Patent Assignees' Collaboration Evolution Networks of CAS, China

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Introduction

Patents have been applied to understand the linkages between industries, nations, or technologies in terms of technological innovations and knowledge flow (Lee, 2010). During these kinds of works many methods had been used including the method of Social Network Analysis (SNA), which just had begun to invade the field of patent analysis (Sternitzke, Bartkowski & Schramm, 2008). The purpose of this paper was to utilize the SNA methods to carry out a pilot study that we undertook to map the evolution of the patent assignees' collaboration networks of CAS from 1985 to 2009. This article depicts the evolution networks of CAS from two levels, which are ego (nodes represented CAS and its collaborators) and global (nodes represented the sub-institutes of CAS and their collaborators) networks.

Data Source & Methods

We collected all the patents of CAS by the names of its sub-institutes in ISI Derwent Innovations Index^{SM} (DII) from 1985 to 2009. Two different network analysis tools NWB (NWB Team, 2006) and Thomson Data Analyzer (TDA) had been used.

Patent Assignees' Collaboration Evolution Networks of CAS (ego & global)

Nodes Growth of Networks

The cumulative number of the sub-institutes (1), collaborators (2) of CAS and the sum of both sub-institutes and the collaborators (3) from 1985 to the end of each year from 1986-2009 had been showed in Figure. The sub-institutes or collaborators that had already occurred in earlier years would not be counted again when it reoccurred in later years. Applying non-Linear regression led to the below equations separately:

$C_1(t)$=40.12ln(t)-20.04 (1:sub-institutes, r^2=0.9479)

$C_2(t)$=0.38$e^{0.27t}$ (2:collaborators, r^2=0.9718)

$C_3(t)$=26.47$e^{0.11t}$ (3:sub-institutes+collaborators r^2=0.9803).

Where *C (t)* denoted the cumulative number of sub-institutes, collaborators of CAS or the sum of the both by the end of each year from 1985-2009, and *t* meant the (year-1984) from 1985-2009 (1<t<26).

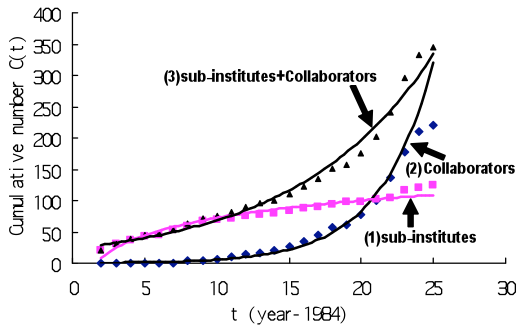

Figure 1. Cumulative numbers of the sub-institutes (1), collaborators (2) and sum of both sub-institutes and collaborators (3): 1985-2009

The results showed that both the cumulative data of collaborators (curve 2, figure 1, ego network of CAS) and the cumulative data of the sum of sub-institutes and collaborators (curve 3, figure 1, global network) had Exponential Growth Laws.

However, the cumulative data of sub-institutes (curve 1 in figure 1) was a Log Curve, which was completely opposed to the curve 2 of collaborators. Therefore, as a combination of curve 1 and 2, the curve 3 of global networks had a much smoother increasing trend comparing to the curve 2 of ego networks.

As was vividly betrayed in curve 1, figure 1 above, in the early few years, the assignees' number increased rapidly and reached 53 sub-institutes in 1991. Since then, the number of sub-institutes grew slowly, especially compared to the number of collaborators. Actually, the number of sub-institutes could not be increasing constantly. Nearly all the sub-institutes of CAS had patents now. Thus, the contribution to the increase of sub-institutes would mostly depend on the new-built institutes. It could be reasonably expected that the new-built institutes could not generate constantly and fast. Therefore the cumulative curve 3 of global network had to be contributed by collaborators if it still wanted to present the Exponential Growth Law.

Densification and growth

The scaling exponent α (a constant in scaling law formula: edges = $A(\text{nodes})^{\alpha}$ of the relation between numbers of nodes and edges in collaboration networks) (Bettencourt Kaiser and Kaur, 2009) had been used to analyze the densification and growth of CAS patent collaboration network, where nodes represented CAS (curve 1 in figure 2, ego network) or sub-institutes of CAS (curve 2 in figure 2, global network) and its collaborators. For there was no collaborators before 1991, the data in the curve started from 1992.

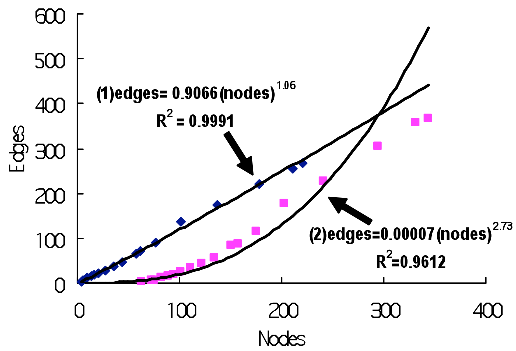

Figure 2. Densification of assignees collaboration networks of CAS (1) and sub-institutes (2)

We found that the scaling exponent of ego network (α=1.06) was much lower than the global network (α=2.73). As the global network included the edges between CAS and its outer collaborators in ego network, it suggested that the number of inner ties between sub-institutes grew faster than that of ties between sub-institutes of CAS and their outer collaborators.

Network Diameter

Leskovec, Kleinberg and Faloutsos (2005) found that the network diameter tends to decrease as a graph grows. Bettencourt Kaiser and Kaur (2009) had found that collaboration graphs for their scientific and technological fields showed an initial fast growth in their diameters, which then tended to stabilize and stay approximately constant d ~ 12-14.

However, in our work, the global collaboration network diameters grew from 1 in 1994 to 16 in 2009 (there was no ties before 1993). There was no indication that whether it would stabilize at about 16 or would increase continually or decrease.

Distribution Patterns of Final Global Collaboration Network

By the end of 2009, there were 125 sub-institutes of CAS had patents published and 219 outer collaborators. These 344 nodes formed the final global collaboration network of 2009, which included one rich component with 252 nodes, two six-node weak component, two four-node weak component, seven three-node weak component, seven two-node weak component and 37 isolates (all isolates were sub-institutes). The data suggested that nearly 30% (37 isolates) sub-institutes had applied patent merely by themselves, which probably meant that these 30% sub-institutes had no patents collaboration activity with others.

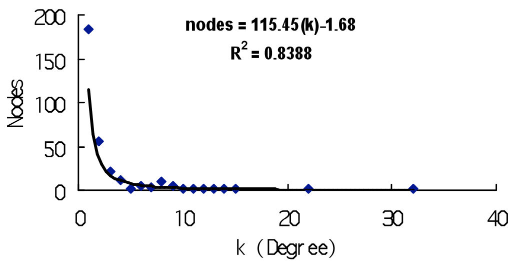

Figure 3. Nodes distribution of global network

Figure 3 betrayed the relation between nodes and their degrees in the global network of 1985-2009, which followed a power law distribution. This probably meant that the global collaboration network had the scale-free property.

Conclusions & Discussion

The collaboration network of CAS is at the stage of growth. The nodes growth pattern of assignees collaboration network would highly depend on the number of new sub-institutes and new collaborators, particularly on the latter, for nearly all the sub-institutes of CAS had patents now. However, the collaboration ties of global network were contributed mostly by the sub-institutes till present. It would be very interesting to watch when the ties would be replaced by the collaborations with the outer collaborators. There would be an important transition of CAS assignees collaboration network.

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