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HOW DO PERSONAL RESEARCH-NETWORKS INFLUENCE INNOVATION? THE BIOMEDICAL CONTEXT

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MOTIVATION OF THIS RESEARCH

Motivations

- To investigate *network configurations* that are most conducive to knowledge creation
  - Multiple types of network configurations: e.g. **structure** and **composition**
  - Multiple types of knowledge outcomes**:** e.g. **scientific** and **technological**

    ... mixed findings and unsolved conceptual puzzles

- Networks in the context of biomedical research
  - ***Translational Research*** has become a high policy priority with the aim to improve healthcare by strengthening research collaborations between basic and clinical scientists

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

- Improve our understanding of how (biomedical) research networks work

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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 it influences the amount of resources and opportunities available

- However, it is not clear what *better connected* means:
  - being *better* connected does not necessarily mean being *more* connected
  - There are different mechanisms to reach advantageous positions in a network

- Two critical aspects of network configurations
  - **Structure: *Dense*** (Coleman, 1988) vs. ***Sparse*** (Burt, 1992; Granovetter, 1973) networks
  - **Composition: *Homogeneous*** vs. ***Heterogeneous*** actors (Fleming et al., 2007; Reagans & McEvily, 2003)

Network structure: Dense vs. Sparse networks

Dense Networks

Networks where everyone is highly connected to each other

- Fast access to information
- Reliable communication, people trust each other (cheating and non-reciprocity are socially sanctioned)

Sparse Networks

Few connections between alters / More opportunities to act as a bridge between actors - brokers - and control information flows

- High access to non-redundant information
- Unique conditions to identify new opportunities

Sparse networks should increase the exposure to different approaches and sources of information, but they may involve lack of mutual trust and slower circulation of information among partners compared to **dense** networks.

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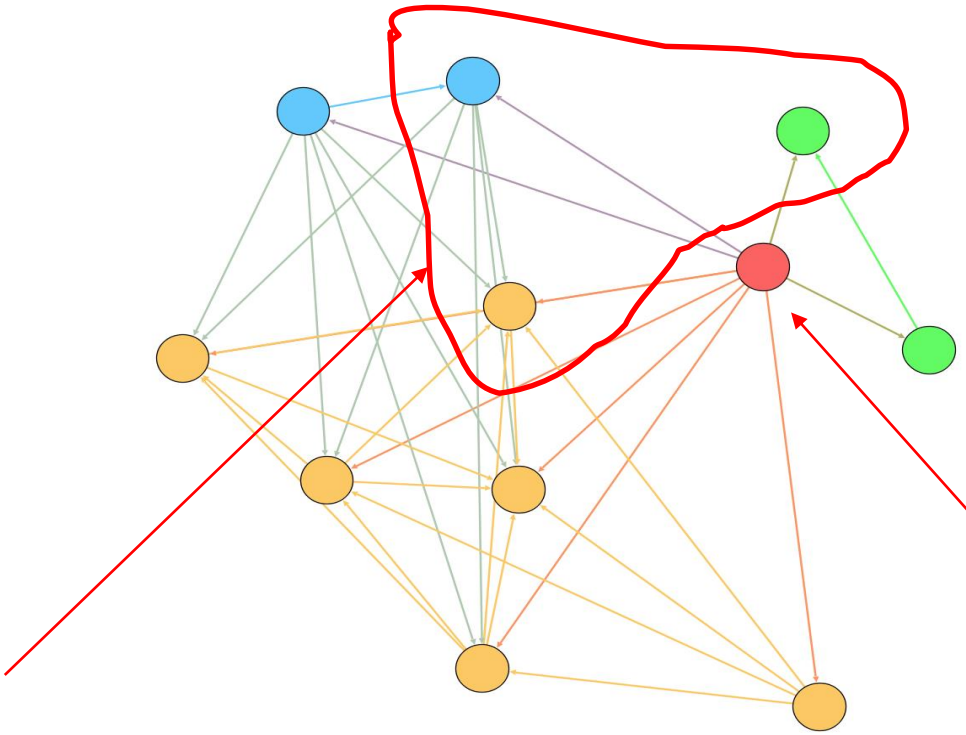
Network composition: homogeneous vs. heterogeneous actors

Network composition refers to the diversity of actors involved in a personal network



DIVERSITY of ACTORS
(where colours represent different attributes of actors)

CENTRAL ACTOR

Heterogeneity in network composition should favour access to non-redundant information

… but it may require greater coordination and cognitive efforts compared to more **homogeneous** networks

Personal network structure / composition and medical innovation

- Actors who have access to diverse sources of information and knowledge as a result of:
  - holding brokerage positions - connecting actors who otherwise would be disconnected
  - building ties to heterogeneous actors

  … are expected to have an advantage for knowledge creation (Burt,1992; Fleming et.al, 2007; Reagans & McKevily, 2003)

- However, actors may face increasing difficulties to benefit from sparse or heterogeneous networks due to:
  - potential lack of mutual trust and weakened expectations on the credibility of partners
  - potential lack of shared cognitive frames and risks of misperceptions

- … We expect ***sparse*** **networks / *heterogeneity* in network composition to facilitate medical innovation up to a point**, beyond which enlarging the range of *disconnected* / *heterogeneous* relationships can be either ineffective or detrimental for innovation (Baer, 2010;Fang et al., 2010; McFadyen & Cannella, 2004; ter Wal et al., 2013).

Hypothesis 1: *Scientists with personal networks characterized by a high degree of* ***brokerage*** *will be more likely to engage in* ***medical innovation****. Engagement in innovation will be maximized at intermediate levels of brokerage (inverted U-shape).*

Hypothesis 2: *Scientists with personal networks characterized by high degree of actor* ***heterogeneity*** *will be more likely to engage in* ***medical innovation****. Engagement in innovation will be maximized at intermediate levels of actor diversity (inverted U-shape).*

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

- Network research has often treated actors as undifferentiated: e.g. cognitive hollow (Phelps et al., 2012)

- However:
  - Differences in Individual behaviour cannot be solely explained by structure-level characteristics. We 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)

Social network research and characteristics of actors in the network

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.*

- **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 is claimed to exert an influence on individuals' disposition to channel this perception into outcomes.

