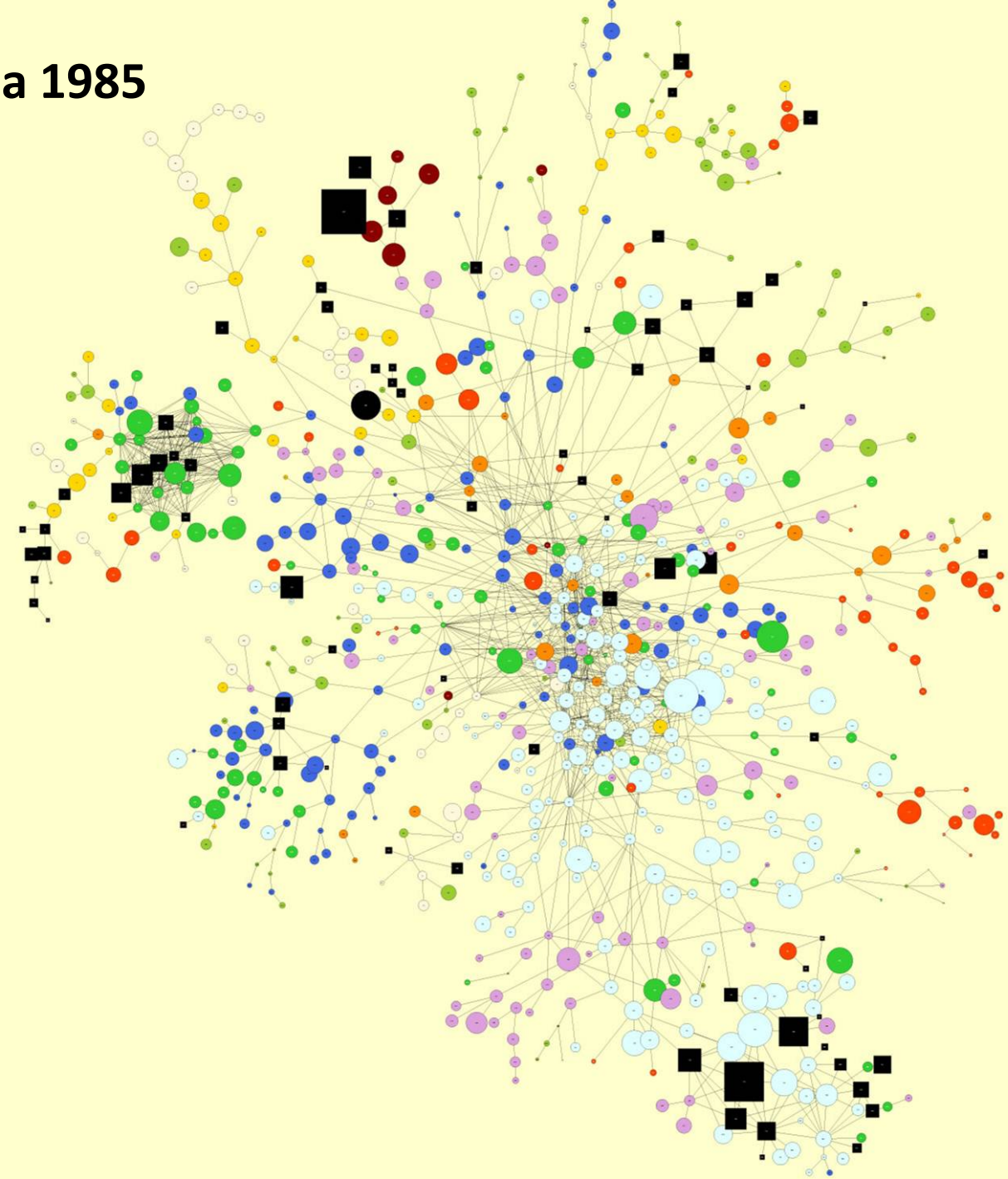
Malaysia 1975



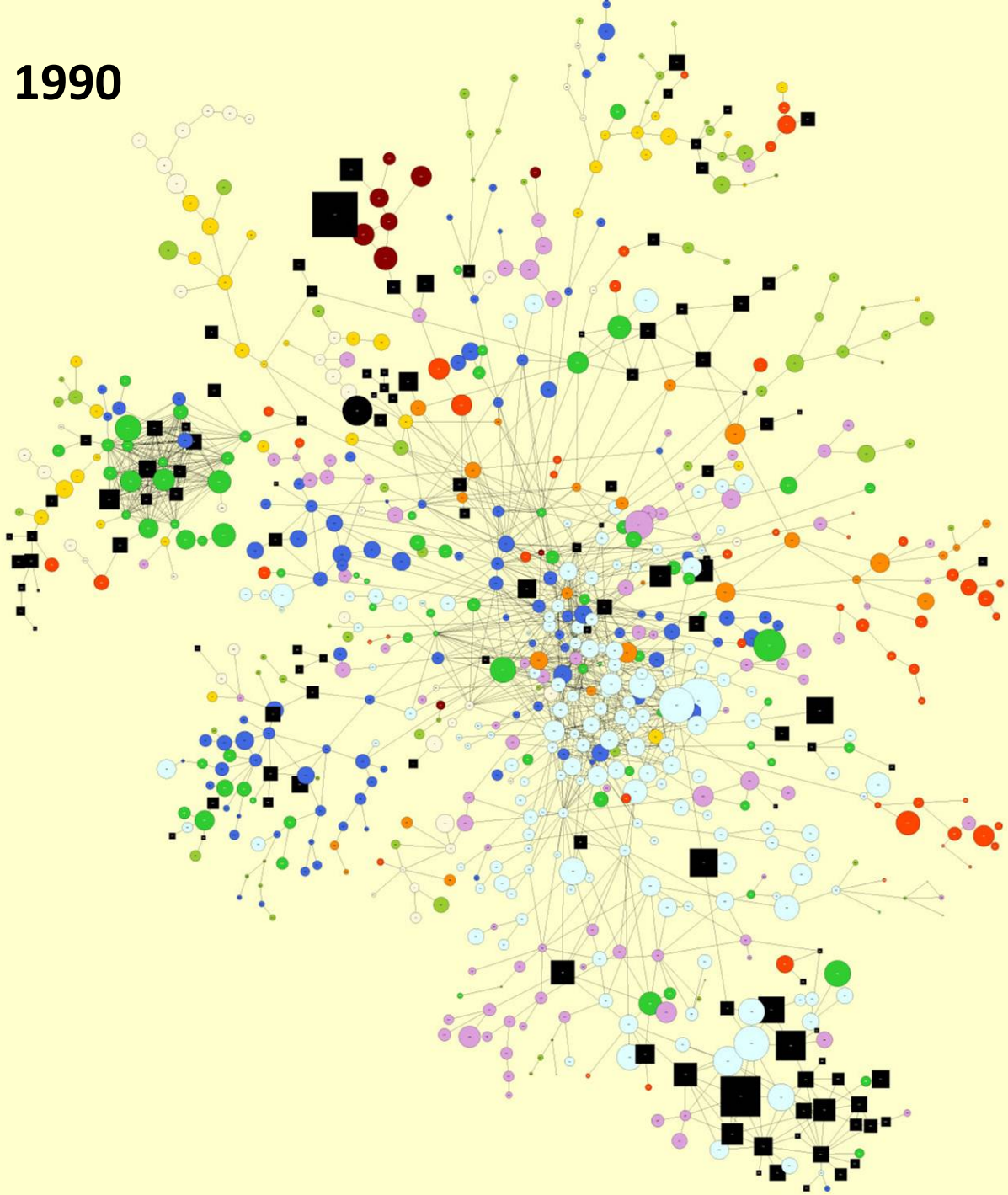
Malaysia 1980



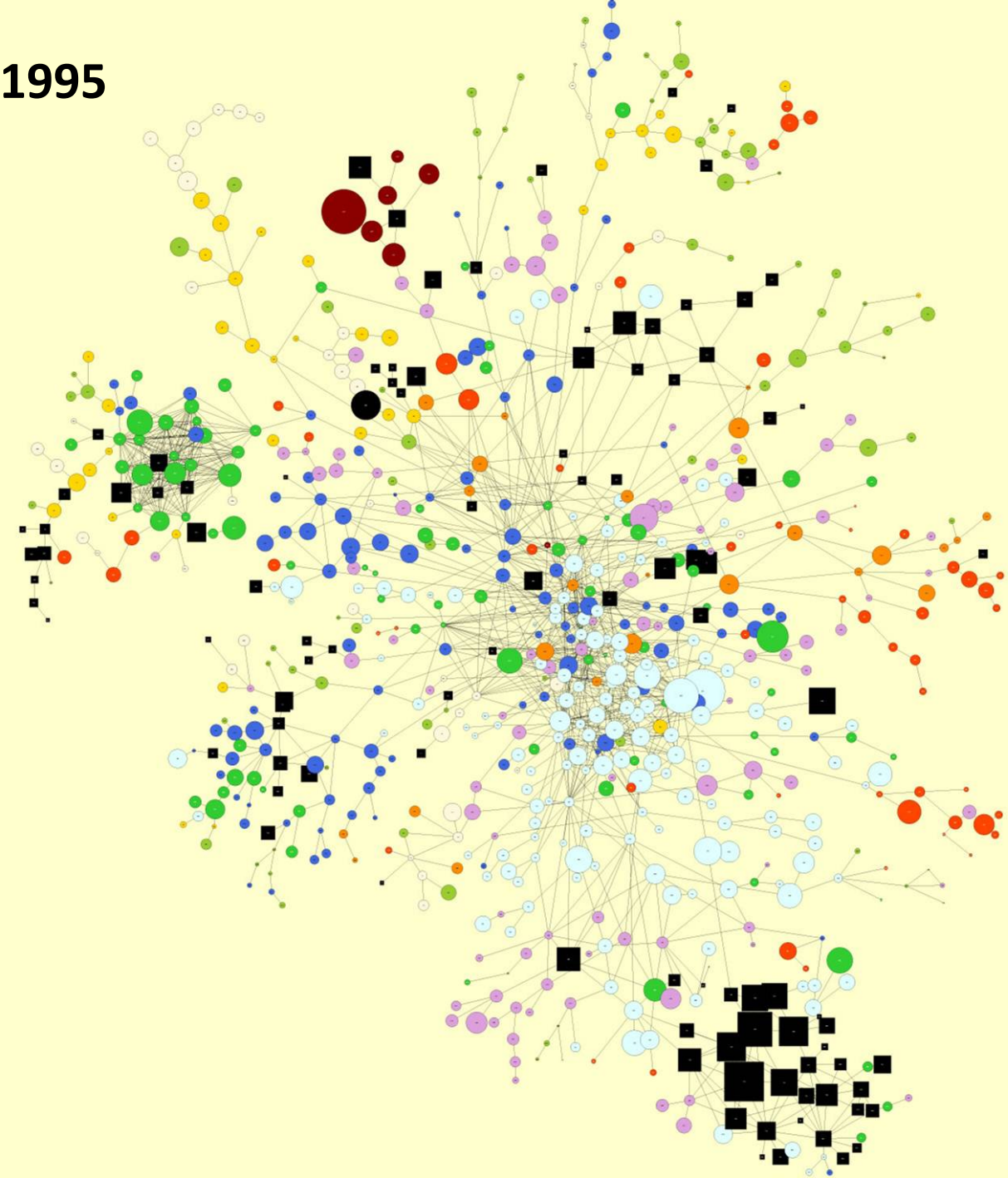
Malaysia 1985



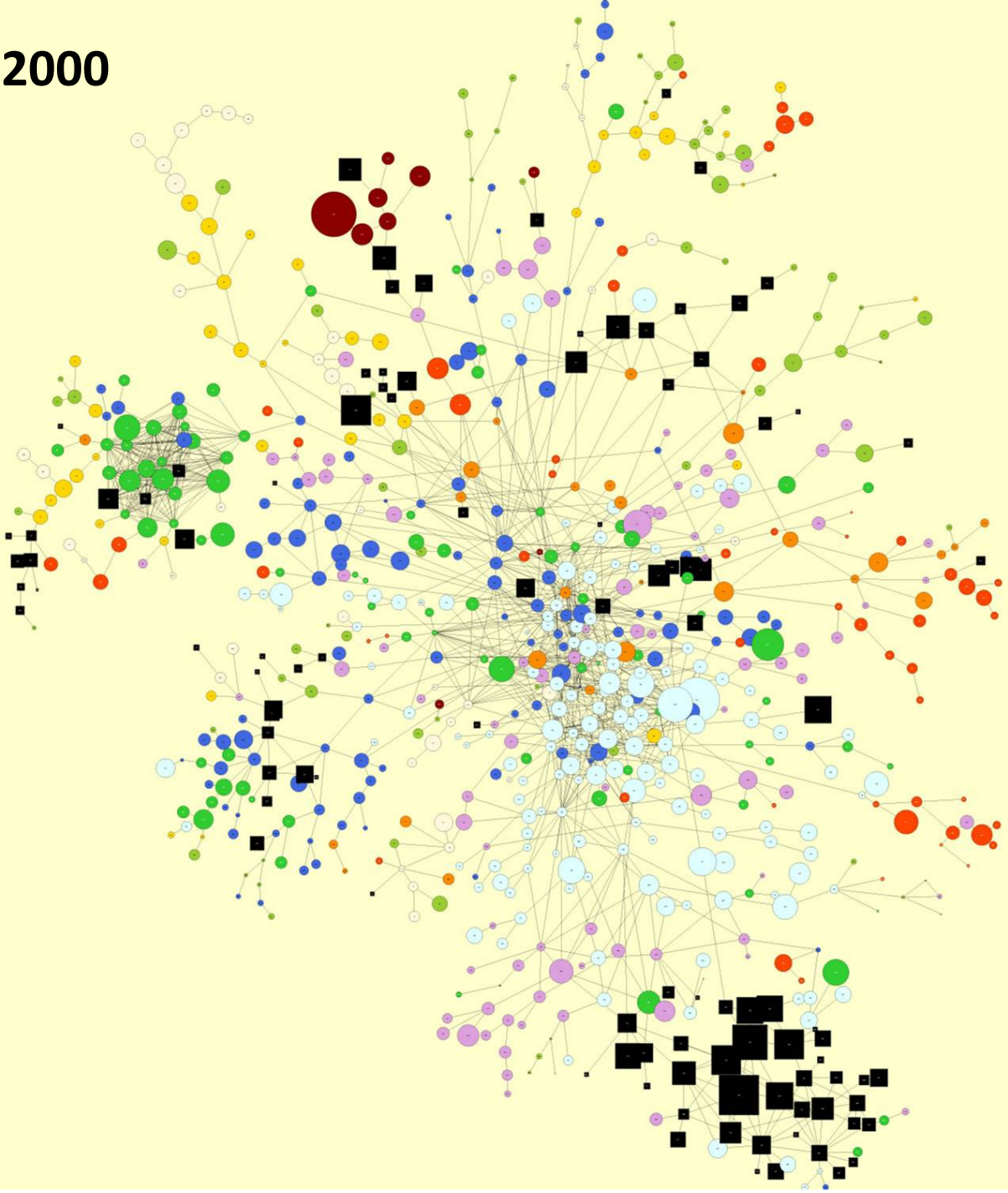
Malaysia 1990



Malaysia 1995

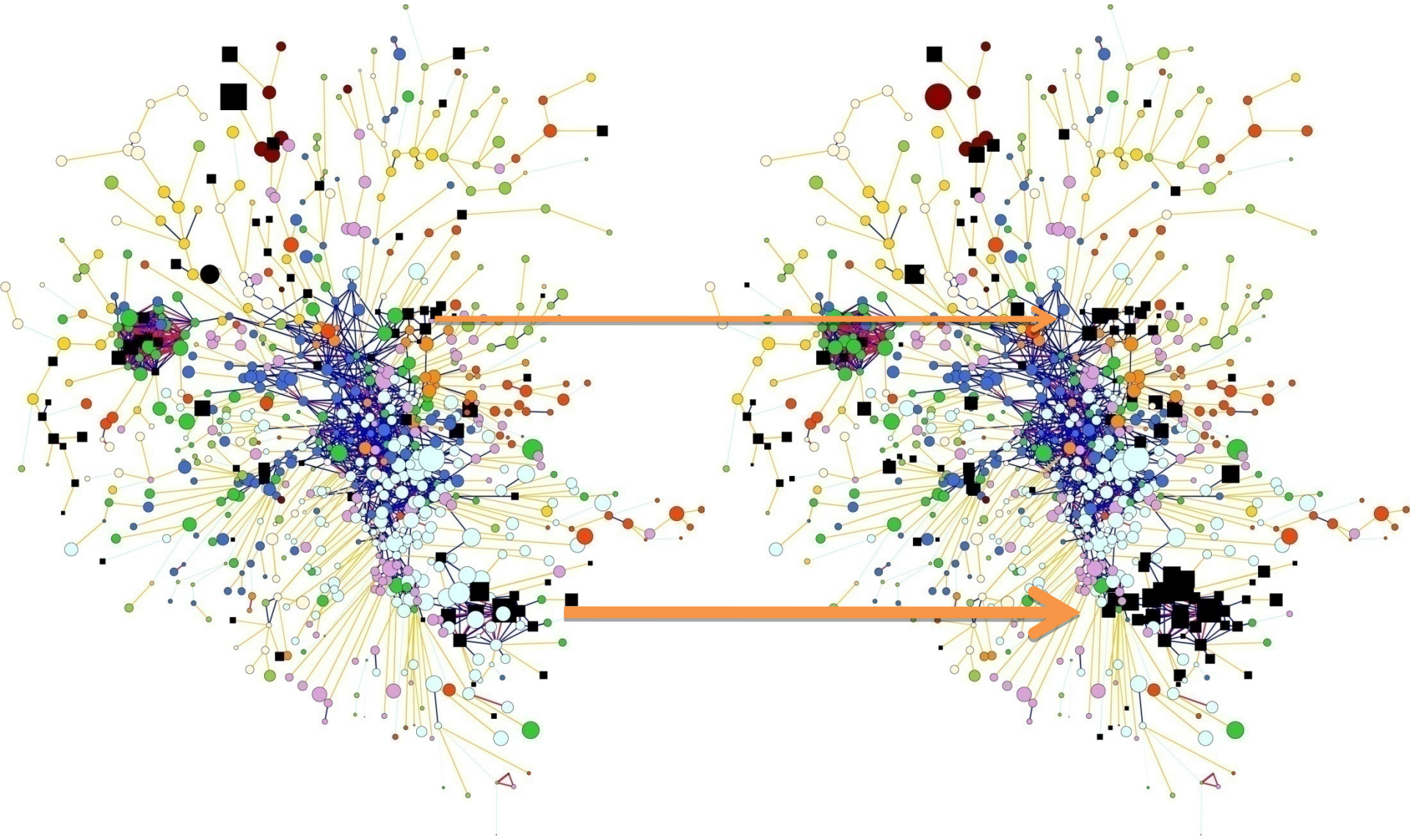


Malaysia 2000



Malaysia

CA Hidalgo, B Klinger, A-L Barabasi, R Hausmann.
Science (2007)



