UCA
"Networks, Information and Digital society" Academy of Excellence

Internal Project Proposal

April 2018

Project Information Sheet

Project Acronym	**SNIF**
Project Title	**S**cientific **N**etworks and **I**DEX **F**unding
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PI E-mail	patrick.musso@unice.fr
Partner 1	GREDEG – UNS
Partner 2	I3S – UNS
Partner 3	INRIA Sophia Antipolis
Partner 4	SKEMA Business School
Total requested funding	250 K€
Which domain is most concerned?	Network

Summary:

Scientific collaboration networks play a crucial role in modern science. This simple idea underlies a variety of initiatives aiming to promote scientific collaborations between different research teams, universities, countries and disciplines. The recent French IDEX experience is one of them. By fostering competition between universities and granting few of them with a relatively small amount of additional resources (as compare to their global budget), public authorities aim to encourage them to deeply reshape the way academic activities are organized in order to significantly increase the quality of their research, educational programs and innovative activities. The development of new collaboration networks is one of the factors at the heart of this global reorganization. Promoting new international and/or interdisciplinary collaborations is supposed to increase researchers' productivity and industry partnerships. This project aims to question the validity of this line of thought. To do this, we will develop both quantitative and qualitative comprehensive analyses. The quantitative analyses will use bibliometric and patent databases to build complex collaboration networks involving researchers of all French institutions that applied to the different waves of IDEX program. The shape and dynamics of these networks will be compared across IDEX applicants to determine if researchers affiliated to a university awarded with IDEX changed their collaborative behavior. Modern microeconometric methods will then be applied to detect if awarded universities benefited from a significant change in the quality of their scientific production (measured by publications and patents) and if this change can be attributed, at least partly, to the network transformation. Qualitative analyses will complement the quantitative ones by conducting semi-structured interviews with researchers involved in IDEX programs. The interviews will investigate the way the dramatic changes implied by the implementation of IDEX programs are perceived by the researchers, the challenges raised by interdisciplinary research collaborations, the researchers' underlying motives to build scientific networks, and the fine-grained content of their informal information exchange. This qualitative research will shed a complementary light on the results that will emerge from the quantitative analysis.

Scientific Context:

This ambitious interdisciplinary project will structure a research team bringing together researchers in computer science, economics, management and sociology from four UCA partners (GREDEG, I3S, INRIA Sophia Antipolis and SKEMA Business School). The intensive transdisciplinary nature of the project relies on the analysis of complex networks that will be at the heart of the scientific contributions of all participants. This shared use of complex networks analysis will imply close collaborations between computer scientist and social scientist at every stage of the project.

Regarding the state of the art in economics, this project will speak to two strands of literature. The first strand aims to estimate the impact of public funding on researchers' scientific productivity. Surprisingly, despite the growing pressure to document the effectiveness of the use of public money, the extant empirical literature on this subject is still limited[1] and far from reaching a consensus. We will contribute to this literature by analyzing the IDEX case. A second contribution will be to complement the standard measures of publication productivity with other outcomes

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[1] Some notable exceptions are Arora et al. (2000); Arora and Gambardella (2005); Carayol and Lanoë (2017) Gush et al. 2015; and Jacob and Lefgren (2011).

