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CONNECTIONS MATTER: HOW PERSONAL NETWORK STRUCTURE INFLUENCES BIOMEDICAL SCIENTISTS' PARTICIPATION IN MEDICAL INNOVATIONS

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MOTIVATION OF THE PAPER

Motivations

- To investigate *research network configurations* at the individual level (ego-networks) that are more conducive to knowledge creation
  - Networks differ in their **structure** and **composition**
  - There are multiple reflections of knowledge creation: e.g. **scientific** and **technological**
- To explore which individual attributes are critical for scientists to engage in medical innovations.
  - In terms of **motivation**: role of ”perceived beneficiary impact”
  - In terms of **abilities**: role of ”cognitive breadth”

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Research context:

- Biomedical field

Translational Research has become a policy priority with the aim to improve healthcare by promoting research collaborations between different biomedical actors (e.g. basic scientists, clinical scientists, practitioners, etc).

... but there is a lack of consensus about whether and to what extent current initiatives to support Translational Res. have been really effective.

Social network literature

- "*People who do better are somehow better connected*" (Burt, 2000)
  - Holding a particular position in a network can be an asset in its own right, as influences the amount of resources and opportunities available

- However, what does being *better connected* means?:
  - There are different mechanisms to reach advantageous positions in a network
  - Different positions in a network can be beneficial for different outcomes

- A critical aspect of network configurations refers to their structure:

  - ***Dense*** (Coleman, 1988): actors highly connected among them

    vs

  - ***Sparse*** (Burt, 1992; Granovetter, 1973): many "structural holes" among actors

BACKGROUND: DENSE vs. SPARSE NETWORKS

Dense Networks

Everyone is highly connected to each other

Benefits:

- Fast flow of knowledge across network members
- Reliable communication, people trust each other (cheating and non-reciprocity is socially sanctioned)

Good for whole network to face complex problems and diffuse knowledge.

Problematic due to information redundancy

Sparse Networks

Few connections between each other

More opportunities to act as a bridge between actors and gain benefits:

- Information benefits: access to non-redundant information
- Control benefits: unique conditions to identify new opportunities for collaboration

Good for few individuals (brokers) to foster innovation and creativity

Problematic due to coordination costs

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Which network structure facilitates more the scientists' participation in medical innovations?

- Scientists whose personal networks are **sparse** (they connect actors that otherwise would be disconnected) are exposed to different bodies of knowledge and resources (Burt, 1992).
  - Access to diverse knowledge is expected to facilitate the scientists' capacity to materialize basic knowledge into new medical treatments (Shervanthi-Homer et al., 2012)
- We expect **brokerage positions to facilitate medical innovation up to a point**, beyond which enlarging the range of (disconnected) relationships can be either ineffective or detrimental for innovation (Baer, 2010; A. McFadyen & Cannella, 2004).

Hypothesis 1: *Scientists' networks characterized by a high degree of brokerage will be positively related with the scientists' participation in medical innovation activities. This participation will be maximized at intermediate levels of brokerage (inverted U-shape).*

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Social network research and attributes of actors in the network

- Network research has often treated actors as undifferentiated (Phelps et al., 2012)

- However, individual-level behaviors cannot be only explained by invoking at the structure-level characteristics of the actors. Need to "bring the individual back" when conducting social network research (Ibarra, Kilduff & Tsai, 2005).

- Individual differences might refer to:
  - Cognitive frames and skills (Rotolo & Messeni-Petruzzelli, 2012)
  - Personality traits (Fini et al., 2012)
  - Motivations and attitudes (Mehra et al 2001)

NETWORK STRUCTURE AND INDIVIDUAL DIFFERENCES

Social network research and <u>characteristics of actors in the network</u>

We consider two types of characteristics regarding central actors:

- **Cognitive skills**

Engagement in medical innovation requires that scientists should be familiar with a combination of basic and clinical skills (Hobin et al, 2012).

Hypothesis 3: *Breadth of cognitive skills will have a positive relationship with the scientists' degree of engagement in medical innovation activities.*

- **Perceived impact on beneficiaries**

Perceived impact on beneficiaries is the degree to which individuals are aware that their own actions have the potential to improve the welfare of others (Grant, 2007, 2008). This awareness should exert an influence on scientists' disposition to engage in medical innovation.

Hypothesis 4: *Perceived impact on patients and medical practitioners will have a positive relationship with the scientists' degree of engagement in medical innovation activities.*

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Spanish Biomedical Research Networking Centers (CIBERs) are formal networks structures created by the Spanish Ministry of Health in 2007.

