Extending A Regional Innovation Network: A Technology Intelligence Approach

Johannes van Der Pol, Jean-Paul Rameshkoumar, Sarah Teulière, Thierry Bazerque

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Johannes van der Pol*†, Jean-Paul Rameshkoumar*, Sarah Teulière**, Thierry Bazerque*

** VIA Inno, GREThA, UMR-CNRS 5113*

*** Conseil Régional de Nouvelle-Aquitaine Direction de l'enseignement supérieur et la recherche*

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---------- Abstract ----------

In France, Regions do not make their own innovation policies, this is the role of the State. A Region implements national policies and uses grants and subsidies to create and dynamize innovation eco-systems important for its economic development. The Region's role is therefore largely influential. In order to influence one needs to how and when to exert this influence. A precise understanding of an innovation eco-system is therefore of vital importance.

On the occasion of the venue of a Nobel laureate to the French region of Nouvelle-Aquitaine the regional counsel aimed to connect her with the regional innovation eco-system around her research.

The purpose of this paper is to show methods and techniques using patents, scientific publications and non-patent literature citations that can help with the identification of an innovation eco-system and how to integrate a researcher into this eco-system.

Keywords : NPL ; Technology Intelligence ; Patents ; innovation networks
JEL : R11 ; O34

†Corresponding Author: johannes.van-der-pol@u-bordeaux.fr

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Introduction

The knowledge economy and the region

Innovation is an important factor for the development of both firms and the region they evolve in (Sternberg 2000). Innovation is thought to be the result of a dynamic and collective environment in which research institutions, firms and decision-makers are interconnected (Crévoisier and Maillat 1989, Spigel 2016). This interconnection of actors at the regional level is also referred to as a regional innovation network. The links in these networks can holster synergies that have positive effects for its participants (Cooke and Morgan 1993).

The importance of research networks

For instance, by integrating a network smaller firms, which normally would have trouble accessing markets outside their local scope, can find help to export beyond their usual scope (Huggins, 1995; Scott, 1996). Technological lock-ins can be avoided by the influx of new ideas and technologies (Sternberg 2000) and hence favor innovation. Creating collaborations with other firms, even outside the region can help nourishing new ideas and foster innovation. These latter points result in networking being associated with benefits for innovation (Kogut and Zander, 1992; Tsai, 2001) as well as survival and growth (Brüderl and Preisendörfer 1998, Watson, 2007), which in turn increases the performance of the region (Sternberg 2000). In short, networks have an important role to play in the development of regions and in technological change.

These regional innovation networks evolve both endogenously and exogenously. Endogenously because actors of a region are often in closer contact with actors that are geographically close (Ferru and Rallet, 2016). Local events play an important part in the creation of new links. The network evolves by exogenous inputs because new firms or researchers can move to the region or be invited to spend some time in the region.

The barriers to entry and the role of the region

However, entering an existing network is not always easy. In many cases, there are barrier to enter a network and being located somewhere does not automatically include one in a network. In certain cases, it can be helpful for institutions to provide help to integrate a given actor into a network.

The Region of Nouvelle Aquitaine was established in 2015 by the fusion of three regions (Limousin, Poitou-Charentes and Aquitaine). The latter are characterized by a heterogeneity in their production landscape and a need to strengthen their economic interactions. In this context, the regional council of Nouvelle-Aquitaine has built a strategy with the aim to increase the relations within the region, in particular those related to collaboration for innovation. Before

the fusion, Aquitaine was one of the regions investing most in research. With the fusion, Nouvelle-Aquitaine ranks second in terms of investment in research as measured by the fraction of the research and technology budget in the total expenses of the French regional councils during the 2014-2017 period (Rapin, 2019).[1]

This proficiency in research, mostly vested in the French state, is inscribed in the actions that allow the region to impulse economic development. In this context the innovation and research strategy of the region is put into action by the "pôle développement économique et environnemental" (which we can translate to "pole for economic and environmental development"). This action is lead by different directions within this pole of which the "direction de l'enseignement supérieur, recherche et transfert technologique (DRESTT)" [2] is one. This direction works with players of the territory in order to put into motion a strategy to dynamize R&D collaborations. Different initiatives have been set up by the Region to this effect such as regional research networks, support for structuring projects in the domains of higher education, research and the transfer of technologies and support for the organization of scientific conferences. By the means of these initiatives the regions aims to accompany the regional innovation eco-system to interact in order to favor the economic development of the territory.

How can the region help to overcome the entry barriers for a researcher?

