The Analysis of Student Mobility Flows in Higher Education. a Multimode Network Perspective

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Outline

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Background and Motivation

Italian university student mobility is worth to be investigated due to the peculiar characteristics of the Italian university system as quasi-market system.
Students could:

- use mobility at university level as an individual "social elevator" to promote their own social mobility
- move from their province of residence to find degrees in specific topics not available nearby
- move to enroll at Universities perceived as higher quality
- move to find context with better quality of life and/or with better job opportunities

The university student mobility flows follow the traditional *South-to-North* migration chain

Few figures

- **2006-2007**: Total Number of Freshmen: 300577

  Resident in Southern Italy: 127677 (42%)

Macro-area of Destination				
Center	**North-East**	**North-West**	**South**	**Total**
14471	4551	4597	104058	127677
11,33%	*3,56%*	*3,60%*	*81,50%*	

- **2016-2017**: Total Number of Freshmen: 285068

  Resident in Southern Italy: 107874 (38%)

Macro-area of Destination				
Center	**North-East**	**North-west**	**Sud**	**Totale**
12582	5477	7878	81937	107874
11,66%	*5,08%*	*7,30%*	*75,96%*	

Santelli, Scolorato, Ragozini, 2019

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Effects of University mobility

Nowadays around 25% of students living in Southern Italy enroll in Universities located in Center or North of Italy (ranging from 14% from Campania to 34% from Apulia).
Student mobility yields a lot of negative effects:

- Imbalance in government funding to universities
- Imbalance in funding given by fees with 2.5 euro billions per year transferred from Southern families to Northern economy (Viesti, 2016)
- Relevant brain drain of high educated and welt young people
- Demographic imbalance

All these effects deepen the never-solved North-South divide.
The analysis of this phenomenon could help local and academic policy makers in promoting interventions to contrast student migration.

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Aims

- Exploring the structural patterns of the university student mobility
  - focusing on North-South student migration route
  - discovering the more attractive destinations in the higher education migration phenomenon

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The Italian Student Registry Office –ANS

- The National Student Registry Office (ANS) is an administrative archive in which students enrolled in the Italian university system are registered.
- Through this portal, the Ministry of Education, University and Research (MIUR) offers the opportunity to consult in an aggregate form the archive and therefore information on enrollments and student careers of all registered universities (both public and private).
- Our data comes from the archive but have been directly downloaded with information at individual level in anonymized form

Data structure

- Traditional Data Matrix students-by-categorical variables (e.g., *sex, age, province of residence, type of secondary school, college grade, bachelor and master degree enrollment at university, type of bachelor and master degree, date of graduation, etc...*) $\rightarrow$ analyzed by Multidimensional Data Analysis (Multiple Correspondence Analysis and Multiple Factorial Analysis)
- From Traditional Data Matrix to Network Data:
  - A set of Affiliation Matrices with disaggregated units: *student-by-university enrollment* (Bachelor or master degree) or *student-by-type of educational program*
  - Weighted two-mode networks with aggregated units: *province of residence-by-university enrollment* or *province of residence-by-type of educational program* $\rightarrow$ students' flows represent the weights
  - Multimode network with different (three) modes $\rightarrow$ *province of residence-by-university of enrollment-by-type of educational program*
  - Multiplex network $\rightarrow$ *province of residence-by-university of enrollment, subject topics as layers*
  - Multilevel network $\rightarrow$ *province of residence-by-type of educational programs, Universities and Regions as possible levels*

How to analyze this complex network data structure?

In this work we try to use multimode approach presenting first results

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Tripartite networks and generalization to multimode data

- Tripartite graphs have three types of nodes and ties exist only between nodes of distinct types (Fararo, Doreian, 1984)
- With three or more modes adjustments are required to place the modes in the same adjacency space (Melamed et al., 2013).

