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Brokerage roles and medical innovation: an empirical analysis

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Motivation of the paper

- To explore how scientists' brokerage positions facilitates their participation in different activities related to medical innovation.
- To analyze whether different brokerage roles are equally effective in facilitating the scientists' engagement in a range of medical innovation activities.
- To explore whether brokerage positions operate differently if the institutional context of the focal scientist is taken into account.

Knowledge brokerage in the biomedical context

- The biomedical context is composed by many institutionalized occupational boundaries that have a diversity of characteristics and interests (Currie et al., 2012). (e.g.: basic scientists, clinical scientists, practitioners, patients).

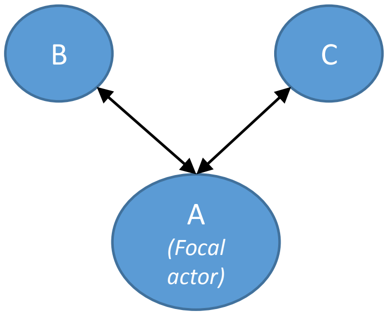
- Need to reduce distance between these actors as a way to translate knowledge "from the bench to the bedside" (Marincola, 2003)

- Thus, "brokers" or "connectors" are critical to translate and coordinate knowledge and interests between disparate communities, as a way to accelerate the diffusion of basic research evidence into clinical practice (Waring et al., 2013).

Background: medical innovation and network brokerage

Knowledge brokerage: definition

In network research, a brokerage position is characterized by the absence of ties between the contacts of a focal actor.



Formally, a *knowledge broker (A)* is a focal actor who mediates the flow of knowledge between two other unconnected actors (Burt, 1992, Wasserman & Faust, 1994). Knowledge and resources between B and C only flow through A.

Background: medical innovation and network brokerage

What is behind the network advantage

Network theory predicts that knowledge brokers' advantage come in two forms:

- An ***information*** advantage. Being a broker provides more opportunities to:
  - …tap into diverse knowledge
  - …spot similarities between unrelated knowledge
  - …synthesize contradictory points of view
  - …come up with novel ideas

  → brokers are in a better position to innovate

- A ***timing*** advantage. Brokers have a faster access to new knowledge (Burt, 1997, 2007). Therefore, where timing is rewarded, a brokerage position may provide a crucial advantage.