Aims of the CIBER networks:

- Bring together research groups from universities, hospitals and research centers working on similar fields.

- Organize biomedical research around **nine** broad range of pathologies of critical interest for the Spanish' National Health System:

    - Neurodegenerative diseases
    - Rare diseases
    - Hepatic diseases
    - Bioengineering, Biomaterials and Nanomedicine
    - Epidemiology and Public Health
    - Obesity and Nutrition
    - Respiratory Diseases
    - Mental Health
    - Diabetes and Metabolic Associated Diseases

RESEARCH CONTEXT AND METHODS (II)

Sample frame for the study:

- All biomedical scientists and technicians belonging to research groups in each of the nine CIBER networks (4,758 individuals).

Implementation of a survey

- We designed a questionnaire to identify each scientist' **collaborative network** (external to his/her research team), their individual **attributes** and their degree of engagement in multiple activities related to **medical innovation**.

- Using email addresses, scientists were invited to participate an on-line survey (between April and June, 2013).

- Overall response rate = 27,5 % (1,309 valid responses)

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We asked respondents to report whether they have participated in any of the following activities during the year 2012.

Included items	Categories
Patent applications for new drugs	**Commercialization**
Granted licenses from patents	
Participation in spin-off	
Clinical trials phases I, II or III for new drugs development	**New drug development**
Clinical trials phase IV for new drugs development	
Clinical trials phase IV for new diagnostic techniques	
Clinical guidelines for healthcare professionals	**Clinical guidelines**
Clinical guidelines for patients	
Patent applications for new diagnostic techniques	**Diagnostics and prevention**
Clinical trials phases I, II or III for new diagnostic techniques	
Clinical guidelines for the general population (prevention)	

DV: Degree of participation in TR; ranges between 0 and 3 according to *:*

"0": No participation in any of the four categories
"1": Participated at least once in any of the four categories
"2": Participated at least once in two of the four categories
"3": Participated at least once in three or four categories

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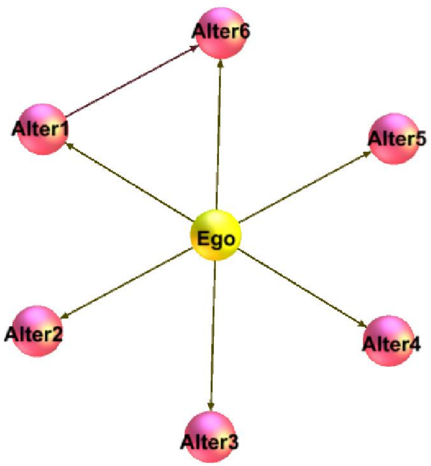
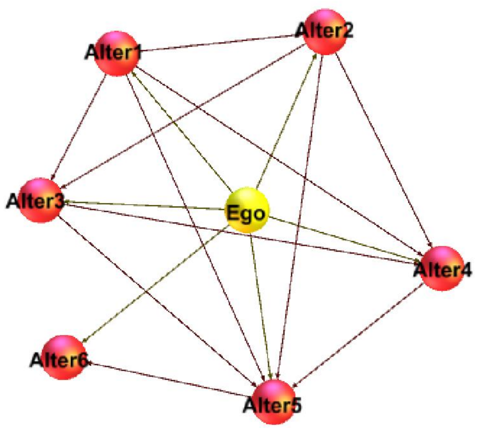
INDEPENDENT VARIABLE 1: BROKERAGE

We measured network brokerage as the rate of actual connections / potential connections between each respondents' contacts from outside her research group.

Scientist A
6 alters reported
Brokerage score = 0,933



Scientist B
6 alters reported
Brokerage score = 0,267



Mean: 0.63
Median: 0.70
Mode: 1.00
Min: 0.00
Max: 1.00

$$\textbf{\textit{Personal network brokerage}} = 1 - \frac{\text{number of alter-alter ties}}{\text{total number of possible alter-alter ties}}$$

Min = 0 (lowest brokerage)
Max = 1 (highest brokerage)

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Independent variable II: *Breadth of cognitive skills*

The survey included the following question:

"*Have you received, through your career, specific training in one or more of the following activities?*" *(tick where appropriate)*

Design of clinical trials	☐
Design of clinical guidelines	☐
State-of-the-technology in your field of research	☐
Clinical pharmacology	☐
Biostatistics	☐
Molecular biology	☐
Experimental methods	☐
Experimentation with animals	☐
Studies with control groups	☐

