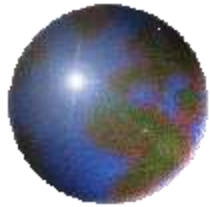


Transnational strategies in the automotive industry workshop
Centre for Innovation Management Research (CIMR)
Birkbeck, University of London
6th February 2015, Room GOR G04 (Gordon Square)



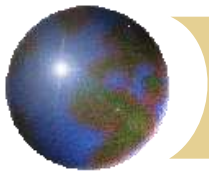
Automotive international trade networks: A comparative analysis over the last two decades

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Outline

- ⊕ Background
- ⊕ The debate
- ⊕ Research questions
- ⊕ Contribution of Network Analysis
- ⊕ Data & Methodology
- ⊕ Results
- ⊕ Conclusions

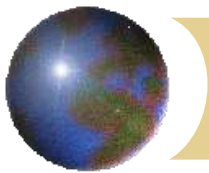
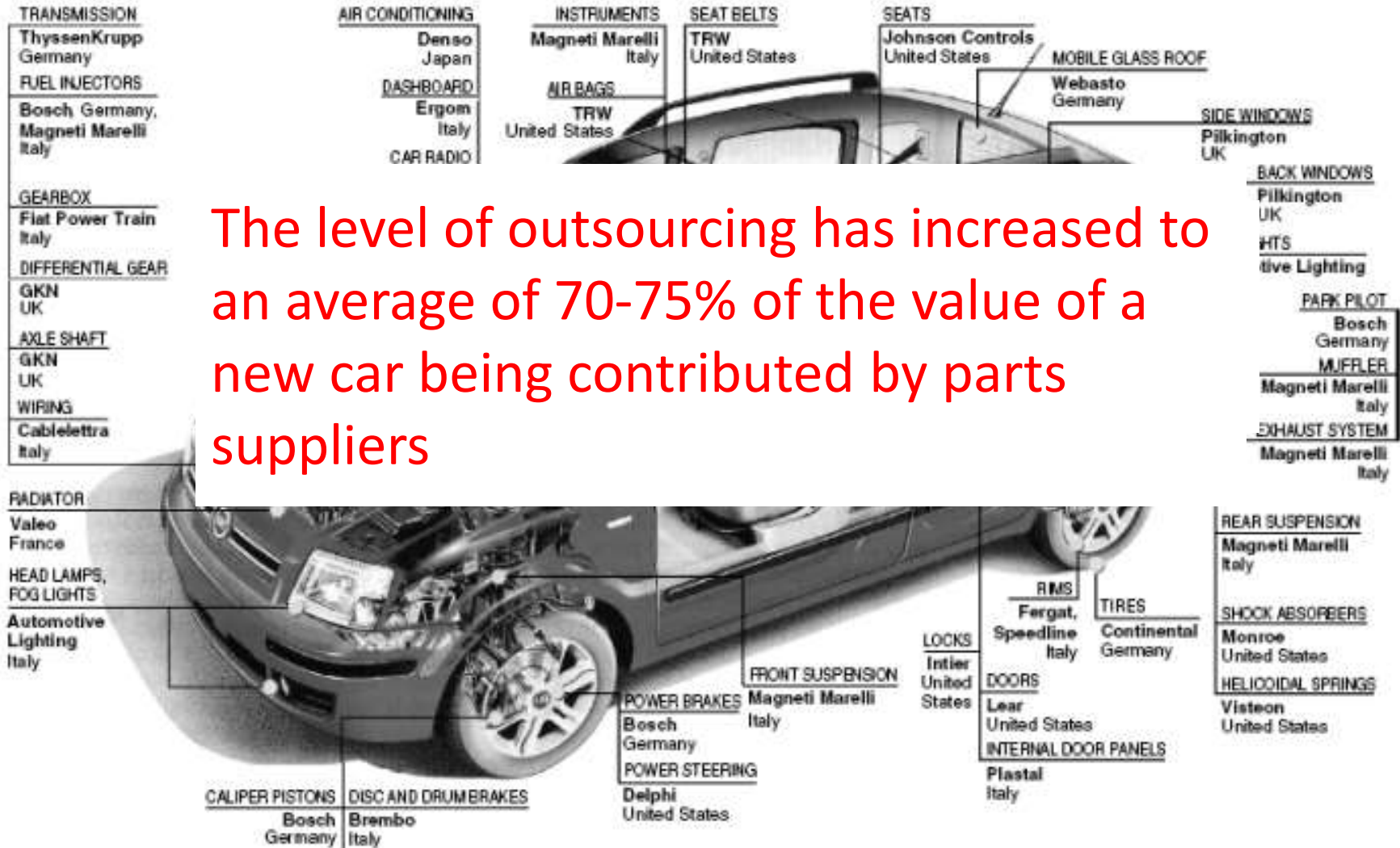
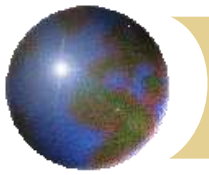


Figure 3 Local Network of Supply Relations for the New Fiat Panda



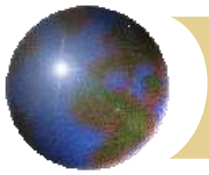
The level of outsourcing has increased to an average of 70-75% of the value of a new car being contributed by parts suppliers

Note. Reprinted courtesy of AUTO magazine.



The industry

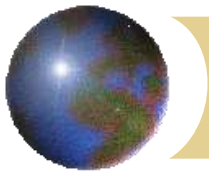
- ⊕ The number of car producers and export nations is comparatively smaller than in other sectors due to the large size of fixed capital investments required in the production of car bodies
- ⊕ Instead, engine production requires smaller fixed investments, and assembly plants even smaller
- ⊕ Original Equipment Manufacturers (OEMs) from Western Europe, North America and Japan-South Korea play a central role in coordinating production networks of first-tier suppliers (system integrators) and lower tier suppliers (parts producers) located in a variety of countries



Debate on evolution of industry

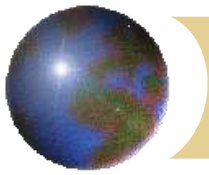
1st aspect

- ⊕ Auto production would become a global industry with low-cost and rising final-demand emerging economies gradually displacing as major producers high-cost and stagnant final-demand industrialised countries
- ⊕ A wave of technological (high-tech microelectronics) and organisational innovations (restructuring of component supply and flexible manufacturing systems) has led to a 'dematurity' stage (Jones and Womack 1985), which makes it unlikely that it will follow similar product life-cycles as those experienced by technologically mature industries (textile, apparel, appliances, etc.), where production migrated towards emerging economies



1^o Research Question

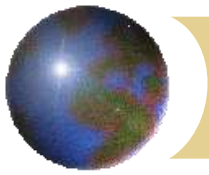
- ⊕ Has the rise of new suppliers of auto parts changed the structure of international organisation of auto production, or has it instead simply changed the geography of suppliers?