For the purpose of this paper we study the case of a highly recognized foreign researcher who spend a few days in the region Nouvelle-Aquitaine in France. The aim of the Region, as an institution, was to manage to integrate this researcher into the regional innovation network in order to impulse collaborations between the actors of the region, the researcher and her team. The question we aim to answer is **how can a region help integrate a researcher into the innovation network in order to favor innovation?**

To answer this question, we use Technology Intelligence methods. Technology Intelligence is the practice of providing a decision maker (here the Region) with a tangible understanding of the scientific and technological trends of its environment (here the domain of the researcher) to facilitate the decision-making process (here the identification of potential sources of collaboration).

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[1] As measured by the fraction of the research and technology budget in the total expenses of the French regional councils during the 2014-2017 period : « *la région Nouvelle Aquitaine constitue la deuxième région en termes de part du budget de recherche et technologie dans les dépenses totales des conseils régionaux français sur la période 2014-2017* »

[2] Direction of higher education, research and transfer of technologies (translation by the authors).

This paper is organized as follows, first we will present the case study. Second, we will discuss the data required to identify potential targets of collaborations before presenting the data sources and the data treatment. We will then present the results and discuss to conclude.

The case of Strickland

In 2019, Donna Strickland, a Canadian Researcher visits the French region of Nouvelle-Aquitaine invited by one of her co-authors who is based in the region. Her research is focused on technologies related to optics and lasers. For her work she received the Nobel prize for Physics in 2018 together with Gérard Mourou and Arthus Ashkin for the scientific advances made in this field. The Nouvelle Aquitaine Region has developed in the recent years an important innovation policy in this domain to develop an emerging sector in the region. The Region wants to use this opportunity to identify potential synergies between the researcher and the regional players. To this end, the Region requested a study to identify who in the territory works on the same topics as Donna Strickland and propose indicators that can help in the decision making process related to the creation and dynamization of links between the researcher and the players of the Region.

Data & Methods

In order to identify synergies between the existing research network in the region and Donna Strickland, we need to be able to answer several questions:

1. What does she work on? Who does she work with?
2. Who in the region researches the same topic?
3. Who in the region is influenced by her research?

In order to answer these questions, we require two types of data. First, we need to identify which topics she is working on. We mean by this that we search for the precise scientific terminology rather than the broad domains we could easily identify online. The aim is to find other publications using the same terminology as that used by DS.

For this purpose, we require a database of scientific publications through which we can identify her work. This will allow us to identify the publications on which she is an author and by extension the topics she publishes on. This same dataset will be used to identify the researchers she works with as well as their affiliations. This will provide us with the first opportunity to see if she already works with a regional actor.

We use the Scopus[3] database and the Web of Science[4] database to identify her publications, this is done as by searching for her name in the author query field. The initial publications were checked for homonyms and we checked for the different spellings of DS and adjusted the initial query (steps 1 and 2 in figure 2).

Second, we want to know who else is publishing on the same topics as DS. For this purpose, we use the same two databases and build a key-word based query to identify publications in the same field, this query can be found in the annex.

In order to identify more players on the topics of DS we also look at patent data. Patents are typically used by player who are closer to market than fundamental research and therefore we might identify other players. Patent hold information on inventions as well as their inventors. By identifying patents filed on the same topics as DS' publications we can identify firms, researchers and research institutions that also work on those topics. For the purpose of this paper we used the Questel Orbit database[5] to identify patents. The detailed patent query can be found in the annex. The method followed to extract relevant patents is described in figure 1.

In order to identify patents that describe inventions related to the topics of DS we combine keywords and technological classifications. Whenever a patent is filed at a patent a patent office, the patent examiner classifies the patent by adding an International Patent Classification (IPC) to the patent. Over 70,000 of these classes exist and allow us to know if the patent is indeed related to the technologies we are interested in. However, since these classifications can be more or less broad be combine them with more specific keywords. The combination of the two ensure the identified patents are indeed in the scope of the technologies we wish to analyze. Finally, since we want to analyze the players in the region, we subset the identified patents by

[3] https://www.scopus.com/home.uri
[4] https://clarivate.com/webofsciencegroup/solutions/web-of-science/
[5] https://www.questel.com, This database offers worldwide coverage and contains over 54 million patent families

only keeping those that have at least one player with an address in the region. This is achieved by checking if the address contains a postcode in the region.