Brief literature review

- Fararo and Doreian (1984) → extended Breiger's formalism to tripartite networks (for example, people are embedded in groups and groups in organizations) and generalized the conceptual basis and the matrix formalisms of bipartite graphs to tripartite networks
- Borgatti and Everett (1992) → showed how to extend regular and structural equivalence to multimode data
- Batagelj et al. (2007) → suggested a dissimilarity measure for 3-mode structural equivalence and applied Ward's algorithm to partition the data
- Melamed et al. (2013) → combined the logic of multimode networks developed in Fararo and Doreian (1984) with Newman's (2006) spectral partitioning of graphs into communities for discovering the community structure of multimode graphs
- Everett and Borgatti (in press) → examined the k(k-1)=2 collection of 2-mode networks between every pair of modes extending community detection algorithm to the case of multimode data

Multimode data structure

- The general tripartite network is represented by the matrix **M** and the tripartite graph associated with it suggest a generalization of the Breiger-Wilson formalism (Wilson, 1982) based on two formal axioms:
  - There are three types of nodes
  - Ties exist only between nodes of different types

The general **tripartite matrix** form ***M*** is given by:

	2 mode	*3 mode*
1 mode	***A***	***C***
2 mode	**0**	***D***

The matrix of paths of length 1 in tripartite networks (i.e., direct links) is (Fararo, Doreian, 1984):

$$Z = \begin{pmatrix} 0 & A & C \\ A^T & 0 & B \\ C^T & B^T & 0 \end{pmatrix}$$

The block off-diagonal matrix represents the **three-mode adjacency matrix** (Melamed et al., 2013).

The logic of this compilation can be extended to **any number of modes**.

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Cohort of students and characteristics

- Student data from the Bachelor degree enrollment year in 2011/2012 to the a.y. 2017/2018 focusing on university career changes of university or/and type of education program from the 1st to the 2nd enrollment year.

	%	
226871		residence in Italy or abroad
223908		residence in Italy
Enrollment		*from 1st to 2nd year*
191240	**85.4**	regular student 2nd year
32668	**14.6**	drop-out
Changes		
161939	**72.3**	stable student
14086	**6.3**	change university mainly in the same region
11982		change university and type of educational program
2104		change only university
27197	**12.1**	change type of educational program
15215		no change university
Career		
102047	**45.6**	Graduates within 2014
133481	59.6	Graduates within 2018
47200	21.1	drop-out
43227	19.3	still enrolled in 2018

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Steps of analysis

Assume a network of edges between three types of nodes
province of residence, *university of enrollment*, and *type of educational program*
Denote the matrix of *province of residence* and *university of enrollment* by **A**, the matrix of *province of residence* and *type of educational program* **B**, and the matrix linking *university of enrollment* to *type of educational program* by **C**. The block off-diagonal matrix representation of the three-mode network could be denoted by **Z** as described above.

1. Borgatti, Everett approach $\rightarrow$ definition of the $k(k-1) = 2$collection of two-mode networks
   - exploratory analysis and community detection $\rightarrow$ student mobility internal and external routes among provinces
   - exploratory analysis and community detection $\rightarrow$ student mobility only external routes
2. Definition of three-mode network
   - Apply usual methods to the multimode adjacency matrix **Z**
   - Adaption of the spectral partitioning of graphs into communities (Melamed et al., 2013) for weighted three-mode networks