(Lane and Bertuzzi, 2011). Specifically, we will investigate the effect of research public funding on the researchers' academic patenting activity, that is part of a broader research topic of the university-industry technology transfer (Henderson et al., 2003; Lissoni et al., 2008; Azoulay et al., 2015). SNIF project will speak to a second literature strand studying the researchers' collaboration. The extant empirical results show a trend of increasing co-authorships in scientific publications and co-inventorship in patents (Wuchty et al., 2007). However, the dynamics behind the formation and evolution of the researchers' network are still largely unexplored (Börner et al., 2010) and there is not conclusive empirical evidence on the effects of researchers' collaboration on their productivity (Defazio et al., 2009; Gush et al., 2015; Katz and Martin, 1997; Lee and Bozeman, 2005). We will contribute to this literature by assessing the effect of public funding on researchers' techno-scientific network of collaborations[2]. Regarding the computer science literature, we will propose models of dynamic weighted networks with disruptive changes on the weight and investigate the evolution of such networks. The weight will be assigned according to the IDEX funding decisions. This is a novelty over literature which mainly considers the evolution of networks without weight changes (Albert and Barabási, 2000). We will investigate metrics to measure the impact of funding on the network global structure, i.e., clustering level and of speed of information diffusion, using methods from graph theory (Crescenzi et al., 2013), complex networks (Luxburg, 2007) and statistical physics (Reichardt and Bornholdt, 2006). Finally, our project will build on the sociological and managerial literature on social networks, innovation and creativity. Indeed, within this literature, two main approaches have been developed. A wealth of social network research has shown that boundary-spanning ties, i.e., social relationships that reach diverse social circles and bridge unconnected individuals, are essential for generating creative ideas and innovation because they provide access to non-overlapping knowledge content. (e.g., Baer, 2010; Brass, 1995; Perry-Smith and Shalley, 2003; Fleming et al., 2007; Zhou et al., 2009). Based on seminal network theories (Granovetter, 1973; Burt, 2004), the general premise underlying most of this research is that weak ties provide access to people that are members of different social circles and thus to diverse information. On the other hand, the "strength of strong ties" (Krackhardt et al., 1992) perspective argues that strong ties are more crucial for creativity because they provide benefits such as reciprocal trust, collaboration, risk sharing and complex knowledge transfer, which in turn support creativity (e.g. Starkey et al., 2000). Weak and strong ties perspectives thus provide a rich and complementary understanding of why and how these ties (strong or weak) enable informal exchanges whose content (support, help, information, and knowledge) is useful for creative workers. However, focusing on the strength of ties (especially with a quantitative approach) has drawn researchers' attention away from the complexity and diversity of exchange behavior (Conway, 1995, p.329). More specifically, we do not know much on *how* researchers build social networks, why they turn to one person (or one laboratory) and not to another, and *what is the content* of their exchange at different stages of their research projects. To address these issues, we will conduct a series of in-depth interviews, with two main objectives: (i) to understand how researchers perceive and understand the new organizational context that the IDEX offers, and the strategies they develop; (ii) to build a detailed, comprehensive typology of the different exchange relationships that researchers build and develop at different stages of their research projects, including a detailed description of the different resources they exchange.

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[2] The term techno-scientific network refers to the two kinds of relationships investigated in SNIF project. We will consider both the technology network, where nodes are inventors and edges are co-inventor relationships, and the scientific network, where nodes are scientists and edges are co-author relationships.

Partnership

Partner	Keywords	Members	Appointment
GREDEG	Bibliometric data, microeconometrics, technology transfer, scientists' productivity, sociology of innovation	Gérald Gaglio Patrick Musso Michele Pezzoni	PR PR MCF
I3S	Network theory, empirical network analysis, network topology	Frederic Giroire Guillaume Urvoy-Keller	CR CNRS PR
INRIA Sophia Antipolis	Graph theory, network analysis	David Coudert Nicolas Nisse	DR INRIA CR INRIA
SKEMA Business School	Bibliometric data, microeconometrics, empirical network analysis, management of creativity and innovation	Mark McCabe Ludovic Dibiaggio Nathalie Richebé	PR PR PR

Challenges, methodology and scientific program

The project consists of 3 main phases over a total duration of 3 years. During this period, the SNIF team will conduct both quantitative and qualitative analyses.

First phase: Data collection (duration 1 year)

Three types of data will be collected: Bibliometric and patent data, data on IDEX specificities, and data on the use of funds.

Bibliometric and patent data will be collected for all the French researchers affiliated to the eleven universities awarded with IDEX funds (including UCA) as well as for the researchers affiliated to the eight universities which applied for IDEX funds but have not been awarded[3]. The sources of raw publication and patent data will be the bibliometric databases *SCOPUS* (Elsevier), *Web of Science* (Clarivate Analytics) and *Patstat* (European Patent Office). Access to these databases will be provided by the platform INSEE@UCA recently launched by UCA (see Section *Positioning with regard to the Idex UCA[JEDI]*).