Debate on evolution of industry

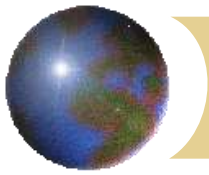
2nd aspect

- ✦ Although the automotive is often described as a prototype of global industry, the internationalisation strategies of world major producers have been largely developed on a regional rather than global scale
- ✦ Search for cost-reduction strategies pushes producers to explore all possible sources of economies of scale , which makes internationalisation of production one of the key features of industry dynamics
- ✦ At the same time, transportation costs make it more convenient for the various stages of production to be located within a relatively limited geographic area, which explains why regionalisation of production processes is a more viable option than global production



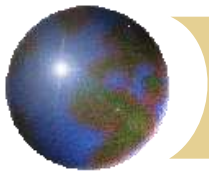
2° Research Questions

- ✚ The rise of new parts producers in some emerging economies has raised the possibility that production strategies organised on a regional scale might be complemented by (if not substituted for) trans-regional sourcing strategies
- ✚ Therefore, a related question we tackle in this paper is: How the two concomitant yet somehow contrasting tendencies towards globalisation and regionalisation of production are shaping the automobile industry?



Network approach

- ✦ Different from standard statistical techniques, network analysis assumes dependency of observations, and therefore represents a more realistic approach to analyse the interdependence that characterises production and, therefore, trade today.
- ✦ Traditional approaches (such as gravitational models) consider only the relationship between countries i and j , assuming that this is independent from any other relationship i and j establish with other countries
- ✦ Most of today's trade is a reflection of production fragmentation among different locations, which imposes the necessity to consider that the choice for a firm to source from country i and country j (i.e. establishing ij relationships) depends from the possibility of also sourcing from other locations (i.e. the possibility for i and j of also forming a tie with countries k, z , etc.)



Applications of NA to trade

✚ World System Theories

Snyder & Kick 1979; Nemeth & Smith 1985, Smith & White 1992; Kim & Shin 2002

✚ Econophysics

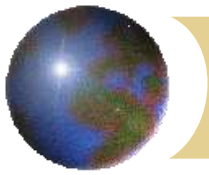
Serrano and Boguñá 2003; Garlaschelli and Loffredo 2004, 2005

✚ Macroeconomic studies

Kastelle et al. 2005; Kali & Reyes 2007; Fagiolo et al. 2007; De Benedictis & Tajoli 2008

✚ Sectoral studies

Cassi et al. 2009



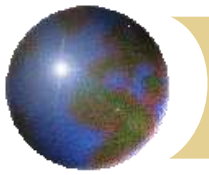
Data & Methodology

DATA

- ✦ Highly disaggregated (5 digits, SITC, Rev 3) trade data (UNSD):
30 commodity groups → 4 product categories (only 3 discussed in this presentation): electrical, rubber&metal, engines and miscellaneous parts
- ✦ Value of bilateral trade flows in 1998 and 2008 as a % over the total world trade value (only > 0.1% of world trade)

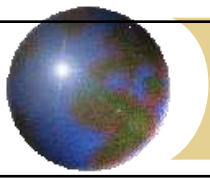
METHODOLOGY

- ✦ 8 Networks: for each of the four components for 1998 and 2008
- ✦ Directed flows $A_{ij} \neq A_{ji}$
- ✦ Binary and Valued data
- ✦ Network Measures



Measures

- ⊕ number of nodes (**Network size**)
- ⊕ Average number of exports partners (**Avg_N_Out-Degree**)
- ⊕ value of exports flows each actor has on average (**Avg_Out-Strength**)
- ⊕ extent to which existing ties are reciprocated (**Reciprocity**)
- ⊕ whether exports are evenly distributed among countries or whether there are only a few countries accounting for the majority of total world exports (**Out-Centralisation**)
- ⊕ hierarchical structure within the network (**core-periphery**)
- ⊕ Tendency towards globalisation (**E-I Index**)



Electrical & electric parts 1998

Electrical & electric parts 2008

Rubber & metal parts 1998

Rubber & metal parts 2008

Engines & parts 1998

Engines & parts 2008

Network size

31

33

22

23

27

34

Actors
In bold are indicated either the countries present in 1998 that disappeared in 2008, or the “new entries” of 2008

Argentina, Australia, Austria, BeLux, Brazil, Canada, China, Czech_Rep, Denmark, **Finland**, France, Germany, HongKong, Hungary, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, Netherlands, **Philippines**, Portugal, Singapore, South_Korea, Spain, Sweden, Switzerland, Thailand, UK, USA

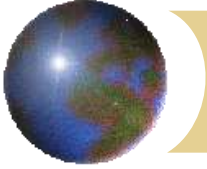
Argentina, Australia, Austria, Belgium, Brazil, Canada, China, CzechRep,, Denmark, France, Germany,, HongKong, Hungary, **India**, Indonesia, Italy, Japan, Malaysia, Mexico, Netherlands, **Poland**, Portugal, **Russia**, Singapore, **Slovakia**, South_Korea, Spain, Sweden, Switzerland,, Thailand, **Turkey**, UK, USA

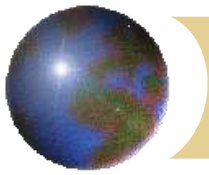
Australia, Austria, BeLux, Brazil, Canada, China, France, Germany, **HongKong**, Italy, Japan, Mexico, Netherlands, Portugal, Russia, South_Korea, Spain, **Sweden**, **Switzerland**, UK, USA, **Ukraine**

Australia, Austria, Belgium, Brazil, Canada, China, **Czech_Rep**, France. Germany, **Indonesia**, Italy, Japan, Mexico, Netherlands, **Poland**, Portugal, Russia, South_Korea, Spain, **Thailand**, **UAE**, UK, USA