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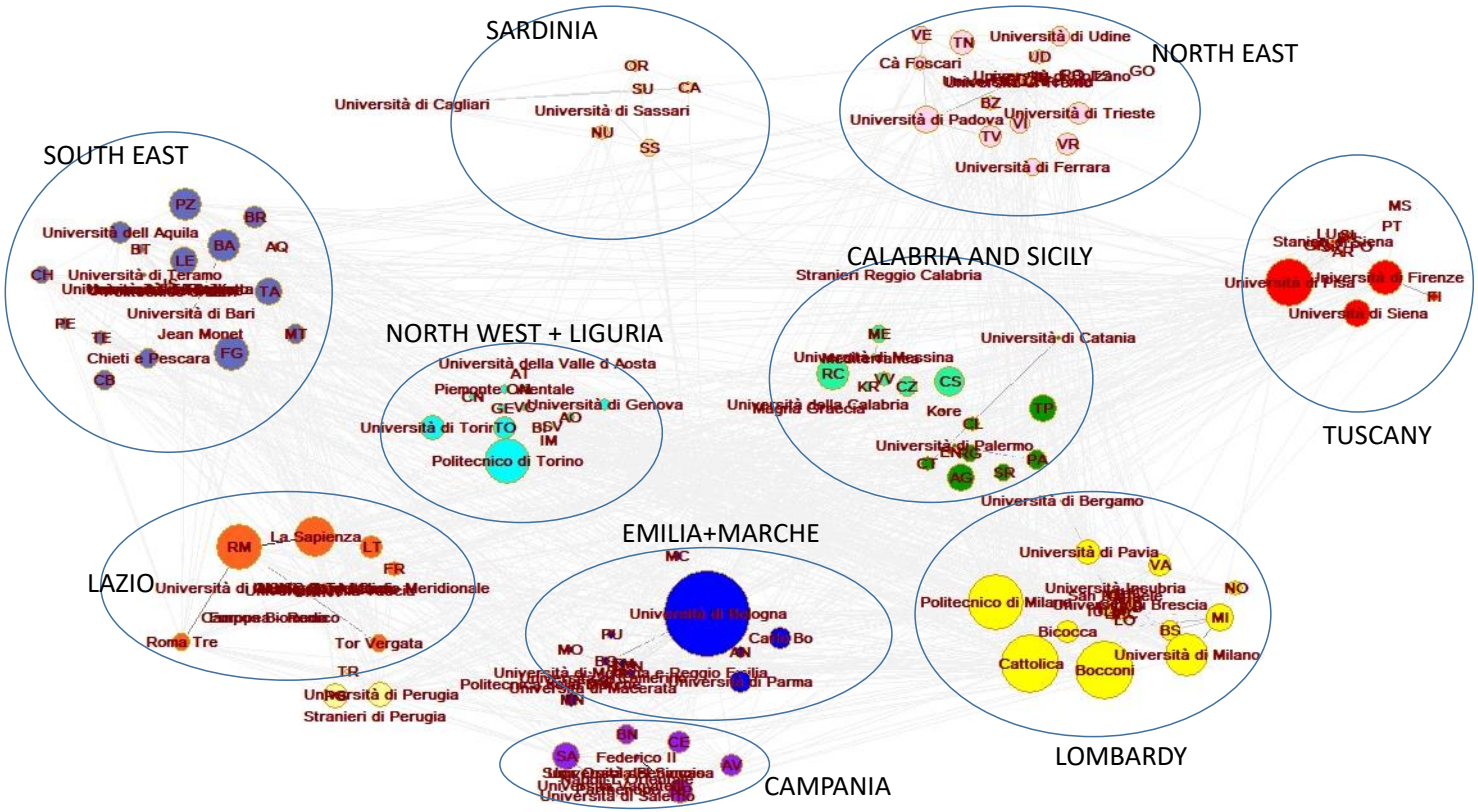
Two-mode network: internal and external mobility routes

We first analyze the Two mode network Province of Residence and University of enrollment