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

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RESEARCH CONTEXT AND METHODS

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

Aims of the CIBER networks:

- Foster research collaboration by bringing together research groups from universities, hospitals, research centres and firms working on similar pathologies.

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

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

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RESEARCH CONTEXT AND METHODS (II)

SURVEY DATA

- **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 collect information on the following aspects
    - **collaborative network** (external to the scientist' research team)
    - individual **attributes** of scientists
    - 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)
    - Non-response bias tests by type of institution, group size, status and CIBERs

SECONDARY SOURCES

- **Records of patent applications from PIs** (period 1990-2010)

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VARIABLES

- **Dependent variable: *Degree of engagement in (multiple types of) medical innovation***

*We asked respondents to report "**how many times**" they have participated in any of the following activities during the year 2012.*

Included items in the questionnaire
Patent applications for new drugs
Licenses from patents
Participation in spin-off
Clinical trials phases I, II or III for new drugs development
Clinical trials phase IV for new drugs development
Clinical trials phase IV for new diagnostic techniques
Clinical guidelines for healthcare professionals
Clinical guidelines for patients
Patent applications for new diagnostic techniques
Clinical trials phases I, II or III for new diagnostic techniques
Clinical guidelines for the general population (prevention)

VARIABLES

- **Dependent variable: *Degree of engagement in (multiple types of) medical innovation***

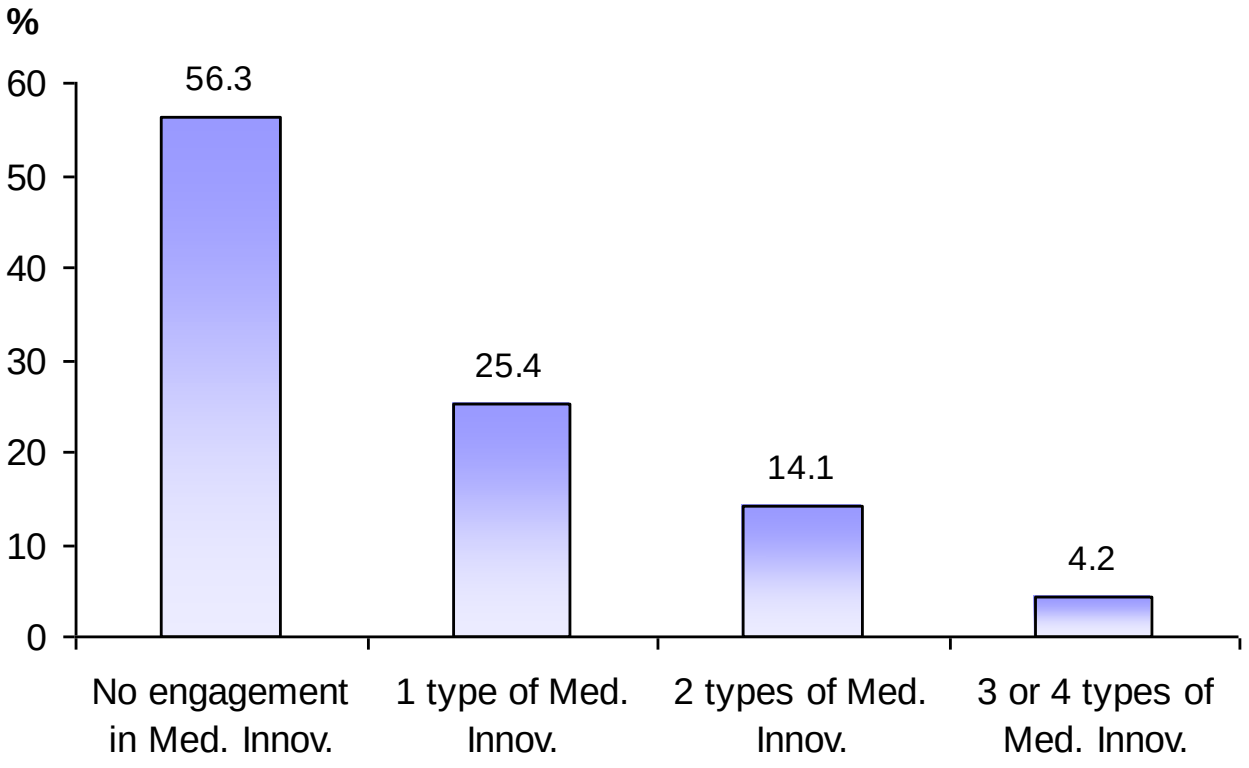
*We asked respondents to report "**how many times**" they have participated in any of the following activities during the year 2012.*

Included items in the questionnaire	Categories
Patent applications for new drugs	**Invention and Commercialization**
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 engagement in Med. Innov.- ranges between 0 and 3 according to the participation in the four types of medical innovation:***

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

- ***Distribution of respondents across the categories of the DV (%)***



MEASURE of Network Structure

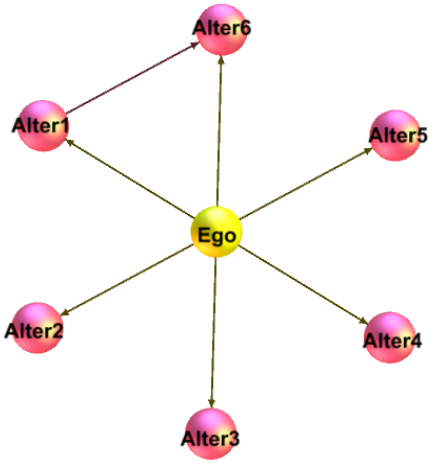
- **Independent variable I: *Ego-network brokerage***

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

Personal (ego) network brokerage as: 1 - $\frac{\text{Number of alter-alter ties}}{\text{total number of possible alter-alter ties}}$