1985

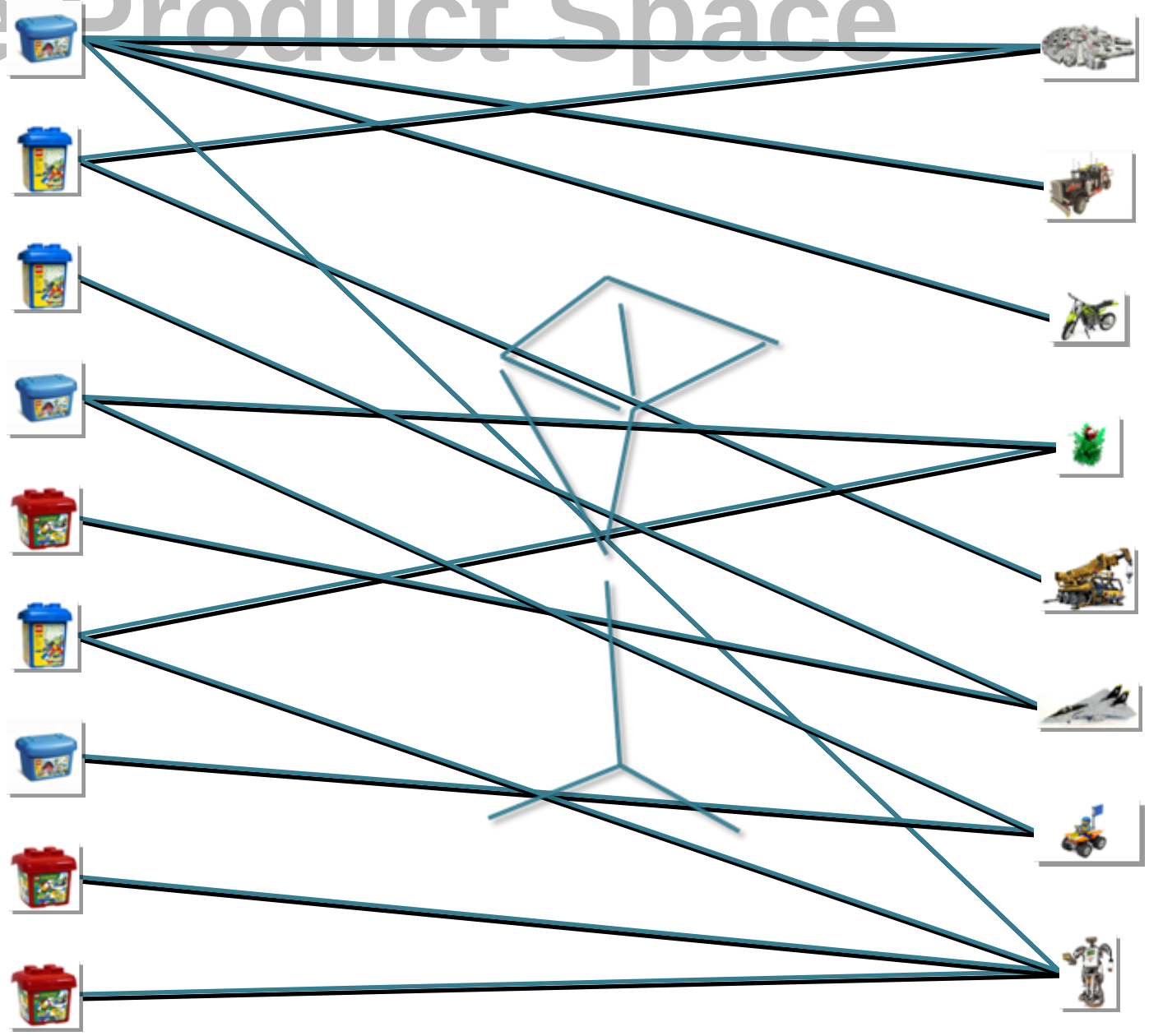
2000

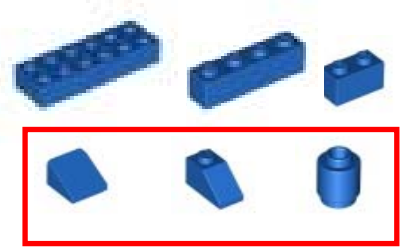

Convergence

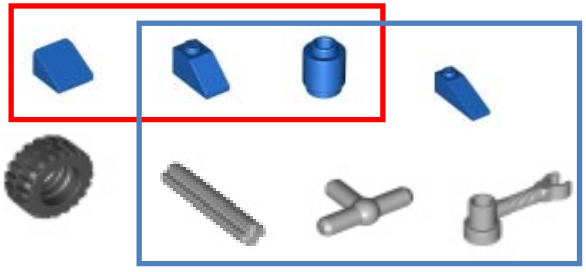

Natural Resource Curse
TEREX
25

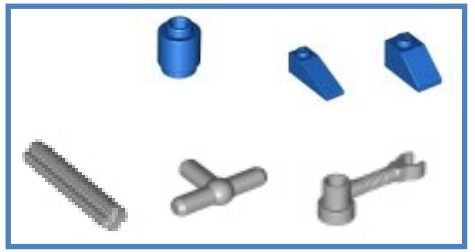
Digging deeper into our assumptions…..

The Product Space





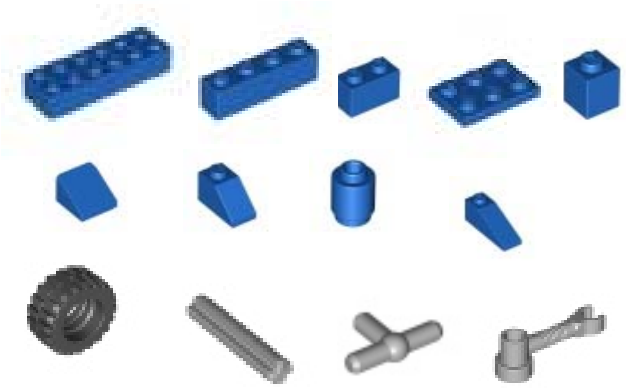


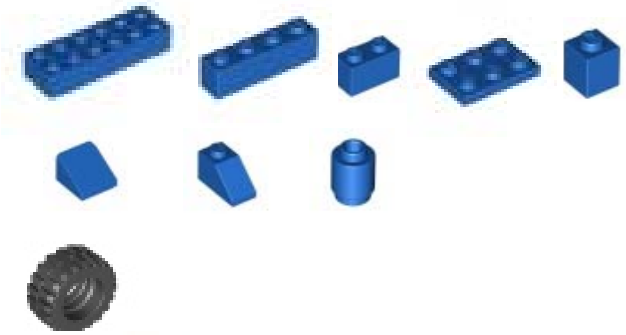


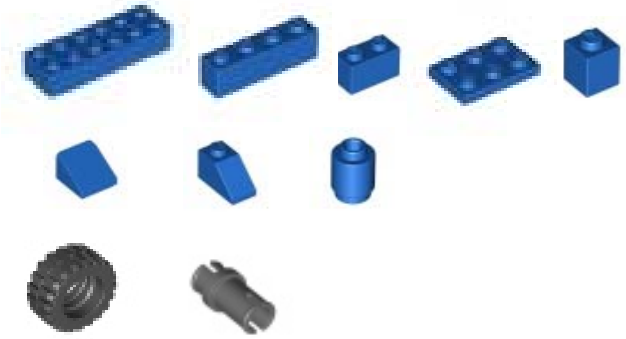
Real World

Lego World

PRODUCTS and capabilities

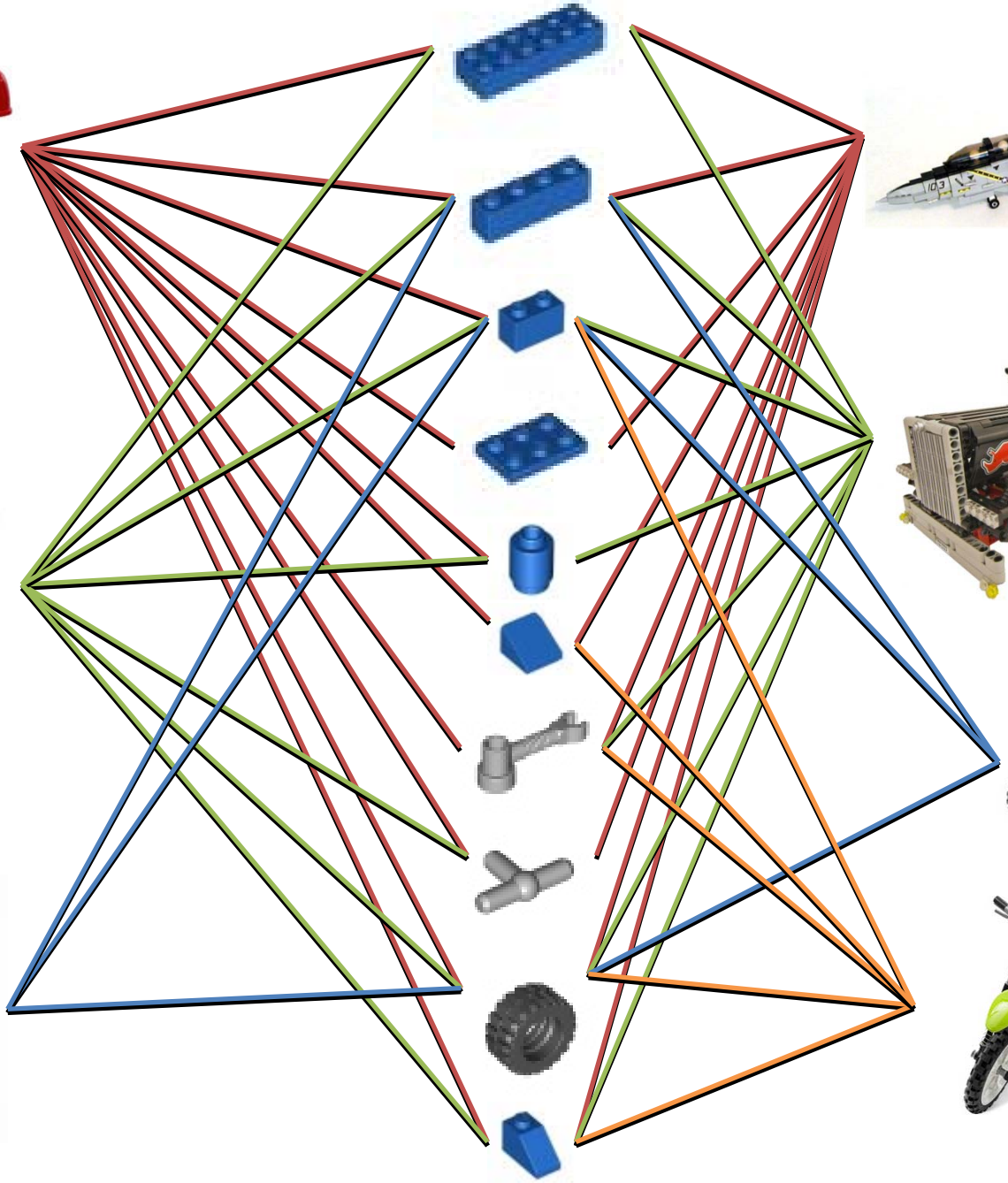






COUNTRIES and capabilities

Countries **Capabilities** **Products**

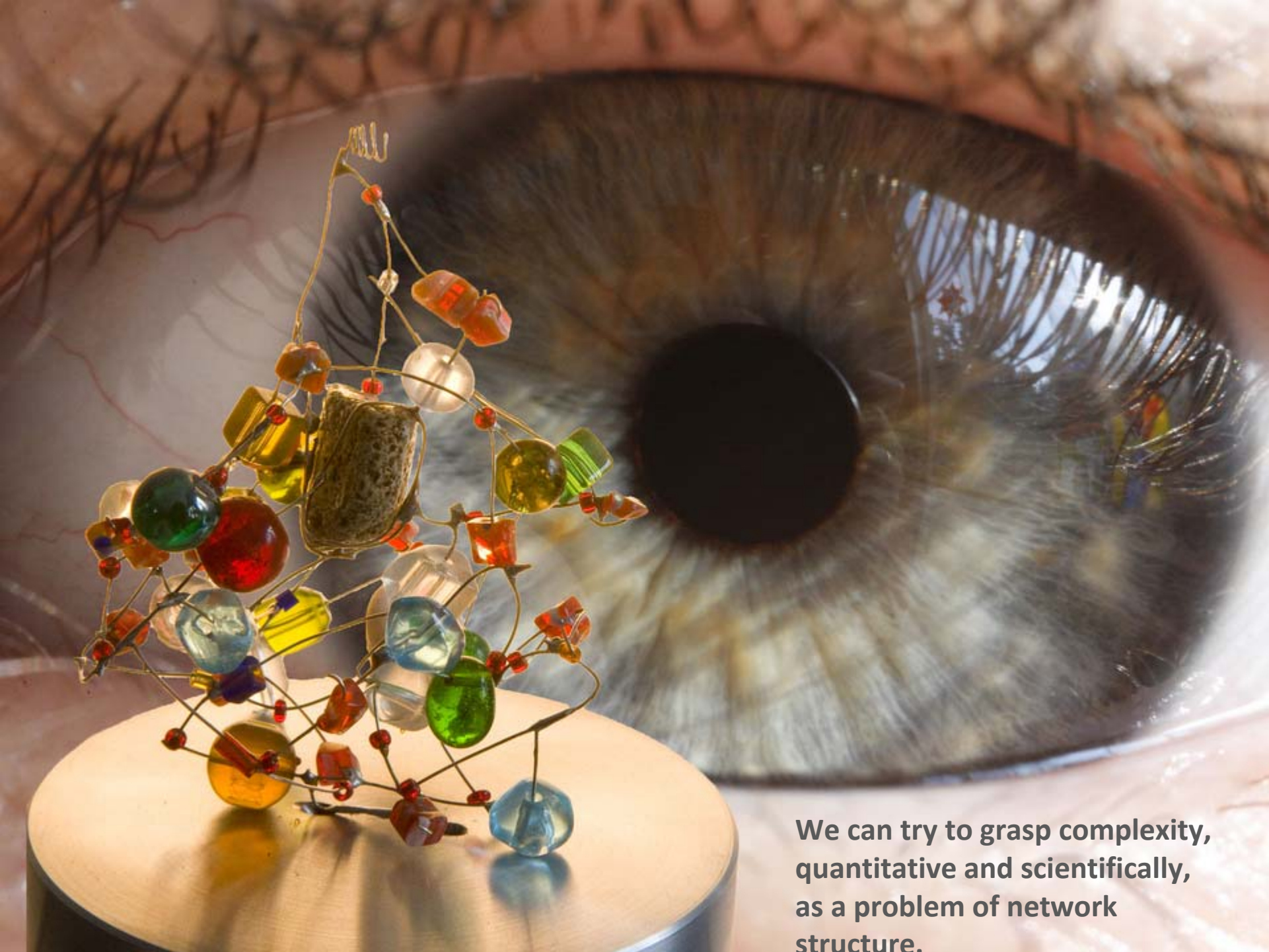


Countries

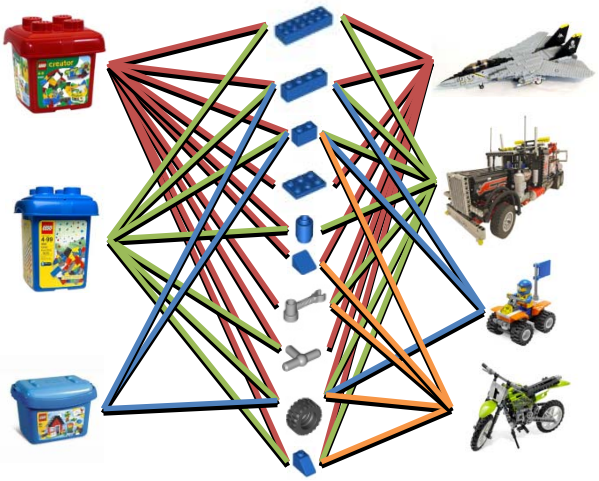
Products

How good is a country’s bucket of Legos?

