Institution: University of Surrey

Unit of Assessment: UOA 23 Sociology

Title of case study: Simulating Knowledge in Innovation Networks

1. Summary of the impact (indicative maximum 100 words)

In a series of European Union funded projects over the last 13 years, a computational simulation model ('SKIN') has been developed at the University of Surrey. SKIN has been used to perform *ex post* and *ex ante* policy evaluation for the European Commission and others to test proposed innovation policies and the model is now also being used around Europe for similar purposes at the national level.

These newly developed computational methods have been applied to allow policy makers to examine and understand the potential effects of interventions in complex innovation systems.

2. Underpinning research (indicative maximum 500 words)

Surrey researchers' development of the computational model, SKIN, (see http://cress.soc.surrey.ac.uk/skin/) dates back to 1997, when Gilbert published a simulation of the structure of academic science (Gilbert 1997) and went on to secure a 4th Framework Programme with colleagues in Germany (Ahrweiler and Pyka) on Simulating Self-Organizing Innovation Networks (SEIN) during which the first version of what was to become the SKIN model was formulated.

At the time, the idea that technical innovation is increasingly powered by network relations was a novelty, but it was to become very influential in Science and Technology Studies. The idea of developing computational models to express complex sociological theories of innovation was also ground-breaking (Gilbert, Pyka and Ahrweiler, 2001). The SEIN project was followed by one funded by the German DAAD and the British Council in which the model was augmented by a representation of the market, so that firms not only had relationships involving the transfer of knowledge but also traded in a market, exchanging products for money. This was continued with a further EC-funded project in which the original model was developed further and applied to the Framework Programme itself.

The model was then made available as program code together with some ten academic publications from the three developers describing various 'experiments' with the model. This encouraged widespread interest in the model by research groups around the world (e.g. in China, Chile, the USA and many European countries), and it now forms the basis of a number of major research efforts examining topics such as the growth of industrial eco-parks in South Korea, the future of the European defence industry and Irish industrial policy (see section 4 for more examples and their impact). Two workshops (with a third planned for May 2014) for users of the SKIN model also encouraged take up, and have led to a book to be published by Springer in 2014 that includes contributions from many users describing their applications of the model.

SKIN is an agent-based model (see N. Gilbert (2008) *Agent-Based Models*. SAGE) in which the agents represent firms. Each firm has a 'kene' (Gilbert 1997) standing for the firm's particular knowledge, expertise and skills. A subset of the kene is the firm's 'innovation hypothesis', a design for a potentially innovative product. In the basic model, firms attempt to sell their products to other firms, and have to source their production requirements from other firms, thus making the model as a whole a circular economy. Firms are able to develop their kenes (and thus their innovation hypotheses and products) through incremental or radical research, and by exchanging knowledge with partner firms. Prices are set by firms according to market conditions, and firms also have to learn what a suitable price for their products is. The model allows for firms to die when they have

no more funds, and for start-ups to enter the market. After calibrating the model with a range of parameters that represent specific industries or sectors, the model can be used to examine the effect of policies such as those that encourage knowledge transfer between firms.

3. References to the research (indicative maximum of six references)

1) Gilbert, N., Pyka, A. and Ahrweiler, P. (2001) 'Innovation networks - a simulation approach', *Journal of Artificial Societies and Social Simulation*, 4 (3): 8.

2) Vaux, J. and Gilbert, N. (2003) 'Innovation networks by design: The case of the mobile VCE'. In A. Pyka and G. Küppers (Eds.), *Innovation networks: Theory and practice*. Cheltenham: Edward Elgar.

3) Gilbert, N. (1997) 'A simulation of the structure of academic science', *Sociological Research Online, 2* (2), 3 http://www.socresonline.org.uk/socresonline/2/2/3.html.

4) Pyka, A., Gilbert, N. and Ahrweiler, P. (2003) 'Simulating innovation networks'. In A. Pyka and G. Küppers (Eds.), *Innovation networks: Theory and practice*. Cheltenham: Edward Elgar.

5) Gilbert, N., Ahrweiler, P. and Pyka, A. (2010) 'Learning in Innovation Networks: some Simulation Experiments'. In P. Ahrweiler, (Eds.) *Innovation in complex social systems*. London: Routledge (Reprinted from *Physica A*, 2007), pp. 235-249.