Network brokerage and medical innovation

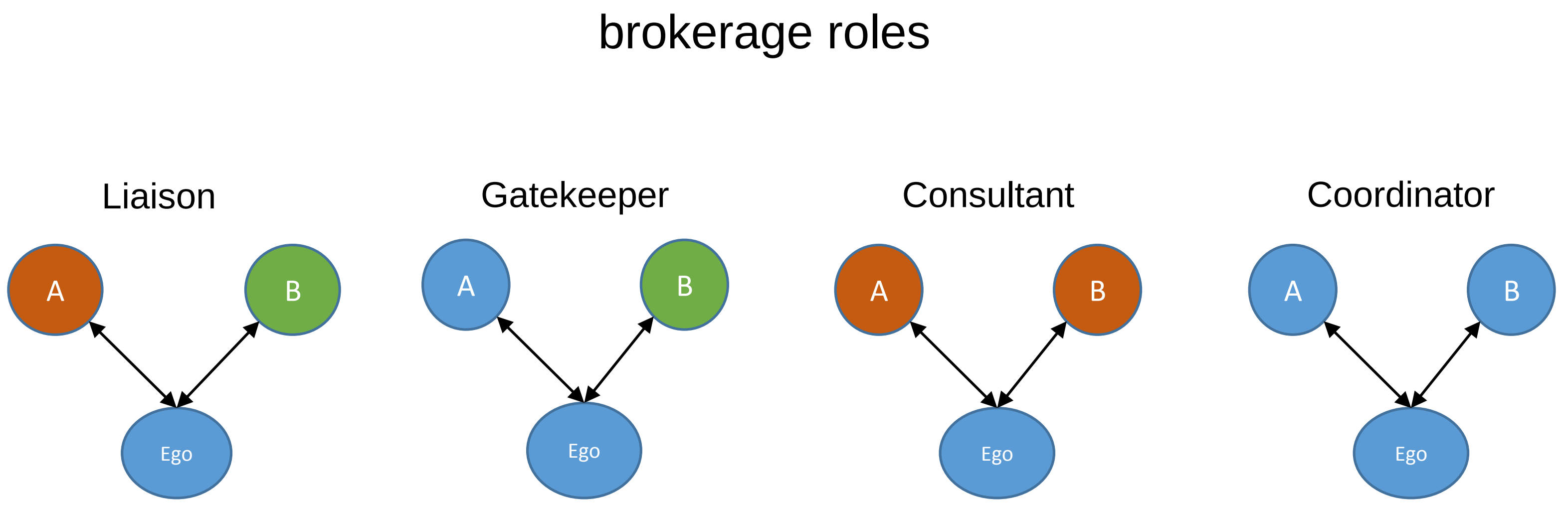
The dark side of brokerage positions

- Holding brokerage positions also entails coordination and cognitive costs for the focal actor:

Coordination costs	Cognitive costs
Maintaining a too large set of brokerage positions may distract the focal actor to engage in other activities that may be also crucial to innovate (Perry-Smith & Shalley, 2003).	When the number of ties is too large, individuals are likely to experience information overload: They may be unable to cope with voluminous and discordant information (Zhou et al. 2009)
A large set of unconnected contacts undermines the creation of trust between the network members and thus, hinders the transfer of tacit knowledge (Coleman, 1998, Hansen, 1999)	Sparse networks are formed by diverse people that are inherently more difficult to mobilize or coordinate, due to disparate interests, perspectives and languages.
Coordination costs accrue from the **structure** of the network (keeping and maintaining a large set of unconnected contacts)	Cognitive costs accrue from the **content** of the network (dealing with an overload of disparate knowledge and interests)

Brokerage roles and medical innovation

- To better understand the link between brokerage positions and medical innovation, we propose to analytically decompose brokerage positions into different types, based on the type of actors each node is connected to (Gould & Fernandez, 1989).



*Colours represent different institutional affiliations or professional groups

Distinctive effects of brokerage roles on medical innovation

- The potential benefits and costs of brokerage partly depend on the diversity of actors involved in the relationship.

Higher knowledge diversity

Lower knowledge diversity

	Knowledge diversity	Cognitive costs	Coordination costs
Liaison	High	High	constant
Gatekeeper	Medium	Medium	constant
Consultant	Medium	Medium	constant
Coordinator	Low	Low	constant

- Cognitive costs depend on the brokerage role played by each actor. Coordination costs arise irrespective of the brokerage role, because they arise from the structure of the ego-network.

- Being a **liaison** means that the broker is an outsider with respect to both contacts he is linking. The actor's role is to link different groups. That means: greater opportunities to obtain heterogeneous knowledge. However, it also requires greater cognitive efforts to integrate and coordinate the disparity of interests.

- Being a **coodinator** means that all actors belong to the same group, so the brokerage relation is completely internal. That implies:
  - Lower access to heterogeneous perspectives.
  - Lower coordination costs.

- **We expect different brokerage roles having distinct effects on medical innovation**

Distinctive effects of brokerage roles: hypotheses

- *Gatekeeper* positions will provide the greater balance between benefits and costs of brokerage. Thus, gatekeeper positions will be more strongly associated to the scientists' participation in a range of medical innovation activities, compared to other positions.

Hypothesis 1*: There is a positive association between holding gatekeeper positions and participating in medical innovation activities.*

- Occupying *coordinator* positions will be the less effective brokerage role in predicting the scientists' participation in medical innovation activities, because it provides the lower access to heterogeneous actors.

The influence of the institutional context

- Network studies have provided growing empirical evidence on the importance of brokerage. However, scarce attention has been given to the institutional and organizational context where social interactions take place (Pachucki & Brieger 2010).

- We know that the institutional settings where scientists work present distinctive goals, values, incentive structuresand cultural norms (Dasgupta & David 1994, Whitley 2000)

- In hospital settings the participation in medical innovation activities is partly embedded in the values and institutional norms. Moreover, access to critical contacts and resources to do so might be more easily found inside the institution.

Hypothesis 2*: Working in hospital settings weakens the positive connection between gatekeeper positions and participation in medical innovation activities.*

Research context and methods

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 scientists from universities, hospitals and research centers working on similar fields.
- Organize biomedical research around **nine** 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 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**.