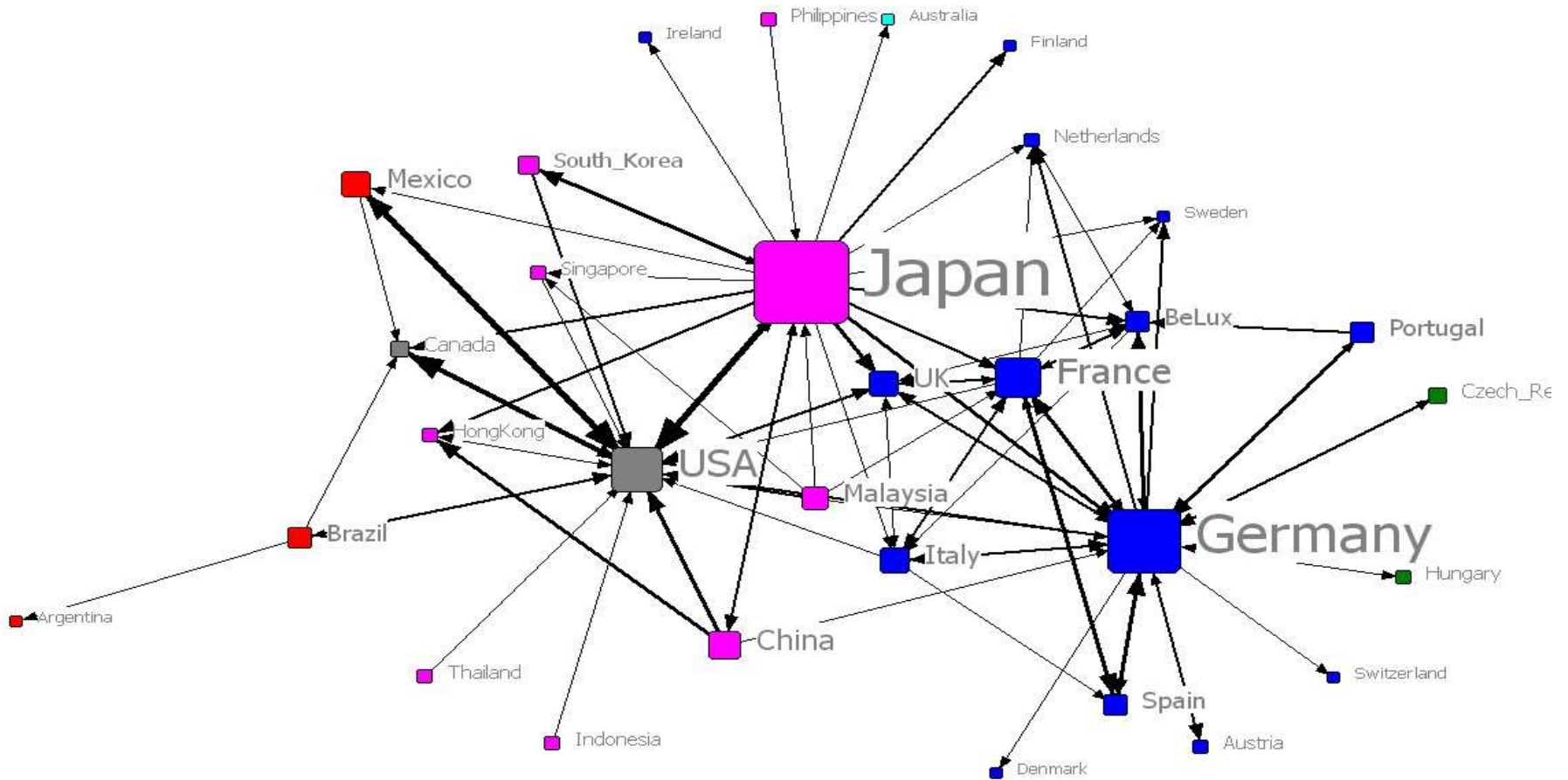
Argentina, Australia, Austria, BeLux, Belarus, Brazil, Canada, China, Czech_Rep, France, Germany, Hungary, Indonesia, Italy, Japan, Mexico, Netherlands, Poland, Portugal, Russia, Slovenia, South_Korea, Spain, Sweden, Turkey, UK, USA

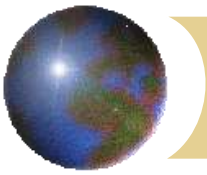
Argentina, Australia, Austria, Belarus, Belgium, Belarus, Belgium, Brazil, Canada,China, Czech_Rep, **Finland**, France, Germany, Hungary, **India**, Indonesia, Italy, Japan, Mexico, Netherlands, Poland, Portugal, **Romania**, Russia, **Slovakia**, Slovenia, **South_Africa**, South_Korea, Spain, Sweden,**Thailand**, Turkey, UK, USA, **Ukraine**

	Electrical & electric parts 1998	Electrical & electric parts 2008	Rubber & metal parts 1998	Rubber & metal parts 2008	Engines & parts 1998	Engines & parts 2008
Avg N_OutDegree (min-max)	9.78 (0.00-56.67)	8.33 (0.00-56.25)	11.25 (0.00-47.62)	8.7 (0.00-36.36)	9.04 (0.00-38.46)	8.29 (0.00-48.48)
Avg_OutStrngth (Std. Dev) (min-max)	5.06 7.60 (0-34)	4.42 7.57 (0-32)	3.59 4.33 (0-14)	2.52 2.68 (0-9)	5.30 6.23 (0-23)	5.35 6.80 (0-31)
Reciprocity	0.38	0.26	0.37	0.22	0.20	0.18
OutCentralization	48.44%	49.41%	38.09%	28.93%	30.18%	41.41%
Core-periphery (C-P) (Final fitness)	C 1.12 0.18 P 0.18 0.01 (0.58)	C 1.90 0.40 P 0.22 0.03 (0.68)	C 1.40 0.29 P 0.19 0.04 (0.55)	C 0.77 0.16 P 0.16 0.01 (0.52)	C 1.57 0.25 P 0.23 0.09 (0.47)	C 0.81 0.17 P 0.11 0.05 (0.40)
Core	Japan, Mexico, USA, Germany, Italy, BeLux, Canada, Uk, France	Japan, Mexico, USA, Germany, China,	Japan, France, Germany, USA, Canada	Japan, France, Germany, USA, Canada, China	USA, Japan, Mexico, Germany, Canada, Spain	USA, Japan, Mexico, Germany, Canada, France, UK, Austria, Hungary, Poland, Turkey
Inter-regional trade (Expected value)	0.30 (0.43)	0.086 (0.56)	-0.21 (0.45)	0.22 (0.60)	0.13 (0.60)	0.09 (0.61)