How many different type of pieces you have in your bucket?

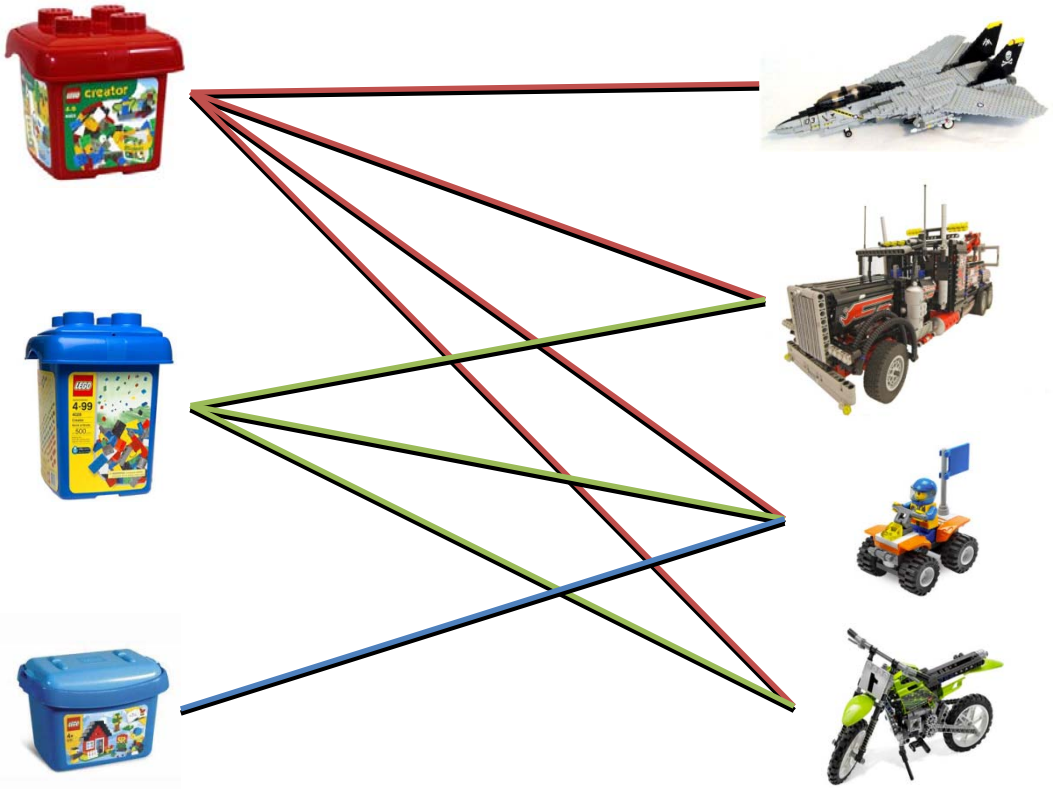


We can try to grasp complexity, quantitative and scientifically, as a problem of network structure.



THOUGHT

WORLD



Intuition

3.- should make many products

2.- with many different Legos (capabilities)



1.- A Country

,BUT

Hence

and

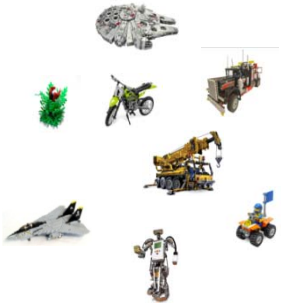
=

and

=

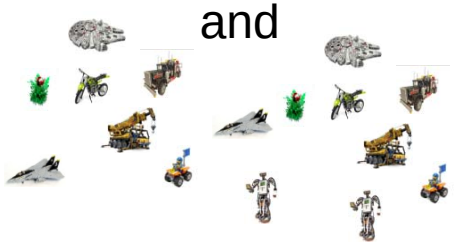
and

=



and

and



=

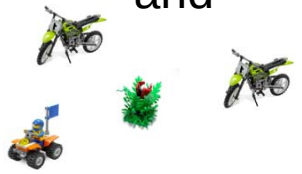
and

and

=

and

and



=


Getting Technical
MAKE ONE AS SHOWN MARK AS #3
MAKE ONE AS SHOWN MARK AS #4
STAIRS AS
FROM BASMT TO 1ST FLOOR
ONTARIO APARTMENTS
WASHINGTON D.C.
ORNAMENTAL IRO

THE DATA

Product

Country

RCA_{cp}

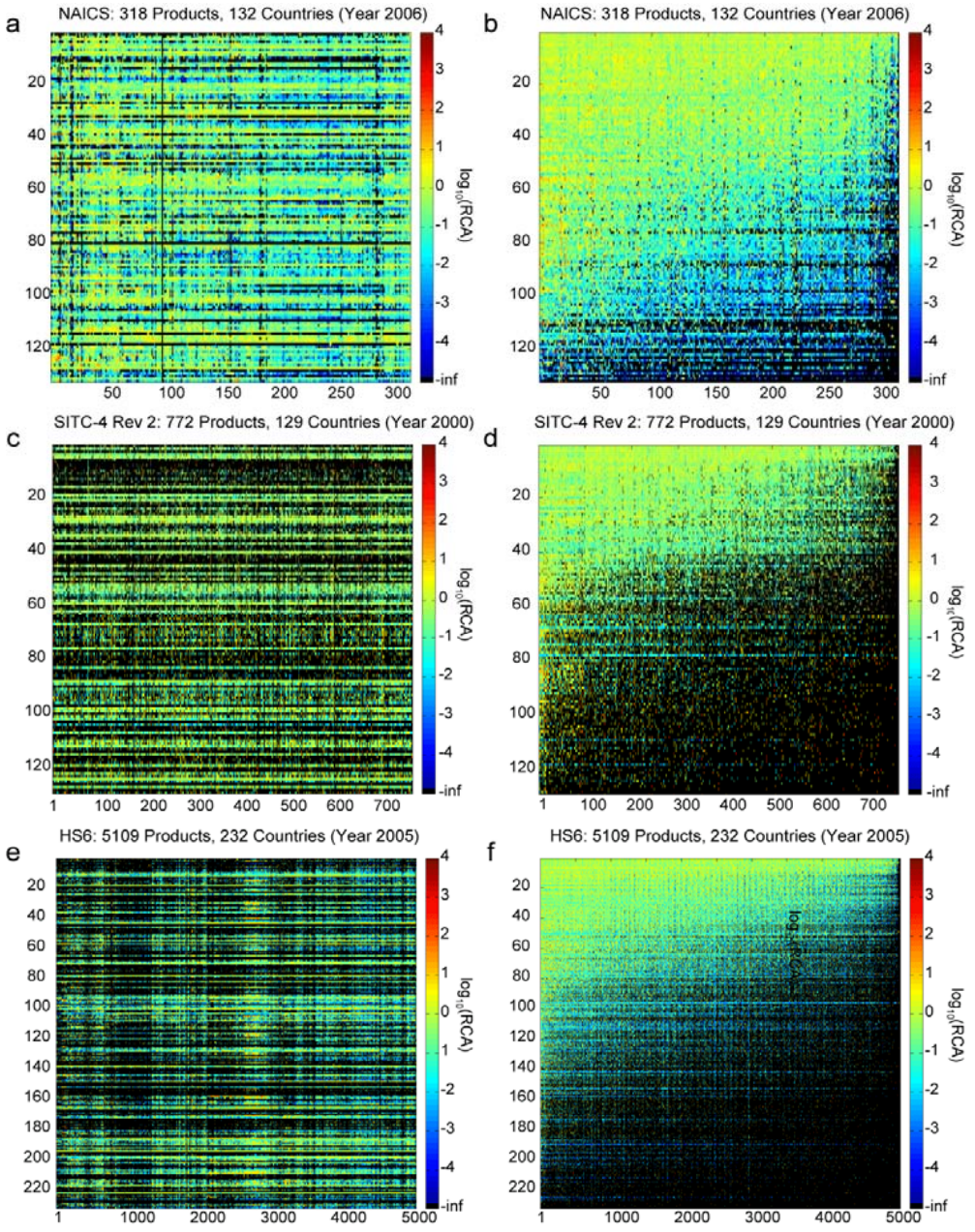
Product

Country

M_{cp}

$M_{cp} = 1$ if $RCA >= R^*$

$M_{cp} = 0$ otherwise



Feenstra's Data 63-05

Cepii Data 00-06

Hausmann and Hidalgo (2010) in preparation

Method of Reflections

Diversification

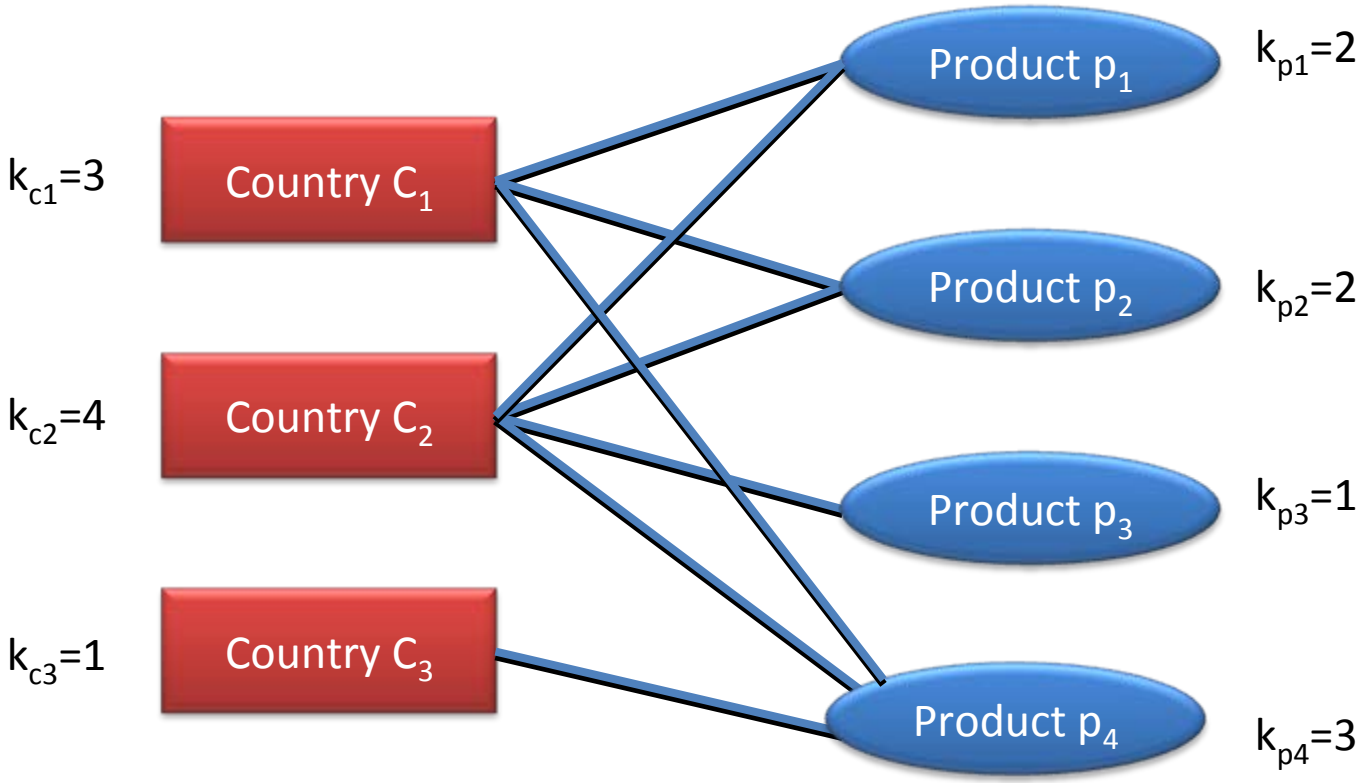
Degree (Countries)

$$k_c = \sum_p M_{cp}$$

Ubiquity

Degree (Products)