Overall response rate = 28 % (1,309 valid responses)

Dependent variables: medical innovation categories

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

Responses could range from 0 (never) to more than 10 times.

Items	Categories
Patent applications for new drugs	
Granted licenses from patents	DV 1: Commercialization
Participation in spin-off	
Clinical trials phases I, II or III for new drugs development	
Clinical trials phase IV for new drugs development	DV 2: New drug development
Clinical trials phase IV for new diagnostic techniques	
Clinical guidelines for healthcare professionals	DV 3: Clinical guidelines
Clinical guidelines for patients	
Patent applications for new diagnostic techniques	
Clinical trials phases I, II or III for new diagnostic techniques	DV 4: Diagnostics and prevention
Clinical guidelines for the general population (prevention)	

- Factor analysis showed the existence of four categories / forms of medical innovation
- DVs: frequency in which scientists have participated in any of the activities listed in each category

Independent variables: brokerage roles

We followed an ego-centric network approach (e.g.: Baer, 2010; Smith et al., 2005) to capture each scientist' personal network structure and composition.

- **Personal network size:**

  Respondents were asked to write down the names of those persons (up to ten) from outside their research group that were of critical importance for the advancement of their research activities.

- **Personal network composition**:

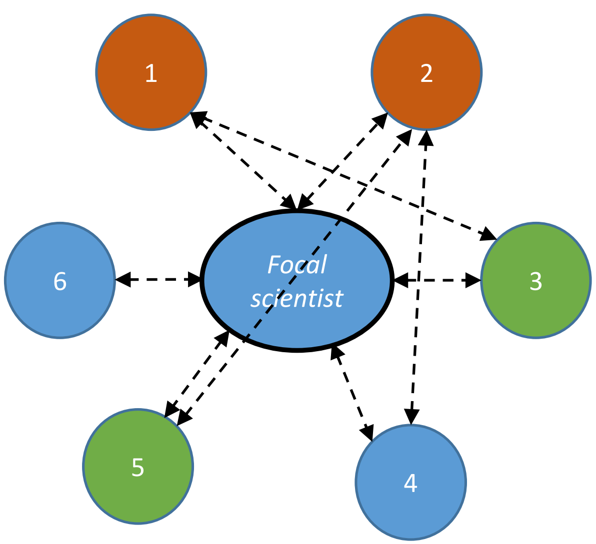
  Respondents were asked to classify each of the contacts previously mentioned into any of the following professional groups: 1=basic scientists, 2=clinical scientists, 3=medical practitioners / patient representatives, 4=public administration, industry / other.

- **Personal network structure**:

  Respondents were presented an alter-alter matrix and were asked to report whether the set of contacts previously mentioned know each other.

Independent variables: brokerage roles

- Personal network structure and content allowed us to compute the brokerage roles.
- We followed Gould and Fernandez (1989) procedure to count separately the number of times each scientist is playing any of the four brokerage roles, based on the affiliations of the three nodes involved in the triadic relationship.
- The same scientist can simultaneously play different brokerage roles. Example:

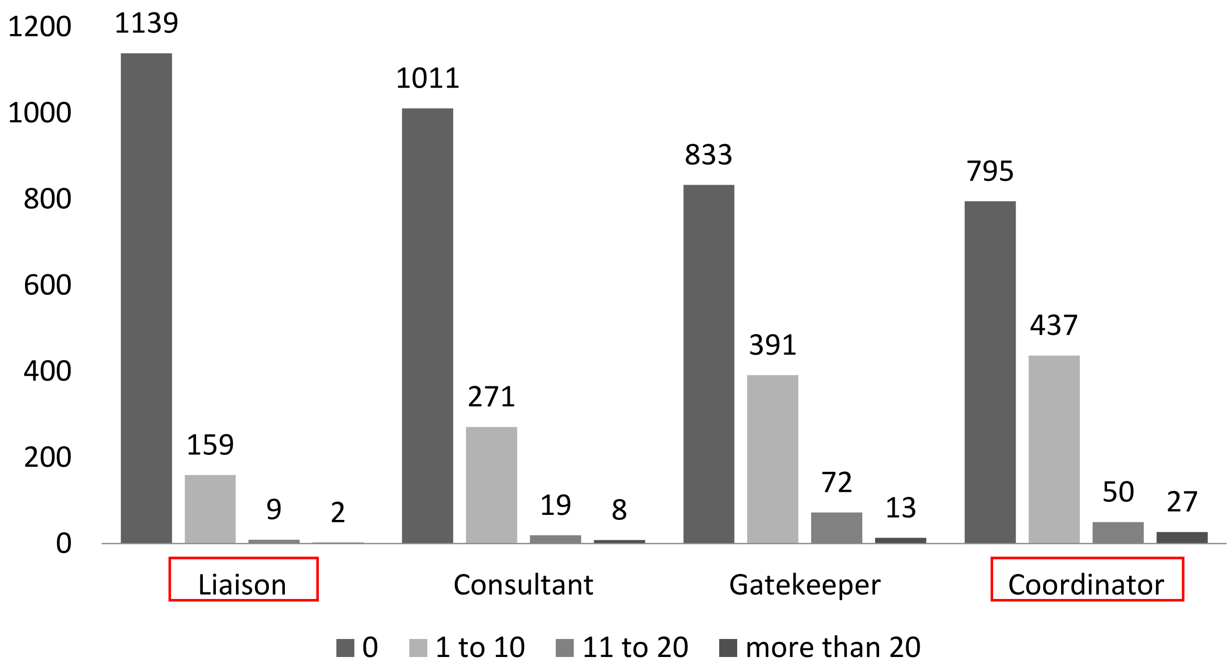


(orange)	Basic scientist
(blue)	Clinical scientist
(green)	Firm employee

Focal scientist is a clinical scientist with 6 direct contacts
He plays 12 brokerage roles:

Coordinator: n=1 (4-6)
Consultant: n=2 (5-3; 1-2)
Gatekeeper n=7 (4-5; 4-3; 4-1; 6-1; 6-2; 6-3; 6-5)
Liaison: n=2 (5-1; 2-3)

Frequency of brokerage roles



- Most of the scientists do not play any brokerage role at all.
- *Coordinator* is the most frequent role.
- Being a *liaison* is particularly rare
- Different brokerage positions are weakly correlated between them

Control variables and econometric model

- **Individual level**:

- Age
- Gender
- Academic position
- External network size

- **Group and Institutional level:**

- Research team's size
- Institutional affiliation: University, Hospital, PROs and Others
- Type of CIBER
- Research teams' past scientific performance
- Research teams' past technological performance

- **Econometric model**

- Our DVs are a count of scores, suggesting the use of a count model.
- DV is skewed. We used a negative binomial regression
- Robustness check with Poisson and OLS

Preliminary results: brokerage roles and medical innovation

Main variables	Commercialization	Drug development	Clinical guidelines	Diagnostics & prevention
Liaison	0.049*	-0.021	0.037	0.048*
	(0.03)	(0.04)	(0.03)	(0.03)
Gatekeeper	0.047**	0.047**	0.041	0.055***
	(0.02)	(0.02)	(0.03)	(0.02)
Consultant	0.009	0.004	-0.021	-0.024
	(0.02)	(0.03)	(0.03)	(0.03)
Coordinator	-0.017	-0.069***	-0.013	-0.061***
	(0.02)	(0.02)	(0.03)	(0.02)
Observations	1094	1095	1095	1095
Pseudo – R^2	0.113	0.0864	0.0738	0.0496

H1 Gatekeeper is positively related to 3 of 4 innovation categories

Negative effect of being a coordinator

* p < 0.1, ** p < 0.05, *** p < 0.01

Control variables: age, academic position, group size, institution type, CIBER, affiliation type, ego-network size, gender, group scientific performance, group technological performance

Preliminary results: distinctive effects in hospital / non-hospital settings

Split sample analysis. Scientists working at hospitals (n=397) vs scientists not working at hospitals (n=698)