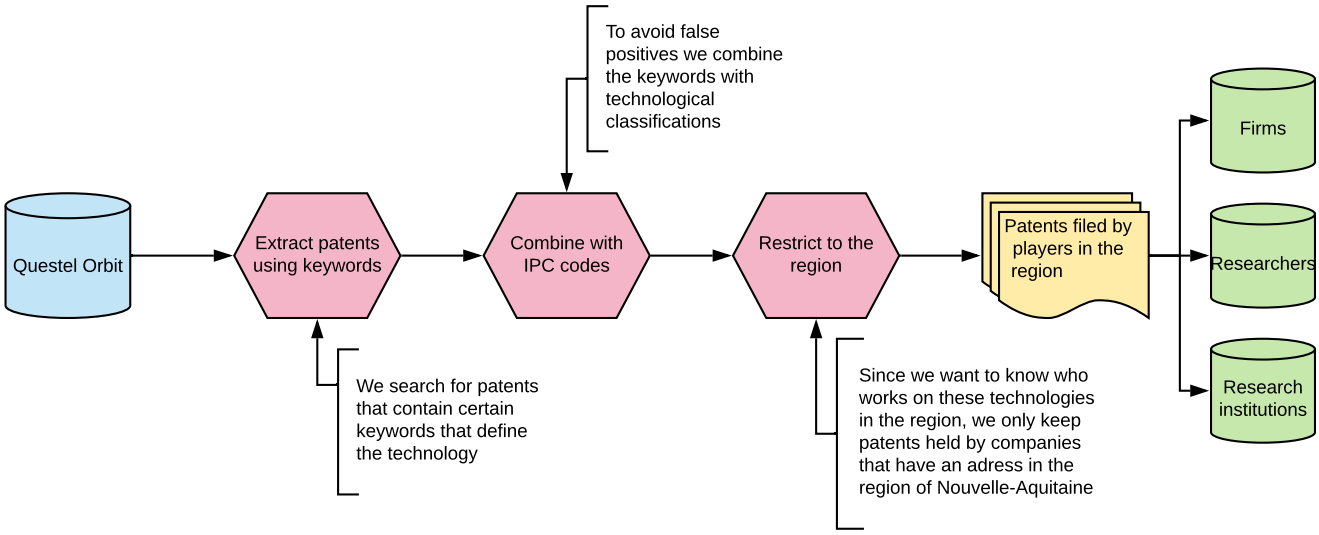

Figure 1: Method followed for the identification of firms, researchers and research institutions working on the topics of Donna Strickland using patent data.

The influence of her works does not stop at scientific publications. There are patents that cite her publications. This means that actors are using her research to innovate.

Patents, just like publications, have a list of citations. This list contains citations to other patents but can also contain citations to Non-Patent Literature (NPL). In our case we are interested in references to the scientific publications of DS. NPL citations are of value because they show a link between science (the publications) and technology (the patents) (Verbeek, 2002). As such they show that the research performed is included in inventions and therefore might be used in products that will be sold on the market. For this reason, NPL citations are used as indicators to measure the Science-Technology link (Van Looy, 2003).

These citations can be added either by the inventor or by the patent office (the patent examiner) whenever they are considered relevant to the invention (Brusoni et al. ,2005). Citations either mean that the patent uses the publication and improves on it or that the part of the patent cannot be granted because it is too close to what is written in the publication. The patent filer then has to adjust the patent so that it does not claim paternity over certain aspects of the invention.

In either case, the citations show that the owner of the patent and the author of the publication work on topics that are very close, and that is what we are interested in.

Once we identified the publications of DS we searched for NPL citation to either the title of her publication or the Digital Object Identifier (DOI) of the publication which is a unique identifier as shown in steps 3-5 in Figure 2. This provided us with a set of 45 patents citing the publications of DS.

