NEMO
Network Models, Governance and R&D Collaboration Networks

Newsletter #6
November 2008

Modelling knowledge exchange on networks

The general focus of workpackage 2 is structure and dynamics of complex random graphs and associated processes. Within this theme teams of Luxembourg and Maastricht universities have developed and analyzed an economic model of knowledge exchange on networks.

Firms operating in environments of growing technological complexity and rapid technical change increasingly discover that in-house R&D is not sufficient for sustaining their competitive positions. At the same time high transaction costs related to fundamental properties of knowledge prevent efficient functioning of arm-length market mechanisms, thus firms have to find other, more efficient ways for acquiring external sources of knowledge.

Recent decades have seen rise of the "networked organization" where knowledge exchange is channelled through face-to-face interactions which take advantage of both market and non-market transactions. This new form of organization poses a challenge for an economic modeller interested in processes of knowledge transmission as it is different from the two relatively well-understood mechanisms of markets and hierarchy.

Diffusion of knowledge on networks can be modelled as an epidemic process: ideas travel from one agent to another with certain probability if there is a direct connection between the agents. While such a formalization permits the application of models and tools from recent advances in network analysis and allows, for instance, inference about the relationship between economic efficiency and network structure, this approach has certain limitations: in contrast with transmitting a contagious disease, passing knowledge is a conscious act.

This newsletter presents and briefly summarizes main results of an economic model of knowledge exchange on a network developed within the NEMO project.

Paper preview

Two modes of knowledge transmission have been observed empirically. Allen (1983) describes a "collective invention" process wherein knowledge is given away as a (local) gift. He illustrated collective invention with a case study of the steel industry in Cleveland UK in the mid nineteenth century, where producers met regularly under the auspices of societies like the Cleveland Institute of Engineers, the South Wales Institution of Engineers or the national Iron and Steel

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The NEMO Newsletter

The objective of the periodic NEMO Newsletter is to provide a platform of interdisciplinary information exchange and discourse for all sciences concerned with complex interorganisational R&D collaboration networks, and to promote the NEMO project worldwide. The Newsletter will offer regular insights into the NEMO project and document its results including previews of NEMO publications.

Other continuous features include the publication of short articles, comments on interesting links, and information about events or publications which are located in the area of our research. External contributions are welcome and should be addressed to the editor. The Newsletter is published quarterly on the NEMO website
http://www.nemo-net.eu

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Institute and disclosed their own recent technological developments. A more recent example of collective innovation is development of open software.

Another mode of knowledge transmission has been documented by von Hippel (1987) in a study of minimill steel producers in the US. He found that engineers from competing firms (with sanction from their management) exchange technical information and explicitly help each other solve problems. In this case however, knowledge is shared on quid pro quo basis, and although exchange is arranged in an informal way, an agent receiving advice is expected to reciprocate or risk being excluded from knowledge exchange in future.

The model of knowledge exchange presented below takes into account interplay between network architecture and knowledge transmission mechanisms. We are interested in relationship between network and population structure and economic performance at levels of individual firms and the whole industry.

MODEL

We model a world in which there is a fixed, finite population of agents, and a fixed, finite number of ideas relevant to production. An agent is characterised by two properties: the set of ideas he has, and his production goal.

Production is controlled by a Leontieff production function for which only a small number of ideas is necessary, different agents having different production functions. Production is done in isolation, but demands that an agent possesses all the ideas that are relevant to his productive activity, i.e. the ideas for which his production function has non zero coefficients. If one or more ideas are missing, they can be acquired via an agent's acquaintances. Thus the set of ideas held by any agent evolves over time, and we assume this takes place through a simple process of one-to-one exchange or gift.

An agent may be a trader or a giver. The latter shares his ideas with neighbours without asking anything in return, while the former exchanges knowledge on a quid pro quo basis. We run a numeric experiment to analyze knowledge diffusion in different settings: a world of knowledge traders, a world of knowledge givers, and a mixed situation in which both co-exist.

We study how properties of the network in which transactions are embedded influence individual and aggregate efficiency. Modification of the Watts-Strogatz rewiring algorithm allows us to generate networks with tunable degree distribution (number of stars) and degree of randomness (therefore clustering).

RESULTS

This section highlights some of the results from the numeric experiment.

- Composition of the population has clear and unambiguous effects on aggregate performance: a higher share of givers increases average knowledge slevel for all levels of asymmetry in the degree distribution and all levels of randomness in the network.
- Effects of asymmetry in the degree distribution on aggregate efficiency depend on the scarcity of knowledge: when knowledge is abundant (in a mature industry for example) asymmetry always has a negative effect on aggregate efficiency, but when knowledge is scarce (young industry) the relationship is non-monotonic – when asymmetry is low the effect is positive, but becomes negative as asymmetry increases.
- Effect of randomness in network structure also depends on the amount of knowledge: when knowledge is scarce increasing randomness (and therefore decreasing clustering in network) has positive effect on overall efficiency of the system, by contrast when knowledge is abundant the effect is reverse.
- At the level of individual agents, it is always beneficial to have many connections. The effect is stronger when knowledge is scarce, when the degree distribution is skewed, and when randomness is high.
- High clustering of an agent's ego network is generally bad for the agent's economic performance. This effect is prominent when knowledge is scarce.
- Traders always outperform givers. The difference decreases with asymmetry in link distribution when knowledge is scarce.
- The effect of having givers as neighbours depends on knowledge abundance: when knowledge is scarce there is no significant gain from having higher share of givers in one's neighbourhood; when knowledge is abundant being close to a giver increases individual performance.

- ◇ Being connected to a star has a negative effect on one's efficiency. This effect is stronger when degree distribution is asymmetric.

POLICY RELEVANCE

Analysis of the model leads to conclusions which are relevant for policy-making in this area. First, under certain conditions (abundance of knowledge, significant share of traders) individual and social preferences may diverge, thus carefully designed policy interventions may facilitate formation of network with socially efficient architecture.

Second, the design of such a policy should take into account specifics of the targeted industry. Indiscriminate application of the same policy in different circumstances may have opposite effects. The details about state of knowledge and the social conventions about knowledge exchange matter a lot, thus in this area policy must be built on a very strong empirical foundation.

COMMENTS AND FEEDBACK

We welcome feedback on our newsletter and work. Do not hesitate to contact us if you have ideas or comments about what you would like to see covered by the newsletter, or if you would like to write a contribution by yourself.

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IMPRINT

Publisher:
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Donau-City-Straße 1
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Company registration number (Firmenbuchnummer): FN 115980i
Court of registry (Sitz- und Registergericht): Wien
VAT identification number (Umsatzsteuer-ID): ATU14703506

Managing Directors:
Prof Dr. Wolfgang Knoll and DI Anton Plimon

Owned by:
BMVIT Austrian Federal Ministry for Transport, Innovation and Technology (50,5 %)

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