Monitoring of Technological Development - Detection of Events in Technology Landscapes through Scientometric Network Analysis

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Introduction

Monitoring technological development is an important challenge for research organisations and regulators. For decision-makers, the detection of early signals of technology maturation is key to designing proper standards and regulations. Anticipating the arrival of new technologies also allows policy-makers to develop and implement fit-for-purpose research or industrial policies. Scientometric analysis (in this case using both publications and patents) is a powerful tool to monitor technological fields and can be used to detect events in the lifecycle of a technology (Rotolo et al., 2014).

Objectives

- to analyse different cases (historical) of technological change by monitoring the evolution of patterns of collaboration between research organisations, the apparition of new keywords and/or subject categories in articles as well as changes in quantitative data such as patent or publication counts;
- to investigate whether network analysis can be used for the detection of events related to technological change;
- to identify potential indicators of technological maturation useful in the context of early warning to regulators.

Methods

Results relating to 4 technologies are presented here. Publications for each technology were retrieved from the Web of Science Core Collection database and patents from Thomson Innovation. To select the technologies, a semantic search was used in the abstract, title and author keywords of the publications.

Different network landscapes were then created using the retrieved patents and publications: sociograms showing how organisations collaborate together (through co-publishing and co-patenting); keywordgrams based on co-occurrence of author keywords in articles; and subject-category-grams based on subject categories given by Thomson Reuters. These three types of network landscapes were created and analysed for each technology.

Results

Shale Gas and horizontal drilling

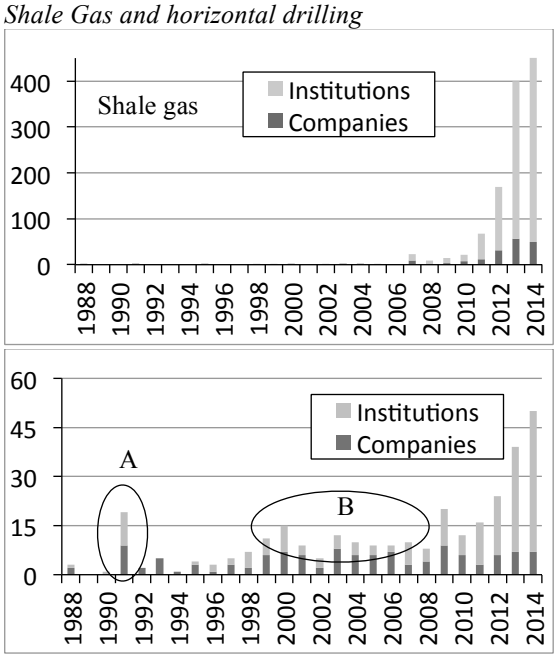

Figure 1. Number of patents and publications for horizontal drilling and shale gas from 1988.

Figure 1 shows that the number of patents and publications mentioning "shale gas" in the abstract, title or keywords started to increase noticeably in 2007 and boomed from 2011 onwards. By contrast, articles mentioning horizontal drilling, one of the key enabling technologies for "shale gas" appeared earlier (A) and rose from the year 2000 onwards (B). In addition, comparison with press content analysis shows that the rise in articles mentioning "shale gas" correlates with an increase of occurrences of press articles about shale gas (data not shown), which leads to think that this rise does not correspond to a technological trend. This shows that for the prediction of technological change the subjacent technologies - not the broad concepts - are more meaningful for the early detection of technological change.

The 2nd graph of Figure 1 shows the need to build composite indicators to avoid false positive signals. The peak of publication activity in 1991 is indeed not correlated to increased activity in other

indicators such as volume of patents or variation of number of players, for example (data not shown).

3D-printing - Detection of new uses of a technology
The number of patents and publications on fused-deposition modeling (a key enabling technology of 3D-printing) is growing steadily from 1995 to nowadays (data not shown). The subject categories of the journals in which the selected publications were published are manifold and evolve in time. As shown in Figure 2, from 1998 to 2014 a few clusters of new subject categories appear. In 1998 the articles relating to fused deposition modeling were belonging to engineering, material science and automation, which are categories describing the core of this technology. Categories describing applications of 3D-printing appear as of 2001, i. e., earlier than the entry of the first 3D printer on the market (2009).