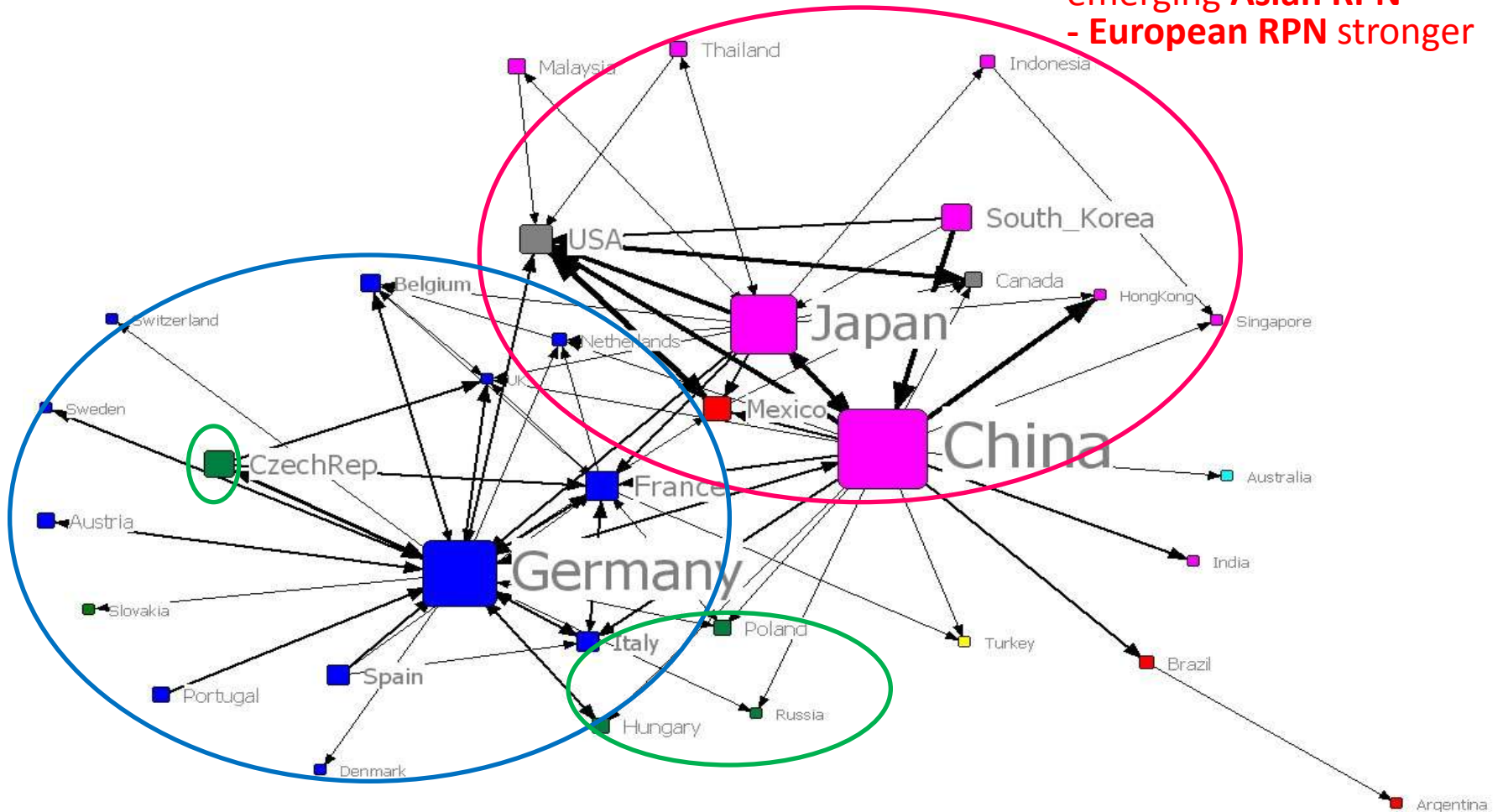
Electrical Parts 1998

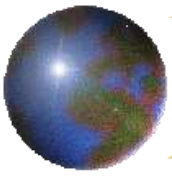




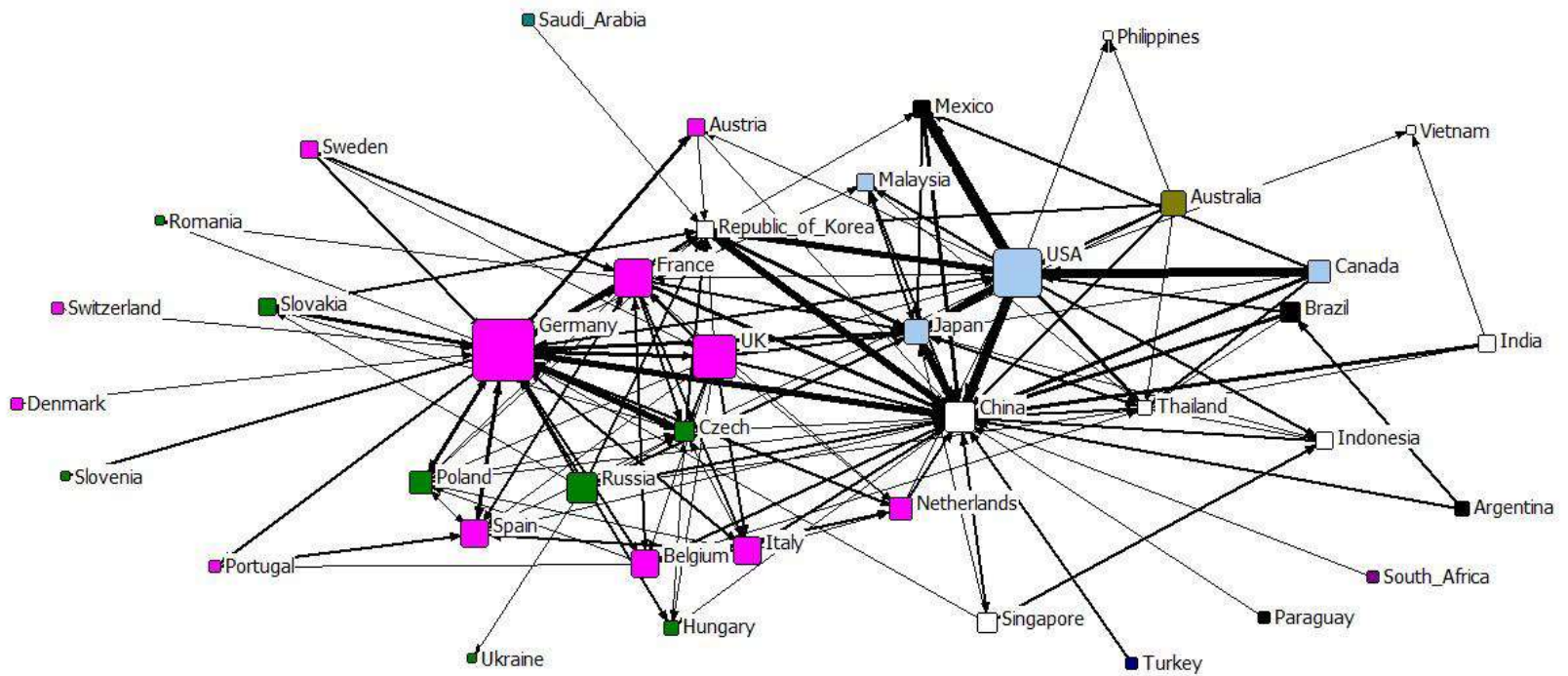
Electrical Parts 2008

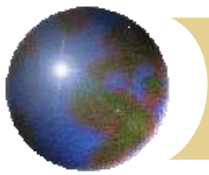
-China new major world producer within an emerging Asian RPN
- European RPN stronger