6) Scholz, R., Nokkala, T., Ahrweiler, P., Pyka, A. and Gilbert, N. (2010) 'The agent-based Nemo Model (SKEIN) – simulating European Framework Programmes'. In P. Ahrweiler (ed.): *Innovation in complex social systems*. London: Routledge, pp. 300-314.

7) Ahrweiler, P., Pyka, A. and Gilbert, N. (2011) 'A new Model for University-Industry Links in knowledge-based Economies', *Journal of Product Innovation Management,* 28 (2): 218-235.

4. Details of the impact (indicative maximum 750 words)

The mechanisms of knowledge creation and utilization in knowledge-based economies have been changing, with an increasing emphasis on the formation of innovation networks, that is, networks that connect innovative firms, government agencies, research institutes and sources of venture capital. Knowledge-intensive industries such as information and communication technologies (ICT) and biotechnology ('biotech') have already undergone structural changes in the direction of these collective modes of knowledge production and application. The SKIN model allows decision makers to examine the potential effect of policy changes. For example, the model has been utilised in the Innovation Policy Simulation for the Smart Economy (IPSE) project funded by the Irish PRTLI and the European Regional Development Fund. The project is using a version of the SKIN model to assist policymakers to 'turn Ireland into a global hub for innovation as a strategy for stimulating economic recovery'. As an example of the type of impact that this project is making, the CEO of Nua Venture Innovations Ltd., a Dublin company that focuses on early-stage technology-enabled ventures across a broad spectrum of sectors including information and communications technologies, sensors and material science, medical devices and ocean technologies and advises at a Government level on the creation, development and evolution of innovation clusters, wrote that the project provides "important strategic guidance for our innovation cluster work at Nua Venture and helps us to better clarify and measure the impact of our innovation activities".

Surrey's research has also been applied by DG CONNECT to examine the possible effects of various proposed modifications to the European Commission's rules for funding projects in the forthcoming Horizon 2020 programme. Gilbert, Ahrweiler and Pyka were contracted by the programme Evaluation Unit of DG-INFSO (now DG CONNECT) to carry out an 'ex ante' evaluation of the effect of changing the rules to have, for example, more or less thematic areas, encourage

larger or small consortia, have more or less funds per Call, and require the participation of SMEs in all consortia, as compared in each case with a baseline scenario of containing the policies implemented in the current Framework 7 (FP7). By adapting the SKIN model to simulate project participants, rather than firms, and making other adaptations, a version was constructed that could reproduce the actual network structure and dynamics of FP7 projects and consortia. The effect of the policy changes of interest to the Commission could then be simulated. The results were reported to the Commission in late 2011 and there is evidence that they are influencing the design of Horizon 2020 (which has a budget of €70 billion).

Other studies that are having an impact on innovation policies across Europe, all of which are based on variations of the SKIN model include:

- A SKIN Model Analysis of the European Defence Industry (Norwegian Institute of International Affairs)
- Modelling the Emergence of a General Purpose Technology from a Knowledge Based Perspective: The Case of Nanotechnology (University College, Dublin)
- Simulating the Effects of Public Funding on Research in Life Sciences: Direct Research Funds Vs. Tax Incentives (Austrian Institute of Technology)
- The Evolution of Innovation Networks in the Nordic Internet Service Industry (University of Oslo)
- The Evaluation of Value Chain Marketing Strategies (Hamburg University of Technology)

5. Sources to corroborate the impact (indicative maximum of 10 references)

Sources in connection with the IPSE project are

C1) CEO of NuaVenture (NuaVenture is an innovation management company supporting venture capital funds). Contact details provided.

C2) Forfás, Ireland's policy advisory board for enterprise, trade, science, technology and innovation. Contact details provided.

The following staff at the European Commission may be contacted to corroborate the impact of the work on policy options for Horizon 2020 (the work is documented in the final report of the study: "Using network analysis to monitor and track effects resulting from changes in policy intervention and instruments" - SMART 2010/0025):

C3) 1st Representative of the EC. Contact details provided.

C4) 2nd Representative of the EC. Contact details provided.

C5) 3rd Representative of the EC. Contact details provided.

C6) The SKIN model has been cited by the Commission (in https://etendering.ted.europa.eu/document/document-file-download.html?docFileId=3808 , 2013) as follows:

"Work conducted by the EC DG INFSO (now EC DG CONNECT), (Project INFSO SKIN), investigated the structuring effects of Framework Programme ICT research. It showed that FPs facilitated more intense and inclusive collaborations over time, and were effective in bringing together different types of actors and integrating European players into global networks."