Methods and Initial Results

Project Topic: How do international economic activities impact a nation's innovation over time?

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1) Model

The model in this project is inspired by the paper 'Enhancing national innovative capacity: The impact of high-tech international trade and inward foreign direct investment' and is an adaption to a close-economy model by Furman & Hayes in 2004. The model by Furman & Hayes builds a relationship between flows of innovations and observable contributors to national innovative capacity. The original model is the following:

$$\bar{A}_{j,t} = (X_{j,t}^{INF}, Y_{j,t}^{CLUS}, Z_{j,t}^{LINK})H_{j,t}A_{j,t}$$

In this model, $\bar{A}$ represents the flow of new-to-the-world innovations; X^{INF} is the level of resource commitments and policy choices that constitute the innovation structure; Y^{CLUS} is the environments for innovation in a country's industrial clusters; Z^{LINK} is the strength of linkages between common infrastructure and nation's industrial clusters; H is the total level of human capital and labor resources; A is the stock of knowledge for this country.

To adapt this model to an open economy, two determinants are added to the original model:

$$\bar{A}_{j,t} = (X_{j,t}^{INF}, Y_{j,t}^{CLUS}, Z_{j,t}^{LINK})M_{j,t}F_{j,t}H_{j,t}A_{j,t}C_{j,t}$$

The new model incorporates M(which is the international trade flows), F(foreign direct investment) as well as C, which include control variables. It is hypothesized that this model is valid to evaluate the impacts of international trade and FDI on country's innovational level. In running regressions, log will be taken on both sides of model for better computation purpose.

2) Data

The mapping of variables to theoretical constructs:

- Flows of innovation: total patents granted by each country (source: WIPO, World Intellectual Property Organization)

- Common innovation infrastructure: GDP, education expenditure as percentage of GDP, Number of scientific journals and articles published (source: WDI, World Development Indicators)

- Cluster-specific innovation environment: percentage of R&D expenditure funded by business sector (source: OECD, The Organisation for Economic Co-operation and Development)

- Quality of linkage: percentage of R&D expenditure funded by government (source: OECD, The Organisation for Economic Co-operation and Development)

- Trade flows: imports of service and goods as a percentage of GDP, ICT goods (Information Communication Technology goods) as a percentage of total imports (source: WDI)

- Foreign direct investment: foreign direct net inflows (source: WDI)

- Control variables: population level, savings and etc. (source: WDI)

Specifically, I am interested in measuring the different effects in leading innovation countries and emerging countries. To create a valid and comprehensive panal data, the leading innovation countries include Canada, Finland, Germany, Israel, Japan, Sweden and United States. The emerging innovation countries include Argentina, Austria, Belgium, China, Czech Republic, Denmark, Greece, India, Ireland, Italy, Mexico, New Zealand, Singapore, Turkey. I collected the data from the sources above and clean and compile them into a panal data ranging from year 2000 to 2016. The summary statistics for key variables are shown below:

Summary Statistics of Key Variables

| Theoretical Construct	Symbol	Variable	Observation	Mean	S.D.
Flows of Innovation	A	Patents granted	335	28574.673	67624.254
Common innnovation infrastructure	X(INF)	GDP(billions)	357	1891.514	3349.438
Common innnovation infrastructure	X(INF)	Education expenditure (% of GDP)	254	5.126	1.365
Common innnovation infrastructure	x(INF)	Scentific journals and articles	294	57910.782	100779.121
Cluster-specific innovation environment	Y(CLUS)	Percent of R&D expenditure by business sector	286	0.525	0.141
Quality linkage	Z(LINK)	Percent of R&D expenditure by government	285	0.343	0.138
Trade flows	M	Import of service and goods (% of GDP)	273	43.789	35.351
Trade flows of high technology products	M	ICT goods import (percentage of total goods import)	357	11.338	6.686
Foreign direct net inflows	F	Foreign direct net inflows (in billions)	355	39.276	72.361
Control Variables	C	To be determined	To be determined	To be determined	To be determined

Time trends summarizing key variables:

1)

Average patents granted by year
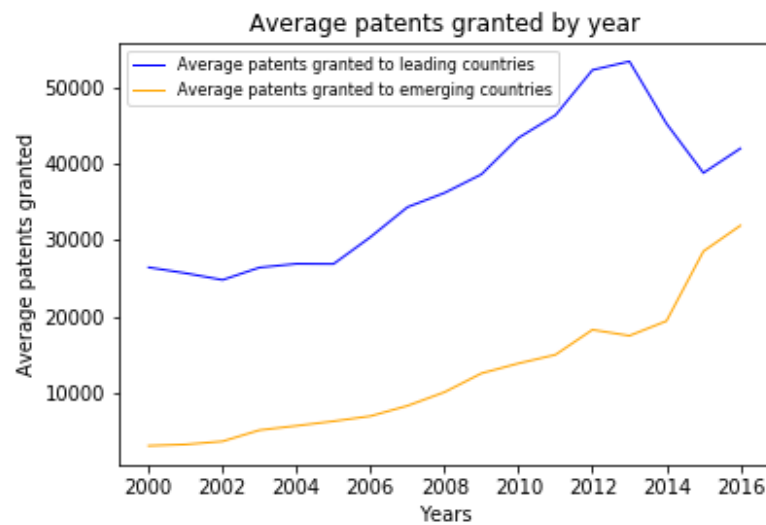
Compared with leading innovation countries, emerging innovation countries
have a higher increase rate of patents granted.

