Random Graph Models Utilization for Economics Purposes

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Abstract: This paper explores the usability of random graph models from the field of social network analysis for selected topics in the field of economic sciences. Specific examples are given in the field of international trade and strategic research as part of international research analysis. At present, there is an increasing need to connect individuals or organizations to increasingly complex networks, and as the complexity of such structures grows, the need for understanding how such structures are created and what they actually mean. The method of random graphs used in the paper serves as an appropriate method for such analysis.

1 INTRODUCTION

From a historical point of view, trade is more common within nations themselves than between each other (Helliwell, 2000, McCallum, 1995). As (Eaton and Kortum, 2002) estimated that areas that do not have geographical boundaries are able to have five times more trade than those with borders. The lack of trade between countries can often be explained by various formal trade barriers such as poor enforcement of international contracts with the help of governments (Anderson and Marcouiller, 2002), or inadequate information on possibilities for international trade (Portes and Rey, 2005). Business and social networks that operate between countries can help to break down these barriers. Researchers can then help to look at how to overcome these barriers. Research can serve as documents and is able to quantify the existence of such barriers.

While transnational networks are primarily researched as a means of overcoming barriers to trade, much of the research on the impact of domestic networks on international trade is rather motivated by the view that they are an informal barrier to trade, with network members colluding to increase their market power by restricting foreign competition. There is also a line of work that measures the effects of domestic networks on the composition of international trade.

The aim of this paper is to highlight the possibility of analyzing international trade between countries in terms of social network analysis. The paper brings some definitions of economic networks and international trade as outlined in the following chapters. Many publications deal with the field of international trade analysis but few of them deals with social network analysis as a tool to analyze international trade. We discuss the possibility to utilize social network analysis to international trade. We use random graph model to analyze some basic international trade characteristic.

2 SOCIAL NETWORK ANALYSIS

Social networks and the analysis of relationships is an important concept in many sorts of areas, from public administration, sociology, management, and even within international trade analysis. Social network analysis focuses on the structure of relationships between individuals or organizations where the network is perceived as a set of actors linked by social bonds. Some analyses focus on organization theory. Over the last few years, there have been many studies that deal with relationships between organizations. There are studies that focus on key factors and indicators of inter-organizational relationships, and this phenomenon has a growing importance as the links from dyads (organizational sets) to networks are gradually shifting. In the academic sphere, there is a view that both business relationships and non-profit sectors are trying to make any cooperation within the framework of the growth alliances as one of the possible ways to be more effective and competitive. It is clear that in the current globally interconnected world, such

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cooperation is an important element among those organizations that seek to take on the global market. Such behaviour is not entirely possible in the traditional market environment.

There are several well-known techniques to measure the properties of networks (Snijders, 2001), actors, or relationships. These techniques help to understand certain features of the network that relate to research questions.

1) Social behaviour is a complex process, and stochastic modelling allows us to capture both regularity in the processes that take place across the network and variability, and we can then model them in detail and detail. Adding a small amount of randomness to an otherwise regular process can significantly change the output of the entire process.

Researchers usually try to capture stochastic process if they believe their model best reflects real world problems. It is very important to design the stochastic model well to allow them understand uncertainty of the observation of real world problems. Researches usually wants to learn something new about the distribution of the possible output.

Researchers need to create such statistical model that allow them to create judgment about certain structure in the network. This structure occurs in the model or occurs in the network with some probability. Researches establish a specific hypothesis about social processes.

The more complex data structures are in the network the more useful model is achieve for data representation.

Sometimes, different social processes can have similar quality assumptions about network structures, and can only be determined by quantitative modelling. For example, clusters in networks can be made from endogenous (self-organizing) structures or from homophily. If researcher want to decide which of the processes is created, then we need to create a model and find out from the results what suits us.

Some problems about social network analysis is to deal with how structures and processes in networks affect forming of global pattern of the network. It is very complicated to understand without any kind of model or modelling. Sometimes it is well understandable due to quality modelling and simulations.

