Networks of inter-industry labor mobility

Sergio De Raco[1,2] and Viktoriya Semeshenko[1,2,3]

1. Universidad de Buenos Aires, Argentina
2. Instituto Interdisciplinario de Economía Política, Argentina
3. CONICET, Argentina

III Taller Interdisciplinario en Sistemas Complejos

5 y 6 de diciembre de 2019, CABA, Argentina

IIEP-BAIRES / FCE-UBA / GIDE-UDELAR

Plan

- Motivation
- Starting point and research questions
- Data and methods
- Results
  - Argentina
  - Partial comparison: Argentina vs. Germany (work in progress)
- Work ahead

Motivation

- Job switchers evidence the mix of capabilities needed by productive activities
- Employment flows between industries shape production system structure

Starting point and research questions

SP: Employment flows *between firms of different industries* carry information about:

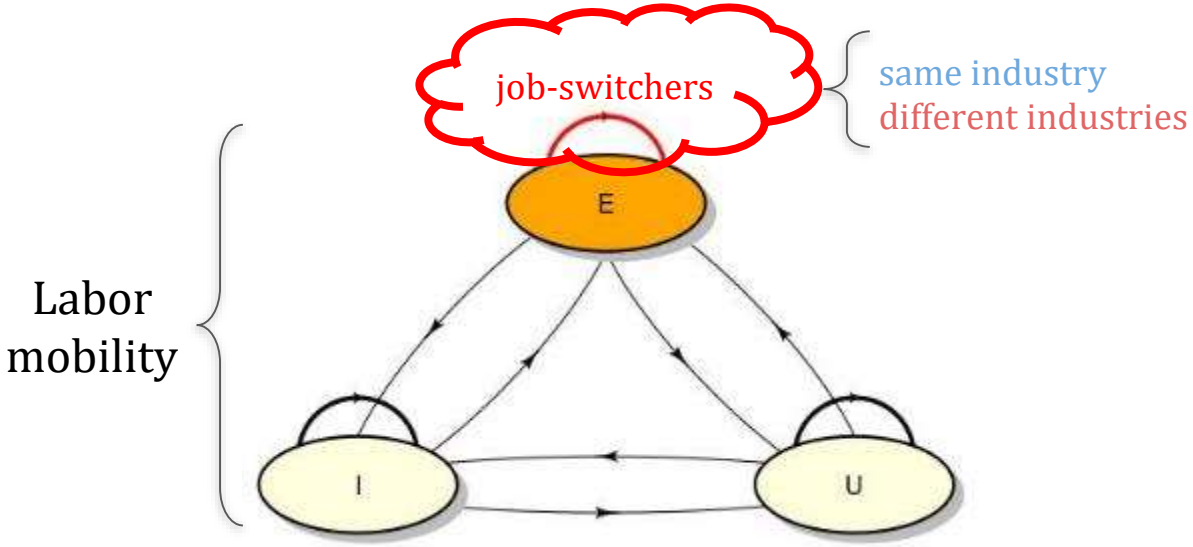
- **capabilities and knowledge exchange** between industries
- local **productive structure**

RQ1: What kind of structure can we find in (formal) inter-industry employment flows?

RQ2: How informative is the industry space derived?

Data and methods

- Data: administrative records (SIPA)
- Methods:
  - Skill-relatedness indicator (Neffke *et al.* 2017)
  - Network analysis



Nodes

t \	I	II	III
t+1			
I			
II			
III			

Edges

employment transition / adjacency matrix

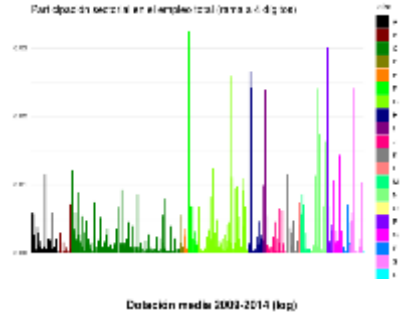
Labor flow networks

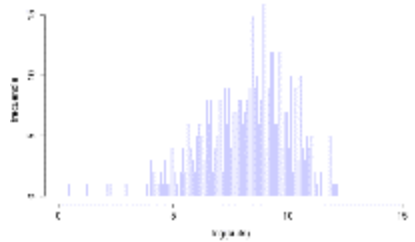
1. **Flow networks**: formal employment job-switching data