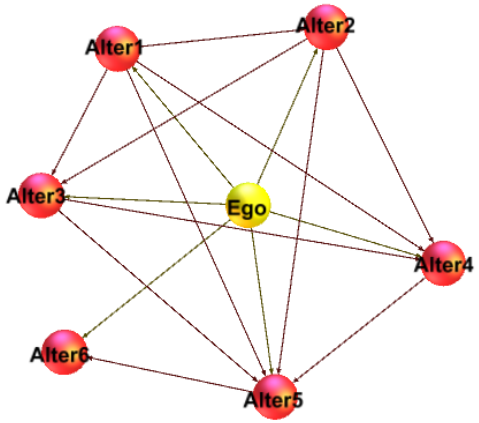
Min = 0 (lowest brokerage)
Max = 1 (highest brokerage)

Scientist A
6 alters reported
Brokerage score = 0,933



High Brokerage
(sparse network)

Scientist B
6 alters reported
Brokerage score = 0,267

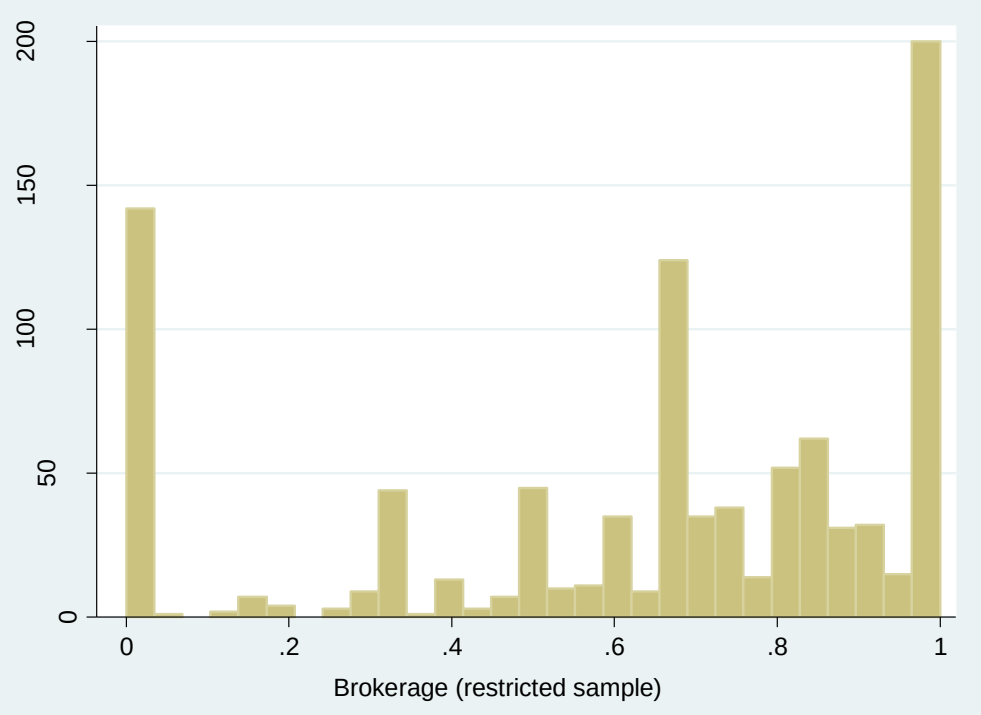


Low Brokerage
(dense network)

MEASURE of Network Structure

- **Independent variable I: *Ego-network brokerage***

Frequency of scientists according to their brokerage score



Ego-Net. Brokerage:

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

(figures for actors who report 2 or more external alters)

Frequencies are largest at the extremes of the distribution: scores of 0 and 1

MEASURE of Network Composition

- **Independent variable II: *Network_Range***

This measure is built from another question in the survey, asking for the following information about the contacts cited by the respondent:

"*Indicate the sector or professional field of the persons you have cited as being a particularly important source of information or advice for your research activities*" (drop-down menu)

	Basic Scientist (NHS, Uni)	Clinical Scientist (NHS, Uni)	Medical Doctor (not involved in research)	Patient or Patient Associations	Industry / Private Sector	Public Administ	Others (specify)
Alter 1	□	□	□	□	□	□	□
Alter 2	□	□	□	□	□	□	□
Alter 3	□	□	□	□	□	□	□
Alter 4	□	□	□	□	□	□	□
Alter 5	□	□	□	□	□	□	□
Alter 6	□	□	□	□	□	□	□
Alter 7	□	□	□	□	□	□	□
Alter 8	□	□	□	□	□	□	□
Alter 9	□	□	□	□	□	□	□
Alter 10	□	□	□	□	□	□	□

MEASURE of Network Composition

- **Independent variable II: *Network_Range***

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Alter 1	□	□	□	□	□	□	□
Alter 2	□	□	□	□	□	□	□
Alter 3	□	□	□	□	□	□	□
Alter 4	□	□	□	□	□	□	□
Alter 5	□	□	□	□	□	□	□
Alter 6	□	□	□	□	□	□	□
Alter 7	□	□	□	□	□	□	□
Alter 8	□	□	□	□	□	□	□
Alter 9	□	□	□	□	□	□	□
Alter 10	□	□	□	□	□	□	□