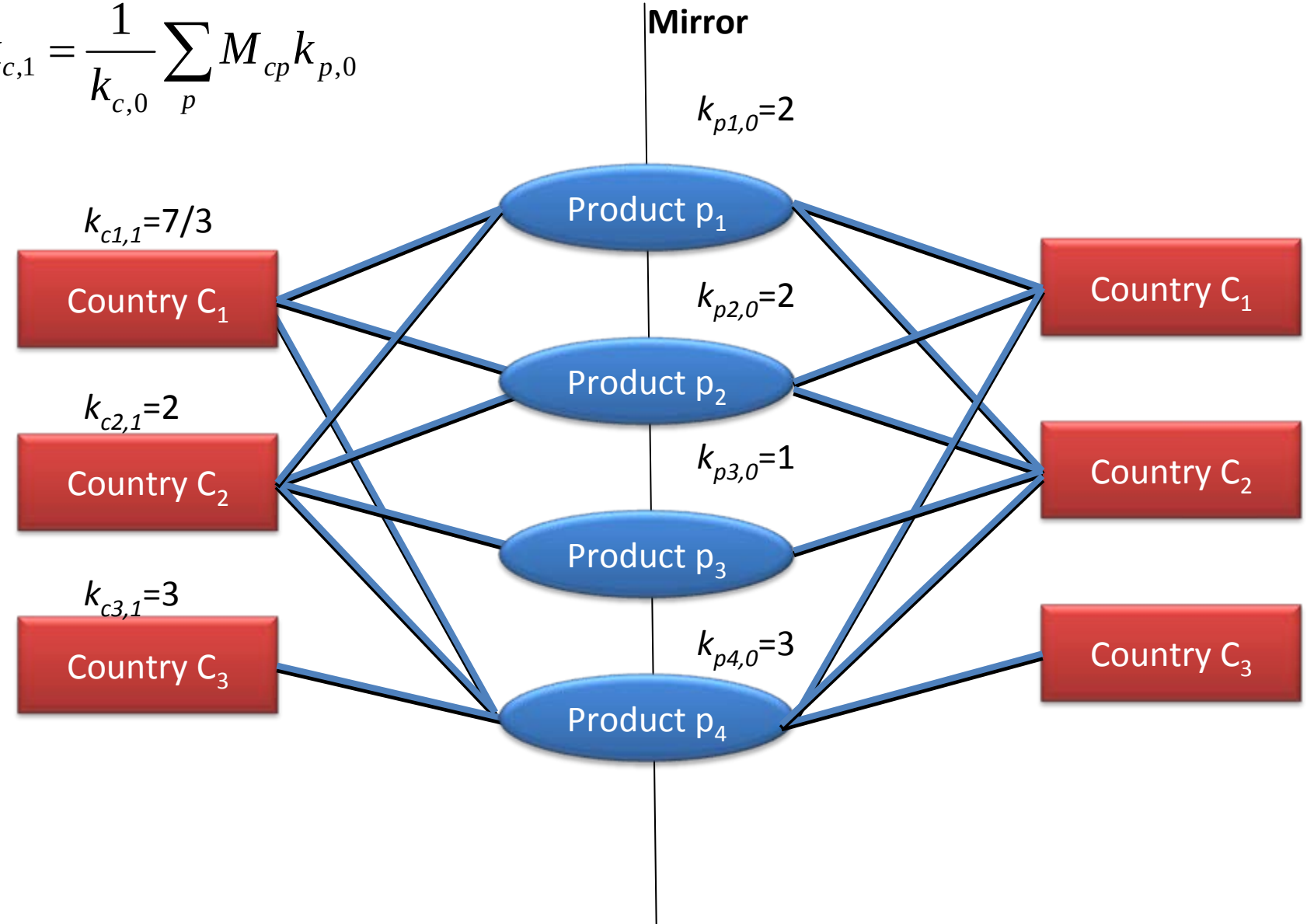
$$k_p = \sum_c M_{cp}$$



Method of Reflections

$k_{c,1}$= Average ubiquity of products exported by a country

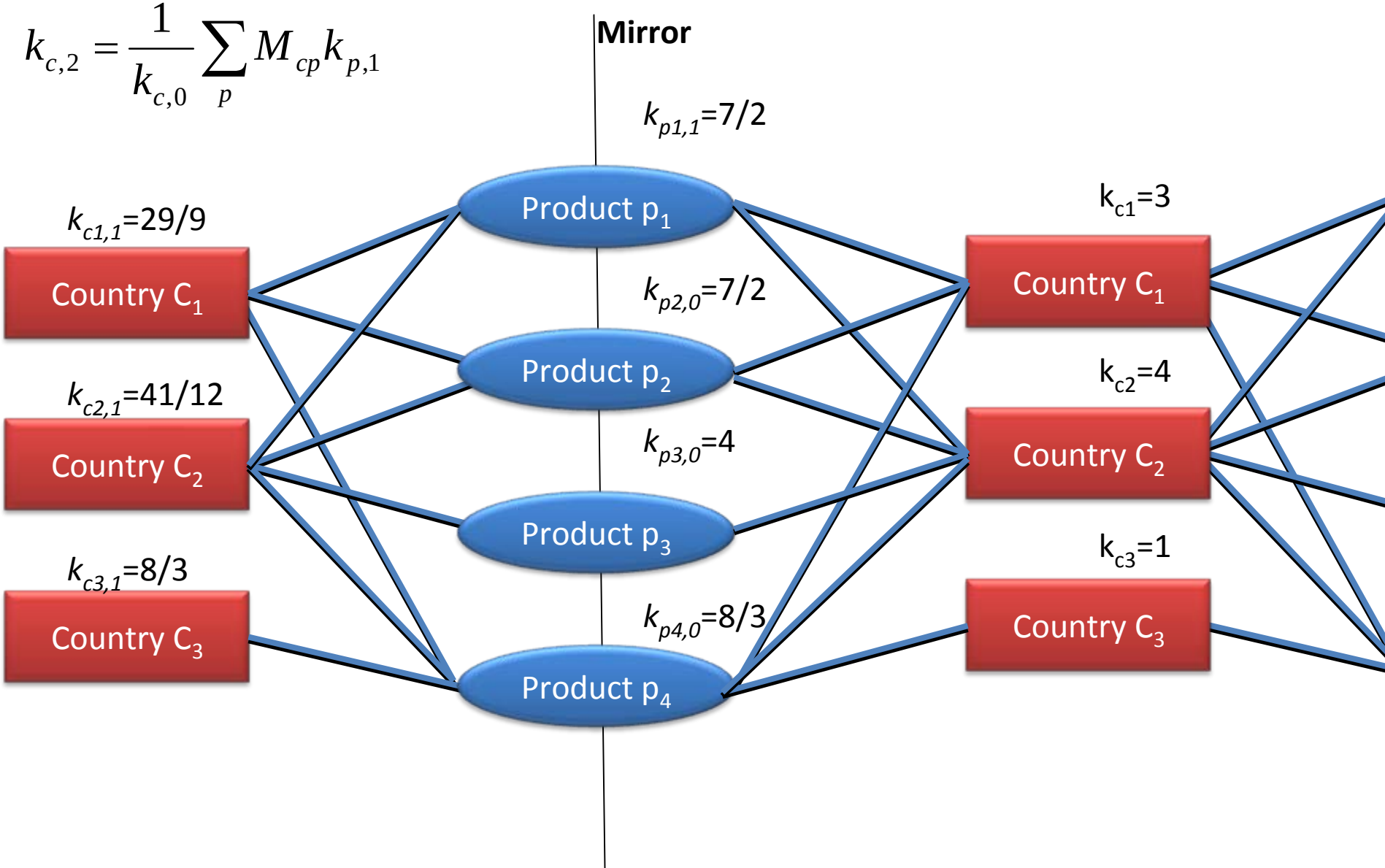
$$k_{c,1} = \frac{1}{k_{c,0}} \sum_{p} M_{cp} k_{p,0}$$



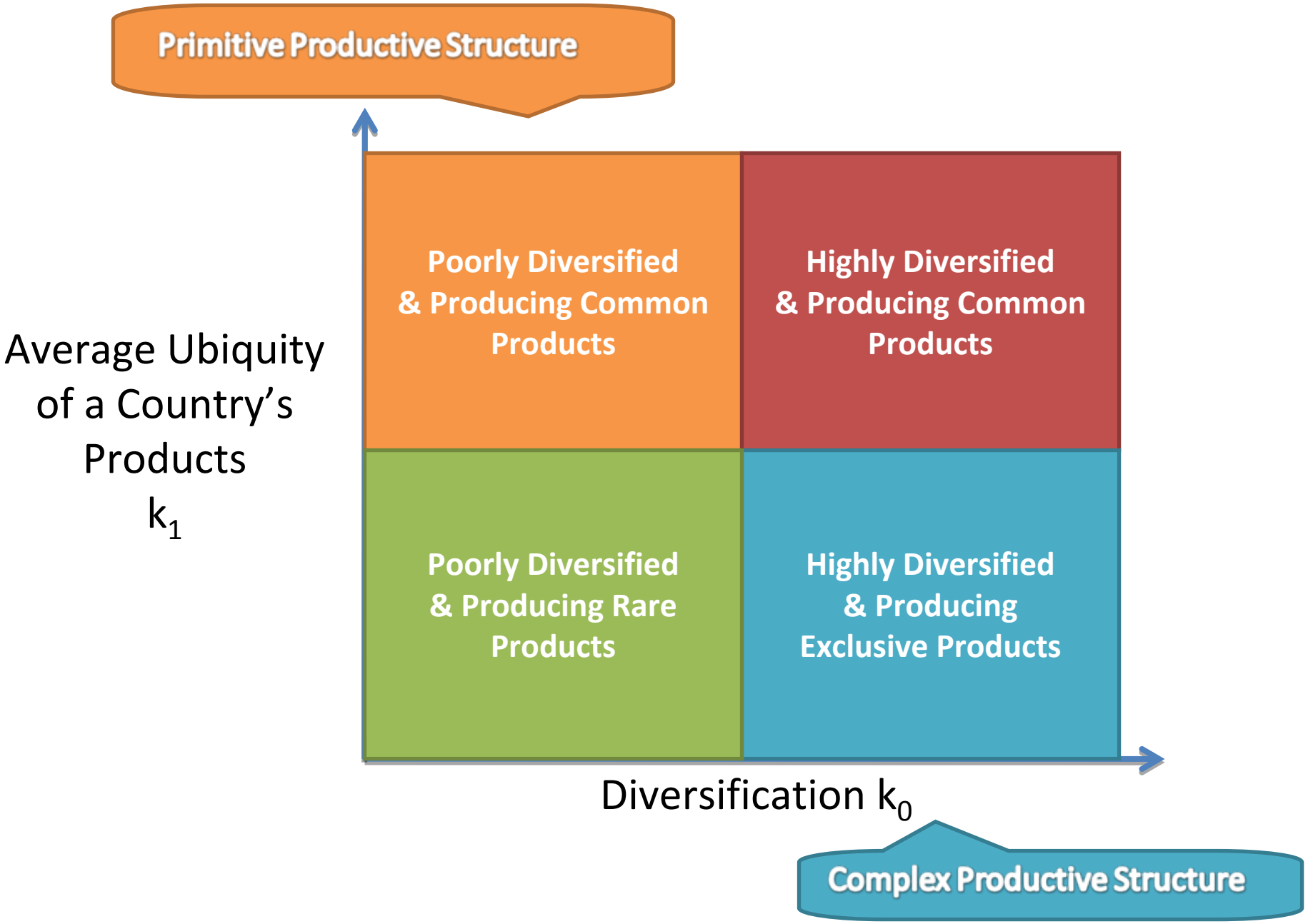
Method of Reflections

$k_{c,2}$= Average diversification of countries that export the products your export

$$k_{c,2} = \frac{1}{k_{c,0}} \sum_{p} M_{cp} k_{p,1}$$

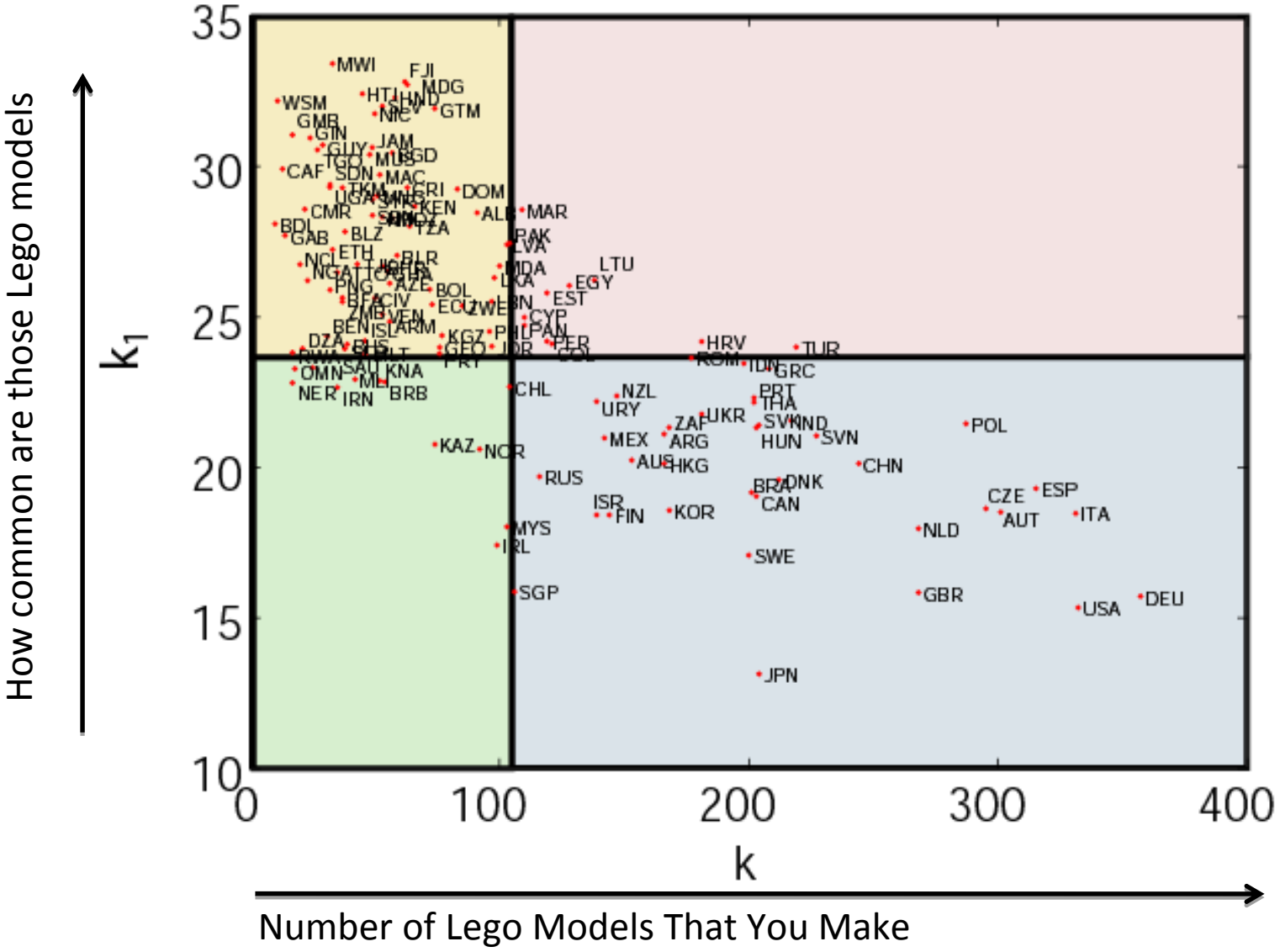


The k_0, k_1 diagram

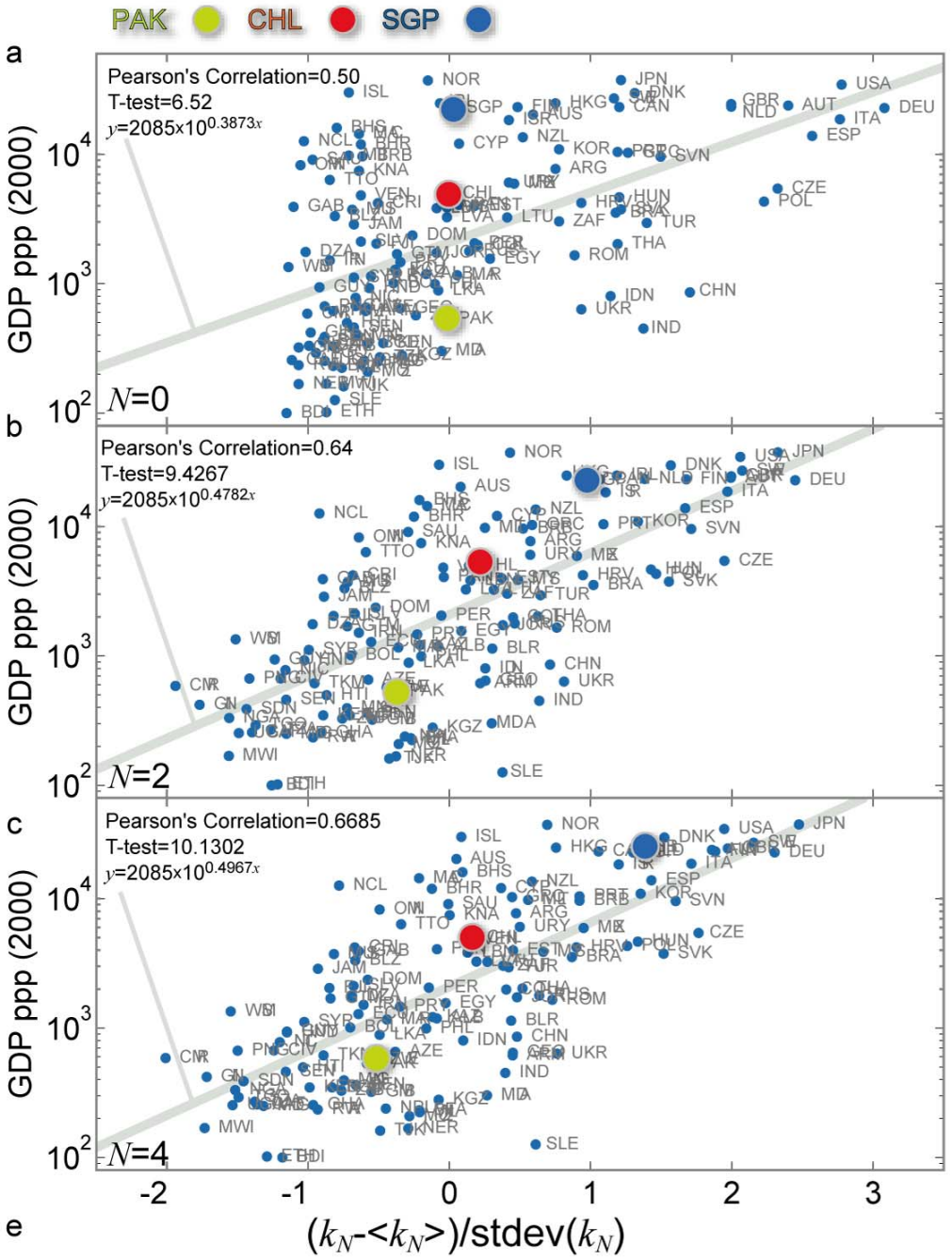


Dataset 1 (Year 2000)

