Chapter 9
The Role of Knowledge Heterogeneity in Industrial Clusters Knowledge Dynamics: An Application of the Boolean Network Simulation Modeling

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ABSTRACT

In high-tech industrial clusters as the aerospace most collaborations for innovations are highly knowledge-specific and form a (relatively dense) knowledge network. With reference to the case of the aerospace industrial cluster of the Lazio Region, in this work we study the network dynamics of its core organizations (firms, universities, and research centers). By applying the methodology of NK simulation modeling, we explore what happens lacking the initial contribution of knowledge provided by universities and research centers. Further, we investigate the effects of the introduction of minimum requisites in terms of knowledge heterogeneity and knowledge amount. We show that, within a general favorable condition of activation rules, trajectories are quite short and knowledge dynamics is sensitive to the requisite of knowledge heterogeneity, when it is set-up around half of its potential range. We will conclude that, despite some interesting results like the ones we have found and many others that could be discovered, this methodology has substantial failures mostly due to its requisites of computational burden and topological and behavioral invariance, which makes it hardly applicable and scarcely informative into empirical analysis of phenomena within economics and management sciences.

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INTRODUCTION

The aerospace (AS) sector worldwide is typically organized in industrial clusters, where firms and research centers and universities exchanges goods and services, and such trades are usually accompanied with strict collaborations to search for innovations or new solutions and improvements of existing products. In many cases collaborations are represented by forms of co-design, extensively required for the complex products and projects that characterize AS industry. Therefore, AS industrial clusters are formed not only by inter-organizational trade networks, but also by inter-organizational knowledge networks. One of the form with which knowledge transfer occurs is through collaborations for innovation.

Based on a research field realized about 10 years ago on the Lazio Region AS industrial cluster, Sammarra and Biggiero (2008) showed that when considering the three broad categories of technological, market, and managerial knowledge single firms patterns of knowledge exchanges are very differentiated and firm-specific. Moreover, the large majority of inter-organizational exchanges employ all the three types of knowledge. Other scholars (Biggiero & Basevi, 2011; Belussi & Sammarra, 2010; Biggiero & Sammarra, 2010; Giuliani, 2006) confirmed that industrial clusters are heterogeneous structures in terms of centrality and other topological and economic variables. Most firms are very specialized and unique, and therefore, products supplied by one firms could be hardly replaced by another one, at least in the short run. This result is corroborated by many other studies on the AS sector (Giuri *et al.*, 2007; Jordan & Lowe, 2004; Paoli & Prencipe, 1999; Prencipe, 1997, 2000, 2001).

We speculated that in AS industrial clusters, likely, this high specificity holds for knowledge-bases too (Acha *et al.*, 2007; Paoli & Prencipe, 1999; Prencipe, 2000; Ryu & Pak, 2010; Smith & Ibrahim, 2006), at least for creating new knowledge that can be combined through collaboration, and thus, transferred to innovation partners. Knowledge relatedness (Breschi *et al.*, 2004; Chen, 2004; Chen *et al.*, 2012; Hussinger, 2010; Piscitello, 2000; Shin & Jalajas, 2010; Tanriverdi & Venkatraman, 2005) and complementarity (Chiu *et al.,* 2008; Giuri *et al.*, 2004; Letel *et al.*, 2007; Makri *et al.*, 2010) could be considered the drivers for inter-firm knowledge recombination. Moreover, being products highly decomposable (Frenken *et al.*, 1999; Marengo & Dosi, 2005; Simon, 1962) and co-designed between a system integrator and first- or second-tier suppliers (Cooke & Ehret, 2009; O'Sullivan, 2006; Rose-Anderssen *et al.*, 2005, 2008, 2009), inter-firm patterns of knowledge combination and product integration could be not dissimilar.

We further speculate that there is a sort of minimum knowledge heterogeneity required to build a combination sufficiently rich to create new knowledge. In other words, a certain variety of knowledge sources is necessary to generate new knowledge. Clearly, being AS firms very different in terms of size, products and degree of centrality within a cluster knowledge network, such a minimum knowledge heterogeneity requirement varies from firm to firm. The study realized 10 years ago discovered a precise topology of the cluster core, and thus, jointly with qualitative and quantitative structural, economic and technological information, it provides the data necessary for identifying a minimum knowledge heterogeneity requirement for each organization, including universities and research centers.

Another research stream employed in this paper is that related to the remarkable role played by university and research centers (URC) – and more generally, the education system – for the development of territorial systems, and in particular for its capacity to innovate. The debate around regional innovation systems (Andersson & Karlsson, 2007; Audretsch & Taylor Aldridge, 2009; Cooke *et al.*, 2004, 2007; Leydesdorff, 2006), innovation networks (Amin & Cohendet, 2004; Nooteboom, 2004; Pyka & Küppers, 2002) and industrial clusters competitiveness (Arikan, 2009; Boschma & ter Wal; 2007; Henry & Pinch,