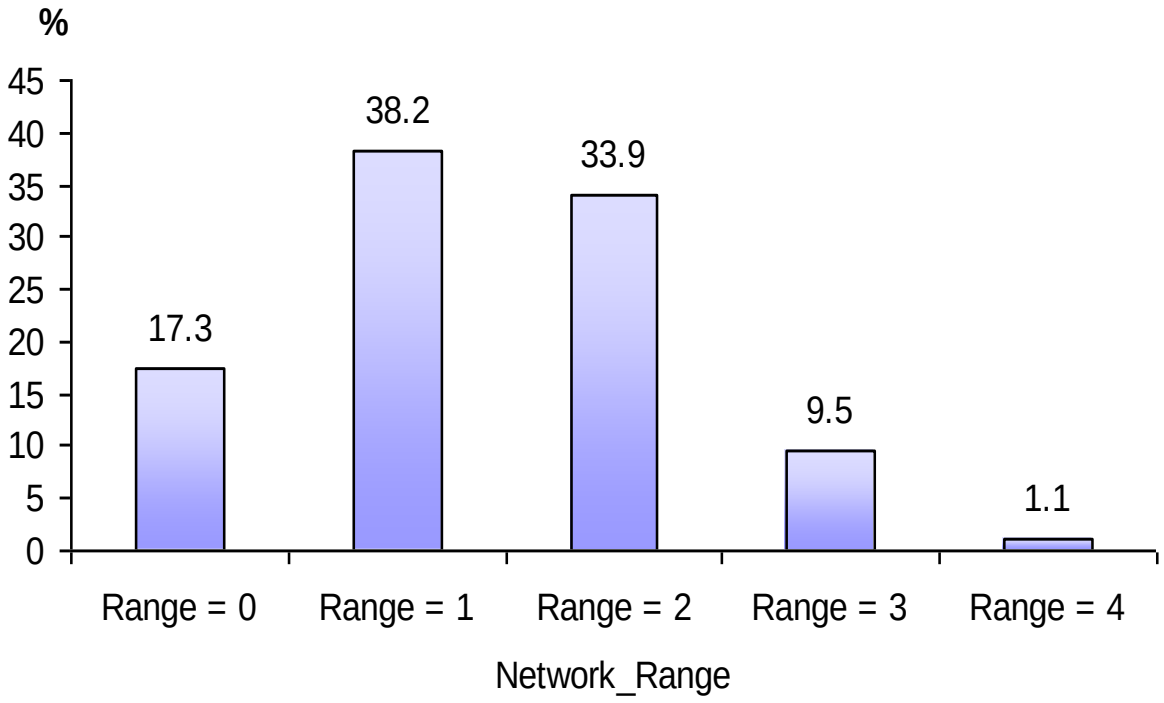
We grouped the alters in these 4 categories.

MEASURE of Network Composition

- **Independent variable II: *Network_Range***

We constructed our variable Network_Range as the count of sector / professional categories of the alters that compose an individual's network.

Network_range takes values from 0 (no external contacts) to 4 (external contacts belonging to the four categories of sectors or professional activity).



About 70% of our respondents report having external contacts who belong to 1 or 2 distinct categories of sectors or professional activity.

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MEASURE of Cognitive Skills

- **Independent variable III: *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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MEASURE of Perceived Impact on Beneficiaries

- **Independent variable IV: *Perceived impact on beneficiaries***

The survey included the following question:

"*Please, indicate the extent to which you consider that the following collectives benefit more directly from the results obtained from your research activities*" *(responses according to a 7 point Likert Scale – from 'not at all' to 'very much')*

Collectives	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 impact on beneficiaries:

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

Control Variables and Econometric Methods

Control variables

Individual level:

- Age & Gender
- PhD degree
- Size of external network
- Patent applications over period 1990-2010

Organizational and Institutional

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

Econometric Method

Ordered Probit / Logit, Fractional Logit and OLS regression methods

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

Consider two samples

- Complete sample, controlling for cases with zero or one external contact (1111 obs.)
- Restricted sample: considering only those cases who report having 2 or more external contacts (820 obs.)

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RESULTS (Ordered Probit)

Dependent variable: Degree of engagement in medical innovation activities *(outcome values: 0 - 3)*

	Total Sample (1111 obs.)				Restricted Sample (820 obs.)*			
	(1a)	(2a)	(3a)	(4a)	(1b)	(2b)	(3b)	(4b)
Predictor Variables								
Ego Net. Brokerage								
Ego Net. Brokerage^2								
Network Range								
Network Range^2								
Cognitive Breadth								
Perc.Impact Benef.								
Control Variables								
Age								
PhD								
Large Ego-Network								
Past Patent Applicat.								
Gender (female=1)								
Group Size								
University								
Hospital								
PROs								
CIBER (8 dummies)								
Ext_net.< 2 (dummy)								
Ps-R^2 (Cragg-Uhler)								

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ / * N. Observations = 820 (scientists who reported at least 2 external contacts)

RESULTS (Ordered Probit)

Dependent variable: Degree of engagement in medical innovation activities *(outcome values: 0 - 3)*

	Total Sample (1111 obs.)				Restricted Sample (820 obs.)*			
	(1a)	(2a)	(3a)	(4a)	(1b)	(2b)	(3b)	(4b)
Predictor Variables								
Ego Net. Brokerage								
Ego Net. Brokerage^2								
Network Range								
Network Range^2								
Cognitive Breadth								
Perc.Impact Benef.								
Control Variables								
Age	0.021***				0.022***			
PhD	0.092				-0.001			
Large Ego-Network	0.195**				0.194**			
Past Patent Applicat.	0.037***				0.033*			
Gender (female=1)	-0.361***				-0.374***			
Group Size	0.004				0.005			
University	0.003				-0.098			
Hospital	0.805***				0.766***			
PROs	0.133				0.112			
CIBER (8 dummies)	Included				Included			
Ext_net.< 2 (dummy)	-0.143				---			
Ps-R^2 (Cragg-Uhler)	0.24				0.22			

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ / * N. Observations = 820 (scientists who reported at least 2 external contacts)

RESULTS (Ordered Probit)

Dependent variable: Degree of engagement in medical innovation activities *(outcome values: 0 - 3)*

	Total Sample (1111 obs.)				Restricted Sample (820 obs.)*			
	(1a)	(2a)	(3a)	(4a)	(1b)	(2b)	(3b)	(4b)
Predictor Variables								
Ego Net. Brokerage		1.103**				1.144**		
Ego Net. Brokerage^2		-0.917**				-0.937**		
Network Range		---				---		
Network Range^2		---				---		
Cognitive Breadth		0078***				0.091***		
Perc.Impact Benef.		0.188***				0.207***		
Control Variables								
Age	0.021***	0.021***			0.022***	0.021***		
PhD	0.092	0.092			-0.001	-0.013		
Large Ego-Network	0.195**	0.025			0.194**	0.013		
Past Patent Applicat.	0.037***	0.044***			0.033*	0.036**		
Gender (female=1)	-0.361***	-0.376***			-0.374***	-0.394***		
Group Size	0.004	0.006			0.005	0.007		
University	0.003	0.053			-0.098	-0.042		
Hospital	0.805***	0.736***			0.766***	0.701***		
PROs	0.133	0.157			0.112	0.153		
CIBER (8 dummies)	Included	Included			Included	Included		
Ext_net.< 2 (dummy)	-0.143	0.081			---	---		
Ps-R^2 (Cragg-Uhler)	0.24	0.30			0.22	0.29		