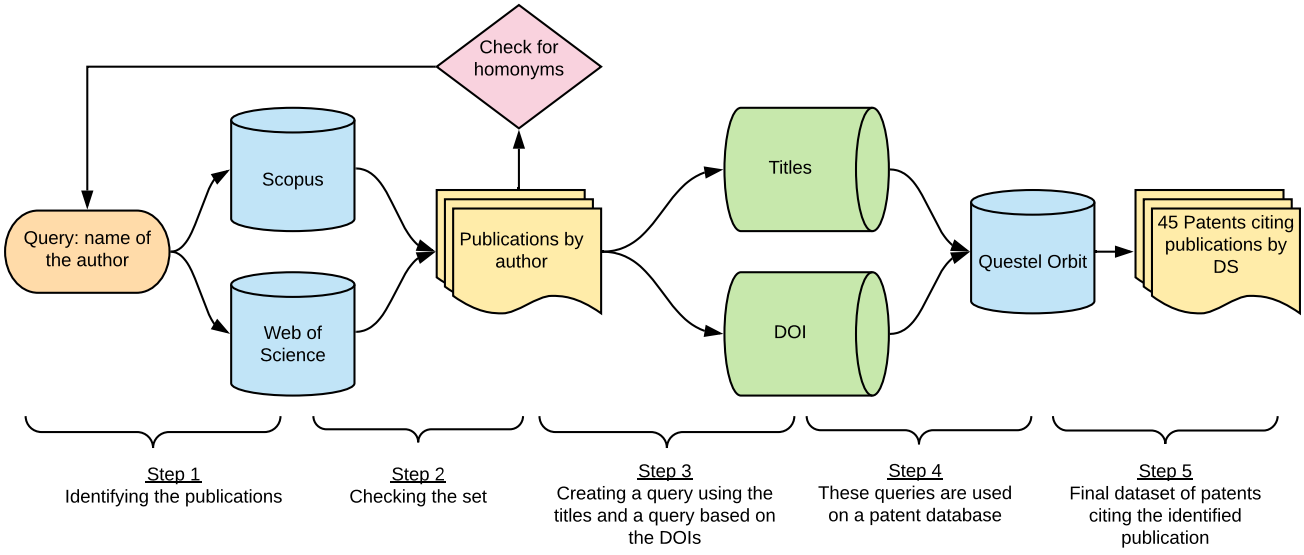

Figure 2: Method followed for the identification of the publications of DS (the "Publications by author" set) and the patent families citing the publications of Donna Strickland (Step 5).

We now have four datasets. In order to clarify which dataset we use for which question, Table 1 summarizes this information.

	What is she working on?	Who is working on her topics?	Who is influenced by her work?
The publications of DS			
The publications in her domain			
The patents in her domain			
The patents citing her publications			

Table 1: Relation between the datasets and the questions

Results

What does she work on and with whom?

From her publications we learn that her earliest work focuses on Chirped Pulse Amplification which is a laser-based technique. In particular it uses short impulses that are later amplified. This technology is used nowadays for laser-eye surgery for example. Together with other identified topics we start by looking at her publications to see if she has worked with a regional player. In figure 3 we show the network of collaboration of DS. Each node represents the affiliation of a co-author on her scientific publications. The thickness of a link reflects the number of co-publications. The most co-publications have been between the University of Waterloo (DS' affiliation since 1997) and the University of Guelph. The latter have a strong collaboration between their physics department and share a graduate program[6]. We can see three French institutions amongst her collaborators, the University of Toulouse, l'Ecole Polytechnique and the Centre National de la Recherche Scientifique (CNRS). None of these are located in the Nouvelle-Aquitaine region although the CNRS is a national center. The French connection came from her French thesis supervisor Gérard Mourou. These collaborations are not active today. We can conclude from this analysis that there have not been any collaborations between players in the region and DS.

[6] https://www.uoguelph.ca/research/discover-our-research/centres-institutes-groups/guelph-waterloo-physics-institute-gwpi