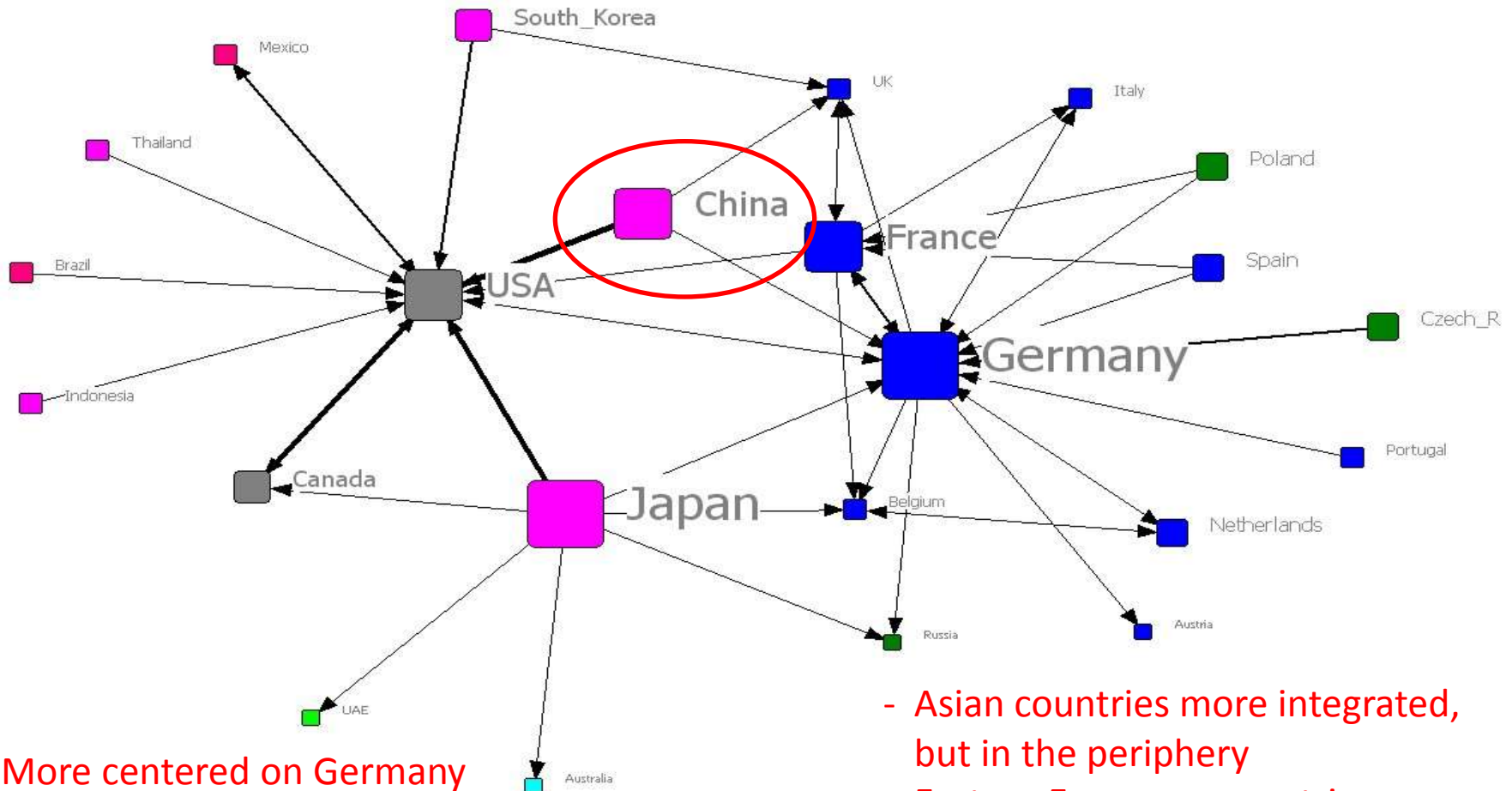


Electrical parts 2013



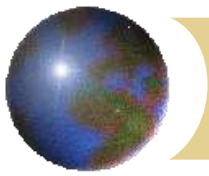


Rubber and Metal parts 2008

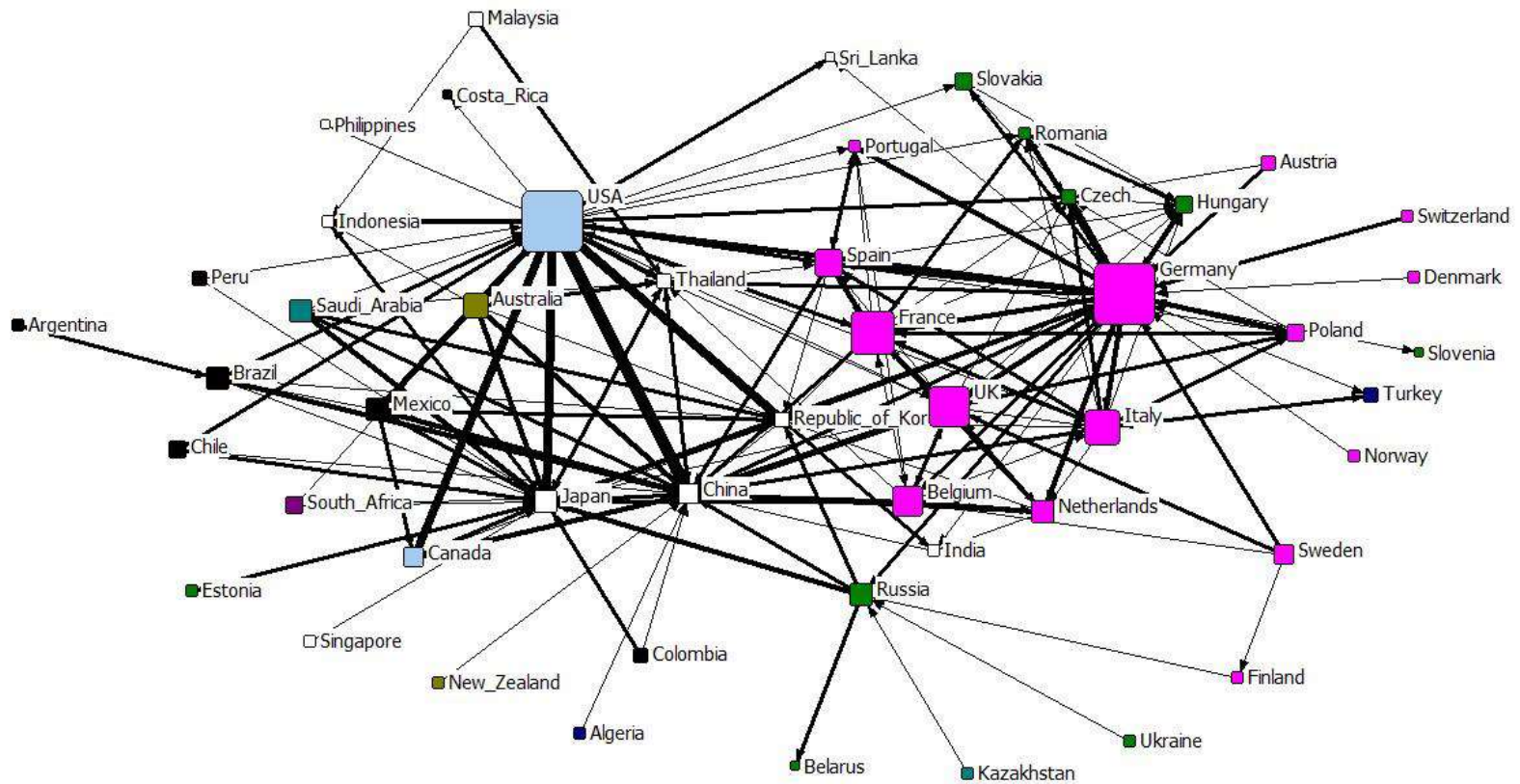


- More centered on Germany
- Higher weight of China, but no RPN in Asia

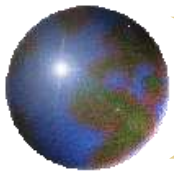
- Asian countries more integrated, but in the periphery
- Eastern European countries more integrated, but in the periphery