H1

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ / * N. Observations = 820 (scientists who reported at least 2 external contacts)

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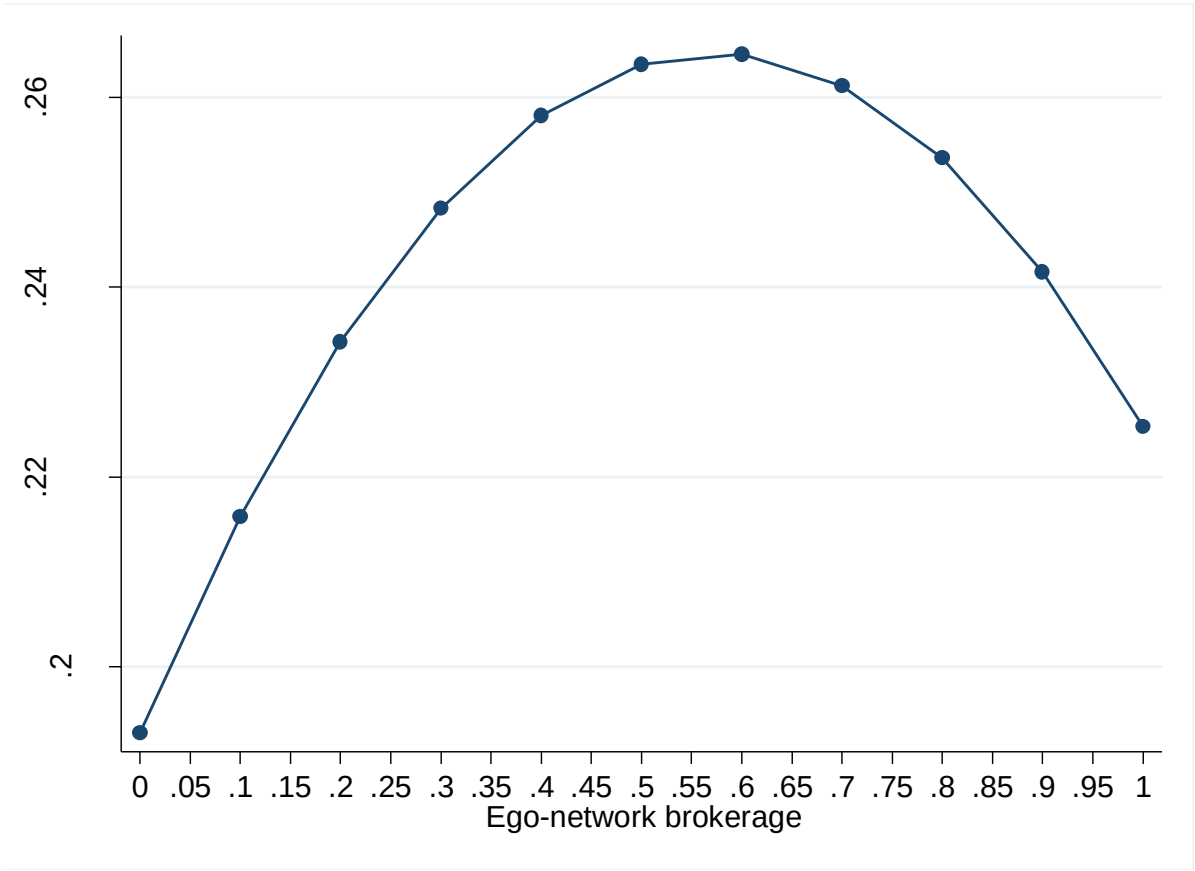
RESULTS: NETWORK BROKERAGE AND MEDICAL INNOVATION

- Curvilinear relationship between ***network brokerage*** and ***engagement in medical innovation***



The highest participation in medical innovation happens at intermediate levels of network brokerage

RESULTS (Ordered Probit)

Dependent variable: Degree of engagement in medical innovation activities *(outcome values: 0 - 3)*

	Total Sample (1111 obs.)				Restricted Sample (820 obs.)*			
	(1a)	(2a)	(3a)	(4a)	(1b)	(2b)	(3b)	(4b)
Predictor Variables								
Ego Net. Brokerage		1.103**	---			1.144**	---	
Ego Net. Brokerage^2		-0.917**	---			-0.937**	---	
Network Range		---	0.164**			---	0.133	
Network Range^2		---	-0.027			---	-0.010	
Cognitive Breadth		0078***	0.075***			0.091***	0.087***	
Perc.Impact Benef.		0.188***	0.181***			0.207***	0.195***	
Control Variables								
Age	0.021***	0.021***	0.021***		0.022***	0.021***	0.021***	
PhD	0.092	0.092	0.084		-0.001	-0.013	-0.019	
Large Ego-Network	0.195**	0.025	0.041		0.194**	0.013	0.040	
Past Patent Applicat.	0.037***	0.044***	0.044***		0.033*	0.036**	0.036*	
Gender (female=1)	-0.361***	-0.376***	-0.386***		-0.374***	-0.394***	-0.404***	
Group Size	0.004	0.006	0.006		0.005	0.007	0.006	
University	0.003	0.053	0.067		-0.098	-0.042	-0.028	
Hospital	0.805***	0.736***	0.738***		0.766***	0.701***	0.702***	
PROs	0.133	0.157	0.176		0.112	0.153	0.166	
CIBER (8 dummies)	Included	Included	Included		Included	Included	Included	
Ext_net.< 2 (dummy)	-0.143	0.081	0.084		---	---	---	
Ps-R^2 (Cragg-Uhler)	0.24	0.30	0.30		0.22	0.29	0.29	

H2

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ / * N. Observations = 820 (scientists who reported at least 2 external contacts)