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[3] In our analysis we consider both waves of IDEX funding, namely the 2011 wave (PIA1) and the 2015 wave (PIA2). Seventeen universities applied to the PIA1 and eight have been awarded with funds, while seven universities applied to PIA2 and three have been awarded with funds. Overall, we count nineteen distinct universities that applied to IDEX (PIA1 or PIA2) and eleven universities awarded with IDEX (PIA1 or PIA2). We will not include in our analysis the universities applying for I-SITE funding.

To identify each IDEX program's specificities (main claims, priorities, relevant statistics, etc.), we will collect complementary data examining the existing documentation for all the nineteen IDEX applications (universities' application documents, IDEX websites created by the universities, etc.).

Finally, at the local level of UCA, we will take advantage of the availability of very detailed data on every research project funded by the UCA^{JEDI} program to build a comprehensive dataset that will feed quantitative and qualitative analyses of the UCA researchers.

Second phase: Data analysis (duration 1 year and 6 months)

This project will articulate quantitative and qualitative analyses at both national level and UCA level. The quantitative approach will rely on up-to-date microeconometric and network techniques and will concern two dimensions of researchers' activity: research productivity and techno-scientific collaboration networks.

Regarding the first dimension (research productivity), we will count researchers' scientific publications and patent applications. Then, we will consider the quality of such outcomes, as proxied by the citations received by the researchers' works. Moreover, we will use the patent information to construct a proxy for the researcher's collaboration with industry. Specifically, we will trace the researcher's inventions, i.e., academic inventions[4], owned by private firms. To assess the IDEX impact on researchers' productivity, we will compare the productivity of researchers affiliated to universities awarded with IDEX and the productivity researchers affiliated to universities not awarded.

Regarding the second dimension (techno-scientific collaboration network) we will consider researchers' co-authorship and co-inventorship networks. Relying on bibliometric and patent information, we will measure the researcher's national, international, and interdisciplinary collaborations. Moreover, we will trace the evolution of the researcher's role played within the network. We will describe the researcher's role by using standard network indicators calculated at node level such as, centrality, betweenness, and clustering. We will analyze also the whole network topology. We will propose models of dynamic networks (e.g. attachment preferential based models (Albert and Barabási, 2000)) to explain the two main properties of the techno-scientific collaboration network: clustering level and the speed of information diffusion. In particular, we will assess if IDEX funding led to a change in the number and size of clusters and in the speed of diffusion of information (research results, measured by the average path length of the graph and diameter in the graph of citations).

Our qualitative work will consist in a series of 30 interviews conducted with researchers of different profiles and disciplines who are members of UCA. The interviews will be taped and entirely transcribed. We will code the responses and observations using the qualitative data analysis software package N'Vivo 11. In this exploratory research, we will allow researchers' categories to emerge from the data rather than establishing categories from the outset. This process will allow us to cross the emergent codes of data and to keep track of the emerging categories – following the method described by Gioia et al. (2010), who themselves claims to follow the ethnographic methodology anchored in the tradition of grounded theory (Glaser and Strauss, 1967). While developing our conclusions, subsequent meetings with the actors will enable to carry out member checks (Lincoln and Guba 1985), also known as "ecological validity," to test that the relevance of

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[4] Academic inventions are those patented inventions having at least one university researcher among the inventors

our interpretation is confirmed by those who experience our creative phenomenon on a day to day basis on the ground (Nag, Corley, Gioia, 2007). This process will improve the credibility of the results by enabling those who took part in the study to comment on its results.

