Chapter 8
The Role of Proximity in Inter-Organizational Network Evolution:
An Application of Actor-Oriented Modeling for Longitudinal Network Analysis

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ABSTRACT

This chapter presents and discusses some methodological issues in the application of stochastic actor-oriented modeling for longitudinal network analysis. By following a forward-selection procedure, three models will be defined and run on four observations of the collaboration network subsidized by the European Union Framework Programmes in the Aerospace sector, covering a 20-years time span (1994-2013). Specifically, the influence exerted by five dimensions of inter-organizational proximity (geographical, organizational, social, institutional and technological) on the longitudinal evolution of the network is analyzed. Results show that organizational proximity is the most important driver for the longitudinal evolution of the network. Further, this form of proximity is constant in time, analogously to the geographical one which, on its side, only moderately affects network's evolution. Network proximity plays a weak but positive influence, while the institutional and technological dimensions do not affect the evolution of the network. Anyway, when proximity is evaluated on single institutional and technological types, different roles are detected. Organizations' patenting activity, introduced as a control variable, does not play a significant role on network's evolution.

INTRODUCTION

Social networks, as well as all social structures, are not steady in time because they change as a consequence of the influence exerted by both endogenous and exogenous forces; time is a crucial variable to deeply understand their mechanisms and regularities.

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Commonly, the approach to longitudinal phenomena is based on time series adopting techniques for the estimation of the influence of some independent variables on one or more dependent variable. Therefore, after taking some pictures at different intervals of time – i.e. the empirical observations of a time-evolving phenomenon – dedicated statistical techniques allow the definition of the relation between the *explanans* and the *explanandum*, assuming the set of independent variables (i.e. the *explanans*) to be composed by uncorrelated elements. When the dependent variable is a network the situation dramatically changes because it is not a vector in which, alike to standard statistic, each row reports the state of the corresponding case on that variable. A network is a square matrix whose cells correspond to the state of each couple of nodes i and j, with $i \neq j$. This object is not linear because all the relations – that is the entries of the cells – are interdependent: a change of one connection can affect also the relations between other couples of nodes, and potentially lead to a global reconfiguration of the topology. Hence, when analyzing the longitudinal evolution of a network, nodes – and the links they form – cannot be considered independently: *auto-correlation* is a basic assumption of the relational approach. The simulation of the changes elapsing between an observation and the following one allows the dynamic modeling of the changes in the relational set considering that a change in each relation can affect all other relations. This is a way to avoid the violation of the interdependence assumption with some limitations that will be discussed in the closing paragraph of this chapter.

Further, nodes are not only characterized by their connections: their heterogeneity is also due to exogenous attributes, for example gender, age, ethnicity etc…in case they are individuals. Hence, also these variables are supposed to affect nodes' position in a network. Purely topological analyses are very common and bring relevant knowledge on reticular phenomena; by the way the joint consideration of nodes' connections and attributes in the analysis permits to deepen both the aspects. On the one side the state of a node on an attribute can be influenced by its position in the network, for example the deviant behaviour (attribute) of a pupil can be influenced by her friends (the nodes connected to her). On the other side, the position of a node in the network – referring to the mentioned example, the friendship relations of a pupil – can be influenced by an attribute, i.e. age, gender etc…that is like saying "birds of a feather flock together".

Stochastic Actor-Oriented Models (SAOMs) elaborated by Tom Snijders and colleagues (Snijders, 1996; 2001; 2005; 2009; Snijders e van Duijn, 1997; Snijders et al. 2007; Ripley et al., 2013; Steglich et al., 2010) are designed to simulate the evolution of a network during the periods – namely the *waves* ($w_1, w_2, \ldots w_{m-1}$) – elapsing between one observation and the following one ($t_1, t_2, \ldots t_m$) bearing into consideration that network change is a consequence of the action of endogenous mechanisms and exogenous factors, and that a local change in the network – i.e. a tie between a couple of nodes can be created or interrupted – affects the behaviuor of the other couples of nodes.

They are defined as "actor-oriented" because the evolution of the network is driven by the choices of the actors (i.e. the nodes), basically modeled by an evaluation function whose characteristics will be specified later on in the chapter. This approach to network modeling can be included in the structural individualism perspective (Snijders, 2001; 2009; Snijders et al., 2009; Udehn, 2002; Hedström, 2005) where actors' agency – i.e. their action consequent to their evaluation of the network – is made possible and at the same time constrained by the structure in which they act, namely the network.

Summarizing, the network is the dependent variable, while endogenous (nodes' position) and exogenous (nodes' attributes) effects are the independent ones. The construction of SAOMs allows the exploration and explanation of the longitudinal evolution of the dependent variable – the network, as mentioned – according to actor's preferences in tie creation or dissolution modeled as "effects" of a function.

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