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Leydesdorff, L.; Strand, Ø.

Published in:
Procedia - Social and Behavioral Sciences

DOI:
10.1016/j.sbspro.2012.09.435

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Citation for published version (APA):
https://doi.org/10.1016/j.sbspro.2012.09.435
10th Triple Helix Conference 2012

Triple-Helix relations and potential synergies among technologies, industries, and regions in Norway \(^a\)

Loet Leydesdorff\(^a\), Øivind Strand\(^b\)

\(^a\) University of Amsterdam, Amsterdam School of Communication Research (ASCoR), Kloveniersburgwal 48, 1012 CX Amsterdam, The Netherlands; loet@leydesdorff.net

\(^b\) Aalesund University College, Department of International Marketing, PO Box 1517, 6025 Aalesund, Norway; ost@hials.no

Abstract

Using information theory and data for all (0.5 million) Norwegian firms, the national and regional innovation systems are decomposed into three subdynamics: (i) economic wealth generation, (ii) technological novelty production, and (iii) government interventions and administrative control. The mutual information in three dimensions can then be used as an indicator of potential synergy, that is, reduction of uncertainty. We aggregate the data at the NUTS3 level for 19 counties, the NUTS2 level for seven regions, and the single NUTS1 level for the nation. Measured as in-between group reduction of uncertainty, 11.7% of the synergy was found at the regional level, whereas only another 2.7% was added by aggregation at the national level. Using this triple-helix indicator, the counties along the west coast are indicated as more knowledge-based than the metropolitan area of Oslo or the geographical environment of the Technical University in Trondheim. Foreign direct investment seems to have larger knowledge spill-overs in Norway (oil, gas, offshore, chemistry, and marine) than the institutional knowledge infrastructure in established universities. The northern part of the country, which receives large government subsidies, shows a deviant pattern.\(^a\)

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Keywords: synergy; R&D funding; Norway; mutual information

1. Introduction

In a number of studies we have used the mutual information in three dimensions as an indicator of potential triple-helix synergy in university-industry-government relations. For analytical reasons, the mutual information in three dimensions is a signed information measure (Yeung, 2008) and not a Shannon-type information measure.

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(Krippendorff, 2009); yet, it can be expressed in bits of information as a measure of uncertainty. If the prevailing uncertainty at the systems level is reduced, this can also be considered as a synergy. The purpose of Triple Helix relations is to generate such synergies in mutual relations between and among university, industry, and government. In a series of studies this potential synergy has been investigated in terms of inter-institutional coauthorship relations among authors with academic, industrial, and governmental institutions in the address bylines of the articles (e.g., Leydesdorff & Sun, 2009; Park et al., 2010). This data is readily available in bibliographic databases such as the Science Citation Index. However, the focus in these studies remains on the science system and not on innovation.

In the present study, we first generalize the Triple Helix model to a neo-evolutionary model by defining the three strands as functional dimensions of an innovation system: (i) economic wealth generation, (ii) socially organized knowledge production, and (iii) normative or regulative control. These functions can operate synergetically, without coupling, or against one another. The relationships can also change over time: synergy can be lost or gained with further development.

Firms are the units of analysis; they can be considered from three analytically different perspectives: as organizations with different economies (small, medium, large); carriers of technological knowledge and know-how; positioned in different administrative units such as regions, nations, and cities. These three dimensions (geography, technology, and organization) can be considered as the “holy trinity” of a knowledge-based economy (Storper, 1997).

The distributions of firms in these three dimensions can be expected to contain uncertainty. If this uncertainty is reduced by interactions among the dimensions, this synergy can be measured as a negative value of the mutual information among the three dimensions.

2. Methodology

The data consists of information about 481,819 firms. The figures were collected for the fourth quarter of 2008 and were harvested from the web site of Statistics Norway (2011). This data covers the complete population of Norwegian firms. All records contain the three variables which can be used as proxies for the dimensions of geography, technology, and organization.

Geography is indicated by a four-digit code for municipalities (NUTS5); this data can be aggregated straightforwardly into higher-level units such as counties, regions, and the national system. At each level one can ask for the amount of synergy, the in-between group synergy, and compare units in terms of their synergy. This study follows on a series of studies for other national systems (in Europe) so that comparisons with other nations (Germany, the Netherlands, Hungary) is also possible.

The organizational dimension is indicated by company size in terms of the number of employees. The data are divided into eight classes ranging from self-employed enterprises without personnel to (666) firms with more than 250 employees. Technology is indicated in our data using the two-digit sector classification of the OECD (NACE) which is also used by Statistics Norway.

In the case of three interacting dimensions, the mutual information can be defined as follows (McGill, 1954):

\[
T_{XYZ} = H_X + H_Y + H_Z - H_{XY} - H_{XZ} - H_{YZ} + H_{XYZ}
\]

in which (Shannon, 1948):

\[
H_X = -\sum_X p_X \log_2 p_X, \quad H_{XY} = -\sum_X \sum_Y p_{XY} \log_2 p_{XY}, \quad \text{etc.}
\]

\[b\] NUTS is an abbreviation for Nomenclature of territorial units for statistics.
\[c\] Nomenclature générale des Activités économiques dans les Communautés Européennes
Each two-dimensional distribution can also be considered as a matrix (or an Excel worksheet), whereas the three-dimensional distribution is contained in a cube of information (or an Excel workbook). The computation is done by using macros in Excel and dedicated software.

3. Findings and Interpretation

Norway has a number of universities, among which a Technical University in Trondheim and a major university in the Oslo region. Contrary to the expectation, these universities were not central to the knowledge-based economy as measured by these indicators. The largest synergy is found in the western part of the country which hosts marine and maritime industry. Norway is a major off-shore oil-producing country. In other words, knowledge intensity of the industries follows foreign-driven investments more than endogenous knowledge sourcing. The main venue for knowledge integration is the global industry more than the local academic settings.

Fig. 1: Contributions to the knowledge base of the Norwegian economy of the 19 counties at the NUTS3 level.

These results accord with our earlier findings for other European nations (Lengyel & Leydesdorff, 2011; Leydesdorff, Dolfsma & van der Panne, 2006; Leydesdorff & Fritsch, 2006): embeddedness of knowledge in industrial activities is more important for generating synergy in the knowledge-based economy than high-tech or knowledge-intensive services. The latter two categories are more “footlose” and can therefore be relatively uncoupled from local contingencies such as a specific location. Similar to the Netherlands, but different from...
Germany and Hungary, Norway has a national innovation system (when measured in these terms as in-between lower-level units synergy).

4. Conclusions and policy implications

Integration and differentiation are two sides of the same coin: the function of knowledge generation can be globalized and similarly economic wealth generation can take place at translocal levels. The crucial question is how and why wealth can be retained from knowledge by shaping proper institutions and infrastructure. This requires an assessment of the dynamic properties of the systems under study.

* A priori assumptions about the targeted level of integration (for example, regions) relevant for governmental interventions can be tested against data. On the basis of the series of studies performed hitherto we dare to state that the results are often counter-intuitive. For example, in Hungary we no longer found a national system of innovations, but were able to distinguish three subsystems. In Norway, the integration assumed on the basis of studies of other Western-European systems was shaped very differently from expected.

This study confirms previous findings that knowledge-intensive services tend not to contribute to local synergies in the economy because of their flexibility of moving across the administrative borders of regions.

References