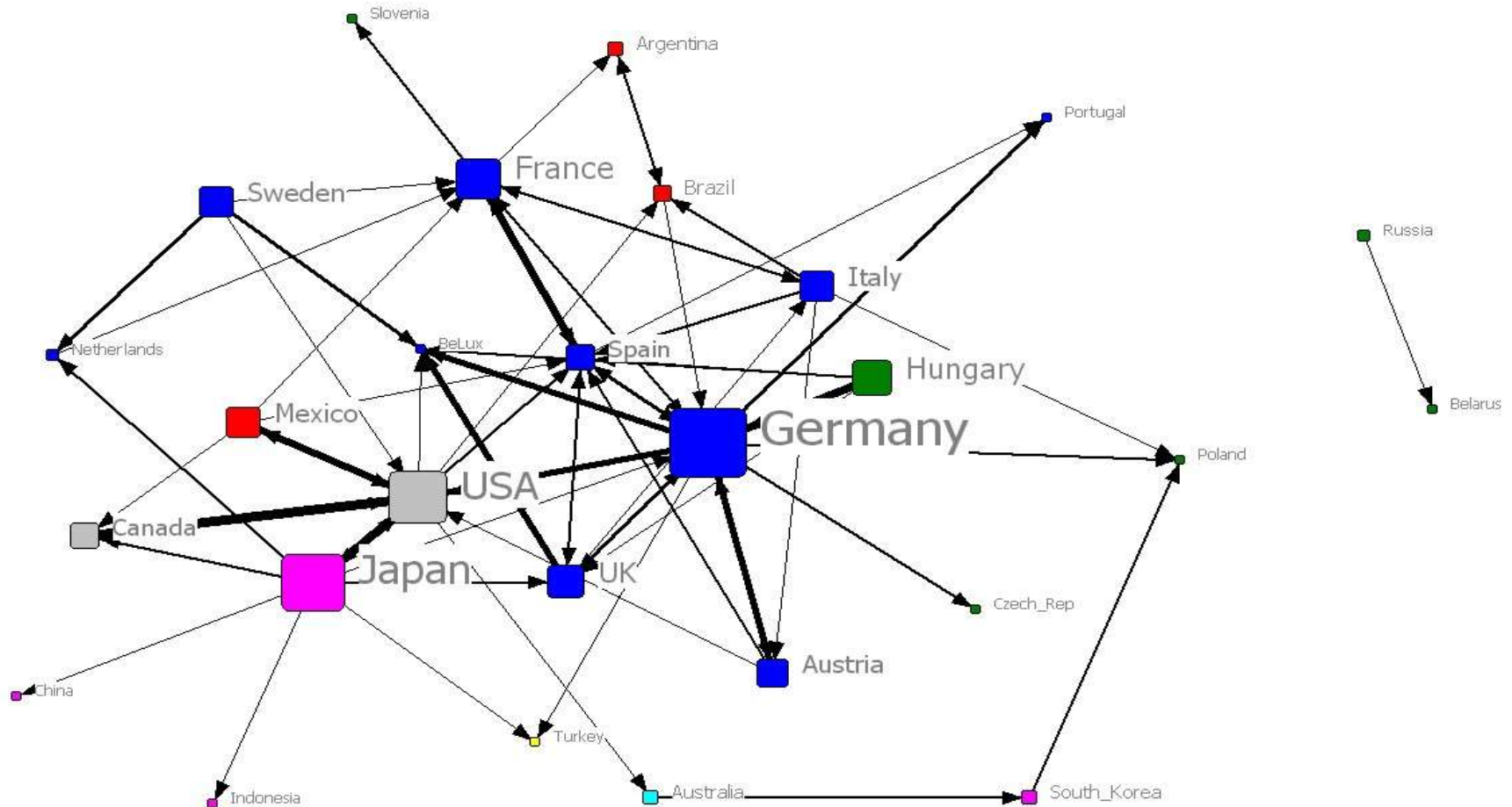
Rubber & Metal 2013



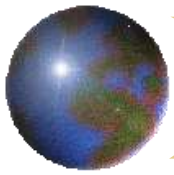
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Engines 1998