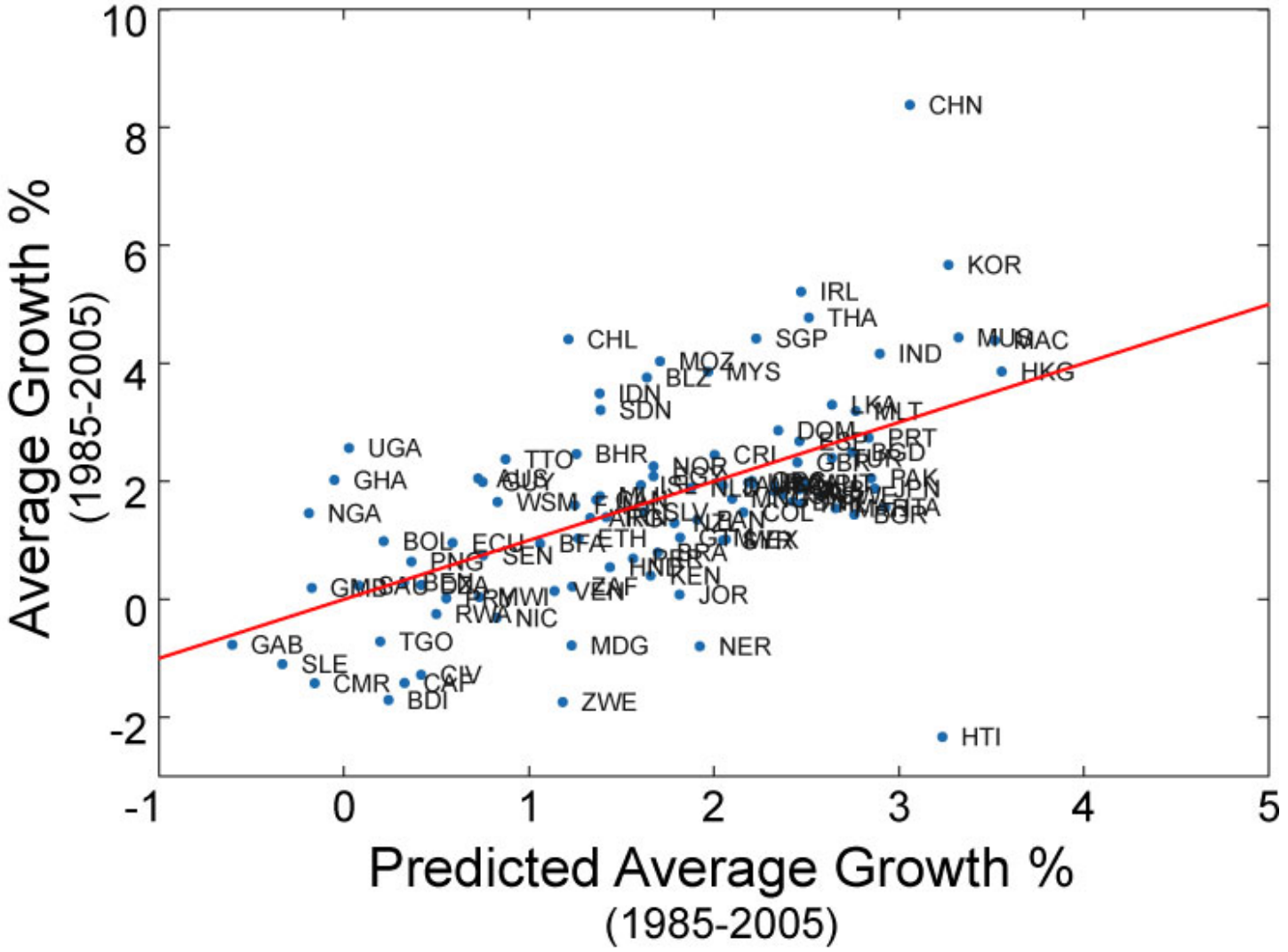
Feenstra 129 countries 772 products (SITC-4)



Hidalgo, Hausmann (2009) PNAS



Hidalgo, Hausmann (2009) PNAS



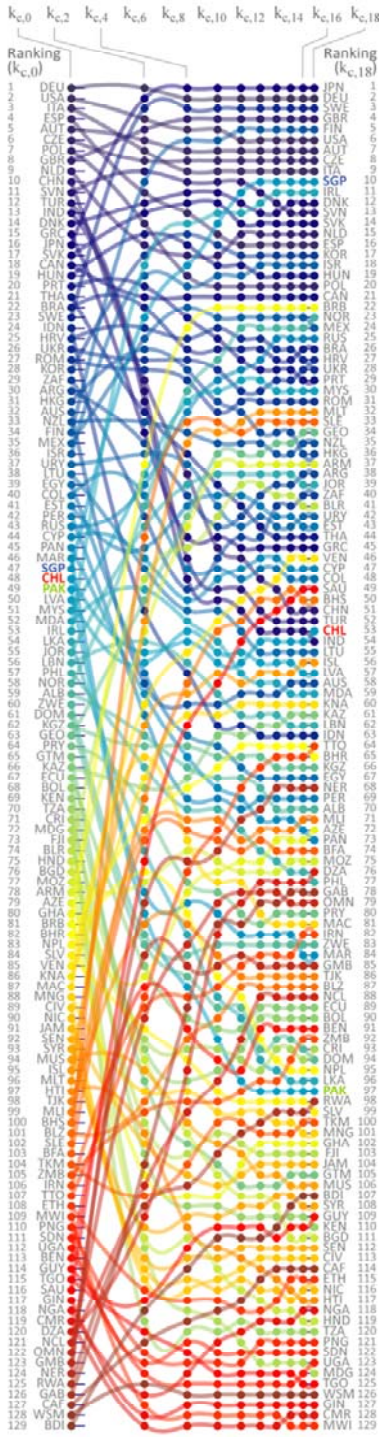
Hidalgo, Hausmann (2009) PNAS

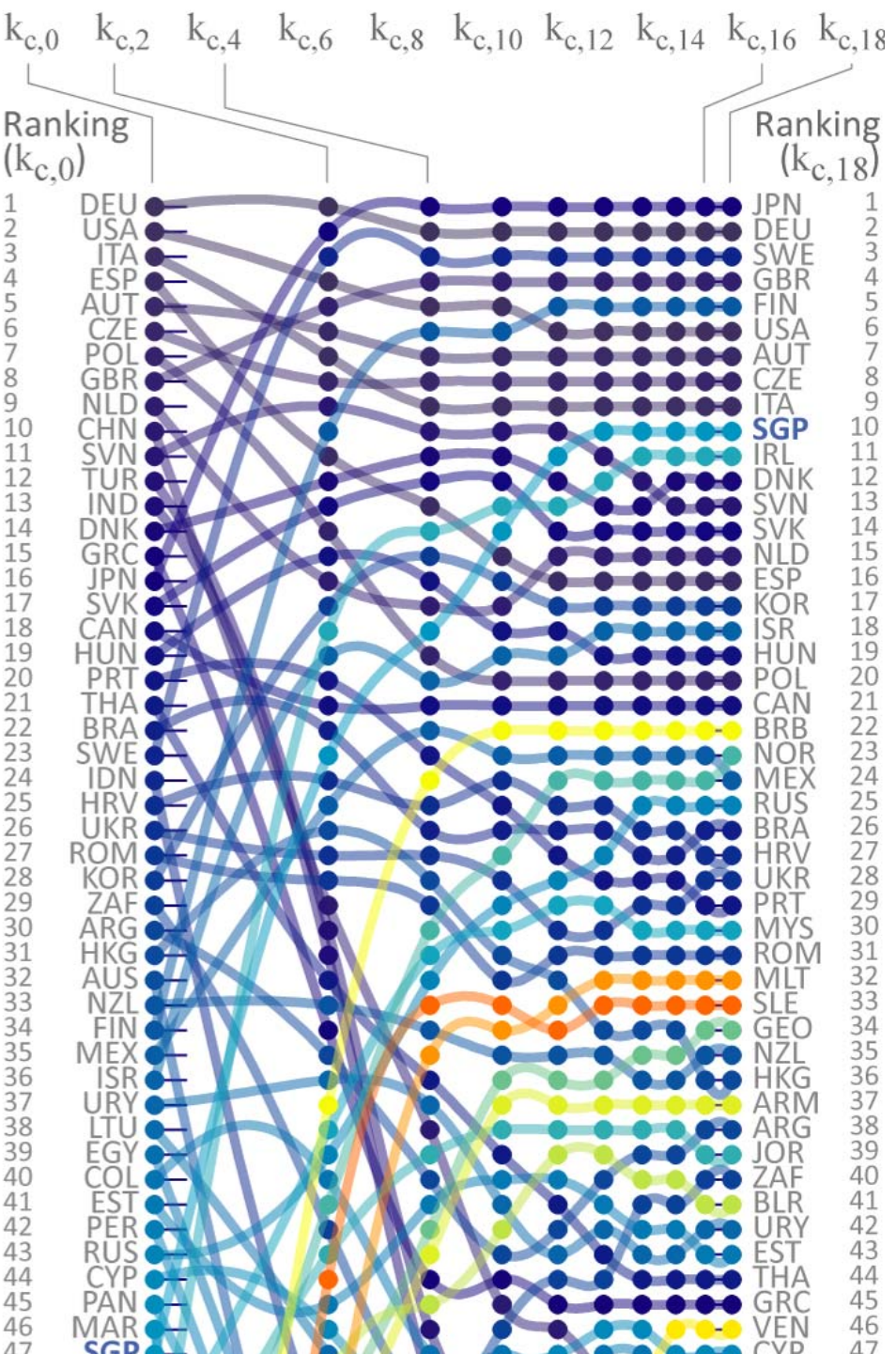
Method of Reflections: 20 year Growth

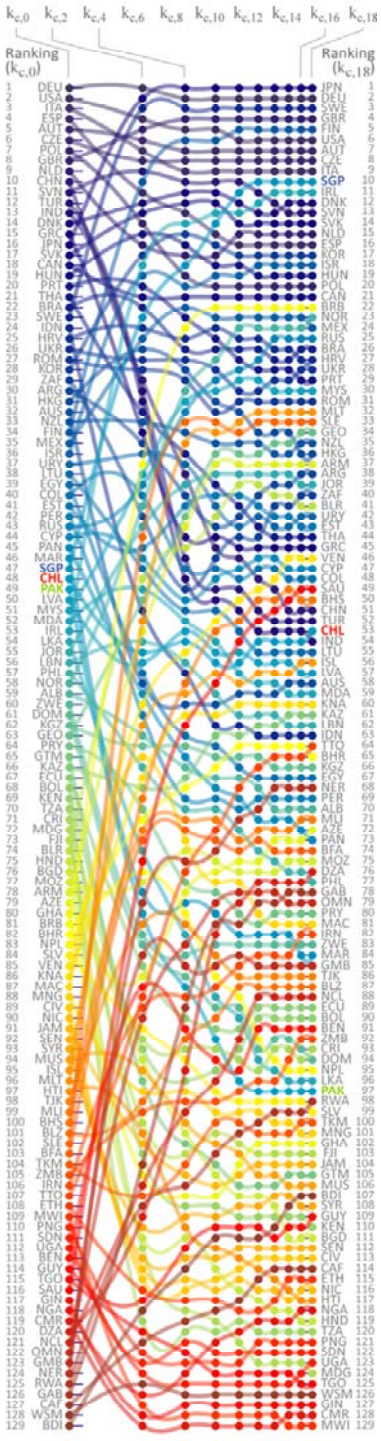
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	***(11)***
Predicted Variable	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**	Growth **(85,95)**
Predictors											
GDP per capita ppp **(1985)**	-0.00176	0.000993	-0.00206	-0.00154	-0.00249	-0.00223	-0.00470	-0.00233	-0.00244	-0.00238	-0.00242
	(-0.794)	(0.533)	(-0.882)	(-0.497)	(-0.735)	(-0.688)	(-1.478)	(-0.758)	(-0.849)	(-0.804)	(-0.831)
Entropy **(1985)**	0.00660***		0.00828**						0.00200		0.00322
	(3.650)		(2.600)						(0.931)		(0.896)
Herfindahl **(1985)**		-0.0273***	0.0116							-0.00414	0.00723
		(-2.765)	(0.760)							(-0.406)	(0.454)
k **(1985)**				6.62e-05**							
				(2.080)							
k_1 **(1985)**				-0.000612							
				(-0.749)							
k_4 **(1985)**					0.00169***						
					(2.866)						
k_5 **(1985)**					0.0321*						
					(1.737)						
k_8 **(1985)**						0.0338***					
						(3.075)					
k_9 **(1985)**						0.890***					
						(2.713)					
k_{18} **(1985)**							0.401***	38.88***	35.05**	37.26***	35.57***
							(3.453)	(2.952)	(2.618)	(2.849)	(2.643)
k_{19} **(1985)**								1127***	1017**	1080***	1033***
								(2.928)	(2.603)	(2.829)	(2.632)
Constant	0.0114	0.0137	0.00650	0.0338	-0.735*	-19.29***	-69.21***	-23801***	-21475**	-22808***	-21801***
	(0.751)	(0.776)	(0.437)	(0.922)	(-1.883)	(-2.807)	(-3.454)	(-2.940)	(-2.610)	(-2.834)	(-2.633)
N	97	97	97	97	97	97	97	97	97	97	97
Adjusted R^2	**0.195**	**0.115**	**0.192**	**0.118**	**0.206**	**0.247**	**0.202**	**0.274**	**0.274**	**0.268**	**0.268**

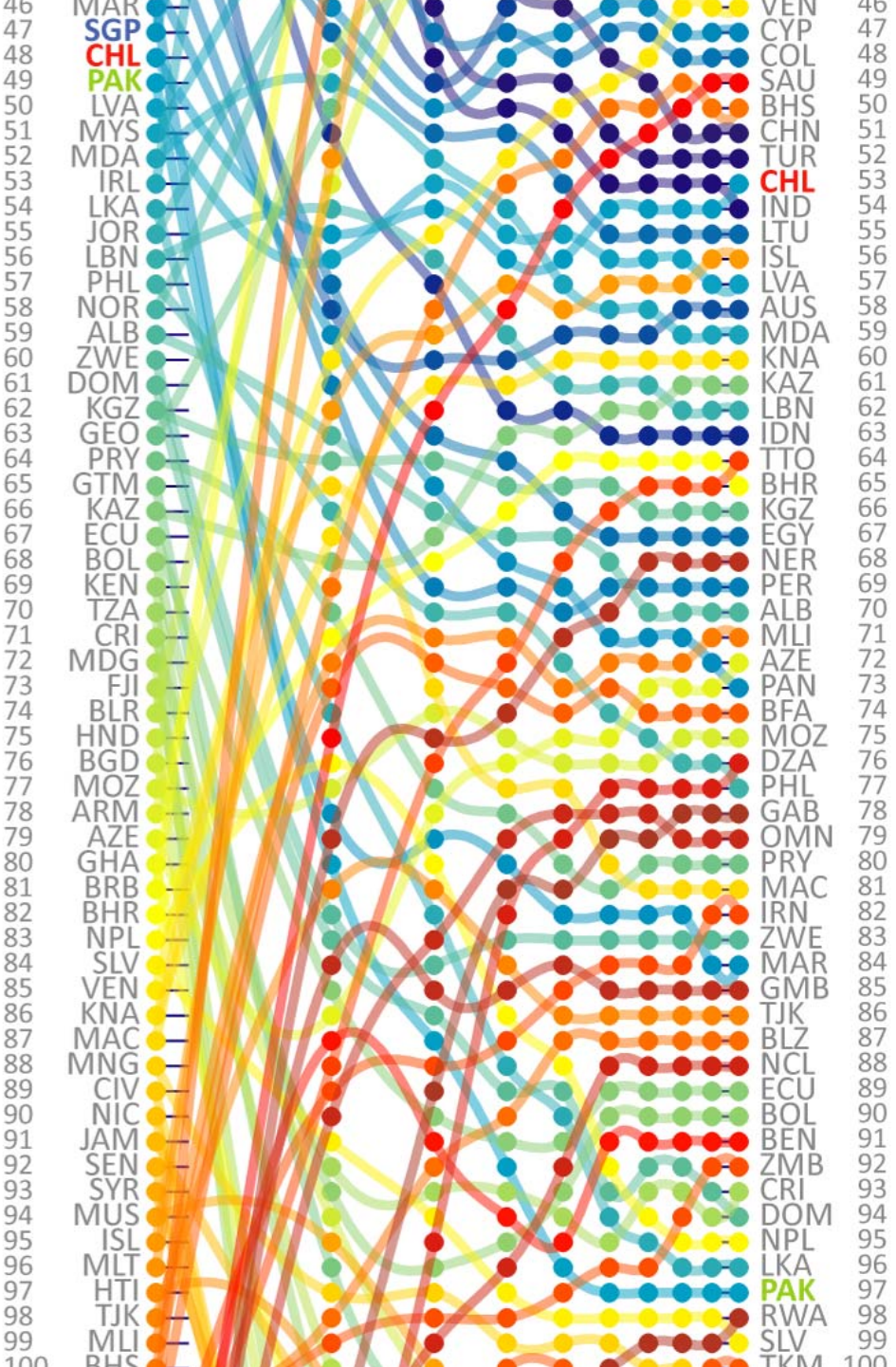
Method of Reflections: 5 year growth, fixed country effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Predicted Variables	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**	Growth **(85-90-95-00-05)**
Predictors											
GDP per capita ppp **(85,90,95,00)**	-0.0585***	-0.0581***	-0.0595***	-0.0773***	-0.0863***	-0.0891***	-0.0651***	-0.0899***	-0.0868***	-0.0884***	-0.0867***
	(-7.911)	(-7.721)	(-8.072)	(-10.11)	(-11.28)	(-11.78)	(-8.337)	(-11.89)	(-11.39)	(-11.58)	(-11.40)
Entropy **(85,90,95,00)**	0.0134***		0.0247***						0.00706**		0.0142**
	(4.478)		(4.037)						(2.453)		(2.435)
Herfindahl **(85,90,95,00)**		-0.0390***	0.0585**							-0.0181	0.0360
		(-2.842)	(2.117)							(-1.435)	(1.410)
k **(85,90,95,00)**				0.000223***							
				(3.710)							
k_1 **(85,90,95,00)**				0.00238***							
				(6.549)							
k_4 **(85,90,95,00)**					0.000537***						
					(2.922)						
k_5 **(85,90,95,00)**					0.00366***						
					(9.287)						
k_8 **(85,90,95,00)**						0.000611***					
						(2.801)					
k_9 **(85,90,95,00)**						0.00410***					
						(8.998)					
k_{18} **(85,90,95,00)**							-0.000535***	0.000601***	0.000653***	0.000618***	0.000673***
							(-2.808)	(2.801)	(3.051)	(2.879)	(3.141)
k_{19} **(85,90,95,00)**								0.00419***	0.00395***	0.00410***	0.00389***
								(8.799)	(8.164)	(8.521)	(8.031)
Constant	0.467***	0.514***	0.429***	0.594***	0.588***	0.589***	0.651***	0.596***	0.543***	0.585***	0.511***
	(7.427)	(8.147)	(6.592)	(9.546)	(8.165)	(8.070)	(8.203)	(8.310)	(7.315)	(8.133)	(6.583)
Observations	451	451	451	451	451	451	451	451	451	451	451
Within R^2	**0.2071**	**0.1784**	**0.2179**	**0.2991**	**0.3379**	**0.3373**	**0.1779**	**0.3372**	**0.3494**	**0.3415**	**0.3535**