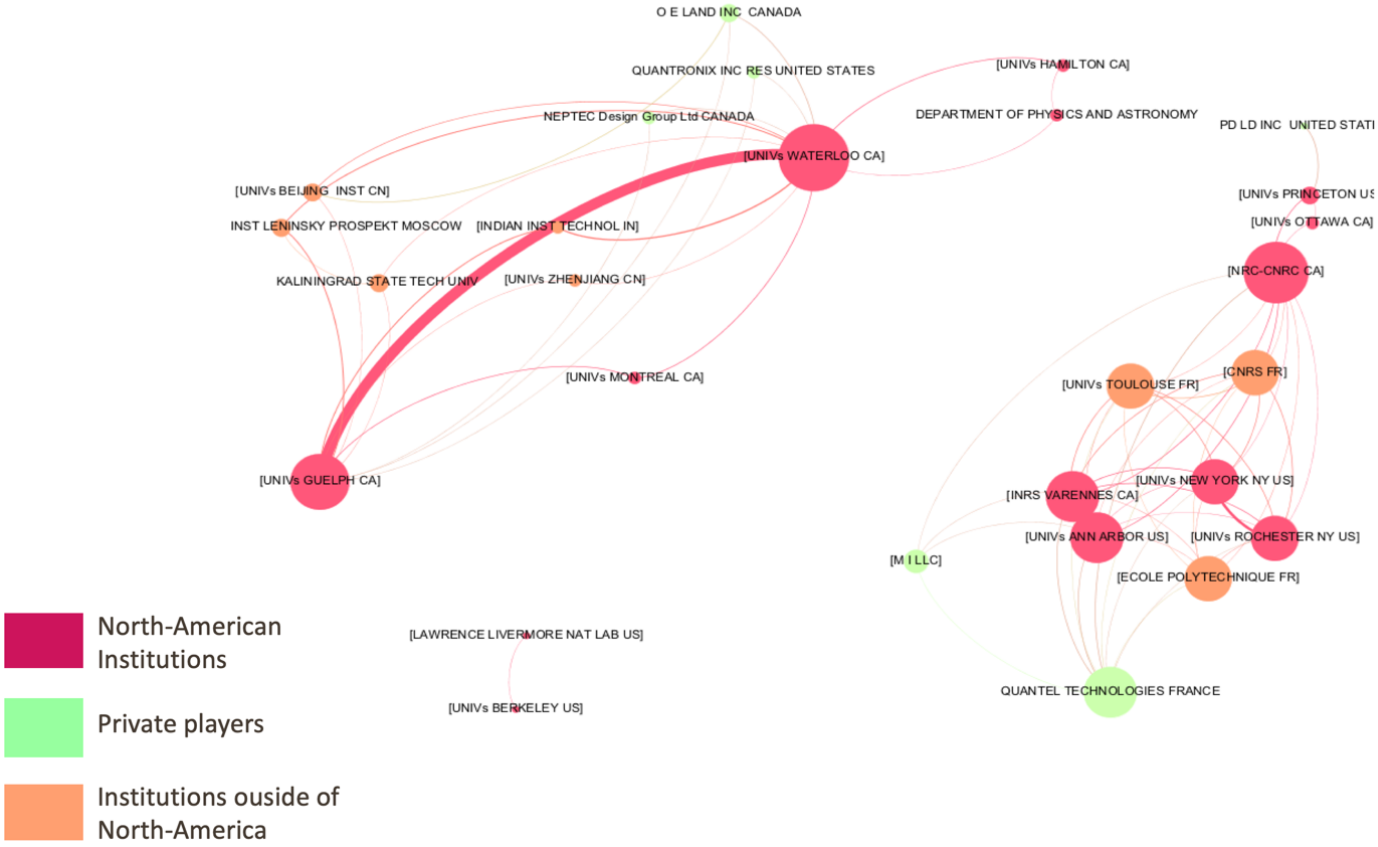

Figure 3: Network of collaboration of Donna Strickland. A link reflects a co-publication between DS and another researcher from another institution or company. Source: Scopus data retreated by the authors

Who works on her topics?

Inviting a researcher such as DS is an occasion to show the strength of a region is a scientific field. This requires to identify who in the region works on the same topics as the researcher. To this end we search for patents and publications in the domains close to those of DS. In figure 4 we show the identified top players in the domain. We exclude the universities to focus on technology centers and companies. Amongst the identified players we can see that there are some large multi-nationals (Safran, Thalès, Total and Airbus) but also some smaller firms that have a strong regional presence (Alphanov, Amplitude Systems, 3DCERAM for example). Glophotronics is an interesting case since they do not have any patents but have over 50 scientific publications. Overall, these numbers show that there is added value in mobilizing both patents and publications when we wish to identify players in a field. Even though Glophotronics does not appear to protect its inventions this does not mean that they do not

use the technology. They might very well innovate but not file patents. The latter point is one of the limits of patents as source of data.