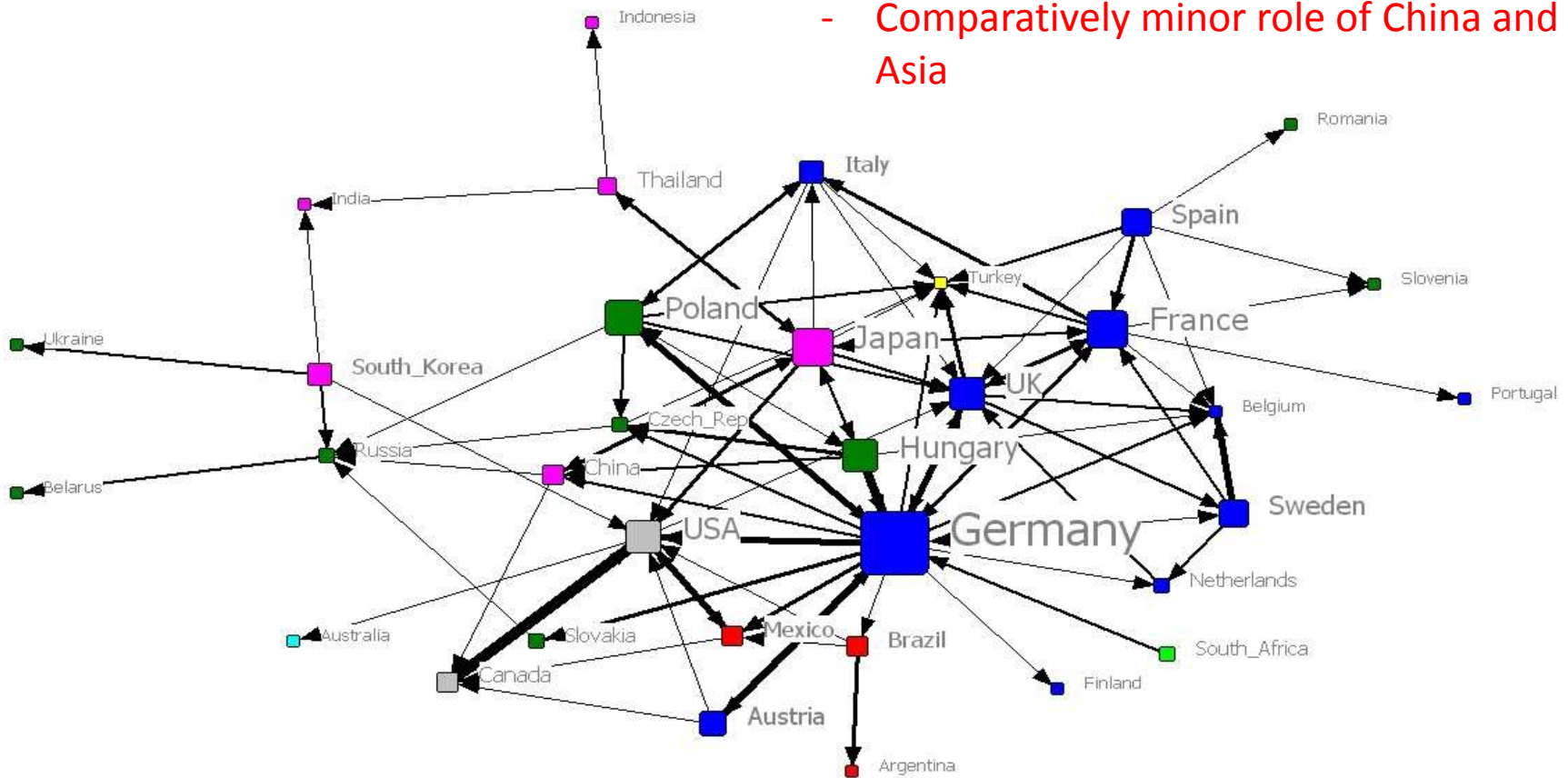


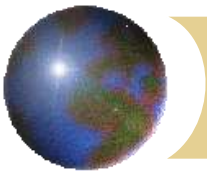
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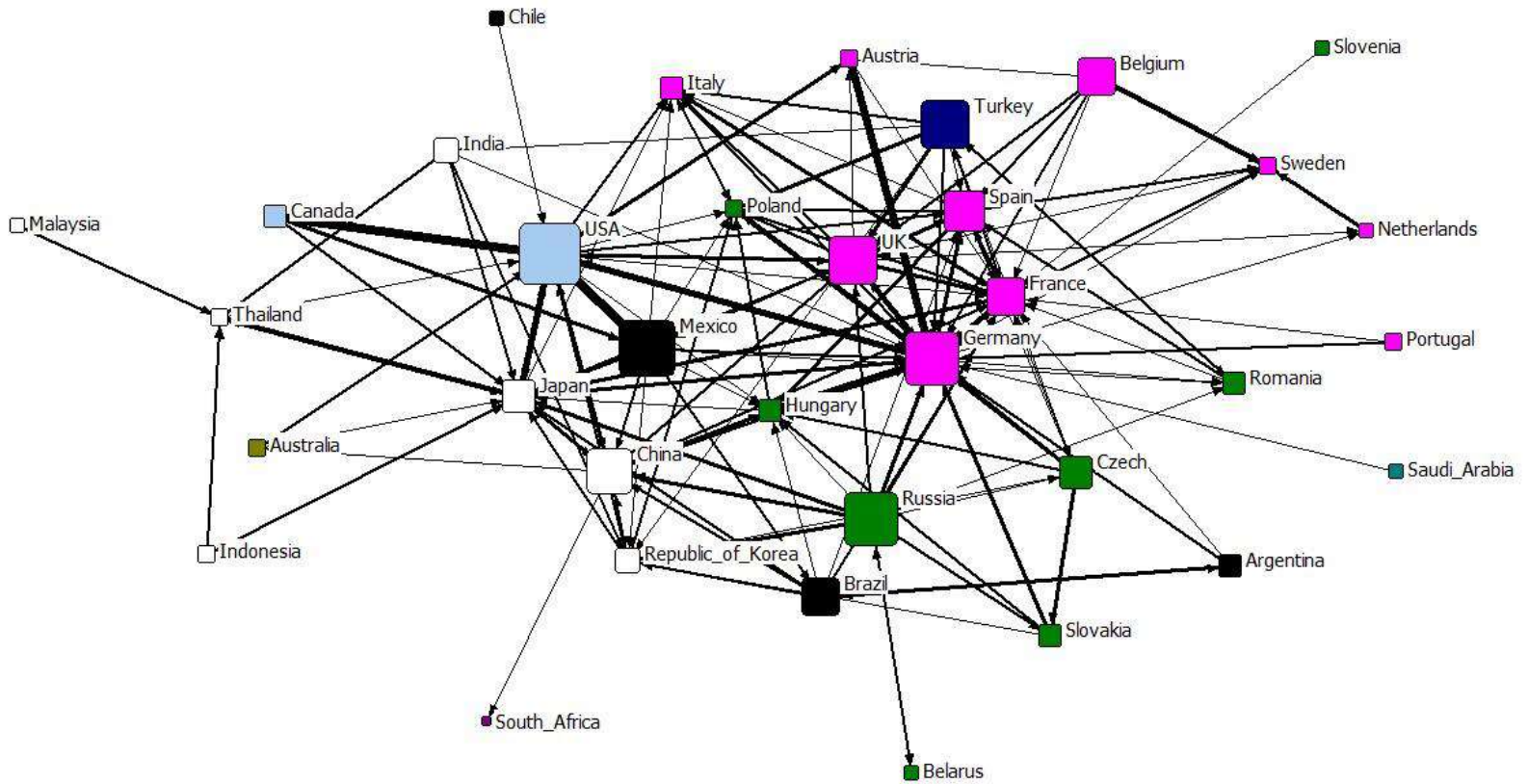
Engines 2008

- Truly globalized network, all regional groupings heavily intertwined
- Comparatively minor role of China and Asia

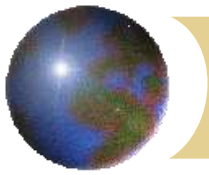




Engines 2013

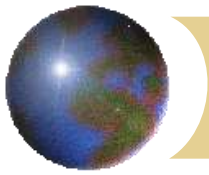


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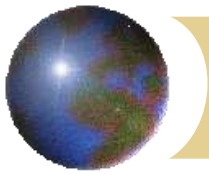
Brokerage roles

- ✦ Refers to roles each country plays in linking various regional groupings
- ✦ This was computed on binary data
- ✦ For each of the instances where a country is a “broker”, five different brokerage roles can be distinguished



Brokerage roles

Brokerage roles	Definition	Economic interpretation
Coordinator	A country that imports from countries belonging to its own region, and exports to other countries belonging to the same region Example (coordinator in bold): Thailand → China → Japan	Coordinators link different countries within the same region, therefore tightening the regional production network they belong to (in the example, China is a part supplier to Japan, and at the same time offshores the production of some components to Thailand)
Gatekeeper	A country that imports from a country belonging to a different region and exports to countries within its own region Example (gatekeeper in bold): Czech Republic → Germany → UK	Gatekeepers act as suppliers of imported parts to countries belonging to their own region (in the example, Germany offshores some production of components to Eastern and Central Europe and supplies all other European countries)
Representative	A country that imports from countries within its own region and exports to countries outside the region Example (representative in bold): Japan → China → Germany	Representatives act as exporters of parts produced within their own production network and destined to countries external to that network (in the example, China processes a number of parts due to offshoring practices by Japanese producers, and then exports to European markets)
Consultant	A country that imports from and exports to countries belonging to the same region, but different from its own Example (consultant in bold): Germany → China → UK	Consultants acts as external players to a production network, linking countries belonging to that production network from the outside (in the example, China imports parts from German producers to be assembled in China for the domestic market and at the same time supplies parts to the UK)
Liaison	A country that imports from and exports to countries belonging to other regions Example (liaison in bold): Turkey → China → Germany	Liaisons link countries belonging to different regional production networks by acting as both importers and exporters of parts (in the example,

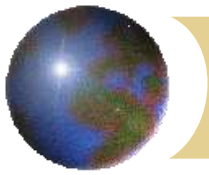


Thailand → China → Japan

Czech Republic → Germany → UK

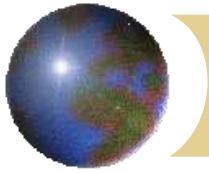
	Coordinator		Gatekeeper		Representative		Consultant		Liason	
	1998	2008	1998	2008	1998	2008	1998	2008	1998	2008
Electrical & electric parts										
Germany	52	49 ↓	58	43 ↓	18	55 ↑	2	12 ↑	10	12
France	13	8 ↓	7	9	2	7	0	1	0	4
USA	0	0	11	4	6	2	11	0 ↓	51	7 ↓
Japan	12	15 ↑	3	0	46	22	0	0	8	0
China	0	5 ↑	0	4 ↑	0	20 ↑	0	0 ↓	0	4 ↑
Miscellaneous parts										
France	6	4	0	0	2	0	0	0	0	0
Germany	30	25	18	28	23	40	1	12	1	6
UK	2	1	2	1	3	0	0	0	0	0
USA	0	0	4	4	3	1	0	0	9	2
Japan	0	2	0	0	0	2	0	0	2	0
China	0	1	0	1	0	0	0	0	0	0
Rubber & metal parts										
Germany	26	22	24	27	3	9	0	2	0	4
France	7	6	0	3	2	2	0	0	0	1
USA	0	0	7	8	3	2	3	1	14	12
Japan	0	0	1	0	0	0	0	0	3	0
Engines & parts										
Germany	13	16	13	24	15	32	2	2	8	24
Spain	10	0	7	0	0	0	0	0	0	0
UK	3	11	3	9	0	1	0	0	0	1
France	9	10	2	2	10	7	1	0	1	1
USA	0	0	3	5	5	3	2	1	19	14
Japan	0	2	2	0	0	1	0	1	5	3
China	0	0	0	1	0	2	0	1	0	3