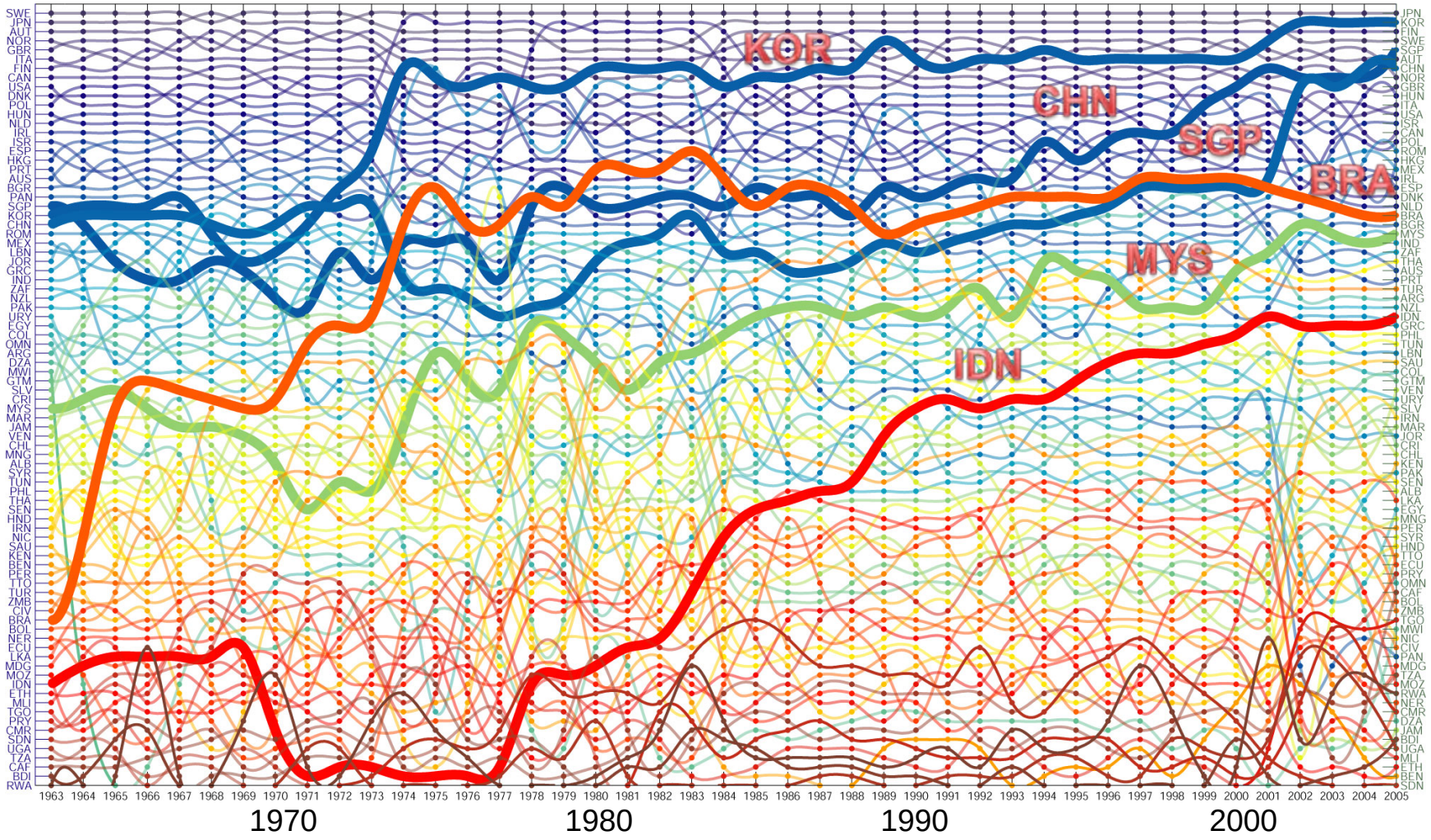

$k_{c,0}$ $k_{c,2}$ $k_{c,4}$ $k_{c,6}$ $k_{c,8}$ $k_{c,10}$ $k_{c,12}$ $k_{c,14}$ $k_{c,16}$ $k_{c,18}$
Ranking ($k_{c,0}$)
Ranking ($k_{c,18}$)


$k_{c,0}$ $k_{c,2}$ $k_{c,4}$ $k_{c,6}$ $k_{c,8}$ $k_{c,10}$ $k_{c,12}$ $k_{c,14}$ $k_{c,16}$ $k_{c,18}$
Ranking ($k_{c,0}$)
Ranking ($k_{c,18}$)
1 DEU 1 JPN
2 USA 2 DEU
3 ITA 3 SWE
4 ESP 4 GBR
5 AUT 5 FIN
6 CZE 6 USA
7 POL 7 AUT
8 GBR 8 CZE
9 NLD 9 ITA
10 CHN 10 SGP
11 SVN 11 IRL
12 TUR 12 DNK
13 IND 13 SVN
14 DNK 14 SVK
15 GRC 15 NLD
16 JPN 16 ESP
17 SVK 17 KOR
18 CAN 18 ISR
19 HUN 19 HUN
20 PRT 20 POL
21 THA 21 CAN
22 BRA 22 BRB
23 SWE 23 NOR
24 IDN 24 MEX
25 HRV 25 RUS
26 UKR 26 BRA
27 ROM 27 HRV
28 KOR 28 UKR
29 ZAF 29 PRT
30 ARG 30 MYS
31 HKG 31 ROM
32 AUS 32 MLT
33 NZL 33 SLE
34 FIN 34 GEO
35 MEX 35 NZL
36 ISR 36 HKG
37 URY 37 ARM
38 LTU 38 ARG
39 EGY 39 JOR
40 COL 40 ZAF
41 EST 41 BLR
42 PER 42 URY
43 RUS 43 EST
44 CYP 44 THA
45 PAN 45 GRC
46 MAR 46 VEN
47 SGP 47 CYP

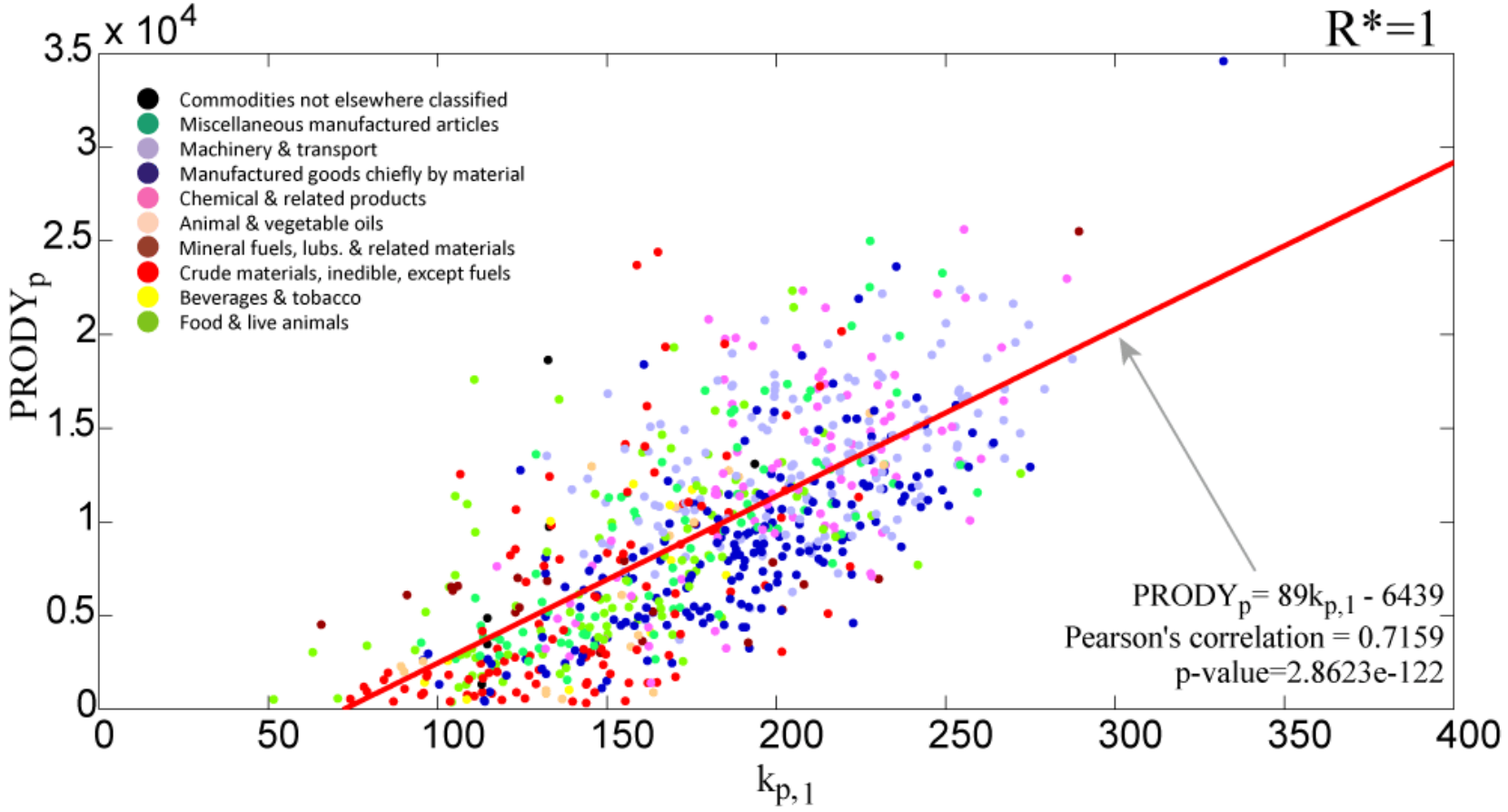

$k_{c,0}$ $k_{c,2}$ $k_{c,4}$ $k_{c,6}$ $k_{c,8}$ $k_{c,10}$ $k_{c,12}$ $k_{c,14}$ $k_{c,16}$ $k_{c,18}$
Ranking ($k_{c,0}$)
Ranking ($k_{c,18}$)


46 MAR
47 SGP
48 CHL
49 PAK
50 LVA
51 MYS
52 MDA
53 IRL
54 LKA
55 JOR
56 LBN
57 PHL
58 NOR
59 ALB
60 ZWE
61 DOM
62 KGZ
63 GEO
64 PRY
65 GTM
66 KAZ
67 ECU
68 BOL
69 KEN
70 TZA
71 CRI
72 MDG
73 FJI
74 BLR
75 HND
76 BGD
77 MOZ
78 ARM
79 AZE
80 GHA
81 BRB
82 BHR
83 NPL
84 SLV
85 VEN
86 KNA
87 MAC
88 MNG
89 CIV
90 NIC
91 JAM
92 SEN
93 SYR
94 MUS
95 ISL
96 MLT
97 HTI
98 TJK
99 MLI
100 BHS
46 VEN
47 CYP
48 COL
49 SAU
50 BHS
51 CHN
52 TUR
53 CHL
54 IND
55 LTU
56 ISL
57 LVA
58 AUS
59 MDA
60 KNA
61 KAZ
62 LBN
63 IDN
64 TTO
65 BHR
66 KGZ
67 EGY
68 NER
69 PER
70 ALB
71 MLI
72 AZE
73 PAN
74 BFA
75 MOZ
76 DZA
77 PHL
78 GAB
79 OMN
80 PRY
81 MAC
82 IRN
83 ZWE
84 MAR
85 GMB
86 TJK
87 BLZ
88 NCL
89 ECU
90 BOL
91 BEN
92 ZMB
93 CRI
94 DOM
95 NPL
96 LKA
97 PAK
98 RWA
99 SLV
100 TKM