Cognitive Breadth: Measured as the count of areas of 'specific training":

Mean: 2.71
Median: 3.00
Mode: 2.00
Min: 0.00
Max: 9.00

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- **Independent variable III: *Perceived beneficiary impact***

The survey included the following question:

"*Please, indicate the extent to which the following collectivities benefit more directly from the results obtained from your research activities" (responses according to a 7 point Likert Scale)*

Collectivities	1	2	3	4	5	6	7
Patients	☐	☐	☐	☐	☐	☐	☐
Clinical Practitioners	☐	☐	☐	☐	☐	☐	☐
Patients' relatives	☐	☐	☐	☐	☐	☐	☐

We averaged the responses to the three items to create a composite indicator of the perceived clinical impact of the research activities (Cronbach's Alpha = 0, 78).

Perceived beneficiary impact:

Mean: 4.44 / *Median*: 4.50 / *Mode*: 5.00 / *Min*: 1.00 / *Max*: 7.00

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MEASURE OF BROKERAGE

Control variables

Individual level:

- Age
- PhD degree
- Size of external network

Organizational and Institutional level:

- Size of the research team
- Institutional affiliation: University, Hospital, PROs and Others
- Type of CIBER

Econometric Method

Fractional Logit *(Robustness check with Ordered Logit / Probit and OLS regression methods)*

- Dependent variable that ranges between 0 and 3
- Re-scale the variable to obtain a measure between 0 and 1: $P_i = (Y_i – Y_{min}) / (Y_{max} – Y_{min})$

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RESULTS (FRACTIONAL LOGIT)

	(Model 1) Control variables	(Model 2) Control variables + Main variables	
Constant	-3.379***	-5.029***	
Control variables			
Age	0.033***	0.036***	
Large ego-network	0.353**	-0.043	
PhD	0.178	0.015	
Type of institution	Included	Included	
CIBER	Included	Included	
Predictor variables			
Ego-network brokerage		**1.721***	Inverted U-shape (H1)
Ego-network brokerage^2		**-1.320***	
Cognitive breadth		**0.125*****	H2
Perceived beneficiaries		**0.323*****	H3
Observations	1164	853	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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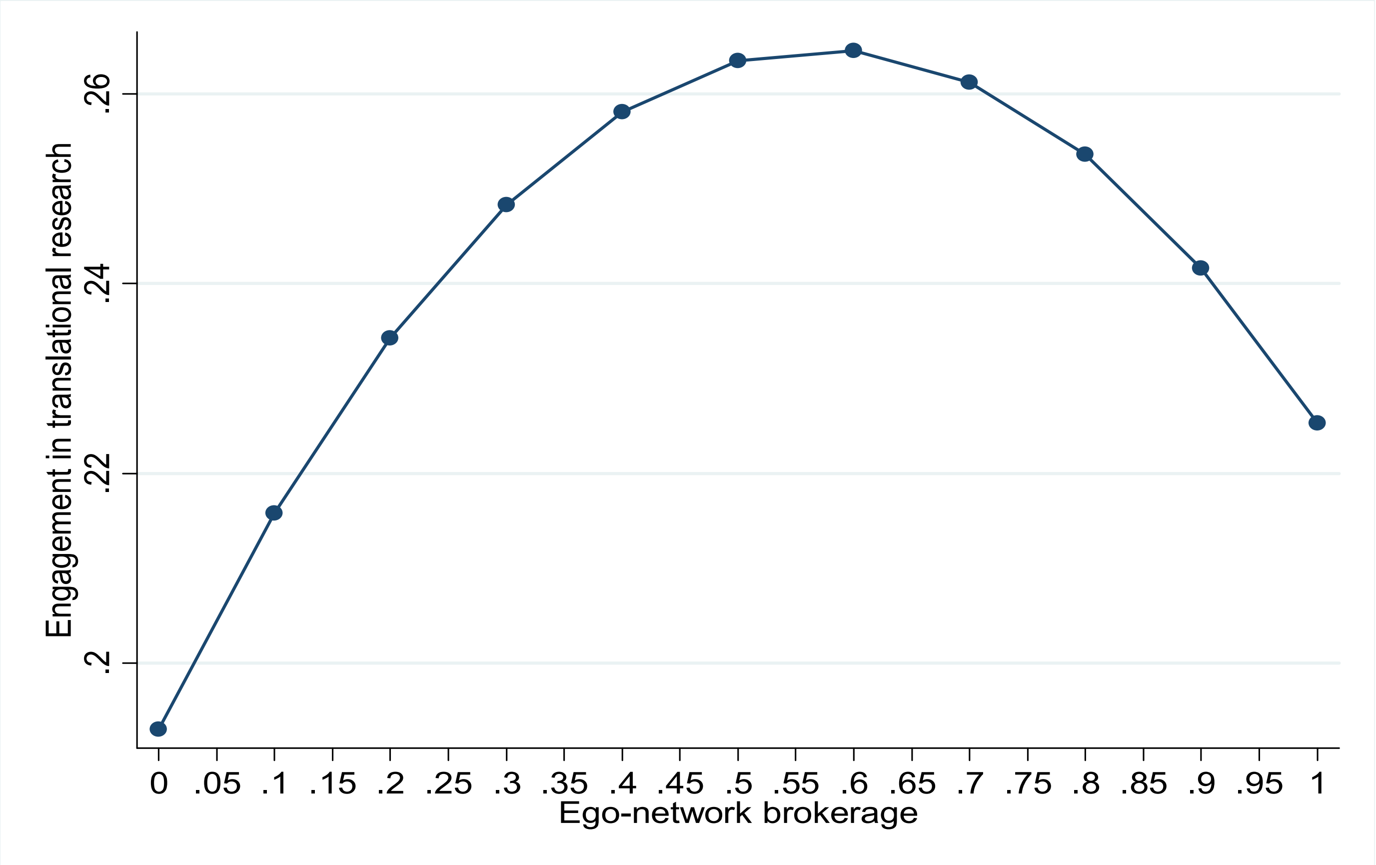
RESULTS: NETWORK BROKERAGE AND TR

