The typology of technology clusters and its evolution — Evidence from the hi-tech industries

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ABSTRACT

Clustering is one of the key drivers for regional economic growth. Development of clusters is a dynamic process shaped by a variety of internal and external factors such as availability of skilled labor, presence of functioning networks and partnerships, technological changes, and market competition, etc. As a result, the patterns of cluster growth may differ from one another. Although each cluster is unique in some way, previous research has attempted to identify few simplified models of evolution of clusters. In this study, we briefly reviewed the literature on a variety of models of clusters. Based on these models, we investigated 15 hi-performing metropolitan-based clusters in the United States, covering communications equipment manufacturing, information technology, and biopharmaceutical industries, in order to find out the similarities and differences between real-world clusters. Specifically, by examining the composition of these high-tech clusters, we attempted to find out the following: 1) What are the typologies of these technology clusters? 2) Whether different industries tend to support different cluster typologies? and 3) How do clusters change their typologies over time? Our analysis results suggest that the real-world clusters rarely feature any single type of typology; a mixed type of typology is much more prevalent in reality.

We also found that different industries tend to support different types of cluster typologies. In other words, an individual cluster's typology is to some extent shaped by the industry group it belongs to. In addition, we note that, as a cluster goes through different stages of its lifecycle, its typology may change significantly.

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1. Introduction

Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standard agencies, and trade associations) in particular fields that compete but also cooperate [1]. We noted that, from literature research, there are many different ways of defining a cluster. In the earliest study in this field, conducted by Alfred Marshall [2], the notion of "industrial districts" was developed and it was referring to agglomerations of firms operating in one industry sector in a well-defined and relatively small geographic area. Building on Marshall's notion, other regional innovative models, such innovative milieu and technology districts have been offered as frameworks for discussing the pattern of agglomerations. What distinguishes clusters from these other models has not been clearly defined [3]. Indeed, these concepts — clusters, industrial districts, innovative milieu, and technology districts — are often used almost interchangeably despite having origins in different conceptual contexts [4]. Although we've recognized that there are studies attempting to distinguish the industrial clusters from technology clusters [5], the differences identified by certain authors were not consistently acknowledged by other studies/researchers. In this study, we follow Porter's [1] definition of clusters, mainly because of the influence of Porter's research in this field.

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Despite the potential confusion caused by the inconsistence in terminology, the contribution of clustering to regional economic development has been well accepted and documented [6,7]. Companies cluster together to benefit from the availability and quality of local labor pools, well-developed intermediate input suppliers, and better information flows which can facilitate the generation of new ideas. Among those factors, knowledge spillovers between economic actors are believed to be a particular important one promoting the development of modern clusters [8–10].

Because of the significant benefits brought by clustering, both academic researchers and regional planners seek to understand the factors shaping the evolution of clusters. In many of the real-world cases, clusters have emerged unplanned and then gone through a dynamic lifecycle process, which typically consists of four stages: embryonic, established, mature and declining. It is noteworthy that, when a cluster goes through its own evolution path, the forces that foster the subsequent growth of the cluster are not necessarily those that provide the cluster its initial advantage [11]. From a perspective of regional planning, it seems to be rather challenging, if not impossible, to develop a cluster from scratch by planning. But policy interventions, when appropriate, can facilitate the development of an existing cluster [12]. In order to come up with appropriate cluster policy interventions, understanding the driving forces of individual clusters would be fundamental, as clusters are all different from one another.

Despite the differences between clusters, there are some important features shared by certain groups of real-world clusters. Previous research has attempted to model the evolution of real-world clusters with those important cluster characteristics. In the following, we will review the literature on cluster characteristics and a variety of cluster typologies. Following the literature review, we will examine 15 U.S.-based hi-tech geographical clusters, covering information technology, communications equipment manufacturing, and biopharmaceutical sectors. By examining the typologies of the select high-performing clusters, we aim to answer the following 3 questions: 1) What are the typologies of these industrial clusters? 2) Whether different industries tend to support different cluster typologies? and 3) How do clusters change their typologies over time? The reminder of this paper is organized as follows. Section 2 reviews the literature on industrial clusters and cluster characteristics. Section 3 describes our methodology for analyzing the select clusters. In Section 4, we present and interpret the data results. In Section 5, we conclude with a discussion about the implications of this study for cluster researchers and practitioners.