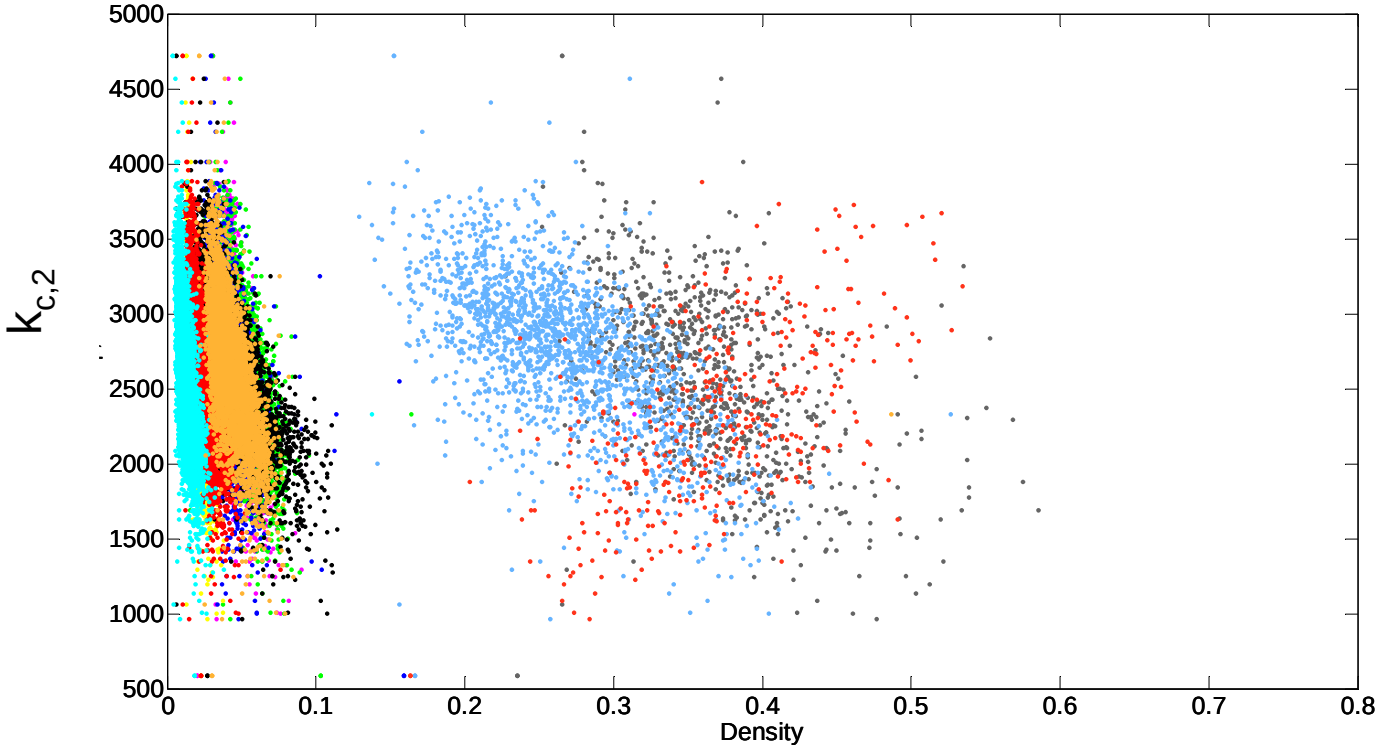
Other Great Transformers… TUR, THA



Hidalgo (2010) in preparation

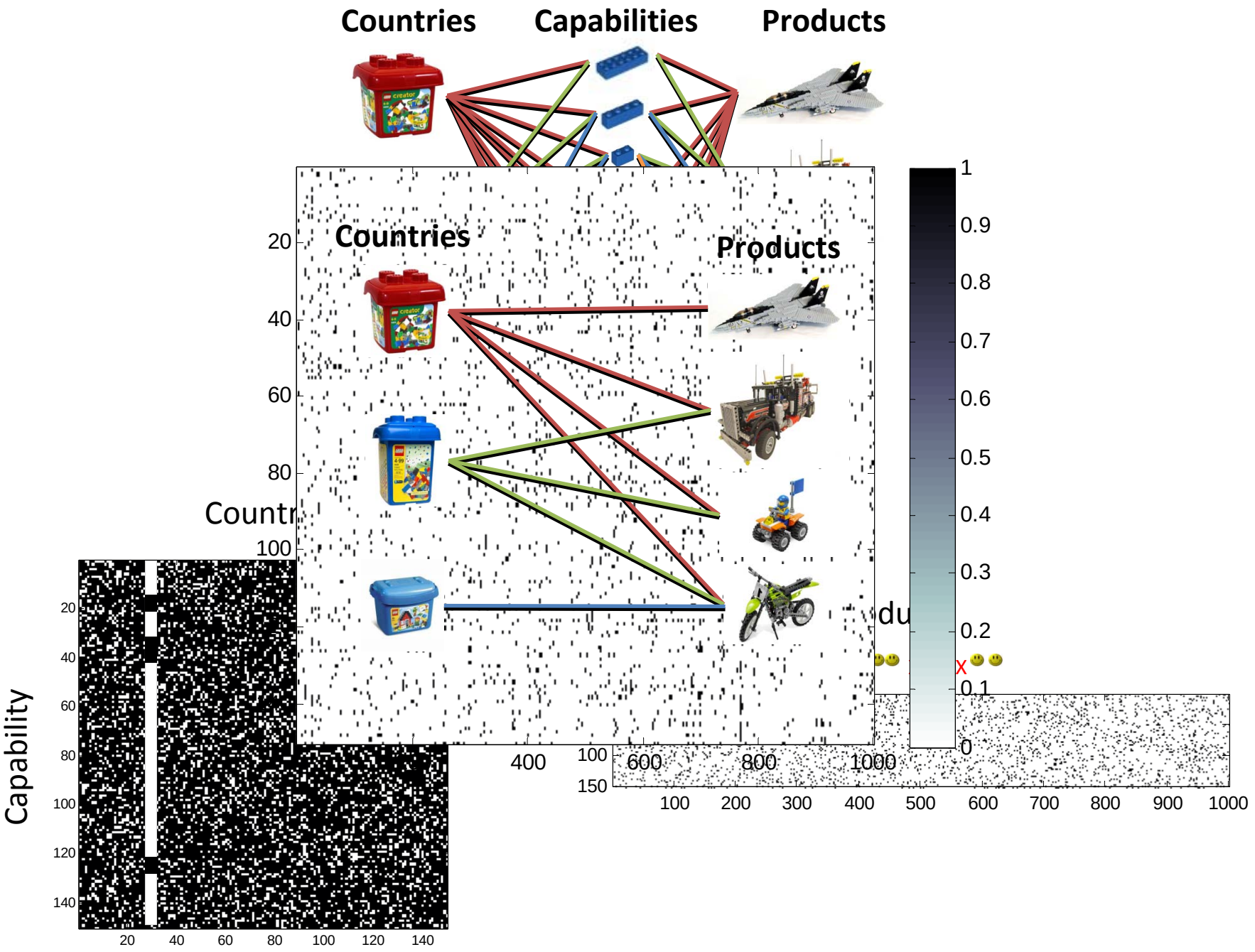

R*=1
x 10^4
3.5
3
2.5
2
1.5
1
0.5
0
PRODY_p
0
50
100
150
200
250
300
350
400
k_p,1
Commodities not elsewhere classified
Miscellaneous manufactured articles
Machinery & transport
Manufactured goods chiefly by material
Chemical & related products
Animal & vegetable oils
Mineral fuels, lubs. & related materials
Crude materials, inedible, except fuels
Beverages & tobacco
Food & live animals
PRODY_p = 89k_p,1 - 6439
Pearson's correlation = 0.7159
p-value=2.8623e-122

AFG IRN KAZ KGZ MNG TJK TKM UZB DEU TUR CHN

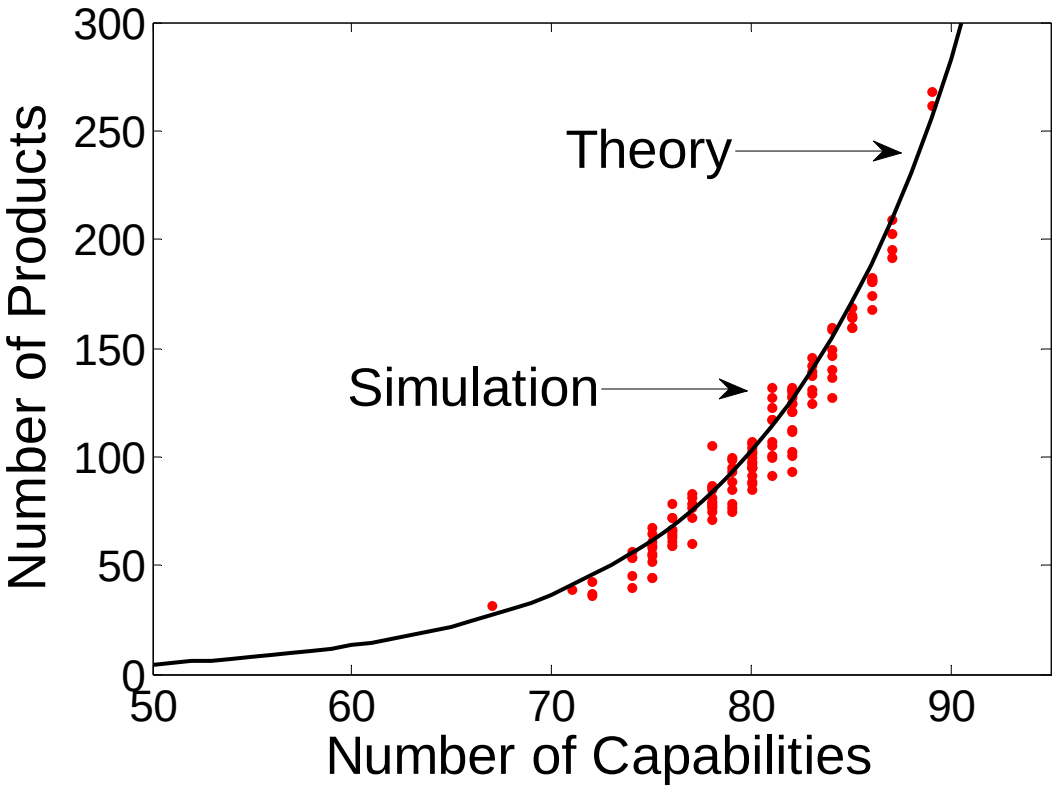


Baci Data from Cepii (2005). 232 Countries, 5109 Products

Analytical Theory: Putting the Pieces together


Countries
Capabilities
Products
Countries
Products
Capability
Countr
du
X
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
20
40
60
80
100
120
140
400
600
800
1000
100
150
100
200
300
400
500
600
700
800
900
1000

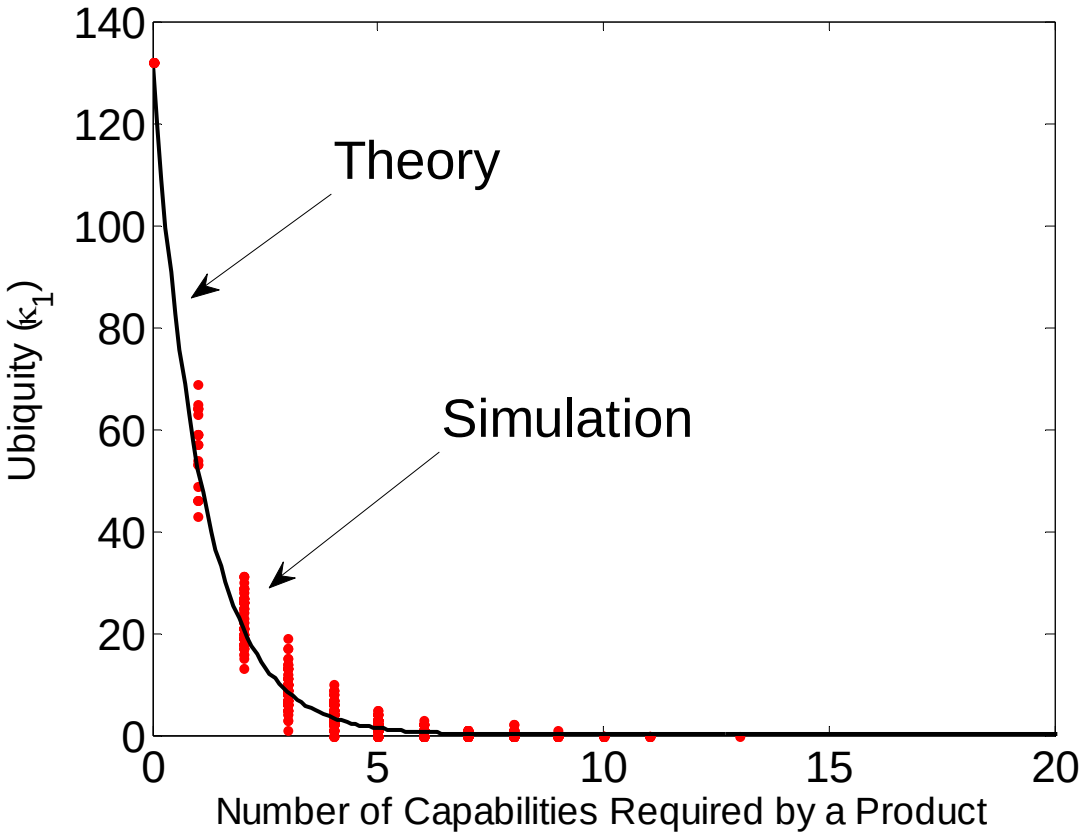
Theoretical Prediction 1: The diversification of a country increases with the number of capabilities that country has.



$$k_{c,0}^{p} = N_p \left(q \frac{k_{c,0}^{a}}{N_a} + 1 - q \right)^{N_a}.$$

Hausmann and Hidalgo (2010) in preparation

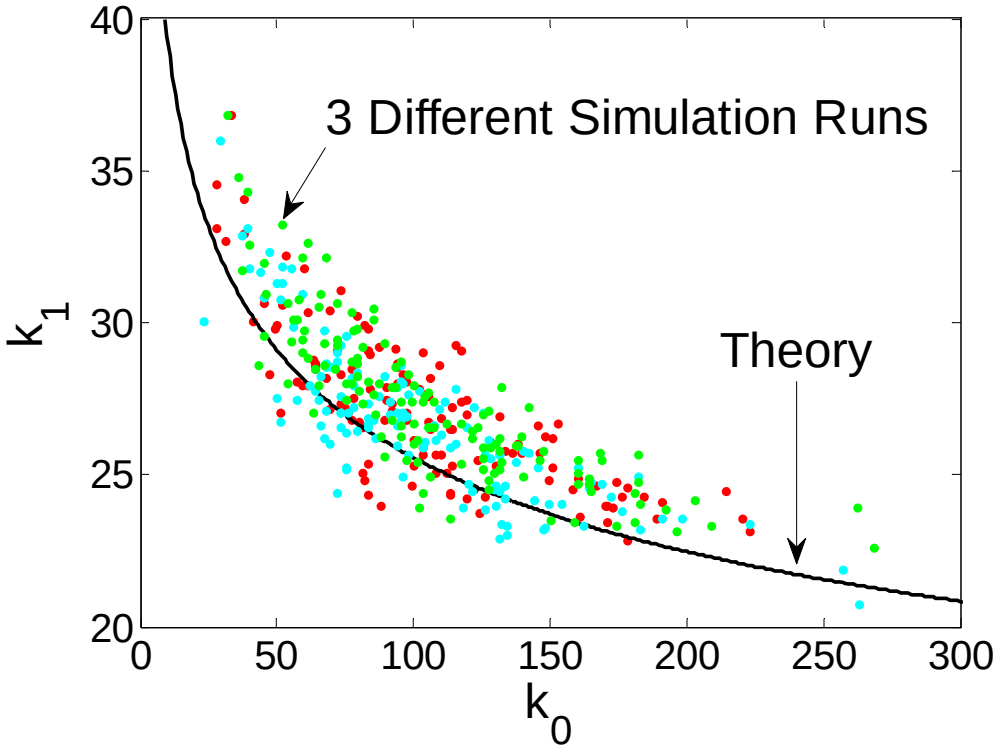
Theoretical Prediction 2: The ubiquity of a product decreases with the number of capabilities it requires.



$$k_{p,0}^{c} = N_c r^{k_{p,0}^{a}}.$$

Hausmann and Hidalgo (2010) in preparation

Theoretical Prediction 3: The ubiquity of a country's products decreases with that country's level of diversification.



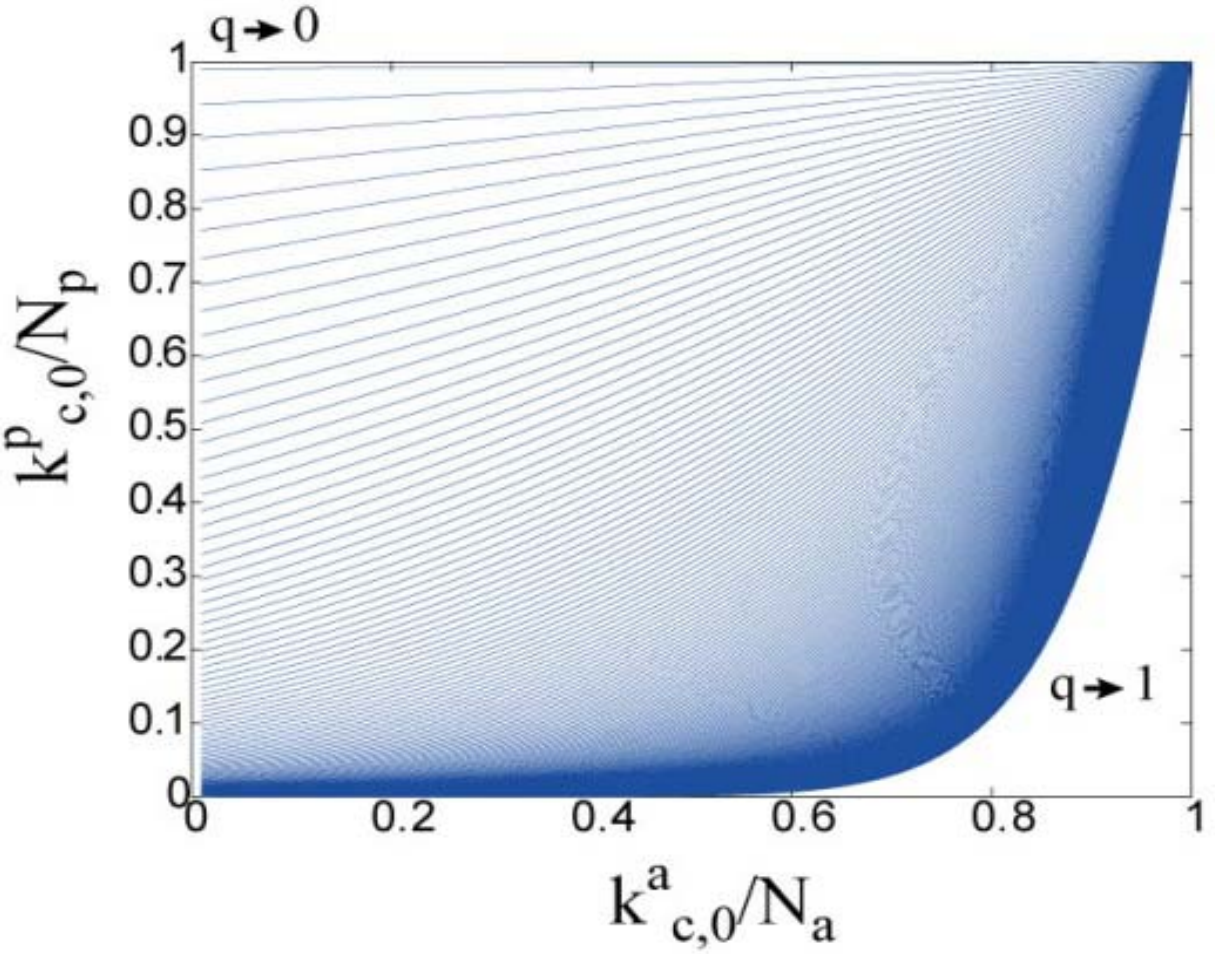
$$k_{c,1}^{p} = \frac{N_p N_c}{k_{c,0}^{p}} \left(r \left(\frac{k_{c,0}^{p}}{N_p} \right)^{1/N_a} + (1-q)(1-r) \right)^{N_a}.$$

$$\frac{dk_{c,1}^{p}}{dk_{c,0}^{p}} = -\frac{N_p N_c}{\left(k_{c,0}^{p}\right)^2} (1-q)(1-r) \left(r \left(\frac{k_{c,0}^{p}}{N_p} \right)^{1/N_a} + (1-q)(1-r) \right)^{N_a - 1}.$$