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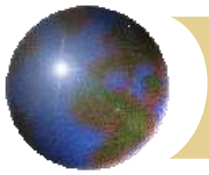
Summary of main results

- ❖ Our analysis shows that **China** and a number of other emerging countries have not simply increased their weight as suppliers to the world's leading auto manufacturers, but **have caused a switch in the international organisation of production**
- ❖ **The world's leading producers now act as the core of a more hierarchical production structure than a decade ago**
- ❖ Among the two contrasting tendencies towards globalisation or **regionalisation of production, the latter seems to be still dominating in the auto industry**



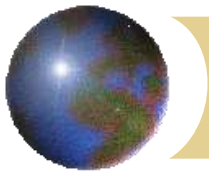
Thank you for your attention
Questions?

s.gorgoni@greenwich.ac.uk



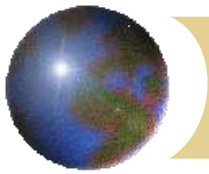
Measures

- ✚ Network size
- ✚ Avg_N_Out-Degree & Avg_Out-Strength
- ✚ Reciprocity
- ✚ Out-Centralisation
- ✚ Core-Periphery
- ✚ Globalisation Index
- ✚ Brokerage



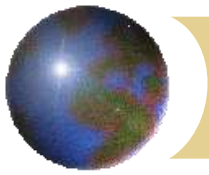
Network size

- ✦ It's the **number of nodes**
- ✦ Size is critical for the structure of a network because of the **limited resources** that each actor has in building and maintaining ties
- ✦ Think of a group of **12 students** in a seminar, it would not be hard for all the students to get to know each other and develop exchange relationships (e.g. exchange notes)
- ✦ It would be much harder for students in a lecture of **300** students to establish relationships with all other students. It would be virtually impossible for there to be a single network for the exchange of reading notes.



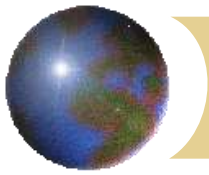
Network size

- ✦ In any network there are $(K \cdot K - 1)$ unique ordered pairs of actors (that is AB is different from BA, and leaving aside self-ties), where K is the number of actors.
- ✦ In a network of 10 actors, there are $10 \times 9 = 90$ logically possible relationships
- ✦ If we had undirected, or symmetric, ties the number would be $90/2 = 45$, since the relationship AB would be the same as BA
- ✦ The number of logically possible relationships grows exponentially as the number of actors increases linearly
- ✦ It follows that the range of logically possible (social) structures (defined as 'complexity') increases exponentially with size



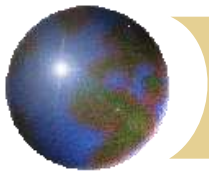
Out-Degree and Out-Strength

- ✦ The number of actors in a network places an upper limit on the connections each individual can have ($K-1$). For most networks, few, if any, actors approach this limit
- ✦ **Degree:** number of connections (trade partners) each individual has
- ✦ Where data are asymmetric, we can distinguish between ties being sent and ties being received
- ✦ **Out-degree:** sum of connections from an actor to others (exports)
- ✦ **Strength:** If we were examining a valued relation instead of a binary, the values of the relations reflect the strength of a tie between nodes. In our case this is the value of trade flow
- ✦ **Out-Strength:** is the sum of outward connections each actor has, weighted by their value. This is the value of exports flows



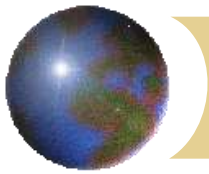
Normalised Out-Degree and Out-Strength

- ✦ **Normalised out-degree:** is the out-degree of each actor expressed as a proportion of the number of elements in the row. This tells us to how many(%) of the remaining actors an actor exports. This allows to make comparisons across networks of different size
- ✦ **Avg_N_Out-Degree:** Is the average of the above. It gives an indication of to how many of the remaining actors, actors in a network export on average
- ✦ **Avg_Out-Strength:** It tells us how much in value actors tend to export on average



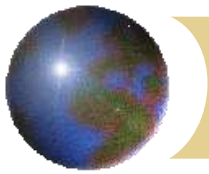
Reciprocity

- ✦ With symmetric data, two actors are either connected or not.
- ✦ With directed data, there are four possible relations:
 - $A \rightarrow B$ and $A \leftarrow B$
 - $A \rightarrow B$ but $A \not\leftarrow B$
 - $B \rightarrow A$ but $B \not\leftarrow A$
 - No connection
- ✦ It is interesting to see to what extent ties in a network are reciprocated
- ✦ A network that has a predominance of null or reciprocated ties is thought to be more equal and stable than one with a predominance of asymmetric connections (which might be more of a hierarchy)
- ✦ We calculate the ratio of the number of pairs with a reciprocated tie relative to the number of pairs with any tie. Of the two methods to calculate reciprocity this is the best in large networks where most actors have no direct ties to most other actors (Dyad method)



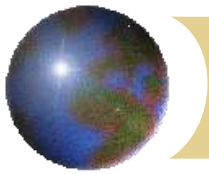
Out-centralisation

- ✦ It is a measure of variability or dispersion
- ✦ It tells whether ties (exports) are evenly distributed among actors (countries) or whether there are only a few actors (countries) accounting for total ties (world exports)
- ✦ The larger it is, the more likely it is that a single actor is more central. Thus, it measures how heterogeneous the actor centralities are
- ✦ Calculated as the the sum of the difference b/w the max centrality index in a network and the other observed centralities, divided by the theoretical maximum possible sum of differences in actor centrality. $C = \frac{\sum(\max c_i - c_i)}{\max \sum(\max c_i - c_i)}$ *
- ✦ Between 0 and 1 (if one actor completely dominates). Allows comparisons across networks



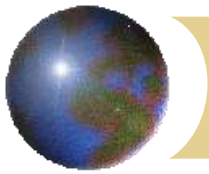
Core-periphery

- ⊕ Allows detection of a hierarchical structure within the network, with a cohesive core tied to hangers-on in the periphery
- ⊕ the model seeks to identify a set of actors who have high density of ties among themselves (the core), and another set of actors who have very low density of ties among themselves
- ⊕ To perform the core-periphery analysis we use the categorical procedure on valued data using the CORR algorithm and 5000 iterations (Borgatti and Everett, 1999).



Globalisation Index

- ✦ Given a partition of a network into a number of mutually exclusive regional groups, we calculate the E-I Index
- ✦ $E-I \text{ Index} = \frac{\text{number of in-between groups ties} - \text{number of within groups ties}}{\text{total number of ties}}$
- ✦ Computed on valued directed data, using 10000 permutations
- ✦ Range from 1 to -1. Negative scores indicate $I > E$, suggesting high regionalisation



Measures

⊕ Core- Periphery

Allows detection of a hierarchical structure within the network, with a cohesive core tied to hangers-on in the periphery. The model seeks to identify a set of actors who have high density of ties among themselves (the core), and another set of actors who have very low density of ties among themselves and are weakly tied to the core

⊕ Inter-regional trade Index

Given a partition of a network into a number of mutually exclusive regional groups, the E-I Index is equal to number of in-between groups ties minus the number of within groups ties divided by the total number of ties. Ranges from 1 to -1. Negative scores indicate $I > E$, suggesting high regionalisation