Third phase: Result dissemination (duration 6 months)

We are planning to present our results in research seminars in the leading European and US institutions within the field. Candidate institutions are the University of Bordeaux, EPFL, CERST-INSEE, KU Leuven, Georgia State University, Boston University, the NBER (Cambridge, Massachusetts), and University of Torino. We are also planning to submit the results of our study to the following conferences: The Organization Economics and Policy of Scientific Research Annual Meeting, the DRUID conference, the American Economic Association Meeting, the Academy of Management Meeting (AoM). An international interdisciplinary workshop will be organized to disseminate our results and increase the international visibility of UCA in this field.

Main technical challenges

We identified in this project 3 main technical challenges we will have to face:

Algorithms: The techno-scientific network is large. Computing properties of such graphs is challenging. To succeed, we will use methods from graph theory (Crescenzi, et al., 2013), complex networks (Luxemburg, 2007) and statistical physics (Reichardt and Bornholdt, 2006).

Metrics: The impact of IDEX might not be immediate. The publication process requires time, especially in some disciplines such as social sciences. For this reason, we will include working papers among the publication outcomes for those disciplines characterized by a particularly long publication process (web scraping techniques will be applied to retrieve working paper metadata). Moreover, in our analysis of the dynamics of the techno-scientific network, we will devote particular attention to develop metrics able to measure the creation of important (and probably rare) new edges leading to interdisciplinary scientific publications and to collaboration of inventors specialized in different technologies.

Unbiased estimation of the IDEX impact: Assessing the impact of IDEX funding on researchers' productivity and collaboration networks is subject to omitted variable bias. That is, if unmeasured characteristics at IDEX applicants (e.g. aggregate researcher quality) is correlated with the likelihood of receiving IDEX funding, then a failure to account for these omitted factors may bias our estimates of this funding/productivity and network relationship. The typical solution under these conditions is to observe the dependent variable (in this case, researcher productivity and collaboration network) over time so that fixed effects can be specified to "difference out" the unmeasured characteristics, removing the bias (see McCabe and Snyder, 2015). Since we will be collecting time series data for each IDEX applicant's researchers, we expect to be able to mitigate any potential bias. To assess the robustness of our results, we will apply as alternative estimation strategy a difference-in-difference approach comparing researchers affiliated to awarded and not awarded universities. We will consider also a variant of the difference-in-difference approach by comparing researchers affiliated to awarded universities with a matched control sample of French researchers with similar characteristics (to the awarded researchers) but not necessarily affiliated to universities not awarded (diff-in-diffs on a matched control sample) (Jaffe, 2002).

Role and contribution of each partner

GREDEG and SKEMA participants, will contribute to the project with their competences in the fields of *microeconometrics*, *economics of science, sociology and management of science and*

innovation. They will leverage on their experience in studying the impact of funding on scientific productivity of academic researchers and on their experience on the themes of innovation and technology transfer activities between university and industry. Their participation to the project is motivated by the possibility of studying a case of research public funding with unique characteristics, namely the IDEX funding program in France.

I3S and INRIA participants will contribute to the project providing their experience in the analysis of large networks and their knowledge of the graph theory, algorithms, and complex network theory. Their motivation to participate to the project is the opportunity to study the characteristics of networks of scientists and inventors, which is a large directed dynamic network.

PhD and Postdoc

A PhD student and two Post-docs will be hired. The PhD student's doctoral thesis will be in the field of economics of science supervised by the GREDEG and SKEMA participants. One Post-doc will be under the supervision of the I3S and INRIA participants, the second one will work in the field of sociology and management of innovation supervised by GREDEG and SKEMA participants.

The PhD student will spend the first year coordinating the activities of database creation and harmonization (*data collection*). Moreover, she will be responsible of the production of a short document describing the peculiarities of the nineteen universities that applied to IDEX. During the second phase (*data analysis*), lasting approximately 1 year and 6 months, the PhD student will apply econometric techniques to estimate the IDEX effect on researchers' productivity. She will also conduct an analysis of the techno-scientific network evolution with the support of the I3S and INRIA participants. During the second phase, she will be responsible for the production of two drafts, one concerning the impact of IDEX at national level and one concerning the impact of IDEX at UCA. In the last 6 months, the PhD student will contribute to the diffusion of the results by participating to international conferences (*Result dissemination*).