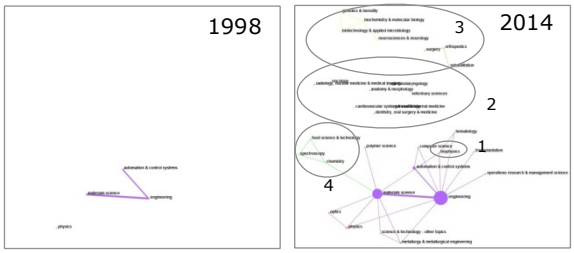

Figure 2. Subject categories for publications on fused-deposition modeling in 1998 and 2014. The circles show appearance of new non-core subject categories. 1. Biophysics (2001), 2. Radiology (2004), dentistry (2005), oncology (2006) 3. Genetics, Biochemistry (2007), Neurosciences (2008) 4. Food science and chemistry (2011).

CRT - Detecting substituting technology
The study of the author keywords for publications related to cathode ray tube (CRT) allowed to observe the emergence of the replacing technology, Liquid Crystal Display, in the CRT space. Figure 3 shows various synonyms of LCD in the keywordgram for CRT. The LCD nodes are quite big, showing their relative importance. The keyword LCD or its synonyms appear in 35 out of 649 publications or 5% of the publications.

Silicon wafer for microelectronic and for solar cell
Two application lifecycles can be observed for silicon wafers by analysing the number of related publications and patents (data not shown). These two lifecycles culminate respectively around the years 2000 and 2010. Analysing the keywordgram for the selected publications we see the keyword "silicon solar cells" appearing in 1999, and being increasingly used until 2011. Figure 4 shows its co-occurrence with other keywords in 2014. The emergence of this keyword reflects the apparition of a new use of silicon wafers for solar applications.

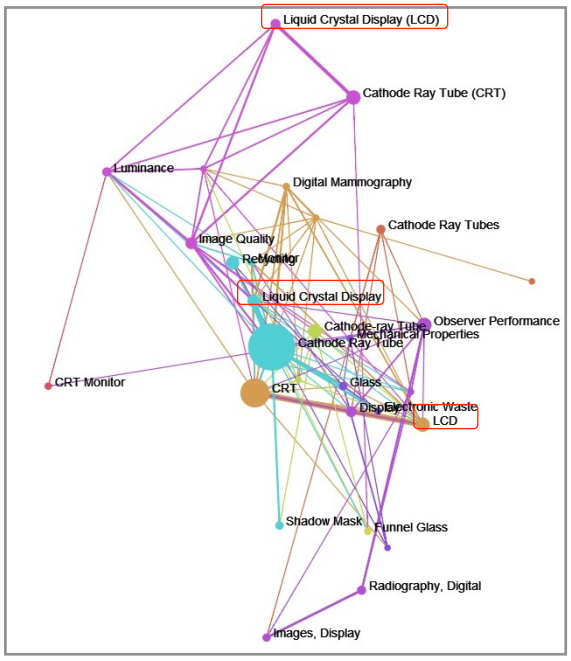

Figure 3. Author keywords view for Cathode Ray Tubes in 2014.

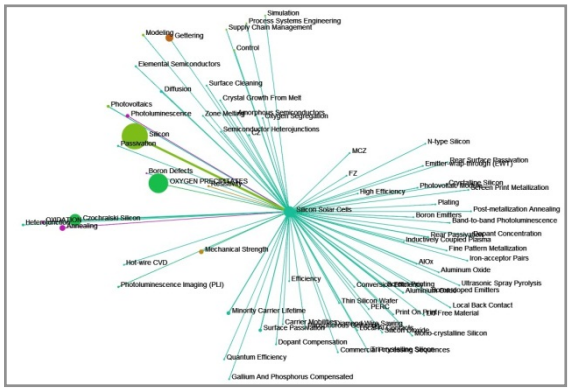

Figure 4. Centric view of keyword "Silicon Solar Cells" and its co-occurrence with other author keywords in the publications space relating to Silicon wafers.

Conclusions

Our study suggests that network analysis can be used for the detection of events relating to technological change.
We have identified several types of indicators that could be combined in order to design an early warning system to alert decision-makers of changes in technology landscapes.

References

Rotolo, D., Rafols, I., Hopkins, M. & Leydesdorff, L. (2014). Scientometric mappings as strategic intelligence for tentative governance of emerging science and technologies. *SPRU Working Paper Series,* 10, 1-40.