Econometric model: negative binomial regression

	Hospital				Non – hospital			
Main variables	Commercializ.	Drug development	Clinical guidelines	Diagnostics & prevention	Commercializ.	Drug development	Clinical guidelines	Diagnostics & prevention
Liaison	0.063**	0.007	0.049	0.048	-0.004	-0.074	0.047	0.055
	(0.03)	(0.06)	(0.03)	(0.04)	(0.07)	(0.07)	(0.07)	(0.04)
Gatekeeper	-0.028	0.059*	-0.002	0.075**	0.068**	0.057	0.081**	0.053**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)
Consultant	0.036	-0.052	-0.006	0.051	0.008	0.029	-0.044	-0.076**
	(0.04)	(0.04)	(0.04)	(0.06)	(0.03)	(0.06)	(0.04)	(0.03)
Coordinator	-0.011	-0.026	0.017	-0.084**	-0.019	-0.119***	-0.007	-0.044*
	(0.04)	(0.03)	(0.02)	(0.04)	(0.02)	(0.04)	(0.04)	(0.02)
Observations	396	397	397	397	698	698	698	698
Pseudo R^2	0.144	0.0683	0.0837	0.102	0.131	0.0801	0.0795	0.0630

H2

- p < 0.1, ** p < 0.05, *** p < 0.01

Wald tests show significant differences on the predictive power of *gatekeepers* in both contexts.

Being a gatekeeper is particularly important in non-hospital settings as a facilitator of the participation in medical innovation

Contributions and preliminary conclusions

- We provide empirical evidence on the relevance of brokerage to facilitate medical innovation. Existing research has been prescriptive or qualitative (e.g.: Currie & White, 2012, Waring et al., 2013).

- We adopted the Gould and Fernandez (1989) classification of brokerage types to count the frequency of scientists holding *liaison*, *gatekeeper*, *consultant* and *coordinator* positions.

- We emphasized the trade-off of benefits and costs of holding brokerage positions.

Contributions and preliminary conclusions (ii)

- We found that the positive effects of brokerage is not that evident if the distinction between brokerage roles is considered: gatekeeper provides the greater advantage.
- We found that being a coordinator may have negative effects on the scientists' propensity to participate in medical innovation.
- We found that the benefits of *gatekeeper* positions operate differently in hospital and non-hospital settings, showing evidence of its critical importance for non-hospital scientists.

Thank you!

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Descriptive statistics

	Mean	SD	Min	Max
Commercialization	0.267	1.133	0	28
Drug development	0.562	1.759	0	22
Clinical guidelines	0.514	1.392	0	14
Diagnostics and prevention	0.328	1.284	0	30
Liaison	0.483	1.871	0	27
Gatekeeper	2.265	4.500	0	25
Consultant	0.940	2.971	0	32
Coordinator	2.259	5.050	0	45
Large ego-network size	0.310	0.463	0	1
Age	41.894	10.651	23	78
Academic position	3.029	1.316	1	6
Group size	18.248	10.457	2	79
Institution type	2.050	0.874	1	4
CIBER	4.581	2.573	1	9
Affiliation type	1.850	0.511	1	3
Ego-network size < 2	0.265	0.442	0	1
Gender	1.531	0.499	1	2
Group scientific performance	53.943	46.351	3	295
Group technological performance	1.002	2.248	0	21

Dependent variables: medical innovation categories

	Mean	SD	Min	Max
DV 1: Commercialization	0.267	1.133	0	28
DV 2: Drug development	0.562	1.759	0	22
DV 3: Clinical guidelines	0.514	1.392	0	14
DV 4: Diagnostics and prevention	0.328	1.284	0	30

- Factor analysis revealed the existence of four distinct categories of medical innovation activities.
- Dependent variables: count of the frequency each scientist has been engaged in any the activities of each category.
- Because they are count of scores, variables take on non-negative integer values
- We selected a negative binomial model to adress the overdispersion and the prevalence of 0 counts in the DVs.

Preliminary results: distinctive effects in hospital / non-hospital settings

We performed four Wald tests to take account of the covariance in the parameters across the two models (hospitals vs non-hospitals). We compared the coefficients of Liaison, Gatekeeper, Consultant and Coordinator in both models and for our four dependent variables.

We found that:

- Occupying *gatekeeper* positions is particularly important among non-hospital settings as an antecedent to their participation in medical innovation activities.

- Occupying *liaison* positions is particularly important for hospital scientists to facilitate their engagement in commercialization activities.