THE INTEGRATION OF THE ECONOMICS PROFESSION ACROSS COUNTRIES: EVIDENCE FROM PAPER CITATIONS

by

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ABSTRACT

THE INTEGRATION OF ECONOMICS PROFESSION ACROSS COUNTRIES;

EVIDENCE FROM PAPER CITATIONS

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By relating country-level journal article citation patterns to country-level proxies for various policies, the current project attempts to uncover possible causal relationships between them. The paper measures patterns of knowledge flows across counties and over time using the citation information from the Social Sciences Citation Index for 174 Economics journals from 1975 to 2006. The results indicate evidence that economic openness and the adoption of the Internet have a positive effect on the spread of knowledge.

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CHAPTER 1

INTRODUCTION

1.1 Summary of the thesis

Academic disciplines are often subject to a certain degree of fragmentation when scholars in one area are unaware of findings developed elsewhere. That is, knowledge does not flow seamlessly throughout the profession even in a "knowledge industry." Often, this flow is inversely related to distance as scholars in an area tend to be more familiar with advances made in their own country. This thesis first documents evidence of growing integration of economics researchers worldwide over the past two decades and then examines potential determinants of this integration

My thesis relates country-level journal article citation patterns to country-level proxies for various policies to uncover possible causal relationships. Citations across papers are similar to a trail left by new research findings as they propagate through the profession. Thus I am able to use changes in such citation patterns to reveal the sources of the flow of knowledge across different regions or institutions. Specifically, I exploit detailed citation information from the Social Sciences Citation Index (SSCI) for 174 Economics journals from 1975 to 2006; these papers include over one million citations that allow me to infer patterns in the flow of knowledge across countries and over time. By aggregating information from published articles regarding citing and cited journal, year, author institution and author country, I am able to uncover more general patterns from granular bits of information.

My tests center on changes in these citations from scholars in one country to scholars in other countries. In particular, from citation information, I calculate both the percentage of

citations from one country to another country or to an institution and the percentage of citations within the citing author's country. With such information, I can identify whether the Internet, as one of the major channels of knowledge flows in modern society, provides an alternative to the traditional pathways of knowledge spillovers. In addition, I can test to what extent the openness of the country would affects the flow of knowledge..

1.2 Organization of the thesis

The second section of this paper provides a literature review. The third and fourth sections explain the economic theory from which hypotheses are derived and the econometric models used to test these hypotheses. After that comes the data description which describes in details the process of generating the dependent variable. The sixth section represents the empirical results I have obtained and the final section is conclusion.

CHAPTER 2

LITERATURE REVIEW

How knowledge diffuses outwards from the institution and geographic location where it was produced has important implications for the modeling of economic growth. Jaffe and Trajtenberg (1998) explore international knowledge flows by exploring the patterns of citations among patents taken out by inventors in the U.S., the U.K., France, Germany and Japan; they found that patents whose inventors reside in the same country are typically 30 to 80% more likely to cite each other than inventors from other countries.

Different researchers have investigated different factors that impact the flow of knowledge. Several factors have been linked citation patterns. Jacob and Lefgren (2007) estimate the impact of receiving an NIH grant on subsequent publications and citations. By using a sample consisting of all applications (unsuccessful as well as successful) to the NIH from 1980 to 2000 for postdoctoral training grants (F32s) and standard research grants (R01s), they found that receipt of either an NIH postdoctoral fellowship or research grant leads to about one additional publication over the next five years. Adams (2009) finds that the slowdown in the growth rate of financial aid decelerates the growth of research output in public universities leading top scientists to move the private universities due to higher funding available there.

The decision to do research is also a process of making self-interested choices, and thus can also be described by the process of profit maximization. Alvarez, Buera and Lucas (2007) describe the technology of an economy based on a probability distribution of costs. An individual producer is characterized by his current cost level and is also subject to a stochastic flow of new ideas. When he receives a cost idea that is better than the one he is now using to produce, the new, lower cost becomes his state variable. If he receives a higher cost idea or no idea at all, his cost state remains unchanged.

Some researches confirmed the impact of the Internet on citation pattern in journals. By focusing on the effect of JSTOR, Depken and Ward (2009) find that a large scale Internet-based searchable archive of articles published in hundreds of journals over the past century or more, on the citing patterns and research productivity. They investigate the effect of this scholarly tool using data from JSTOR's own records of journals archived and institutions' access arrangements from ISI's Social Science Citation Index (SSCI) database for the economics discipline from 1985 through mid-2007. By analyzing the effect of JSTOR access on both inputs and outputs, they find that JSTOR access lowers researcher costs to finding, reading, benefiting from and ultimately referring to papers available in the archive.