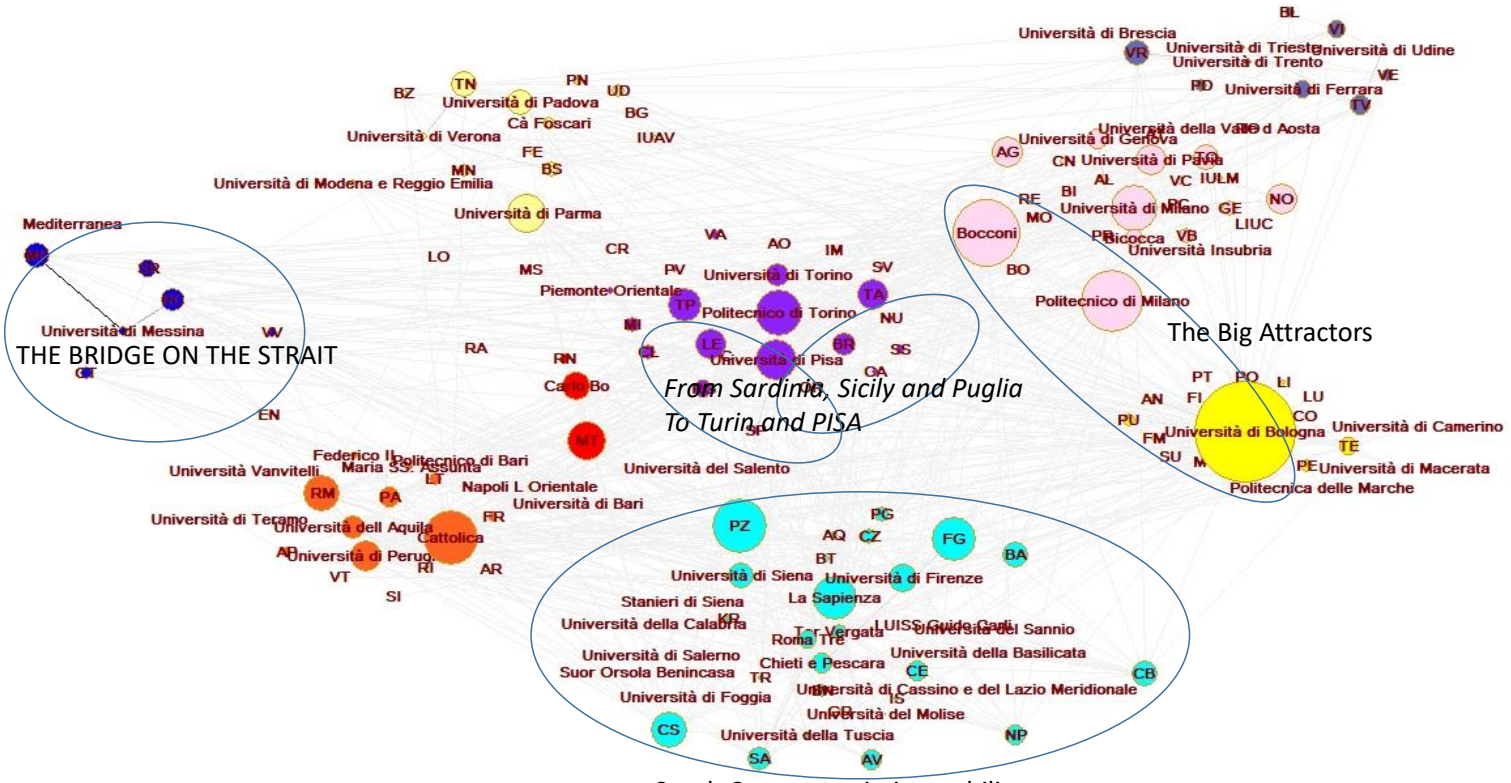
- Line with value lower than 10 have been removed
- Node are colored by community detection algorithm (Louvain)
- Size of vertices is proportional to betweenness



Two-mode network: external mobility routes

Then we analyze the Two mode network Province of Residence and University of enrollment focusing on mobility