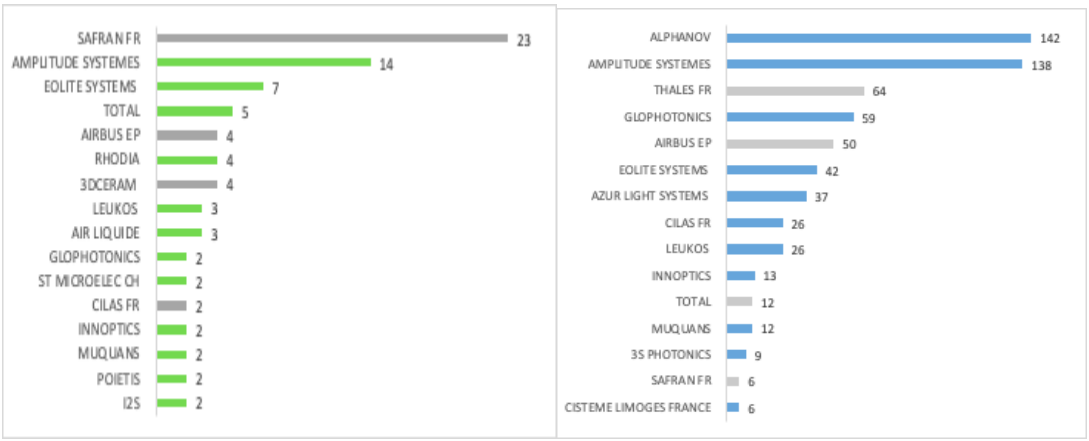

Figure 4: On the left the top players (universities excluded) as measured by the number of patent families. On the right the top players (universities excluded) as measured by the number of scientific publications. Sources: Questel, Scopus, treatment by authors.

There is a strong presence in the Region of players working on the identified topics. This information can be used by a policy maker to contact these companies and discuss if there is a potential for collaboration or if setting up a meeting could be of use. This is also true for the Universities and other research institutes in the region.

For the purpose of refining this dataset of identified players, we want to focus on the actors that have a close proximity to the publications of DS. In order to achieve this, we take the publications of DS and check which corporate actors cite her research. The results are presented in figure 5. From these results it becomes clear that her research is used by large corporations, Tata in particular cites DS' research continuously in their publications. The influence of her research is international and continuous in the private sector.

At the regional level we see that Amplitude started citing DS' research in 2004 and has been doing so continuously since. Even though Thales has been citing DS' research this has been less continuous and there has been no citation since 2013. We therefore conclude here that there are strong synergies between Amplitude and DS'.

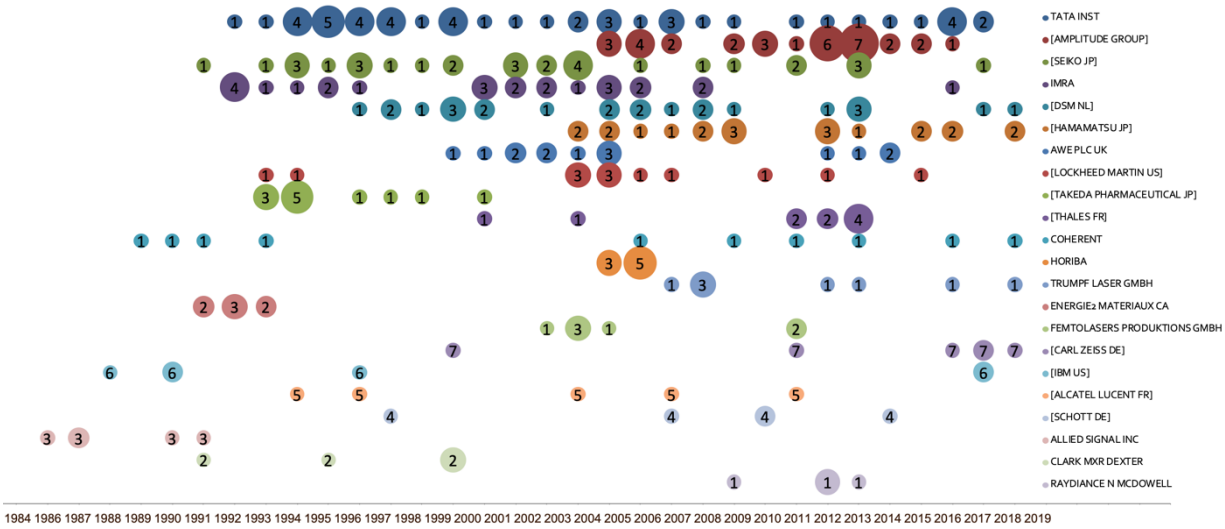

Figure 5: The corporate actors citing the publications of Donna Strickland over time.

We can go one step further to study the influence of DS on Amplitude Systems. We can check if the patents of Amplitude systems have citations to the publications of DS. The steps to obtain this dataset was presented earlier in figure 2.

