Knowledge creation in a nascent biotech innovation system: the case of Pécs city region

Anna Varga-Csajkás (MTA-PTE Innovation and Economic Growth Research Group), Manfred Paier (AIT Austrian Institute of Technology)

Extended Abstract
Submitted to the ERSA 2022 Congress

1. Background and aim

The EU´s Smart Specialization Strategy (S3) aims at strengthening the innovation capacity and competitiveness of regions that are structurally disadvantaged. The S3 concept, going back to Foray et al. (2009), underlines the use of local technological strengths, knowledge resources as well as place-based governance and represents the backbone of the EU´s regional innovation policy of the last decade. However, it has been argued that political decisions on local or regional priorities often lack a sound scientific basis, for instance provided by economic modelling (Varga et al. 2020, Sebestyén and Varga 2019).

Within the widely established literature on regional innovation systems (Cooke 1998), related variety has been discussed in the context of improving competitiveness by utilizing knowledge spill-overs, while unrelated variety was assigned a more defensive, resilience-oriented role against external shocks (Castaldi et al. 2015, Frenken et al. 2007, Fritsch and Kublina 2018). While such arguments have been empirically confirmed for advanced regions, it the situation is less clear for less favoured regions. Where distinctive specialization patterns are absent, the role of unrelated variety might also be crucial for finding new trajectories for the regions (Grillitsch et al. 2018, Trippl et al. 2019), but empirical evidence is still scarce. At the same time, the importance of long-range networks has been recognized and considered in conceptual and computational policy modelling (e.g., Pyka et al. 2018, Ponsiglione et al. 2018).

This ongoing research addresses the issue of innovation pathway creation focusing on the peripheral region of Pécs in Southern Hungary. Here, an S3 strategy is being implemented and cutting-edge technologies including industrial biotechnology is one of the eight national priority areas for the 2021-2027 period. The region of Pécs (Baranya County) is considered a knowledge region, where strengthening the university-centric innovation ecosystem is a policy objective. The paper aims at developing an empirically guided agent-based model (ABM) of new regional knowledge creation and early regional pathway development. The model is implemented in the context of the biotechnology sector of Pécs, and its surroundings and it is used for exploring different policies with scenario simulations.

2. Methodology

We develop an empirical ABM which describes how the actors of the biotech innovation system individually and jointly create new knowledge, leading to new knowledge paths in the city region. ABMs are a class of computational models for simulating the simultaneous actions and interactions of multiple agents in an attempt to resemble the appearance of complex phenomena (Kirman 1997). As such, a key notion is that simple behavioral rules at the micro level generate complex behavior at the macro level, ABMs provide a framework to simulate behavior and interactions of heterogeneous agents within a given environment, with the objective to model the complexity of real-world systems (Nikolic et al. 2013). Compared to previous models of knowledge creation in biotech sector (Dünser and Korber 2017, Paier et al. 2017), the current model focuses on the early stage of innovation pathway development including explicitly the university sector at the level of institutes, regional characteristics, and region-external knowledge sourcing channels.

3. Model description

The agents in the model represent firm and university institutes that are endowed with individual characteristics. The model grabs knowledge creation and exchange process as a crucial part of regional innovation systems. Each agent has a knowledge endowment which is represented by knowledge fields that the agent is active on, and their respective expertise levels. The agents´ knowledge endowment is embedded in a so-called knowledge space which determines the proximity relationships between the different knowledge elements. It forms the basis for knowledge development of the agents, i.e., the way how agents can acquire new knowledge given their existing knowledge endowment.

Besides knowledge endowment, agents are characterized by their research strategy, collaboration memory, organizational figures, and a success score. According to organizational figures, it is determined whether the agent innovates or not at the given timestep. In the beginning of the research, the agent choses a knowledge element from the knowledge space as a research target. The aim of the research process is to achieve this element, which is possible in three ways, through spillover, internal research, or collaborative research. If the agent did not receive the knowledge element via spillover, it carries out innovation alone (internal research) or in cooperation (collaborative research) with some other agent, depending on its research strategy. During collaboration, they exchange knowledge mutually and with actors from outside the region. As a result of the research process, the agents may acquire knowledge gains which may turn into knowledge and innovation outputs, such as patents and publications. These outputs feed back on the initial agent characteristics.

