Dynamic Formation of the Knowledge Networks and Implications on Innovation Policy

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U.S. patent citation data show that majority of patent citations are cross-sectoral and the knowledge networks constructed using cross-sector citations evolve dynamically over time. New linkages of the knowledge networks expand the applications of existing knowledge and provide new methodology for future innovators. This project studies the dynamic formation of cross-sector knowledge networks and its implications on innovation policy.

Background

Large stream of growth literature study the input-output table and its importance to the economic development (e.g. Ciccone 2002; Jones 2011a, 2011b; Acemoglu et al. 2012; Cai and Li (2012)). However there are limited studies on the dynamic formation of input-output table, such as Oberfield (2013), let alone the research on cross-sector knowledge input-output networks. Previous mainstream endogenous growth models are one-sector models, even in most multi-sector models, either all sectors are symmetric or the network structure is exogenously given and static. However, cross-sector citation networks in the data evolve over time and the most central nodes change every decade. For example, in the 1980s, the automobile industry was the center of the network; in the 1990s computer and electronic devices took the place of automobile; and in the 2000s, bio-medical related sectors gained the dominance. Above all, current economic growth literature does not incorporate the dynamic change of knowledge networks.

Objectives and Research Questions

The empirical part answers the following questions. First, which firms are the pathfinder firms who made the first cross-sector citations for a given sector pair? Second, if using knowledge from a new sector involves much higher R&D cost, how do the pathfinder firms benefit from such innovations? Third, are other firms affected by the dynamic change of technology networks? Fourth, from the matched inventor and firm information, what are the factors that help the formation of new linkages in knowledge networks? The theoretical part builds an endogenous growth model to rationalize the facts presented in the empirical part and then proposes the optimal growth policy under dynamic knowledge networks.

Empirical Methods

The empirical analysis uses the historical citation data from NBER patent data to study the dynamic formation process of cross-sector knowledge networks, distinguish the firms who first made a citation cross a given sector pair and analyze such firms' characteristics. This helps us formalize firms' motivation to create a new link in the model.

Then combining the patent citation data with inventor data and Compustat, I compare the pathfinder firms' market values before and after discovering a new link, hence derive the private return to pathfinders. In the same manner, I can estimate the new links' impact on other firms and study the spillover effects of new knowledge linkages. Accurately estimating the spillover effects is the key to provide optimal policy in the theoretical analysis.

Finally, from inventor and firms' information, I can find the factors that help new links from emerging, such as city population density, firm scale and inventor age.

Theoretical Approach

The model is an extension of Cai and Li (2012), where cross-sector knowledge networks are constant. There are two types of innovations in the economy: methodology innovation to build the

technology networks and variety innovations to invent new varieties in a given sector using knowledge from every possible sector through the current technology networks. The former type of innovation enhances the productivity of the latter while applying knowledge capital in the innovation of other sectors. The new knowledge linkages once patented become public knowledge and all other firms can copy the same path when doing innovation in the using sector of the new links. The firms that own knowledge capital in the used sector also gains because their current knowledge capital is more valuable due to wider applications.

The model describes a more complicated firm innovation behavior with two types of innovation going on. The first step, firms will take into account the fact that technology networks will change in the future when conducting the traditional product innovation. Under constant technology networks in Cai and Li (2012), a sector's knowledge value depends on how many other sectors can apply its knowledge, the strength of the knowledge linkages, and the value of the applying sectors. If the networks are subject to stochastic changes, the knowledge valuation function needs to predict the pattern of network changes in advance.

Next step, knowing the knowledge prices under different technology networks, I can derive that private return and public spillover effects created by a new link. Then firms choose if they want to engage in methodology innovation or not. If yes, pathfinders decide how much they invest in methodology innovation. Finally, all firms take the knowledge price as given and choose their optimal decision in product innovation.

Lastly, I use GMM to estimate the model parameters by bringing data into general equilibrium conditions in the model. Then I take the estimated model parameters into the growth rate equation to decompose the new linkages' contribution to aggregate growth. Finally, I use counterfactual simulations to evaluate different policies' growth outcomes.

Contribution to the Advancement of Knowledge

Despite of its importance, new knowledge link creation has been largely ignored by the literature, because this type of innovation creates enormous knowledge spillovers that are hard to observe and measure. The empirical part overcomes the measurement issue and tries to find the factors that nurture knowledge network formation. The model also has potential to shed light on the structural transformation of the economy driven by the dynamic change of technology networks.

Significance to Innovation Policy

If I only concentrate on the product innovations in specific sectors, and ignore the methodology innovation that builds new links of the knowledge networks, the so called `optimal policy' is only a sub-optimal policy for a given static knowledge network. I can derive the global optimal policy only if I simultaneously consider the methodology innovation and new product innovation.

Candidate's Role

All the data used in empirical section are publically available and I have used them before for other projects. I will carry out the theoretical section using empirical section results as motivation. This project is a nature extension of my previous works with Nan Li and I will pursue it regardless of the fund application result.

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Positions

Assistant Professor, School of Economics, Shanghai University of Finance and Economics 09/2015 - present
Lecturer, School of Economics, University of New South Wales, 07/2009 – 07/2014
Visiting professor at University of Victoria, 07/2012-12/2012
Visiting scholar at International Monetary Fund, 12/2010 and 07/2014

Research Fields

Macroeconomics, International Economics, Firm Dynamics, and Network Theory

Teaching

Advanced Macroeconomics, 2015
Honor's Macroeconomics 2009-2012
Graduate and Undergraduate International Trade 2009-2012

Education

University of British Columbia, Canada. Ph.D. of Economics 2010
Peking University, China. M.A. of Economics, 2002
Renmin University of China, China. B.S. of Computer Science 1999

Nationality

Citizen of Canada, Originally from Qinhuangdao, HeBei, China

Grants

Australian School of Business Internal Grants 2010 (AUD 2,5000) and 2012 (AUD 5,000)
Australian School of Business International Conference Grants 2009, 2010, 2011, 2012

Papers

"Growth through Inter-Sectoral Knowledge Linkages", joint with Nan Li, R&R 2nd round at Review of Economics Studies.
"Population Ageing and Comparative Advantage", joint with Andrey Stoyanov, R&R 2nd round at Journal of International Economics.
"Composition of Knowledge and Cross-Country Income Differences", joint with Nan Li, under review at International Economic Review.

Presentations

Midwest Macroeconomics Meeting 2009, American Economic Association Meetings 2010 and 2012, Econometrics Society Meetings, World Congress at Shanghai 2010, North American Meetings, 2010, 2011 and 2012, NBER EFJK Growth Group Meeting, 2012, 1st Annual CIRANO Workshop on Networks in Trade and Finance 2012, Society of Economic Dynamics, 2015, Ohio State University, University of Adelaide, University of California, at Berkeley, University of Melbourne, University of Sydney, University of Technology Sydney and University of Victoria.