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RESULTS (Ordered Probit)

Dependent variable: Degree of engagement in medical innovation activities *(outcome values: 0 - 3)*

	Total Sample (1111 obs.)				Restricted Sample (820 obs.)*			
	(1a)	(2a)	(3a)	(4a)	(1b)	(2b)	(3b)	(4b)
Predictor Variables								
Ego Net. Brokerage		1.103**	---			1.144**	---	
Ego Net. Brokerage^2		-0.917**	---			-0.937**	---	
Network Range		---	0.164**			---	0.133	
Network Range^2		---	-0.027			---	-0.010	
Cognitive Breadth		0078***	0.075***			0.091***	0.087***	**H3**
Perc.Impact Benef.		0.188***	0.181***			0.207***	0.195***	**H4**
Control Variables								
Age	0.021***	0.021***	0.021***		0.022***	0.021***	0.021***	
PhD	0.092	0.092	0.084		-0.001	-0.013	-0.019	
Large Ego-Network	0.195**	0.025	0.041		0.194**	0.013	0.040	
Past Patent Applicat.	0.037***	0.044***	0.044***		0.033*	0.036**	0.036*	
Gender (female=1)	-0.361***	-0.376***	-0.386***		-0.374***	-0.394***	-0.404***	
Group Size	0.004	0.006	0.006		0.005	0.007	0.006	
University	0.003	0.053	0.067		-0.098	-0.042	-0.028	
Hospital	0.805***	0.736***	0.738***		0.766***	0.701***	0.702***	
PROs	0.133	0.157	0.176		0.112	0.153	0.166	
CIBER (8 dummies)	Included	Included	Included		Included	Included	Included	
Ext_net.< 2 (dummy)	-0.143	0.081	0.084		---	---	---	
Ps-R^2 (Cragg-Uhler)	0.24	0.30	0.30		0.22	0.29	0.29	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ / * N. Observations = 820 (scientists who reported at least 2 external contacts)

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RESULTS (Ordered Probit)

Dependent variable: Degree of engagement in medical innovation activities *(outcome values: 0 - 3)*

	Total Sample (1111 obs.)				Restricted Sample (820 obs.)*			
	(1a)	(2a)	(3a)	(4a)	(1b)	(2b)	(3b)	(4b)
Predictor Variables								
Ego Net. Brokerage		1.103**	---	0.979**		1.144**	---	1.048**
Ego Net. Brokerage^2		-0.917**	---	-0.386*		-0.937**	---	-0.875**
Network Range		---	0.164**	0.125**		---	0.133	0.097
Network Range^2		---	-0.027	---		---	-0.010	---
Cognitive Breadth		0078***	0.075***	0.075***		0.091***	0.087***	0.088***
Perc.Impact Benef.		0.188***	0.181***	0.183***		0.207***	0.195***	0.201***
Control Variables								
Age	0.021***	0.021***	0.021***	0.021***	0.022***	0.021***	0.021***	0.021***
PhD	0.092	0.092	0.084	0.086	-0.001	-0.013	-0.019	-0.018
Large Ego-Network	0.195**	0.025	0.041	-0.035	0.194**	0.013	0.040	-0.032
Past Patent Applicat.	0.037***	0.044***	0.044***	0.044***	0.033*	0.036**	0.036*	0.036**
Gender (female=1)	-0.361***	-0.376***	-0.386***	-0.387***	-0.374***	-0.394***	-0.404***	-0.405***
Group Size	0.004	0.006	0.006	0.006	0.005	0.007	0.006	0.007
University	0.003	0.053	0.067	0.060	-0.098	-0.042	-0.028	-0.037
Hospital	0.805***	0.736***	0.738***	0.733***	0.766***	0.701***	0.702***	0.697***
PROs	0.133	0.157	0.176	0.167	0.112	0.153	0.166	0.159
CIBER (8 dummies)	Included	Included	Included	Included	Included	Included	Included	Included
Ext_net.< 2 (dummy)	-0.143	0.081	0.084	0.184	---	---	---	---
Ps-R^2 (Cragg-Uhler)	0.24	0.30	0.30	0.30	0.22	0.29	0.29	0.29

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ / * N. Observations = 820 (scientists who reported at least 2 external contacts)

PRELIMINARY CONCLUSIONS

- ***What type of personal networks are most conducive to innovation?***
- Our results suggest that:
  - **A. The structure of scientists' collaboration network *<u>does</u>* influence innovation**

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

    - Scientists devoting efforts to cultivate a **sparse** network are more strongly **engaged** in medical innovation
    - However, maintaining sparse networks may undermine trust or involve coordination difficulties

    ➢ *Most effective network structures combine elements associated to both dense and sparse networks*

PRELIMINARY CONCLUSIONS

- **B. We find partial evidence of a positive impact of Network range on innovation**
  - Networks composed of heterogeneous actors seem to be conducive to innovation among scientists
    - ✓ However, contrary to ego-network brokerage, the potential benefits of having a divers network does not show decreasing returns.
    - ✓ These results do not hold for the restricted sample: low variability of network range (85% of obs. have a range score of 1or 2).
- **C. Network structures should be analyzed in conjunction with Individual attributes:**
  - **Cognitive breadth**: the higher the diversity of (basic & clinical) skills, the higher the probability of scientists to engage in medical innovation
    - ✓ More Inter-disciplinary univ. degree programs - bridging basic and clinical research requires sets of skills that are not typically offered by traditional curricula
  - **Perceived impact on beneficiaries**: scientists who are particularly aware of the positive impact they exert on patients and clinical practitioners are more prone to engage in multiple forms of medical innovation
    - ✓ Our results support Soc. Psych. Lit. suggesting that when individuals perceive that their actions have an impact on beneficiaries, they are particularly motivated to make a positive difference in the wellbeing of these beneficiaries (e.g. developing new med. treatments)