2.1 Random Graph Model

Random graph model (Erdos and Renyi, 1966, Albert et al., 1999, Molloy and Reed, 1995) is usable tool for creating some models and simulation of real world problems. Many scientific applications is used by helping of this model. We should follow these steps for using random graph model.

1) Each network connection is perceived as a random variable. This step involves a stochastic base with a set of fixed points. The combination of these points is then perceived as a relationship that arises with a certain probability. It is not possible to perceive this as the principle of creating a relationship based, for example, on fashion, etc. We'd rather determine that we do not know much about the network and that we do not know much about forming relations, that our model is not capable of creating perfect deterministic predictions, and that the results will contain some noise that we cannot explain.

2) Eventualities are defined by hypothesis dependence. Hypotheses represent local social processes that are capable of networking. Consequently, connections can be independent of each, as people create social connections independently of their previous connections.

3) Researcher should create a hypothesis for introducing the particle formation into the model. Each parameter corresponds to a network configuration, a subset of possible network connections. Such configurations refers some structural characteristic of interest. The model represents the distribution of a random graph. The configuration is usually created by simple connection between two actors.

4) It is recommended to simplify parameters. This simplification is provided by using of homogeneity and other restriction. Model is defined by better way if the researcher limits the number of parameters. The researcher equate some of the parameters to unify or link other parameters in different way.

5) Design and interpretation of the model and its parameters. The focus for modelling is the emphasis on designing and interpreting the model. However, this approach usually requires the completion of the previous four points. This last step is very complex if the model structure is complicated, as the real world problems usually are. Researchers often use the benefits of statistical models for networks in case of parameter estimates, as well as an estimate of the uncertainty of the model.

Creating a random graph is done by taking a number of N nodes and interconnecting each other so that each pair i,j has a connection with an independent probability of p. However, if we want

to examine models that are close to the real base, we have to accept it. That such a simple model has some weaknesses. One of them is the distribution of degrees in the graph, which is to be calculated as in the real world.

Consider a node in a random graph. With a certain probability, p is linked to each of the *N-1* other nodes in the graph, and hence the probability p_k that is assigned to node k with a binomial division

3 INTERNATIONAL TRADE AND SOCIAL NETWORKS

Many authors highlight as a positive feature the transmission of information from the network can serve as a source of information about the possibilities of the business itself or of the investments possibilities. Literature often uses the notion of characteristic knowledge as a network definition. The key is basic characteristic knowledge of the agents that tend to create a network or business in the future. Transnational networks can facilitate such interconnection through commissions of marketing operations that let potential traders know that there are customers who are interested in the product in another country (Chin et al., 1996). Within a given market, these networks can help find a suitable distributor of goods for specific customers (Weidenbaum and Hughes, 1996).

Empirical analyzes point to the positive effect of international trade on the creation of conditions for trade between groups operating between borders and for immigrants. Immigrants know the characteristics and properties of buyers and sellers in their homeland, and carry this knowledge to new countries as well. However, it is often difficult to predict the extent to which the impact of transnational cooperation works by providing market information or using official information. Often customers' desire for goods from their homeland is apparent rather than having any effect of being part of any network (Gould, 1994). Gould estimates separate import and export equations and the impact of immigrants' influence on bilateral trade between the United States and its partners during the 1970-86. Gould also shows that for the two different rates of immigration, the estimated coefficients are positive and significant for both export and import. Long-term elasticity for preferred goods shows that there is a 10 percent increase in exports from Canada to the countries of origin of immigrants by 1.3 percent and the increase in imports to Canada from these countries by 3.3 percent.

Possible consequences for economic efficiency in transnational networks that provide information on profitable business opportunities are provided by (Rauch and Casella, 2003). They use a model that considers the following: the manufacturer needs to match to his needs if such agreement is acceptable, then it is possible to employ an internationally immobile labor force and then to realize the production. Within its home country, the manufacturer is able to match his needs (i.e. what he needs to produce and with which resources he can find) based on his own experience. Typical needs and knowledge abroad are not so familiar to manufacturers from other countries, and they cause problems. Such international consensus can then serve to shift labor demand in the form of services to manufacturers from countries where such labor is rare in countries where it is enough.