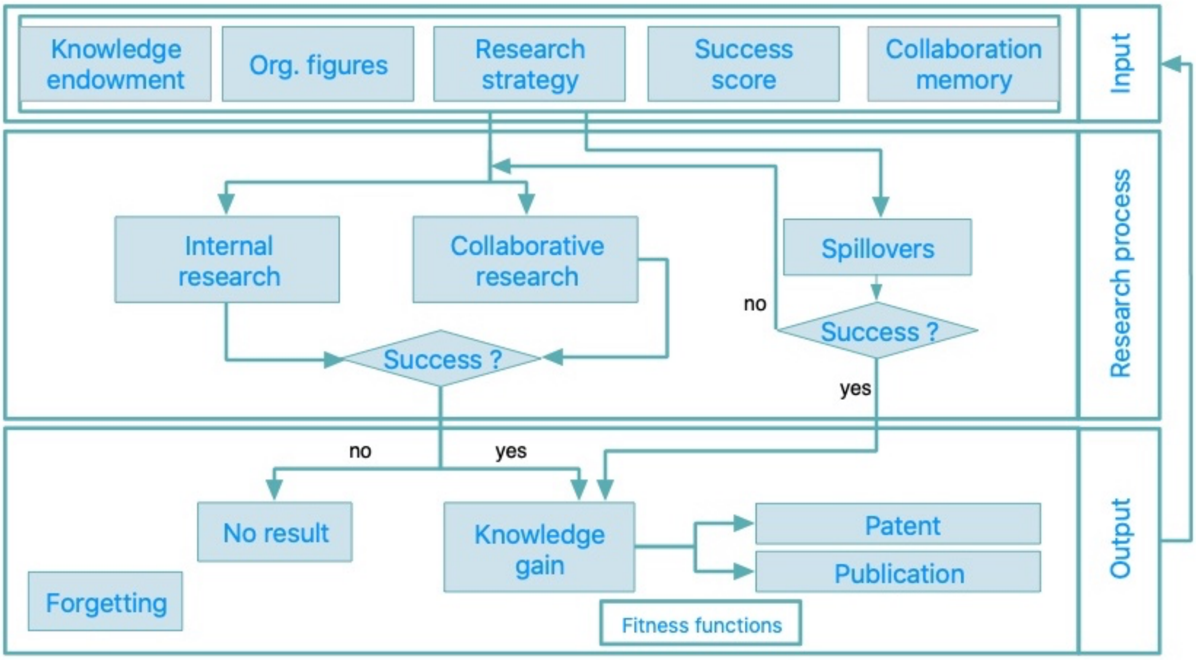

Figure 1. Agent-level research processes in the model

3. Empirical data

Pécs is a less favoured region where, e.g., the university sector is relatively strong, but the related industry is still weakly developed. In connection with biotechnology, the University of Pécs can be highlighted, which has outstanding educational institutions and research activities in the field of health science, therefore human biotechnology could be a breakthrough point (Lengyel 2021). However, only a few firms exist in the region with R&D in biotechnology as principal activity; most of these firms are primarily active in a wider range of science and technology areas.

To initialize, calibrate and validate the model with empirical data, different data sources are tapped. On the one hand, personal interviews were conducted with representatives of 14 biotech related firms and 16 university institutes in Pécs and its surroundings (Varga-Csajkás 2020) to gain information for region-specific model features and processes. On the other hand, we use patent data from the PATSTAT database and publication data from the Web of Science (WoS). We select biotechnology patents (1985-2018) with at least one inventor from the Pécs region. Technological knowledge elements correspond to International Patent Classification (IPC) codes that are assigned to biotechnology patents. Scientific knowledge elements are operationalized by biotechnology-related WoS Research Areas (RAs). We use WoS publications with authors from the Pécs region (including the publication years 2000-2021), to define the biotechnology-related RAs. We searched for the publications which has the string "biotec*" in the name of the RA with at least one author from the region, then we identified the further RAs that are also assigned to these publications.

The knowledge space in which the agents operate, i.e. acquire new knowledge, consists of two distinct parts, scientific knowledge and technological knowledge. The technological knowledge space builds up from the proximity network of technological knowledge fields, operationalized by IPC subclasses of the selected patent dataset, while the scientific knowledge space builds up from the proximity network of scientific knowledge fields, operationalized by the WoS RAs. We use an ontology of industrial biotechnology developed in the KNOWMAK project (Maynard et al. 2020) to link scientific and technological knowledge elements of the agents, to enable technically the knowledge flows.

Based on these empirical data our Pécs biotech model comprises 68 agents (50 university institute agents,18 industrial firm agents), which operate in a knowledge space that comprises 29 scientific fields and 25 technology fields.

4. Model implementation and application

The model is being implemented in NetLogo, a multi-agent fully programable modelling environment. Agent characteristics and the knowledge space are initialized based on the abovementioned empirical data. System parameters that do not have an empirical counterpart are calibrated. Through the calibration process, we set the model parameters in a way that provides the best fit to the observed output data. The baseline scenario represents the case where model parameters are calibrated towards total patent and publication output of the region, while alternative scenarios represent policy options that are operationalized through variations of the baseline parameters. Simulation output describes the evolution of the regional knowledge profiles and formal output levels (patents and publications). We will apply the model to analyse S3 policy scenarios by showing how prioritization of different fields of biotechnology would affect the dynamics of knowledge production in the system.