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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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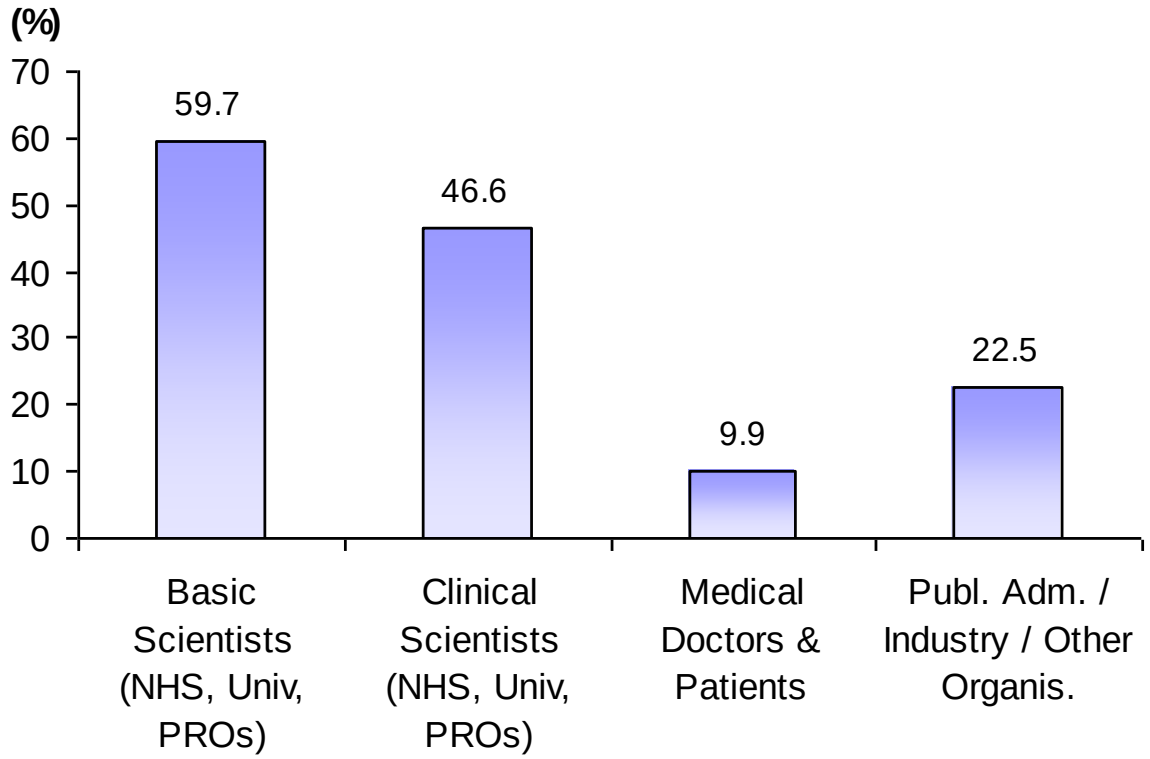
Response rates by CIBER:

CIBER	Population surveyed	Nº Complete Returned Questionnaires	Response rates (%)
BBN-Bioeng.,Biomaterials & Nanomed.	872	238	27.3
DEM-Diabetes & Metabolic A. Diseases	331	96	29.0
EHD-Hepatic Diseases	459	154	33.6
ER-Rare Diseases	517	177	34.2
ES-Respiratory Diseases	439	159	36.2
ESP-Epidemiology & Public Health	610	107	17.5
NED-Neurodegenerative Diseases	750	186	24.8
OBN-Obesity & Nutrition	303	71	23.4
SAM-Mental Health	477	121	25.4
Total	*4758*	*1309*	*27.5*

MEASURE of Network Composition

- **Independent variable II: *Network_Range***

Proportion of individuals who report having <u>at least one</u> contact corresponding to each of the four sector / professional categories



E.g.: About 60% of our respondents report that at least one of their (external) informants were Basic Scientists.

…. Should “optimal” network configurations lay somewhere in-between?

Personal networks where actors enjoy the advantages of both types of structures

MEASURE of Network Structure

- **Independent variable I: *Ego-network brokerage***

The survey included the following question:

"*Write down the names of those persons (up to ten) from outside your research group who have been a particularly important source of information or advice for the advancement of your research activities in 2012*"

A subsequent question was then activated with the following matrix (size depending on the number of alters reported) asking for the following information:

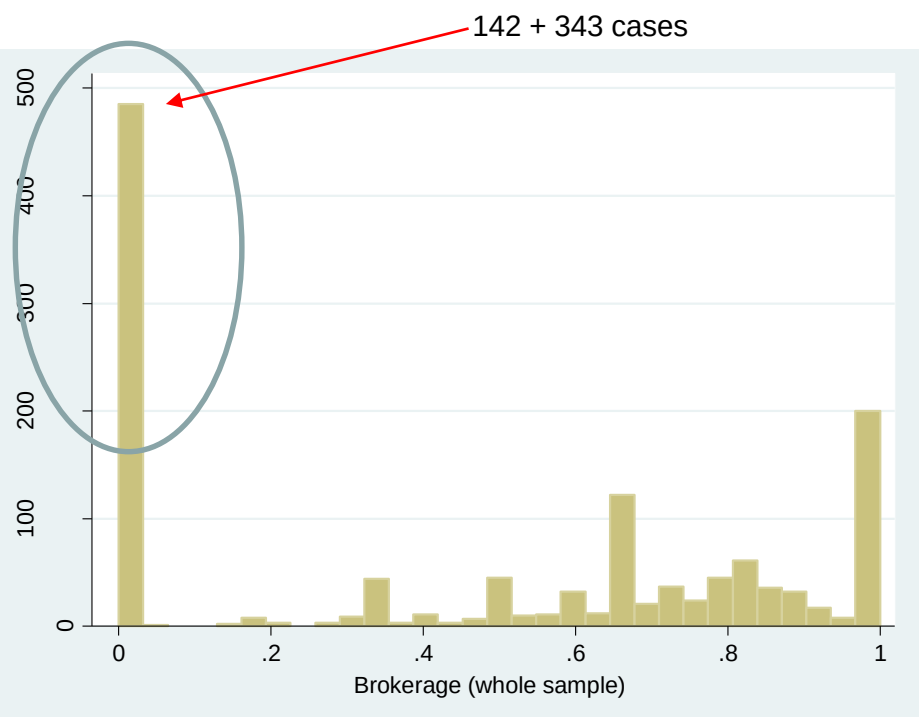
"*Indicate if, according to your knowledge, the persons you have cited exchange information or advice with each other, in connection with their professional activities*" (tick as many as appropriate)