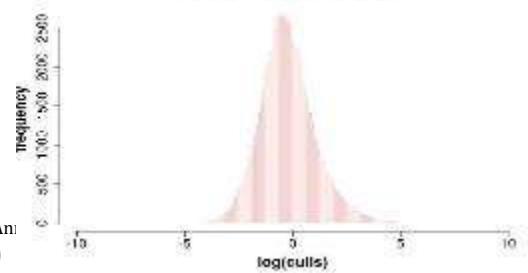
2. **SR networks**: skill-relatedness indicator

Inter-industry employment flows

Workers (thousands)	Germany (*) 1999-2008	Argentina (**) 2009-2014
	NACE Rev 1.1	ISIC Rev 4
	5-digits	4-digits
Stock:		
Employment	19,897.1	5,619.1
Absolute flows:		
Job Switchers	1,206.7	412.1
No Industry Switch	321.1	206.1
Industry Switch	885.7	206.0
Different Sector	519.8	119.4
Same Sector	365.9	86.6
Same 2-Digit Industry	225.9	37.1
Same 3-Digit Industry	117.3	14.6
Same 4-Digit Industry	62.3	n.a.
Relative flows (w.r.t. total average employment):		
Job Switchers	6.1%	7.3%
No Industry Switch	26.6%	50.0%
Industry Switch	73.4%	50.0%
Different Sector	58.7%	58.0%
Same Sector	41.3%	42.0%
Same 2-Digit Industry	25.5%	18.0%
Same 3-Digit Industry	13.2%	7.1%
Same 4-Digit Industry	7.0%	n.a.







Nodes (attrib.)

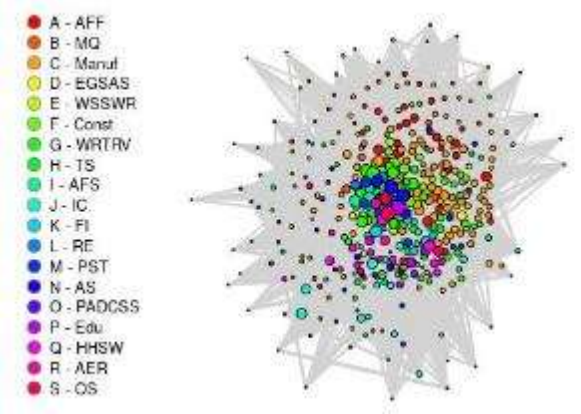
Edges (attrib.)

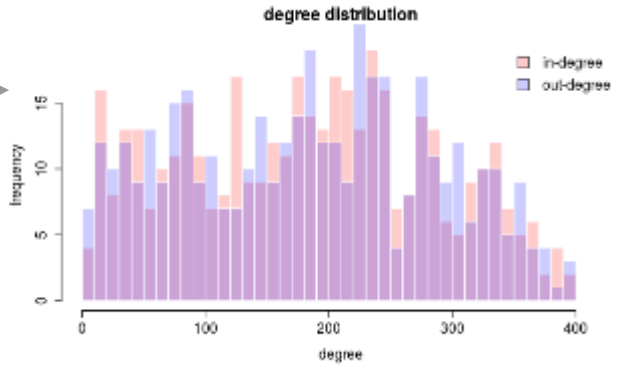
(*) Neffke, Frank; Otto, An
(**) MTEySS-OIT (2018)

1. Flow network

Directed graph	
Nodes (order)	416
Edges (size)	76,544
Weights	206,028
Cohesion	
Density	0.4434
Reciprocity	0.7983
Transitivity (global)	0.7404
Node centrality	
Average total degree (*)	368
Connectivity	
Diameter	3
Average shortest path	1.5577
Components	1