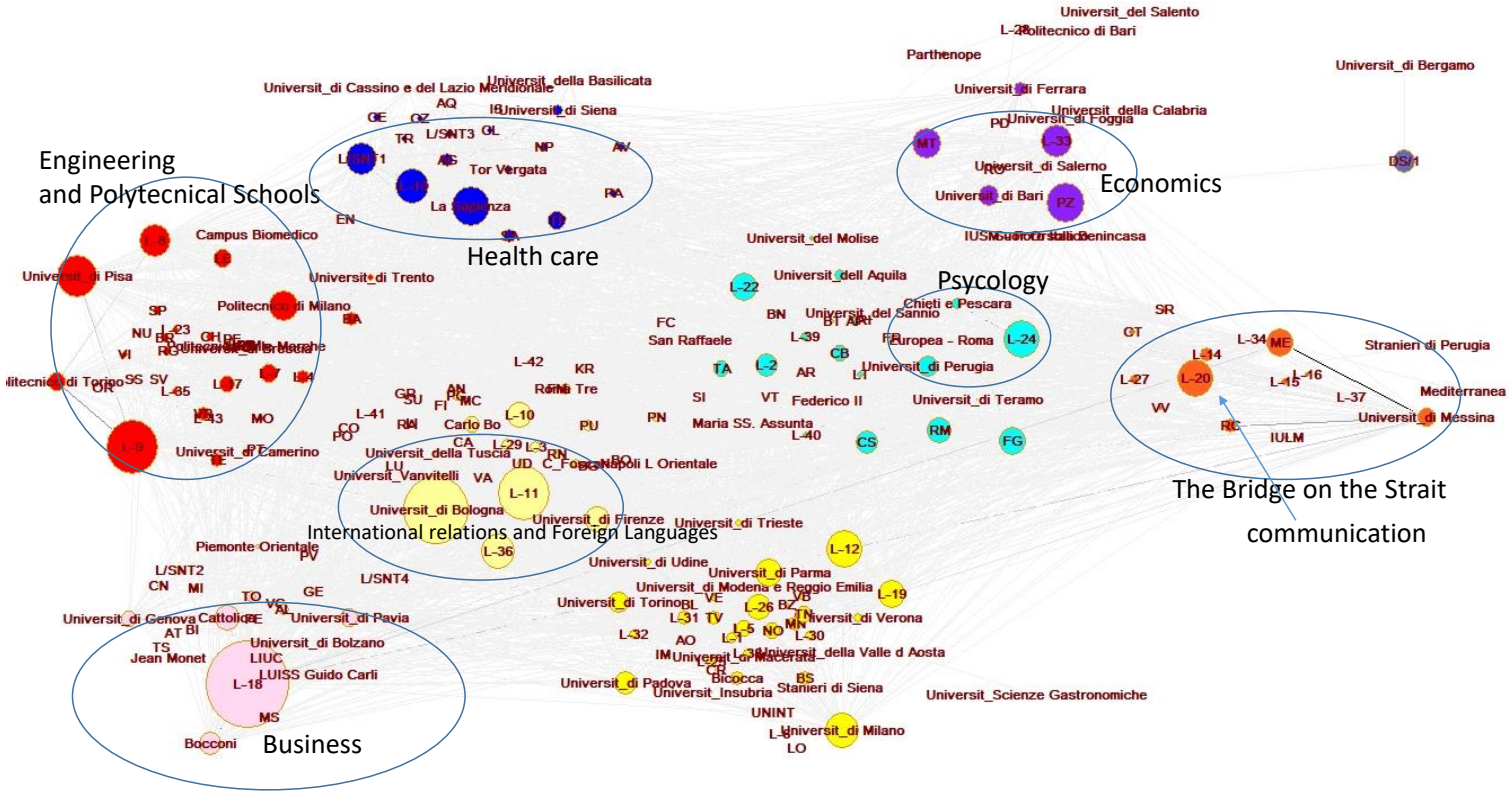
- Enrollment inside the region have been removed
- Line with value lower than 10 have been removed
- Node are colored by community detection algorithm (Louvain)
- Size of vertices is proportional to betweenness



Three-mode network: external mobility routes

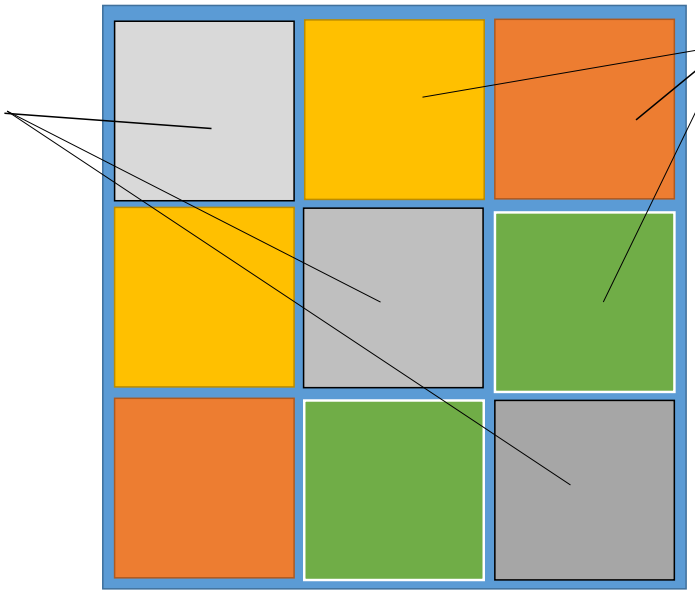
Then we analyze the three-mode network Province of Residence and University of enrollment and type of educational program focusing on mobility