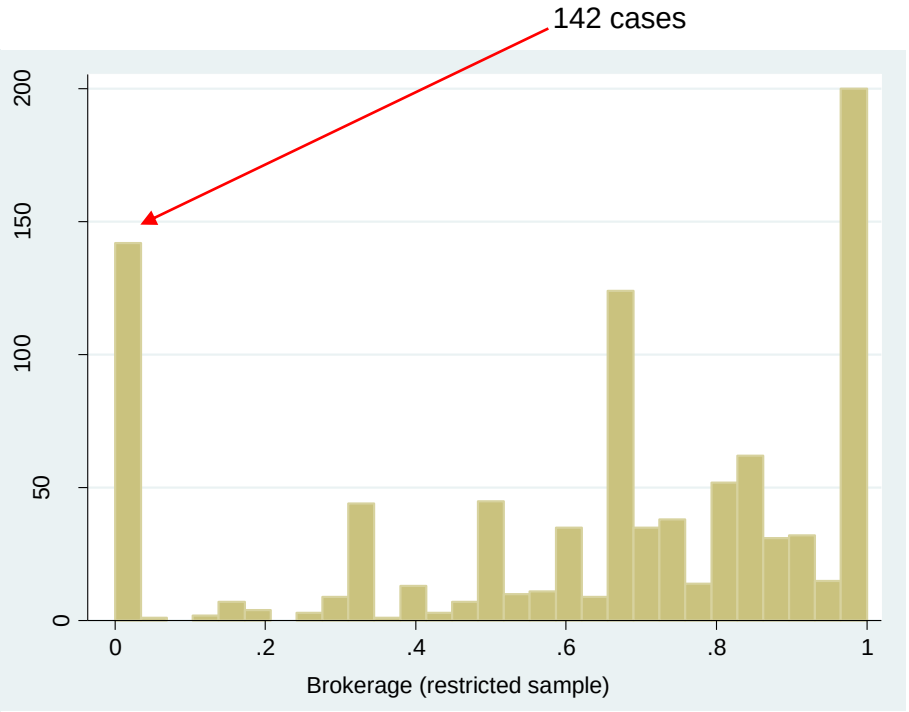
	Alter 1	Alter 2	Alter 3	Alter 4	Alter 5	Alter 6	Alter 7	Alter 8	Alter 9
Alter 2	□								
Alter 3	□	□							
Alter 4	□	□	□						
Alter 5	□	□	□	□					
Alter 6	□	□	□	□	□				
Alter 7	□	□	□	□	□	□			
Alter 8	□	□	□	□	□	□	□		
Alter 9	□	□	□	□	□	□	□	□	
Alter 10	□	□	□	□	□	□	□	□	□

MEASURE of Network Structure

- **Independent variable I: *Ego-network brokerage***

Network structure measures are computed for two samples





Whole sample: N. Obs. 1309

- ***Includes all obs., including those cases reporting zero or 1 external contacts***

Restricted sample: N. Obs. 949

- ***Includes only those cases reporting 2 or more external contacts***

PRELIMINARY CONCLUSIONS

- **Avenues for further research**:
  - Variety of indicators for medical innovation: (i) drug development, (ii) clinical guidelines, (iii) invention and commercialization: and (iv) diagnostics/prevention:
    - ✓ Results by type of medical innovation
    - ✓ Distinct explanatory factors from different types of brokerage
  - Moderating factors:
    - ✓ Interplay between Structure and Composition
    - ✓ Network configuration – Individual Attributes
  - Scientific performance:
    - ✓ to explore whether scientific excellence is a predictor of engagement in med. Innov.
    - ✓ to examine whether scientific performance could contribute to enact personal networks
  - Differences in network configurations for innovation and scientific discoveries

PRELIMINARY CONCLUSIONS

– **Individual attributes** should be explicitly considered as they critically contribute to knowledge creation (in addition to network features)**:**

- **Cognitive breadth**: the **higher** the **diversity** of (basic & clinical) skills, the **higher** the probability of scientists to engage in medical innovation

  ✓ More Inter-disciplinary univ. degree programs - bridging basic and clinical research requires sets of skills that are not typically offered by traditional curricula

- **Perceived impact on beneficiaries**: scientists who are particularly aware of the positive impact they exert on patients and clinical practitioners **exhibit a stronger engagement in multiple forms of medical innovation**

  ✓ Our results support Soc. Psych. Lit. suggesting that when individuals perceive that their actions have an impact on beneficiaries, they become particularly motivated to make a positive difference in the wellbeing of these beneficiaries (developing new med. treatments)

  ✓ Implementation of mechanisms to increase scientists' awareness of the practical impact on patients and clinical practitioners, to foster their participation in medical innovation activities: particularly among **basic** scientists

RESULTS (Ordered Probit)

Dependent variable: Degree of engagement in medical innovation activities *(outcome values: 0 - 3)*

	Total Sample (1111 obs.)				Restricted Sample (820 obs.)*			
	(1a)	(2a)	(3a)	(4a)	(1b)	(2b)	(3b)	(4b)
Predictor Variables								
Ego Net. Brokerage		1.103**	---	0.979**		1.144**	---	1.048**
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- ***Proportion of scientists who participate in the different types of medical innovation, by type of Institution (%)***

	Invention & Commercializ.	Drug Development	Clinical Guidelines	Diagnostics & Prevention	Total obs.
Universisty	19,2	7,5	11,7	8,8	386
Hospitals	12,0	41,4	47,8	12,5	409
Public Research Centres	15,5	8,8	9,4	10,3	341
Private Research Centres & Others	15,2	8,8	12,0	7,2	125
Total	***15,5***	***19,0***	***22,8***	***10,2***	***1261***