2. Cluster characteristics and the variety of cluster typologies

The studies of clusters date back to Marshall [2], who developed the agglomeration concept, based upon the cost-saving scale effects brought by industrial localization. According to Marshall, companies in a particular industry tend to cluster together for taking advantage of external economies brought by co-locating, including reduced transaction costs, increased specialization, and efficient information flows. Although Marshall's original model successfully explained some earliest industrial clusters, observations from recent clusters suggest that the phenomenon of clustering appears to be much more complex than the original Marshallian agglomeration model has suggested. For example, case studies on many recent clusters suggested that social interactions as well as knowledge flows between cluster members play an important role in the development of many modern clusters [8–10,13]. Social relations, however, were not considered an important element in Marshall's original cluster model.

Following Marshall's work, Becattini [14], Brusco [15], and Sforzi [16] identified a newer type of cluster by examining the economic success of several Italian cities and regions. The modified Marshallian model not only acknowledges Marshall's original agglomeration concept, it also recognizes the roles of social relations as well as inter-firm cooperation/competition within industrial clusters. While Marshall stressed the direct benefits of co-locating (e.g., input cost reduction, availability of labor, etc.); the modified Marshallian model (sometimes referred to as "Italian version of Marshallian model" in the literature) emphasized the role of social interactions between co-located firms/individuals when explaining the success of clusters. The modified Marshallian model is important as it provides a good foundation to explain many successful modern clusters including Silicon Valley and Orange County [9,10].

Even with its Italian version, the Marshallian formulation wasn't able to explain the flourishing of some clusters and demise of others. In order to address the increasing complexity and variety of real-world clusters, Markusen [17], through inductive inquiries, broadened the picture by introducing additional models of clusters. Besides the Marshallian formulation, three additional models of clusters were proposed by Markusen — "hub-and-spoke", "satellite platform", and "state-centered".

Fig. 1 illustrates the typology for each of the cluster models. The links depicted in this chart reflect regular inter-firm business activities such as supplier–customer transactions. In the categorisation shown in Fig. 1, Markusen [17] stressed the distinct roles played by different groups of cluster members, as well as the way different players interact with each other. We noted there are other categorisations proposed by different researchers; based on our understanding, other models are not as comprehensive as the Markusen's model when it comes to capturing the structures of real-world clusters. For example, Lorenzoni [18] proposed a categorisation based on asymmetries among the cluster members and introduced the concept of "leader firms" and "surrounding firms".

According to Markusen [17], a hub-and-spoke cluster, is structured around one or few dominant firms supporting the regional cluster. In this type of cluster, suppliers and other entities spread around and are connected to the hubs like wheel spokes. In a simple version as depicted in Fig. 1, a giant hub firm trades with local small firms as well as external suppliers and sells mainly to external customers, which could be large or small ones. In reality, single-hub-based clusters include the Seattle-based aircraft manufacturing cluster supported by Boeing, and the Toyota City-based car manufacturing cluster supported by Toyota. A multi-hub-based cluster can be found in Detroit, where the "Big Three" auto manufacturers dominate the regional economy and are surrounded by a number of small and large suppliers. In such a cluster, substantial trades take place between hub firms and local smaller suppliers. However, cooperative activities among competitors within this type of cluster are remarkably lacking. Cooperation may occur between hub-firms and surrounding suppliers, but the terms of cooperation are often set by the hub-firms. Due to its very nature, the dynamics of a hub-and-spoke cluster are largely determined by the hub firm(s), either via its success or failure.