

## ***Statistica Neerlandica* special issue on Statistical Network Science**

We are pleased to present you here with a special issue of *Statistica Neerlandica* on Statistical Network Science. Ironically, while we are writing this editorial at home, a contagion process is spreading across people's contact networks with a speed that has surprised many. Governments are trying desperately to contain the most devastating effects of the COVID-19 epidemic by limiting contacts between people. At the same time, epidemiologists are trying to learn from imperfect screening data about the infection fatality rates in various parts of the population, about whether the disease can be asymptomatic and how quickly the virus spreads. Although many things are not yet clear, the coronavirus pandemic has shown that there is much more to learn about these types of processes.

For the past 4 years, the EU COST Action COSTNET (CA15109) has brought together European statisticians and other quantitative scientists to study all kinds of processes in and on networks. From infectious disease networks, social networks, graphical models, phylogenetic trees, financial networks, and brain networks, the COST Action has been studying communalities and possible synergies between various approaches and, in the process, it has established a healthy community of over 500 network data scientists. This is a truly open effort to advance an important field of science through the grassroots EU COST funding scheme, allowing scientists to join also after the funding had been granted.

In this special issue, people from within and outside the COST Action have created a beautiful mosaic of many of the issues that have been studied in the past 4 years. We begin, appropriately, with two papers on infectious disease modeling. Britton provides an overview of epidemic models on social networks, discussing common transmission mechanisms, introducing the now well-known basic reproduction number  $R_0$  and providing ways to perform inference in these models. Hansson and Strömdahl consider the special case of sexually transmitted diseases and how to infer transmission properties when we observe only the immediate neighborhood of the sampled individuals, the so-called ego-centric networks. Still a biological network but with a focus on evolutionary processes, Richter and coauthors focus on modeling the spreading process of evolution by means of speciations and extinctions. The challenge in such networks is the almost complete absence of information about extinct species, which severely biases naïve estimates of the dynamics in such processes.

Many processes on networks, such as those described above, are inherently dynamic and specific methodologies have been developed to capture this. Fritz and coauthors provide a comprehensive overview of both discrete and continuous time network models. They contrast temporal exponential random graph models (s-TERGMs) in discrete time with relational event models (REMs) in continuous time and show how existing software implementations can be used to analyze dynamic network evolutions. Snijders and coauthors also explore dynamic network

models. They show how the popular stochastic actor-oriented model (SAOM) can be extended to node sets with a nesting structure and they apply their method to the within and between social network dynamics of seven villages in Senegal.

Processes on networks may spread at a different rate in different parts of the network or across different groups of nodes. The following set of three papers all attempt to model some form of node heterogeneity within a random graph model setting. D'Angelo and coauthors consider a latent space formulation to generate (dis)similarities between individual nodes across multiple network observations—a so-called multiplex. Whereas the latent space ties the individual nodes together, the typical excess edge dispersion is modeled through node heterogeneity. Schweinberger as well as Pavlovic and coauthors propose extensions to the well-known stochastic blockmodel for modeling clusters of nodes. Schweinberger extends the blockmodel to a temporal setting with discrete time observations and applies this to ownership networks of nonfinancial companies in Slovenia in the transition from a socialist to a market economy. Pavlovic et al. consider brain networks and argue for the importance of including random effects in blockmodels to account for dependencies that may exist within subjects.

Another class of network processes are those with fixed links, but random nodes, normally referred to as *graphical models*. These models consider multivariate observations where the links are interpreted as conditional independence structures. Scutari provides an overview of a class of directed graphical models, also known as Bayesian networks. He focuses on dynamic data with incomplete observations, which is the norm in many practical applications. Besides learning about the dynamic parameters in such models, he also shows how the methods can be used to learn the underlying network structure. Also Petrakis and coauthors consider the problem of structure learning, but in the context of undirected graphical models. They show how the use of (power) expected-posterior priors can aid in learning the structure of conditional independence graphs within a Bayesian inferential procedure.

The special issue concludes with an effort by Sadeghi and Rinaldo to marry the domain of random graph models, discussed in the first part of the special issue, with the domain of graphical models, discussed in the second part. They introduce a new family of random graph network models, in which each member can be associated with a graphical model defining conditional independence clauses among the dyads of the network. This provides an excellent end to the special issue and a nice illustration of the progress that has been made in statistical network science over the past decade, where models from one field have been adapted to suit new needs and answer new questions. We are still in the middle of these transformative research efforts, but we hope to have been able to give a glimpse of the activities in this field with an open invitation to all to join.

Veronica Vinciotti<sup>1</sup>

Ernst C. Wit<sup>2</sup>

<sup>1</sup>*Brunel University London, London, UK*

<sup>2</sup>*University of Groningen, Groningen, The Netherlands*

### Correspondence

Veronica Vinciotti, Brunel University London, London, UK.

Email: veronica.vinciotti@brunel.ac.uk