Based on the above information, it goes without saying that social networks, as an analytical tool is an appropriate way to describe and understand networks at international level. There is a large number of problems in transnational co-operation where it is necessary to establish relationship with other producers or employees who know the environment and are a suitable tool for how to efficiently use resources in the countries concerned. The exponential random graph model (ERGM), which will be described in the next chapter, is then an appropriate tool for analyzing and modeling a given situation.

4 ERGM AS AN ANALYTIC TOOL

Exponential random graphs model is a part of random graph model has following form:

$$P_r(X = x) = \left(\frac{1}{k}\right) exp\left[\sum_A \mu_A z_A(x)\right] \quad (1)$$

Where X_{ij} is a random graph that represents the connection between actors. X then represents the element matrix n and x then represents the matrix of the realized network connections. A then represents another network of configuration types. $Z_A(x)$ represents a set of dependent variables on the model, expressing that any set of statistics A calculated on x affects the probability of creating a given network. An unknown parameter is represented by μ_A coefficient and this parameter estimated and

expresses the effect of network statistics in the monitored network model. The coefficient *k* represents the number of numerators displayed in a possible network with *n* number of elements.

Parameters are initially estimated in ERGM using pseudo-similarity (Strauss and Ikeda, 1990) but this approach is often not reliable. Instead, it is more appropriate to use the Markov Chain of Monte Carlo as a similarity estimate (Geyer and Thompson, 1992). Monte Carlo simulates the distribution of a random graph using the initial values of the parameters, and this process is repeated until we reach the cleaned values that we compare with the simulated distribution of the given graph with the observed data (Snijders, 2002). The advantage of this approach is that with an infinite number of network configuration distributions, we give an estimate equivalent to maximum like-hood estimation and provide a reliable number of standard errors (Wasserman and Robins, 2005). A series of other network specifications, called the social circuit dependence (Pattison and Robins, 2002), have been developed that significantly reduce cases where the high level of triads often occurs due to poor model specification (Hunter and Handcock, 2006, Robins et al., 2009).

5 DISCUSSION

The possibilities of using the ERGM method on economic themes have been demonstrated in (Kim et al., 2016), when the connections between firms and their boards of directors (Mizruchi, 1996) were modeled. The number of selected companies were set on 95. The influence of the independent variables on the characteristics of various companies was studied, namely the company characteristics, dyad co-variates and structural effects. These properties identifies as important features for establishing a connection within a multinational network in international trade. If companies have similar or even the same company characteristics, or Structural effects, it is possible with some probability to define that there is a connection within the network.

The ERGM methodology allows significant expansion for the development of a strategy to expand business opportunities or attract new potential customers and businesses in the field of transnational trade. ERGM's ability to directly describe network dependencies allows for a more accurate analysis of the factors that were examined in the previous research. The results can be used to test the formation of connections to create rigorous empirical evidence for developing models that are not only attractive but also scientifically valid (Colquitt and Zapata-Phelan, 2007). Previous research proves that the influence of organizational resources on alliance formation is important. Multi-source companies have more opportunities to build links, and their higher level of resources makes it possible to eliminate the need for co-operation through the alliances.

The promising area where ERGM can be used is also the area of micro-transactions in the area of inter-organizational and transnational cooperation. Various research highlights the important role of existing links between individuals and their connection to the creation of links between organizations (Gulati and Westphal, 1999, Rosenkopf et al., 2001). Typical examples are new startups that are founded by people who previously worked in multinational companies. These people are then linked to the staff of these large companies and can be contacted for further cooperation.

In conclusion, ERGM is an important technique that can be used in various areas of research, be it in the field of international trade and modeling of producer and vendor networks, but also in other economic areas such as strategic research, that can be taking into account of transnational trade. As the interconnection between individuals, organizations or entire communities grows, there is a growing need to better understand and understand structures within networks. The ERGM method can build on the classic foundations of social network analysis and move them in the next direction to better understand the organization network genesis.

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