5. Acknowledgements

This research has been supported by the European Union and Hungary and co-financed by the European Social Fund through the project EFOP-3.6.2-16-2017-00017, titled "Sustainable, intelligent and inclusive regional and city models".

6. References

CASTALDI, C., FRENKEN, K., LOS, B. (2015) Related Variety, Unrelated Variety and Technological Breakthroughs: An analysis of US State-Level Patenting. *Regional Studies,* 49**:** 767-781

COOKE P. (1998) Origins of the concept, in BRACZYK H.-J., COOKE P. and HEIDENREICH M. (Eds) Regional Innovation Systems, pp. 2-25. University College London Press, London, Bristol PA.

DÜNSER, M., KORBER, M. (2017) Regional Specialization and Knowledge Output: An Agent-Based Simulation of the Vienna Life Sciences. In: VERMEULEN, B., PAIER, M.

(eds) *Innovation Networks for Regional Development. Concepts, Case studies, and Agent-Based Models.* Springer International Publishing Switzerland,

FORAY, D., DAVID, P. A., HALL, B. (2009) Smart Specialisation – The Concept. *Knowledge Economists Policy Brief n°9.* Lausanne/Stanford/Berkeley

FRENKEN, K., VAN OORT, F., VERBURG, T. (2007) Related Variety, Unrelated Variety and Regional Economic Growth. *Regional Studies,* 41**:** 685-697

FRITSCH, M., KUBLINA, S. (2018) Related variety, unrelated variety and regional growth: the role of absorptive capacity and entrepreneurship. *Regional Studies,* 52**:** 1360-1371

GRILLITSCH, M., ASHEIM, B., TRIPPL, M. (2018) Unrelated knowledge combinations: the unexplored potential for regional industrial path development. *Cambridge Journal of Regions, Economy and Society,* 11**:** 257-274

KIRMAN A. I. (1997) The economy as an interactive system, in ARTHUR W. B., DURLAUF S. N. and LANE D. (Eds) The Economy as an Evolving Complex System II, pp. 491-531. Addison-Wesley, Santa Fe and Reading, MA.

LENGYEL, I. (2021) Proposals for the development of the biotechnology innovation system in Pécs (in Hungarian). In: REGIONAL INNOVATION AND ENTREPRENEURSHIP RESEARCH CENTER - UNIVERSITY OF PÉCS (ed) *RIERC Research Reports #2021/2.* Széchenyi 2020, Pécs

MAYNARD, D., LEPORI, B., PETRAK, J., SONG, X., & LAREDO, P. (2020) Using ontologies to map between research data and policymakers' presumptions: the experience of the KNOWMAK project. *Scientometrics,* 125(2), 1275-1290.

NIKOLIC I., VAN DAM K. H. and KASMIRE J. (2013) Practice, in VAN DAM K. H., NIKOLIC I. and LUKSZO Z. (Eds) Agent-Based Modelling of Socio-Technical Systems, pp. 73-140. Springer Netherlands, Dordrecht.

PAIER, M., DÜNSER, M., SCHERNGELL, T., MARTIN, S. (2017) Knowledge Creation and Research Policy in Science-Based Industries: An Empirical Agent-Based Model. In: VERMEULEN, B., PAIER, M. (eds) *Innovation Networks for Regional Development. Concepts, Case studies, and Agent-Based Models.* Springer International Publishing Switzerland,

PONSIGLIONE, C., QUINTO, I., ZOLLO, G. (2018) Regional Innovation Systems as Complex Adaptive Systems: The Case of Lagging European Regions. *Sustainability,* 10**:** 2862

PYKA, A., MUELLER, M., KUDIC, M. (2018) Regional Innovation Systems in Policy Laboratories. *Journal of Open Innovation: Technology, Market, and Complexity,* 4

SEBESTYÉN, T., VARGA, A. (2019) Knowledge networks in regional development: an agent-based model and its application. *Regional Studies***:** 1-11

TRIPPL, M., ZUKAUSKAITE, E., HEALY, A. (2019) Shaping smart specialization: the role of place-specific factors in advanced, intermediate and less-developed European regions. *Regional Studies,* 54**:** 1328 - 1340

VARGA-CSAJKÁS, A. (2020) Survey of the biotechnology sector of the Pécs city region (in Hungarian). In: REGIONAL INNOVATION AND ENTREPRENEURSHIP RESEARCH CENTER - UNIVERSITY OF PÉCS (ed) *RIERC Research Reports #2020/004.* Széchenyi 2020, Pécs

VARGA, A., SZABÓ, N., SEBESTYÉN, T. (2020) Economic impact modelling of smart specialization policy: Which industries should prioritization target? *Papers in Regional Science,* 99**:** 1367–1388