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Where is synergy indicated in the Norwegian innovation system? Triple-Helix relations among technology, organization, and geography

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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.

1. Introduction

Innovation takes place in a landscape of interactions, collaboration, and knowledge exchanges among firms, academic institutions, and various government agencies [1]. Firms and institutional agents cooperate and participate in networks at various geographical scales; locally, regionally, nationally, and internationally [2]. Whether and how government interventions, or the presence of academia, matter for regional innovation is an issue of political significance in many countries because innovation in the regions is considered to be a condition for increasing prosperity [3–5]. Accordingly, national and regional governments in several countries have developed programs and centers for enhancing innovation in the regions [6,7]. A number of factors are important in this context: the industry structure [8], the role of the universities [9,10], the role of knowledge networks [2,11], proximity and localization [12–15], and organization and culture [16,17].

Leydesdorff and Meyer [18] raised the question of how to measure whether a knowledge base in the economy is developed more at the regional than the national level (or vice versa). Can something as elusive as the knowledge base of an economy be measured in terms of the interactions in a Triple Helix between economic development, organized knowledge production, and political control? The purpose of this paper is to estimate the characteristics of such Triple-Helix dynamics in the Norwegian innovation system. Combining the use of information theory and the Triple-Helix model of university–industry–government relations, we propose a tool for measuring the extent to which innovations have become systemic.

Canter et al. [2], for example, used patent data from firms in three industrial regions to characterize the knowledge base of the regions. Our approach provides an empirical alternative to the a priori assumption that such systems would exist geographically

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either at the national or regional levels. We use an information-theoretical method on a complete set of micro-level data for all – that is, almost half a million – Norwegian firms registered during the last quarter of 2008. Each of these firms is attributed a municipality code (as a proxy for geography), a sector code (proxy for technology), and a size code for firms (proxy for organization).

The study leans on three previous papers using a similar method, but containing data from the Netherlands [19], Germany [20], and Hungary [21]. These studies have similarities in their methodological approach, but were different in several ways. The Hungarian study focused on firms from high-tech industries and knowledge-intensive services. The German study did not contain data about self-employed firms. The study of the Netherlands used postal codes instead of municipalities as the geographical proxy. Furthermore, the geography and the industry patterns in Norway are different from the other countries studied. The state can be expected to play a more active role in Norway than in the other countries for which similar studies were performed [1: p. 111].

This study broadens the picture from previous studies by including two new elements in the analysis. First, by including the geographical distribution of foreign factors [22,23], such as foreign direct investment and export incomes (at the county level). Second, by discussing the distribution of research funding among Norwegian counties. Following Leydesdorff et al. [19], we first combine the theoretical perspective of regional economics [24] with the Triple-Helix model [1]. Three dimensions are thus distinguished: technology, geography, and organization. These dimensions cannot be reduced to one another, but interactions among them in networks of university–industry–government relations can be expected. The synergy in these interactions can be measured in the Norwegian innovation system and can also be decomposed at different levels of scale [25].

The mutual information among the three dimensions (geography, technology, and organization) can be negative and can then be interpreted as an indicator of reduction of uncertainty or synergy. Lengyel and Leydesdorff [21] specified the synergetic functions as 'knowledge exploration' (between technology and geography), 'knowledge exploitation' (between technology and organization) and 'organization control' (between organization and geography). Spurious correlations among these interacting subdynamics of a knowledge-based system may reduce the uncertainty that prevails, and this reduction can be measured using the mutual information in three dimensions. Yeung [26] specified the resulting indicator as a signed information measure. A signed measure can no longer be considered as a Shannon entropy [27].

When this signed information measure is negative, the synergy among the functions reduces uncertainty that prevails at the systems level. The synergy is an attribute to the configuration, and not of the composing subdynamics. It emerges as a virtual knowledge base that feeds back on the composing subdynamics. However, information theory allows for the precise decomposition into components of this knowledge base in terms of bits of information [25]. We study the measure at four geographical levels: the national system (NUTS1),[1] seven regions (NUTS2), 19 counties (NUTS3), and 430 municipalities (NUTS5). The results enable us to specify where synergy is highest and whether the respective innovation systems have more regional or national characteristics.

Etzkowitz and Leydesdorff [1; p. 111] used Norway as an example for the Triple-Helix I model, where the strong state governs academia and industry. Onsager et al. [28] reported that the largest city regions in Norway seem to have limited capacity to utilize their resource advantages and potential synergy. Herstad et al. [29] concluded that firms in the capital region (Oslo) are less engaged in innovative collaboration than firms in the rest of the country, whereas Isaksen and Wiig Aslesen [30] argued that the knowledge organizations in Oslo do not (yet) function as hubs in a wider innovation system.

The relations between innovation, policy, and inter-firm linkages in Norway were also discussed by Nooteboom [31]. He concluded that central government should limit itself to facilitation in the formation of enterprise clusters. An OECD report [32], analyzing the roles of knowledge institutions in the Trondheim region, concluded that in spite of being Scandinavia's largest independent research institution and technical university, there is a need to 'broaden the innovation dynamics' and increasing the absorptive capacity within this region. The existence of fragmentation [28] and 'parallel worlds' [32] within the Norwegian innovation system, can be considered as indications of redundancy rather than synergy.

In this study, we address these Triple-Helix issues empirically by using data and information theory. We focus on the geographical decomposition of the configurations. The main research question is to find and explain geographical areas where synergy among the knowledge-based innovation functions is higher than in other areas. From a methodological perspective, it is interesting to study first the complete populations of firms, that is, without focusing on sectors or geographical areas which are a priori defined as relevant systems of innovation. The finely grained geographical mesh of the Norwegian firms allows us to estimate at which geographical levels synergies occur. Additionally, we relate our results to the geographical distribution of government spending on R&D and foreign factors in areas of high or low synergy. Finally, we also reflect and elaborate on some counter-intuitive results.

2. Theoretical perspectives

Storper [24] defined a territorial economy as a 'holy trinity' of relational assets. In Fig. 2.3 on page 49 of his study (see Fig. 1 below), the economy is considered as a set of intertwined, partially overlapping domains of action. The building blocks of this 'holy trinity' are technology, organizations, and territory (geography). There are three bilaterally overlapping domains between the three spheres and one trilateral. A domain where technology and organizations overlap is then characterized as the 'world of production' with a specific 'system of innovation.' The domain where organizations and territory overlap is denoted by Storper as

[1] NUTS is an abbreviation for Nomenclature of territorial units for statistics.