(*) Maximum ATD : undirected= N, directed = 2N

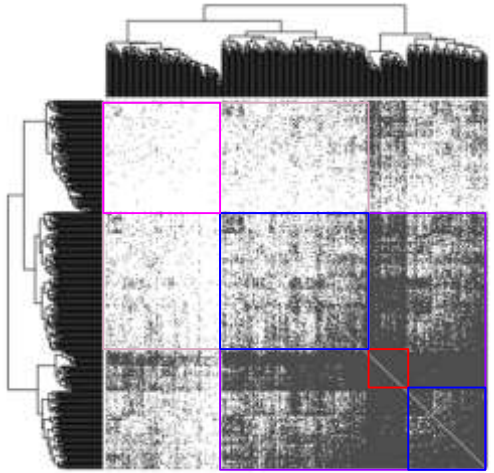


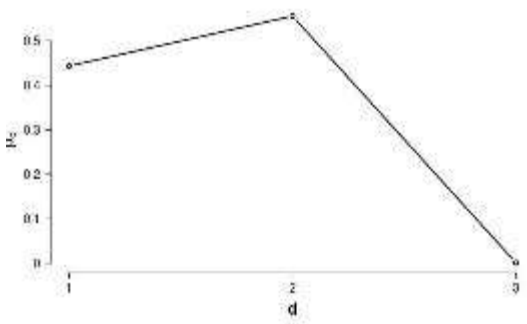


1. Flow network [cont.]

Properties

- Core-periphery structure
  - Core: subset of high degree nodes, highly interconnected
  - Periphery: subset of low degree nodes, connected (almost only) with core nodes
- Small world (Watts-Strogatz)
  - High clustering coefficient (transitivity)
  - Short average paths





Methodological note: Skill-Relatedness indicator (SR)

- Mobility costs associated with specificities (i.e.: firm, industry, task) in worker's capabilities
- Neffke *et al.* (2017): Labor flows show *degree* to which human capital moves between industries
- **SR**: Similar to an χ^2 independence test in contingency tables (observed / expected ratio)
- **Expected**: a random benchmark (proportional to row and column totals)

Observed inter-industry flows matrix

f_{11}	f_{12}	...	f_{1n}	$F_{1.}$
f_{21}	f_{22}	...	f_{2n}	$F_{2.}$
...	...	...	...	...
f_{n1}	f_{n2}	...	f_{nn}	$F_{n.}$
$F_{.1}$	$F_{.2}$	...	$F_{.n}$	$F_{..}$

Expected value in cell

$$f^{e}_{ij} = \frac{F_{i.} * F_{.2}}{F_{..}}$$

SR value in cell

$$R_{ij} = \frac{f_{ij} * F_{..}}{F_{i.} * F_{.2}}$$

Adjusted SR value in cell

$$R^{a}_{IJ} = \frac{R_{ij} - 1}{R_{ij} + 1}$$

2. SR networks - AR and DE

Grand division	Description	Abbrev	Argentina ISIC Rev4, 4d			Germany NACE Rev2, 4d		
			Employment		Sector	Employment		Sector
			#	%	#	#	%	#
A	Agriculture, forestry and fishing	AFF	319,233	5.7	34	229,394	0.8	30
B	Mining and quarrying	MQ	79,511	1.4	15	85,754	0.3	14
C	Manufacturing	Manuf	1,162,085	20.8	134	6,446,209	23.0	230
D	Electricity, gas, steam and air conditioning supply	EGSAS	45,465	0.8	4	236,283	0.8	8
E	Water supply; sewerage, waste management and remediation activities	WSSWR	39,997	0.7	6	225,906	0.8	9
F	Construction	Const	378,701	6.8	13	1,640,705	5.9	22
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	WRTRV	1,033,359	18.5	62	4,083,799	14.6	91
H	Transportation and storage	TS	401,544	7.2	19	1,467,801	5.2	22
I	Accommodation and food service activities	AFS	220,460	3.9	4	873,633	3.1	8
J	Information and communication	IC	177,059	3.2	24	862,878	3.1	26
K	Financial and insurance activities	FI	173,152	3.1	15	1,000,463	3.6	18
L	Real estate activities	RE	64,594	1.2	2	217,893	0.8	4
M	Professional, scientific and technical activities	PST	177,160	3.2	13	1,707,804	6.1	19
N	Administrative and support service activities	AS	462,142	8.3	20	1,148,587	4.1	30
O	Public administration and defence; compulsory social security	PADCSS	1,800	0.0	1	1,685,782	6.0	9
P	Education	Edu	266,215	4.8	8	1,104,130	3.9	11
Q	Human health and social work activities	HHSW	224,485	4.0	12	3,985,586	14.2	12
R	Arts, entertainment and recreation	AER	79,367	1.4	8	240,827	0.9	15
S	Other service activities	OS	290,017	5.2	16	806,438	2.9	19
T	Activities of Households as Employers; Undifferentiate Goods and Services Producing Activities of Households for Own Use	HUGP						
U	Activities of Extraterritorial Organisations and Bodies	EO						
	Total		**5,596,346**	**100.0**	**410**	**28,049,872**	**100.0**	**597**