Network brokerage and engagement in TR activities and outputs



The highest participation in TR happens at intermediate levels of network brokerage

PRELIMINARY CONCLUSIONS

- ***What type of personal networks are most conducive to innovation?***

- Our results suggest that:
  - **A. The structure of scientists' collaboration network *does* influence innovation**

    ... ***but it is important to keep an appropriate balance between sparse and dense networks***

    - Scientists devoting efforts to cultivate a sparse network are more likely to engage in medical innovation
    - However, maintaining sparse networks may undermine trust or involve coordination difficulties
    - Most effective network structure lies at intermediate levels between dense and sparse networks

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PRELIMINARY CONCLUSIONS

- **B. Network structures should be analyzed in conjunction with individual attributes**:
  - **Cognitive breath**: Breadth of basic / clinical skills: the higher the diversity of skills, the higher the probability of scientists to engage in medical innovation
  - **Perceived beneficiary impact**: scientists that are particularly aware of the positive impact they exert over patients and clinical practitioners are more prone to engage in different forms of medical innovation

- **Avenues for further research**:
  - Differences in network configurations for <u>different types of innovation.</u>

    Variety of indicators for medical innovation: (i) drug development, (ii) clinical guidelines, (iii) invention and commercialization: and (iv) diagnostics/prevention

  - Lagged innovation performance, to address potential reverse causality problems

THANK YOU

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VARIABLES (II)

Independent variable I: Ego-network brokerage

"Write down the names of those persons (up to ten) from outside your research group that are particularly important for the advancement of your research activities"

Ego-network brokerage = $\frac{\text{Number of alter-alter ties}}{\text{total number of possible alter-alter ties}}$

Min = 0 (lowest brokerage)
Max = 1 (highest brokerage)

Independent variable II: Breadth of cognitive skills

"*Have you received, though your career, training on one or more of the following activities?"*

Battery of 8 skills. E.g.: "development of clinical trials", "biostatistics", "molecular biology" , "experimental methods"

Independent variable III: Perceived impact on beneficiaries

"*Please, indicate the extent to which the following collectivities benefit more directly from the results obtained from your research activities" (Likert scale, 1 -7)*

a) Research community,
b) Patients;
c) Clinical practitioners
d) Vulnerable social groups

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VARIABLES

Perceived beneficiary impact

"*Please, indicate the extent to which the following collectivities benefit more directly from the results obtained from your research activities*".

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- *Patients*
- *Clinical practitioners*
- *Patients' relatives*

VARIABLES

Breadth of cognitive skills

“Have you received, though your career, specific training in one or more of the following activities?”

- *Design of clinical trials*
- *Design of clinical guidelines*
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- *Experimental methods*
- *Experimentation with animals*
- *Studies with control groups*