Hausmann and Hidalgo (2010) in preparation

Bonus: A Poverty Trap Model

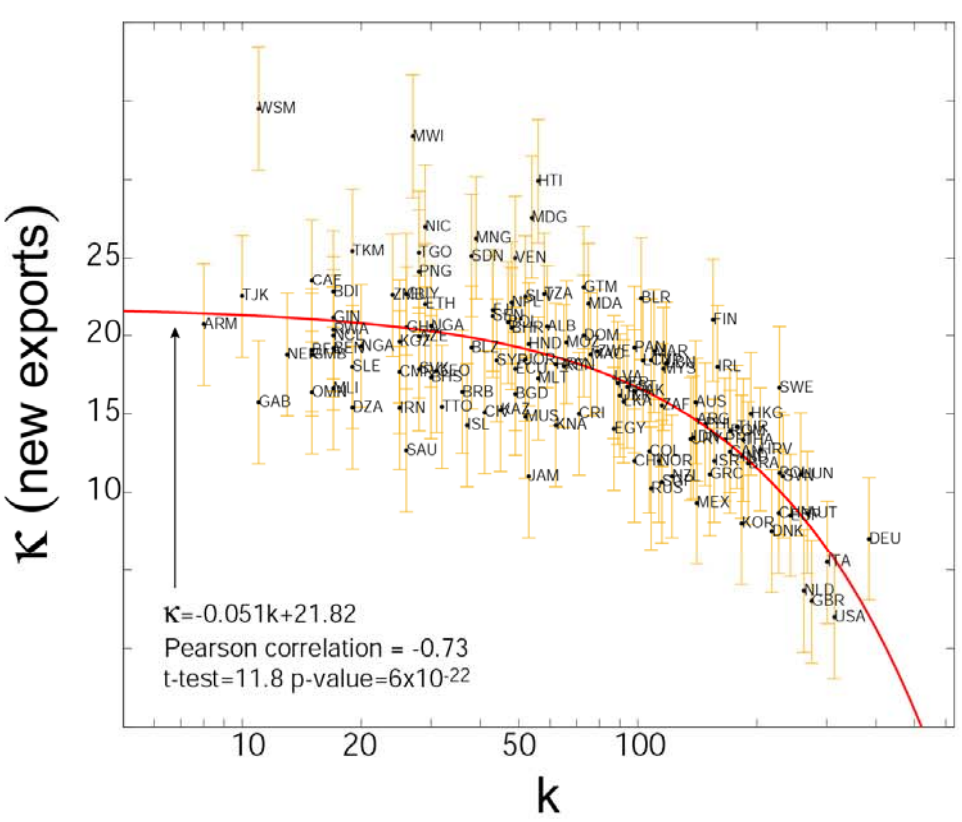
$$k_{c,0}^{p} = N_p \left(q \frac{k_{c,0}^{a}}{N_a} + 1 - q \right)^{N_a}.$$

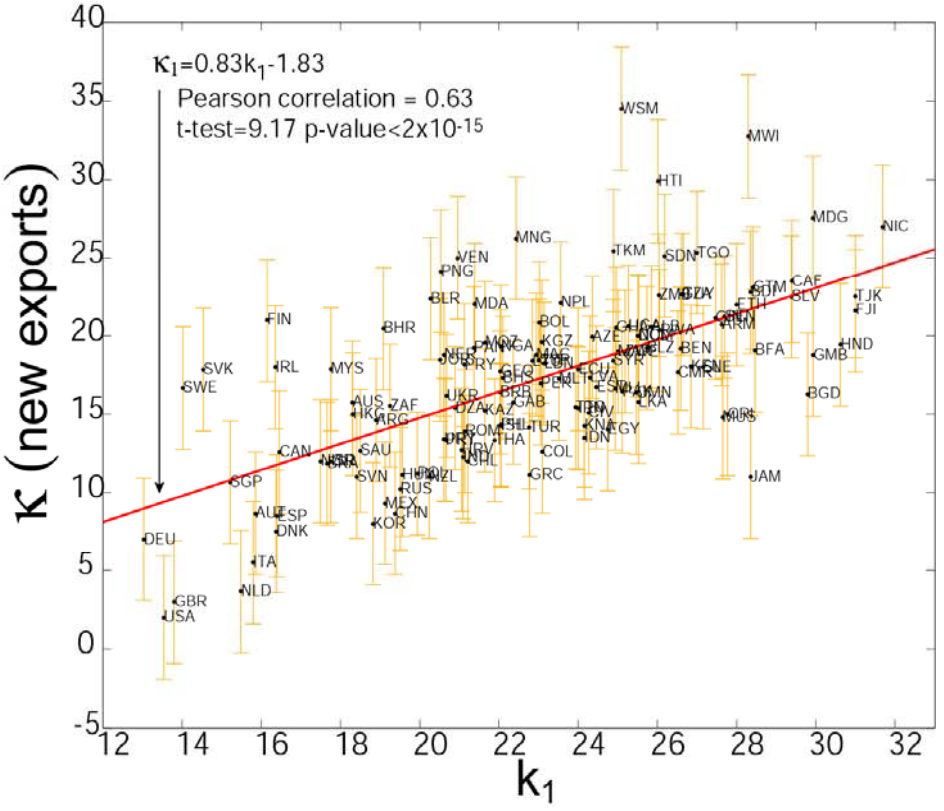


Hausmann and Hidalgo (2010) in preparation

Coordination Problem

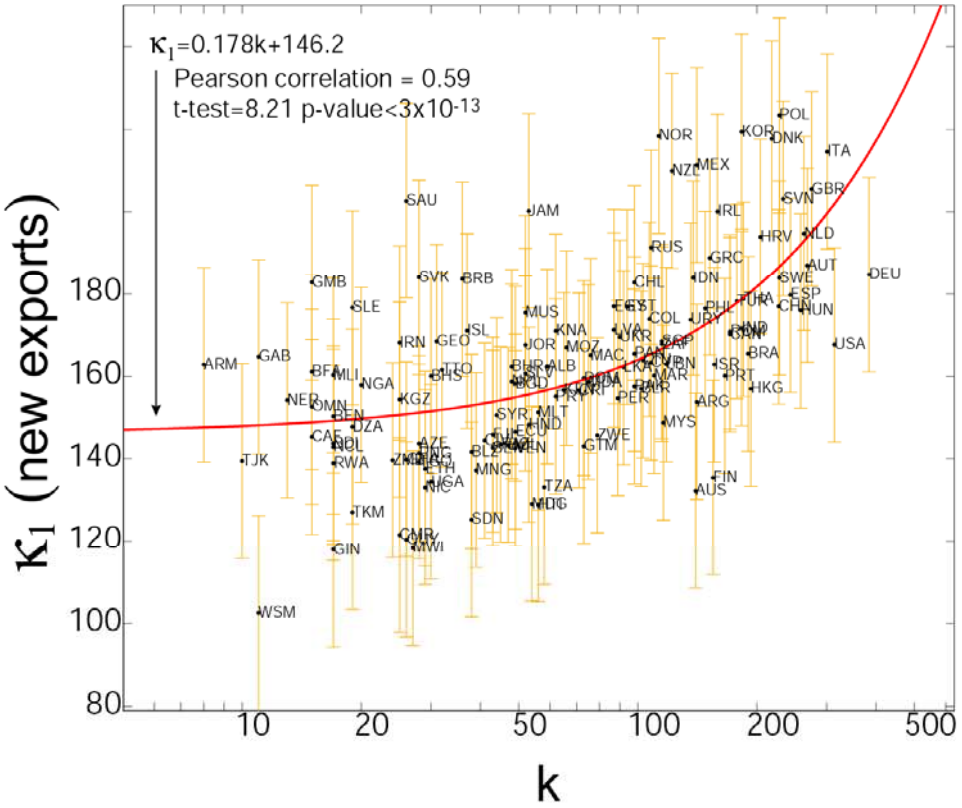
Method of Reflections: Predicts network properties of future products

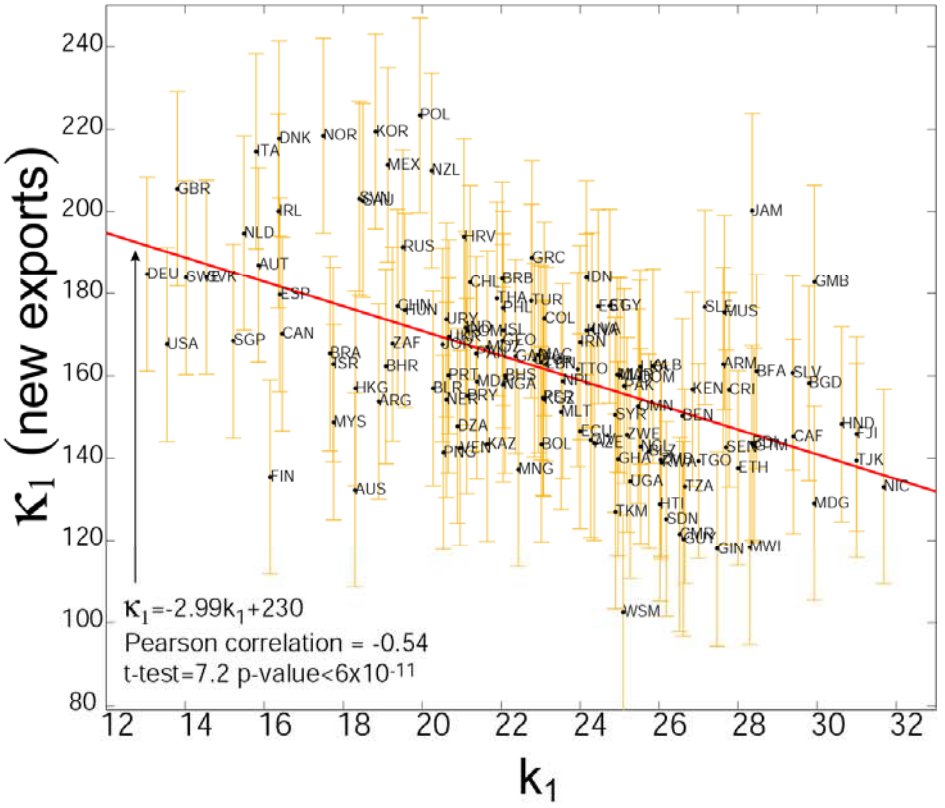




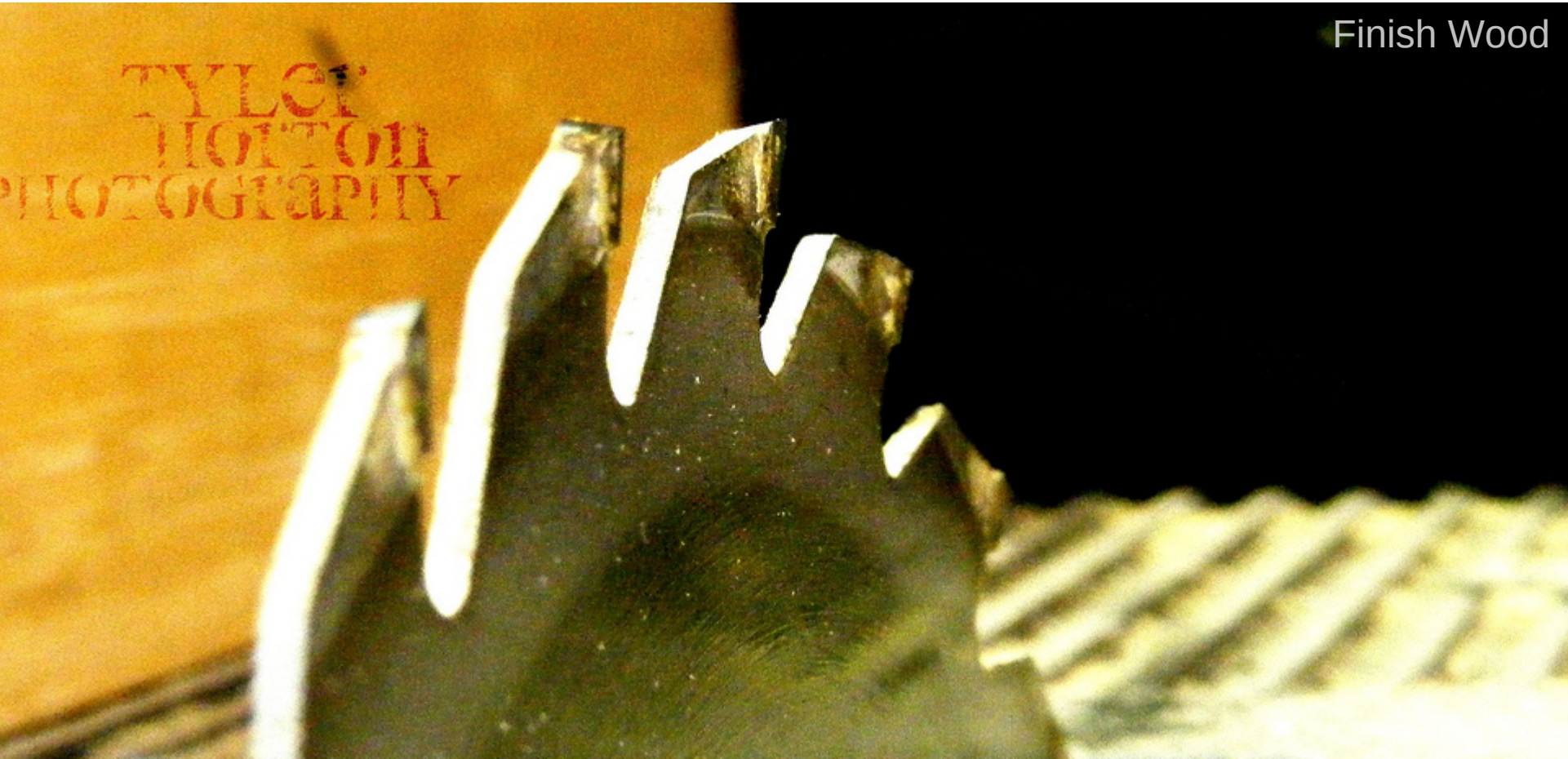
Hidalgo, Hausmann (2009) PNAS

Method of Reflections: Predicts network properties of future products





Hidalgo, Hausmann (2009) PNAS


Finish Wood

Thanks!

(more info @ **www.chidalgo.com**, or google “cesar hidalgo”)

Hidalgo et al. *Science* (2007)
Hidalgo Hausmann, *Development Alternatives* (2008)
Hidalgo Hausmann, *PNAS* (2009)

Cesar A. Hidalgo,
Research Fellow, Center for International Development, Harvard University
Adjunct Lecturer in Public Policy, Harvard Kennedy School

Ricardo Hausmann,
Director, Center for International Development, Harvard University
Professor of the Practice of Economic Development, Harvard Kennedy School

NetSci2010

April 2010, Boston, MA

Harvard, MIT and Northeastern University

www.Netsci10.net

- *Systems Biology*
  - ***Economics and Business***
- *Computer Science/ Social Media*
- *Physics*