The post-doc in the field of sociology and management of innovation will conduct an in-depth literature review on scientific collaboration networks. Then she will select a panel of representative researchers and conduct a series of 30 interviews. To build the interview guideline, findings from the quantitative analysis will be taken into consideration (some questions might be designed to help interpret specific results). Interviews will be entirely taped and transcribed to be coded and analyzed using the qualitative data analysis software package N'Vivo 11. During the last 6 months, she will start developing research articles, and contribute to the diffusion of the results by participating to international conferences.

The post-doc in computer science will be hired for the second year of the project. We will target a specialist in algorithms for large networks. She will be in charge of helping the PhD student in the second phase of her project, *data analysis*. In particular, she will develop algorithms to compute global properties of the network (clusters, time to diffusion information, …), then propose models of dynamic networks to explain its properties. She will participate to *result dissemination* by writing papers targeting international conferences and journals.

PhD and Postdoc activity schedule

	Month 6	Month 12	Month 18	Month 24	Month 30	Month 36
PhD in economics of science						
Data collection	███	███				
Data analysis			███	███	███	
Result dissemination						███
Post-doc in computer science						
Data analysis (Algorithms)			███			
Data analysis (dynamic network models)				███		
Result dissemination				███		
Post-doc in sociology and management of innovation						
Literature review		███				
Data collection (interviews)		███	███			
Data analysis			███			
Results dissemination			███			

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Expected Outcomes

Our project will pursue several scientific objectives. First, it will cast light on the impact of public funding on scientific and techno-scientific collaboration networks. Second, it will produce a comprehensive, quantitative, and rigorous exercise of policy evaluation on the effect of obtaining IDEX funds. Finally, we expect our project to help gain a better understanding of the main limitations and challenges that researchers experience in building collaboration networks. It will therefore highlight how initiatives such as IDEX could better accompany and support the emergence, growth, efficiency and persistence of research collaboration networks.

This project will not only foster interdisciplinary research between the partners, but also lead to new research in their respective scientific domains. For instance, members of INRIA and I3S will have to design new or improved algorithms for measuring various properties of the networks, in particular when existing algorithms do not scale the size of the networks we will study or are not suitable for dynamic networks.

The research conducted in this project is also expected to benefit to other connected research projects such as the *Regional Expertise Alignment and Firm Performance* IDEX project headed by Ludovic Dibiaggio (SKEMA Business School). The work that will be done to collect and organize bibliometric databases (especially regarding disambiguation issues) could also be useful for the UCAGATE platform (see the *Positioning with regard to the Idex UCA[JEDI]* Section below).

More generally, one important ambition of the project is to structure long-term interdisciplinary scientific collaborations among UCA members to study social interaction networks in various domains of application.

The expected outcome of the project are publications on high-quality journals and an international interdisciplinary workshop organized at UCA to disseminate our results and increase the international visibility of UCA.

Requested funding

For the 3 years of duration of the project, the total requested funding, including the funding of 1 PhD Student and 2 Post-docs, comes to 250 K€(see template below).

Other secondary academies potentially concerned:

Our project is also related to Academy 2, "*Complex systems*" and Academy 5, "*Human societies, Ideas, and Environments*".

Academy 2: "Complex systems"

The SNIF project analyzes large networks of social interactions between scientists and inventors. These networks are complex systems. The analysis of their characteristics and dynamics fits the scientific objectives of Academy 2 that aims to "discover the common fundamental principles that govern behavior of complex systems". This project is also in line with two of the major ambitions of this Academy, namely "encouraging, in transversal research topics, the identification of common methodological approaches and the emergence of shared study objects" and "creating and reinforcing links between teams from different domains, and combining existing skills in UCA^{JEDI}, in modeling and simulation of complex systems, in order to place them effectively in the service of current significant societal issues". The funds requested to Academy 2 will be used to provide good working conditions to the PhD student and the 2 Post-docs (computers, software, missions, etc.) and to organize a scientific interdisciplinary workshop to confront and disseminate the results of our research.