2. SR networks - AR and DE [cont.]

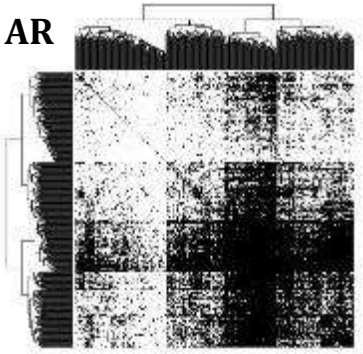
Metric	Argentina		Germany	
	Original SR	Industry Space	Original SR	Industry Space
Order	410	410	597	597
Size	75,938	1,639	203,099	2,387
Density	0.453	0.020	0.571	0.013
Reciprocity	0.799	1.000	0.832	1.000
Transitivity	0.742	0.185	0.798	0.224
Diameter	3	8	3	9
Avg. Path Length	1.550	3.554	1.431	3.955
Avg. total degree	370	8	680	8

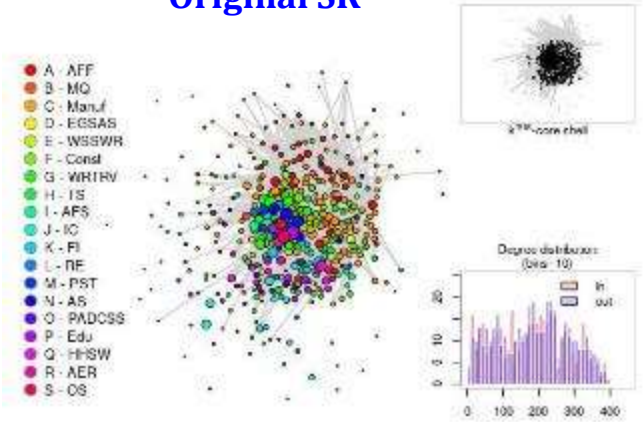
Sources:
* AR: SIPA, own construction.
* DE: Neffke, Frank; Otto, Anne; Weyh, Antje (2017), own construction.

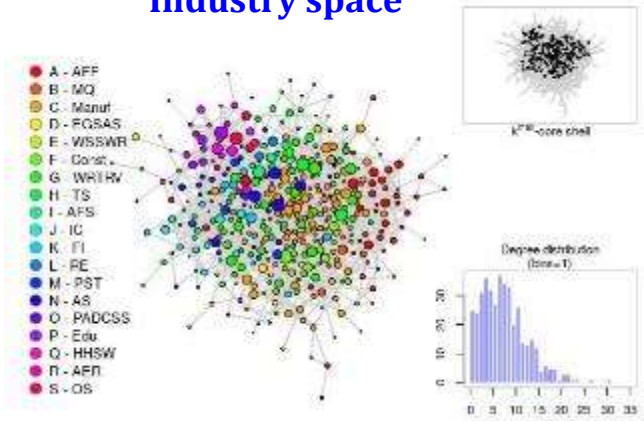
2. SR networks - AR and DE [cont.]