2)

Average FDI by year
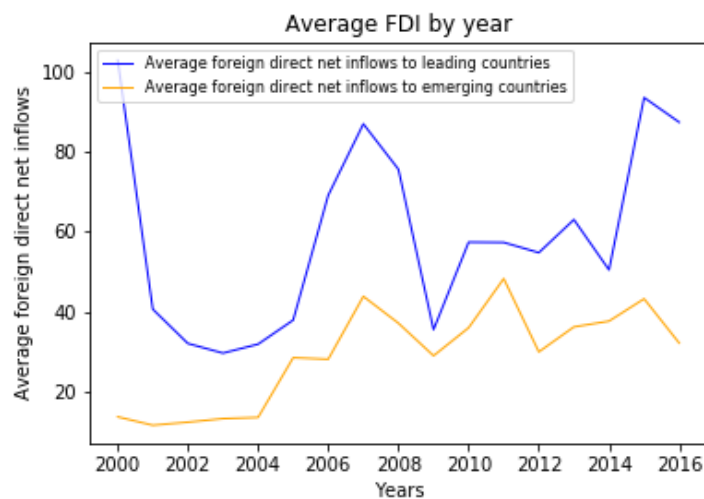
The FDI level fluctuates more for leading innovation countries compared with
emerging innovation countries.

3)

Average percentage of ICT goods in goods imports by year
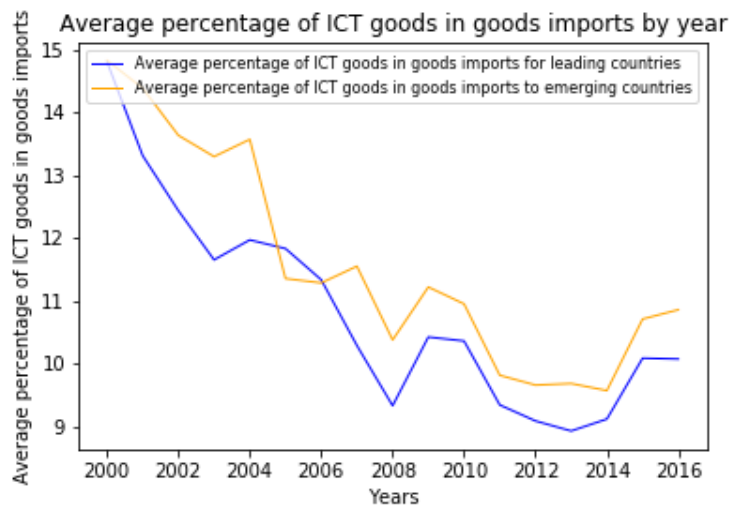
Overtime, emerging innovation countries have a larger portion of ICT import

goods. However, general trend for both leading and emerging countries is

shrinking.

4)

Percentage of R&D Expenditure froms Business sector by year
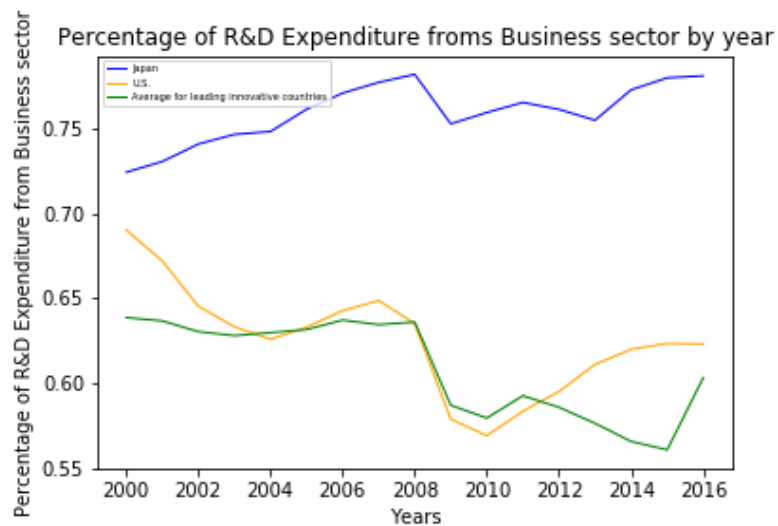
The R&D expenditure funded by business sector is more than that in United

States.

5)

Percentage of R&D expenditure froms government by year
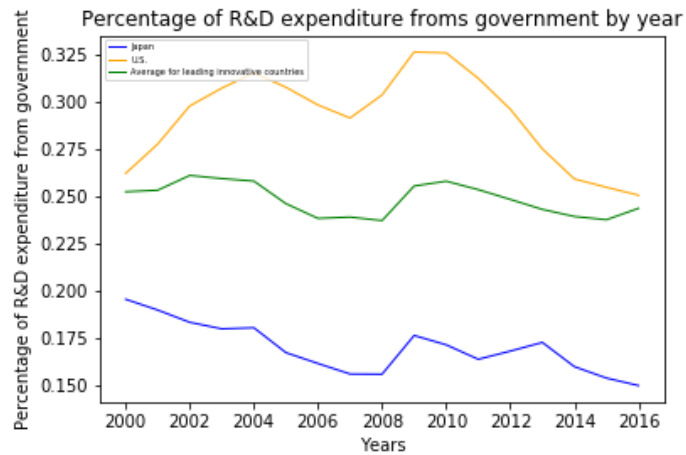
In contrast, R&D tend to be funded more by the government in U.S. and the trends are decreasing for both countries over time.

3) Computational Methods

Principle component analysis will be used to find out the most relevant control variables. Autoregression in python is the main method with an appropriately chosen lag. Deep learning method including neural networks will be used to predict patents from the key variables as an exploration.

4) Further Steps

Initial Results are not yet available due to lack of determined control variables from PCA. Very recently, the control variables will be determined. Besides, different variables and countries will be used to map the theoretical constructs to compare the different results.