- Enrollment inside the region have been removed
- Line with value lower than 10 have been removed
- Node are colored by community detection algorithm (Louvain)
- Size of vertices is proportional to betweenness



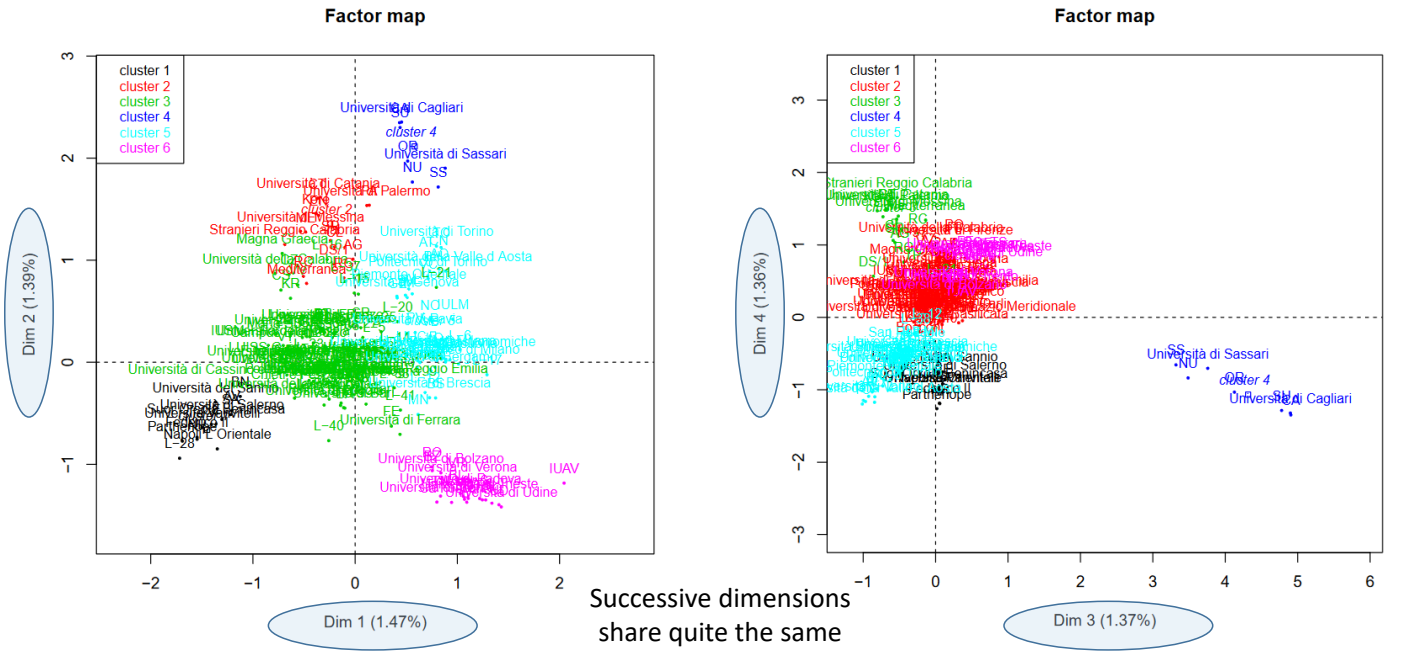
A comparison with MCA results

Analyzing contingency tables as a Burt-like matrix in the scope of Correspondence Analysis



A comparison with MCA results

MCA Results and Clustering



Successive dimensions share quite the same amount of inertia!!

Concluding remarks

- MCA performs not so good
- The methods that we used are better, but the results are not enough satisfying
- Melamedd community detection algorithm proper for three-mode networks performed bad, maybe because it is designed for small binary three-mode networks
- Networks we are dealing with should be better defined in their nature (multi*?)

At the end, we have more open questions than results

People talk so much about the beauty of confidence. They seem to entirely ignore the much more subtle beauty of doubt. (OSCAR WILDE)

Thanks for the attention

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