We use a method to visualize the citations in a way that highlights both the technological dependence of actors on the technologies of DS and highlights her influence. This method is inspired by the influence/dependence graph used on patent citations (van der Pol and Virapin, 2020). We adjust this method here by using NPL citations instead of patent citations only. Figure 6 shows what is called an influence graph. The blue node in the represents the focal player, in this case DS. Linked to her are here publications (orange nodes). We only represent here the publications that have received citations from patents. The green nodes are the patents that cite the publications of DS, the purple nodes are the assignees of those patents. From this graph is becomes immediately clear that one of her publications in particular has a vast influence on technology. Even though four other publications receive citations, “Compression of Amplified Charped Optical Pulses” is cited by 37 different firms. In particular COHERENT and RAY DIANCES are largely dependent upon her work since they cite her publication with 14 different patents. Other players only cite her once with one patent.

We also see that Amplitude Systèmes is the only regional player to cite DS, with two patents they cite the most influential publication of DS. The conclusion we can pull from this graph is that Amplitude systems should be contacted to provide an opportunity for them to discuss with DS.

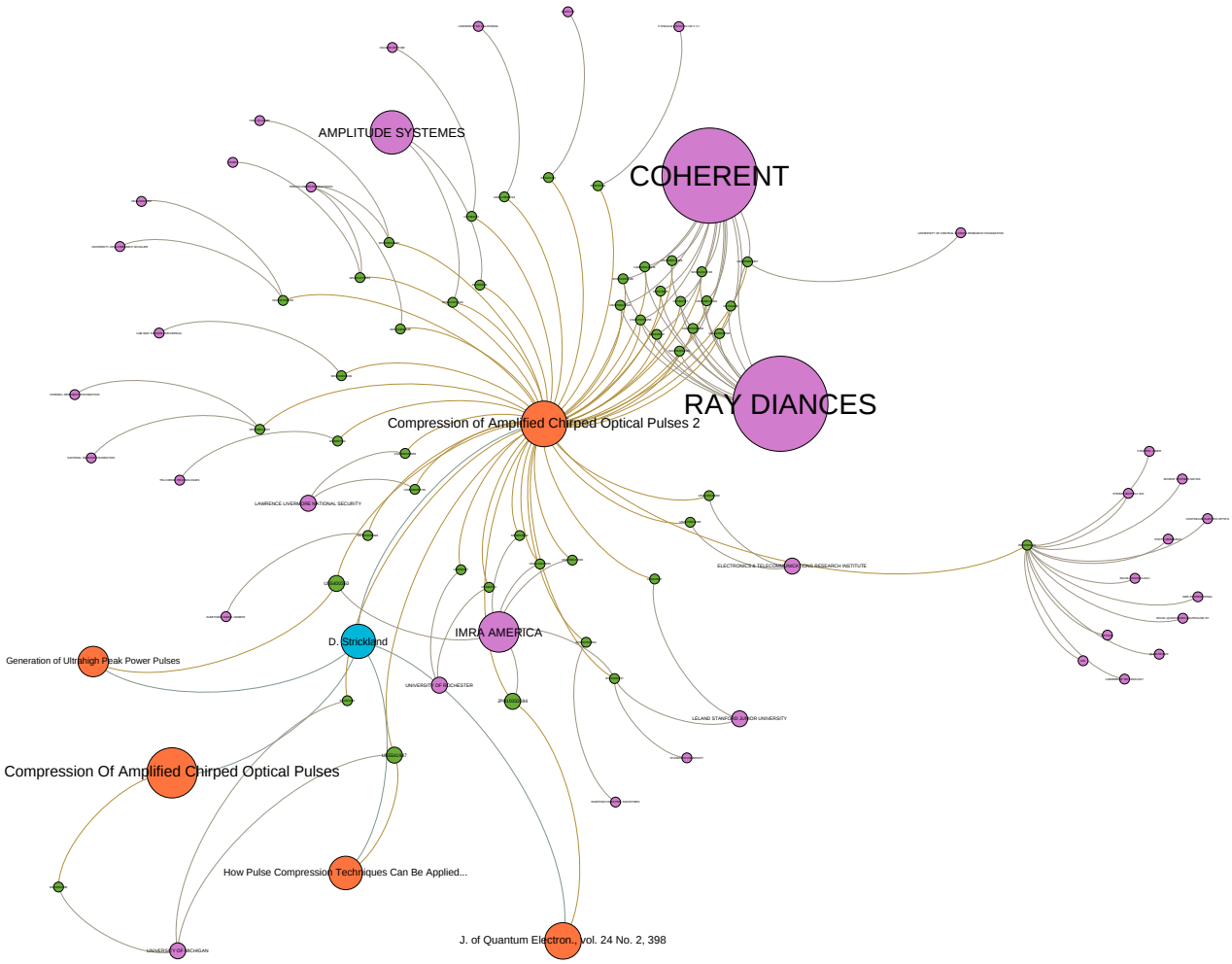

Figure 6: The influence in technology of the publications of DS, and the dependence of the players on her research