Academy 5: "Human societies, Ideas, and Environments"

The SINF project brings together 6 researchers in social sciences to study social interactions between scientists, using both quantitative and qualitative methods developed in the fields of economics, management and sociology. The topic of the project, its interdisciplinary nature and the composition of the research team fit the objectives of Academy 5 and the criteria of its call for project. The funds requested to Academy 5 will be used to hire a Post-doc for one year (from January to December 2019) in order to conduct the highly time-consuming face to face interviews required by the qualitative part of our study.

Positioning with regard to the Idex UCA^{JEDI}

This project is closely related to the structuring UCA^{JEDI} Program "Social Interactions and Complex Dynamics" and, more precisely, to the project "Regional Expertise Alignment and Firm Performance". It is also related to the IDEX platforms INSEE@UCA and UCAGATE.

The project "Regional Expertise Alignment and Firm Performance" is headed by Ludovic Dibiaggio (SKEMA Business School). This project analyses the ability of regions to exploit potential synergies between local scientific and technological expertise (what we call regional alignment, RA) to improve regional economic performance. The working assumption is that regions that have invested in scientific domains and technological fields with complementary properties may have developed institutions and collaboration infrastructures between universities and local entrepreneurs that facilitate technological transfers, and therefore innovative capacities. Relying on the RA framework, our project will test whether, everything else being equal, RA positively interacts with IDEX funding to (i) affect researchers' productivity and (ii) increase innovative productivity (e.g. local patent authors' outcome).

INSEE@UCA (INdicators of Evolution of Science and Education at UCA) is a platform recently created by UCA with the aim to produce quantitative monitoring indicators for a variety of IDEX programs (L@UCA and Disrupt Campus, among others). Headed by Ali Douai and Patrick Musso, INSEE@UCA will provide us with the raw bibliometric and patent data needed for the quantitative analyses.

UCAGATE is a project of platform headed by Pierre Kornprobst (INRIA) et Mylène Leitzelman (Mnemotix). It aims to use web semantic and network analysis techniques to map the scientific competencies of UCA researchers to facilitate technology transfers. So far, the UCAGATE project members are using the *HAL* open access repository online archive to build their bibliometric database, which is a strong limitation. The UCAGATE project could greatly benefit from the work that will be done in our project to build comprehensive bibliometric databases from *SCOPUS* and *The Web of Science* sources.

TEMPLATE
RÉPONSE A UN AAP
➢ Partie budgétaire

IMPORTANT :
- Les porteurs soumettant un projet relevant du périmètre de plusieurs Académies d'Excellence et souhaitant bénéficier du financement conjoint de plusieurs académies sont invités à déposer un seul dossier auprès de "l'Académie de référence" qu'ils ont choisie, en y présentant à la fois le budget global et la ventilation demandée entre académies.
- Les porteurs sont invités à préciser la somme demandée à chacune des Académies concernées.

Dépenses		Description	Ventilation envisagée par Académie *(si applicable)*					Total
			A1	A2	A3	A4	A5	
Fonctionnement								
	Equipement de moins de 4000€	Environnement du doctorant et des post-docs	10	15				25
	Missions	Participation à des séminaires et conférences	10					10
	Gratifications de stages							
Autre		Retranscription d'entretiens	5					5
		Organisation d'un workshop interdisciplinaire	5	5				10
Investissement								
	Equipement de plus de 4000€							
Masse salariale		1 Doctorant	120					120
		2 Post-docs	40				40	80
TOTAL			190	20			40	250

Co-financement								
	Obtenu							
	En prévision							
TOTAL								

Equipe projet :

Indiquer l'identité de toutes les personnes impliquées dans le projet (y compris celles issues de la structure d'appartenance du porteur) :

Name and surname	Position and Rank	Employer / organization	Estimated time devoted to the project	Contact
David Coudert	DR INRIA	INRIA	10%	david.courder@inria.fr
Ludovic Dibiaggio	PR	SKEMA	10%	dibiaggio@skema.edu
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