Heatmap **Original SR** **Industry space**

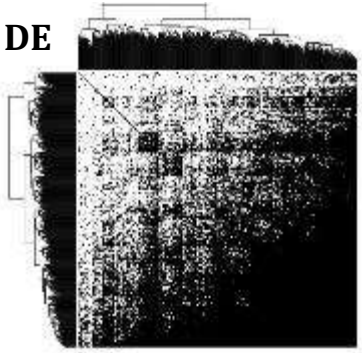
AR

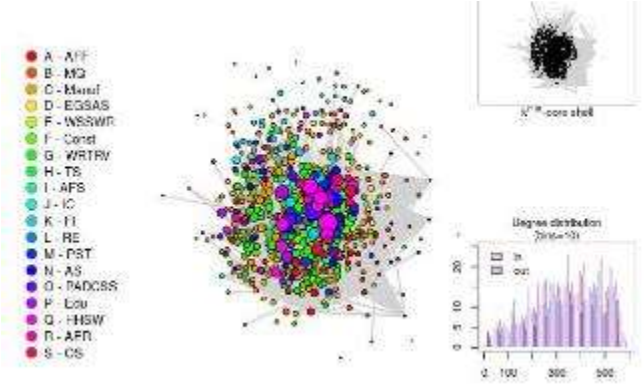


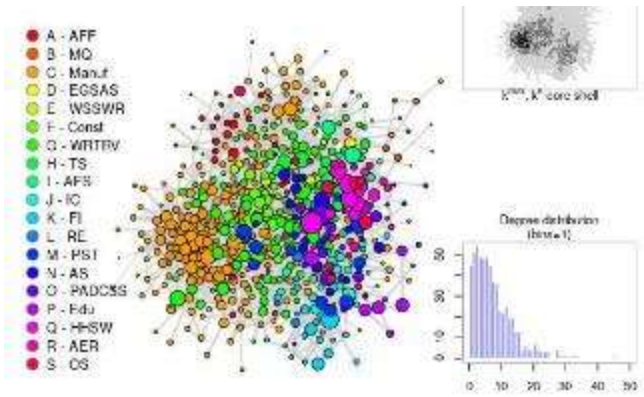




DE







2. SR networks: Industry Space

Argentina

k-core	Employment		Sectors		Degree			
	#	%	#	%	Min	Max	Avg	SDev
1	28,620	0.5	28	6.8	1	2	1	0.31
2	76,385	1.4	31	7.6	2	4	2	0.62
3	164,689	2.9	36	8.8	3	5	3	0.55
4	470,714	8.4	62	15.1	4	9	5	1.30
5	776,840	13.9	62	15.1	5	12	7	1.48
6	4,079,098	72.9	191	46.6	6	31	12	4.29
Total	**5,596,346**	**100.0**	**410**	**100.0**				

Germany

k-core	Employment		Sectors		Degree			
	#	%	#	%	Min	Max	Avg	SDev
1	244,069	0.9	47	7.9	1	2	1	0.20
2	523,642	1.9	61	10.2	2	3	2	0.40
3	1,230,904	4.4	69	11.6	3	7	4	1.00
4	4,026,870	14.4	97	16.3	4	11	6	1.69
5	9,731,103	34.7	121	20.3	5	18	8	3.05
6	8,951,832	31.9	145	24.3	6	34	12	4.98
7	436,633	1.6	11	1.8	8	19	11	3.04
8	1,033,986	3.7	18	3.0	9	29	16	5.45
9	1,870,833	6.7	28	4.7	12	46	22	7.26
Total	**28,049,872**	**100.0**	**597**	**100.0**				

k-coreness

- AR: large heterogeneous max-core capturing 3/4 of total employment
- DE: more stratified, highly connected small max-core concentrated in manufacturing activities

Conclusions

- Inter-industrial flow network
  - Relevant structure caused by more disaggregated activities granularity
  - Dense and connected network
    - Unique giant component
    - Small world property, core-periphery structure
- SR networks
  - Dense and core-periphery structure
  - Similar distribution of short path lengths, reciprocity and transitivity
- Industry spaces comparison
  - Manufacturing and related activities inside more connected core
  - Deeper coreness structure in DE
  - Contrast in the sectoral composition of the core and periphery subsets

Work ahead

- Economic interpretation of results
  - Sectoral relations through SR and productive structure (local structure)
  - Clustering, communities, core-periphery, k-coreness (meso structure)
- Analysis of temporal networks (evolution and dynamics)
  - Stability and clustering analysis
  - SIPA: longitudinal sample and universe data
  - EPH: analysis of activities and occupations in the open system and linking with SIPA
- Comparative studies in progress
  - DE: ongoing (SR data)
  - UY: ongoing cooperation, UDELAR, PhD student (administrative data)
  - CL: cooperation in view (administrative data)
  - Potential collaboration with authors of similar studies (SE, FI, MX, BR)

Thank you!