Conclusion

Nouvelle Aquitaine is one of the regions investing most in research and innovation in France. However, the Regional council isn't a policy maker in public research support and founding which, in France, are a national matter. Its action is merely influential, by subsides and grants through calls of proposals, and is focused on a limited range of scientific fields related to economic sectors and firms present in its territory. This role means that getting the best comprehension of research and innovation as an eco-system (and being a part of it) is the core of its own policies. This way, the venue of any remarkable person in any scientific or economic domain has to be anticipated and prepared to maximize serendipity opportunities.

The decisions made by the region are required to be structured in order to ensure scientific correctness of the indicators, methods and results as well as to ensure reproducibility if the same case re-occurs.

Technology Intelligence allows the performance of analyses that are structured in such a way that they allow decisions to be made based on their results. In particular we have used Technology Intelligence in this paper to:

- Better understand the regional eco-system of a domain (laser in this case) and the interactions with external interlocutors (in this case Donna Strickland).
- Favor the ability of these players to develop valuable relations that are mutually beneficial by providing descriptive elements that allow them to better know each-other.
- Identify research opportunities interesting for both parties

These elements allow the region to better adjust propositions and the help they can provide for certain topics of interest for the players of the region. By extension the different elements provided can help a region to better structure devices that can help players in the region.

A next step is to extend this approach to identify who a Region could invite to impact an eco-system. In the discussed case, the venue of DS was exogenous.

Patent Query:

(LASER OR (NANOSECOND AND PULS+ AND WIDTH) OR (PICOSECOND AND PULS+ AND WIDTH) OR (MILLISECOND AND PULS+ AND WIDTH) OR (MICROSECOND AND PULS+ AND WIDTH) OR (FEMTOSECOND AND PULS+ AND WIDTH) OR (FEMTOLASER) OR ULTRAFAST OR ULTRA?FAST OR (ULTRA FAST) OR (TEMPORAL 1D PULS+ 1D SHAPIN+) OR (PHOTONIC CR?STAL AND (FIBRE OR FIBER)) OR (PHOTO+ AND (HOLLOW CORE OR HOLLOW?CORE)) OR HCPCF OR (PULS+ SHAPE GENERATOR) OR (DIOD+ 1D PUMP+ 1D SOLID 1D STATE) OR (PHOTODIOD+ 1D PUMP+ 1D SOLID 1D STATE) OR (MONOLITHIC AND PHOTONI+) OR (QUANTUM CASCADE LASER) OR (QCL) OR SUPERCONTINUUM OR (LOW COHERENCE) OR (KAGOME 1D (FIBER OR FIBRE)))

AND

(H01S-005+ OR H01S-003+ OR B23K-026+ OR H01J-027/24 OR G01N-021+)/IPC

AND

The assignee has an address in the region of Nouvelle-Aquitaine

Publication Query

(TITLE-ABS-
KEY ((laser) OR (nanosecond AND puls* AND width) OR (picosecond AND puls* AND width) OR (millisecond AND puls* AND width) OR (microsecond AND puls* AND width) OR (femtosecond AND puls* AND width) OR (femtolaser) OR ultrafast OR (ultra?fast) OR (ultra fast) OR (temporal W/1 puls* W/1 shapin*) OR ((photonic cr?stal) AND (fibre OR fiber)) OR (photo* AND (hollow core OR hollow?core)) OR hcpcf OR (puls* shape generator) OR (diod* W/1 pump* W/1 solid W/1 state) OR (photodiod* W/1 pump* W/1 solid W/1 state) OR (monolithic AND photoni*) OR (quantum cascade laser) OR (qcl) OR supercontinuum OR (low coherence) OR (kagome W/1 (fiber OR fibre)))) AND (TITLE-ABS-KEY ((additive manufact*) OR (additive print*) OR (3d W/2 print*) OR (3-
d W/2 print*) OR (stereolithograph*) OR (fused deposition model*) OR (rapid prototyp*) OR (rapid manufactur*) OR (desktop manufactur*) OR (on-demand manufactu*) OR (three-
dimensional W/2 print*) OR (three-
dimensional W/2 manufactur*) OR (selective laser sintering) OR (selective laser melting)))

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