Agrawal, Ajay and Goldfarb (2006) examine the effect of a decrease in collaboration costs resulting from the adoption of Bitnet (an early version of the Internet) on university research collaboration in engineering. Exploiting the variation in year of adoption and publication output over time in the 270 universities that published in seven top electrical engineering journals from 1981 to 1991, they find that a Bitnet adoption did seem to facilitate a general increase in multi-institutional collaboration (by 40%, on average). At the same time, not all adopters benefited equally. Overall, Bitnet seems to have facilitated a disproportionate increase in the role of second-tier universities, particularly those co-located with top-tier institutions.

Brown and Goolsbee (2000) study the impact of Internet on insurance markets. The hypothesis is that the Internet has the potential to significantly reduce research costs by allowing consumers to engage in low-cost price comparisons online. By analyzing the rise of Internet comparison shopping sites has had for the prices of life insurance in the 1990s, they found that, controlling for individual and policy characteristics, a 10 percent increase in the share of individuals in a group using the Internet reduces average insurance prices for the group by as much as 5% and that prices did not fall with rising Internet usage for insurance

types that are not covered by the comparison websites, nor did they in the period before the insurance sties came online.

Vasileiadoua and Vliegenthart (1999) claim that the Internet is used for coordination, exchange of resources and sharing work, with the underlying assumption that Internet use increases research productivity. They investigate the assumption in the context of two distributed research teams, with different coordination and management needs. Their results suggest that the positive impact of Internet use on research productivity is limited and may be relevant only when collaborative endeavors suffer coordination problems.

Furthermore, Ellison (2007) argue that the Internet could be disruptive in that it could allow high-profile researchers to disseminate their work without subjecting it to peer review, which would in turn lead to a broader unraveling of the peer-review system. By examining two main sources of information: data on publications and data on citations which provide additional details about how economics publishing has changed over the past decade, he found out that that the role of journals in disseminating research has been reduced is one of the explanation for the two trends: economists in several highly-regarded departments are publishing fewer papers in the top field journals; and Harvard's economics department is also publishing fewer papers in the top general interest journals. One hypothesis is that the citation benefit to publishing in a top general-interest journal now appears to be fairly small for top department authors. Another is that Harvard authors appear to be quite successful in garnering citations to papers that are not published in top journals.

Hamermesh and Oster (1998) exploit the direct impact on the productivity of scholarship by considering how high technology might alter patterns of coauthoring of articles in economics and their influence. By measuring productivity as the quality of the paper produced as measured by citation counts, their Poisson model results show that distant co-authorship by otherwise identical coauthors, publishing articles of the same length and type in the same

journals is less productive than co-authorship by near neighbors. Also there is no evidence that the average productivity changed over time even though the cost of communication had fallen.

Many other authors use citation information to check the different aspect of academy studies. Maberly and Pierce (2007) study the Citation Patterns within the leading Top-Tier Finance Journals. Their paper examines all citations and self-citations to a list of 94 finance journals appearing in the Journal of Finance, Journal of Financial Economics and Review of Financial Studies from 1995 through 2005 (The publication profile of 100 prolific authors in top-tier finance journals is tabulated for those 94 finance journals). By constructing five ranking schemes with each scheme identifying the top fifty finance journals, they find that Citations to finance journals are highly concentrated within ten journals and similarly for self-citations. Authors of papers appearing in top-tier finance journals pay scant attention to the bulk of research published in other finance journals. Furthermore, authors cite other economic journals with greater frequency than their counterpart in finance.

Albarran, Ortuno-Ortin and Ruiz-Castillo (2010) consider a situation in which the world citation distribution in 22 scientific fields is partitioned into three geographical areas: the US, Europe (EU), and the rest of the world (RW) and use two real valued indicators to describe the shape of each area's distribution: a high- and a low-impact measure defined over the set of articles with citations below or above a given citation critical value (CCL). It is found that, when the CCL is fixed at the 80 percentile of the world citation distribution, the U.S. performs dramatically better than the EU and the RW according to both indicators in all scientific fields. This superiority generally increases when moving from the incidence to the intensity and the citation inequality aspects of the phenomena in question. Surprisingly, changes observed when the CCL is increased from the 80th to the 95th percentile are of a relatively small order of magnitude. Finally, it is found that international co-authorship increases the high-impact and reduces the low-impact level in the three geographical areas. This is especially the case for the EU and the RW when they cooperate with the U.S.

The existing research has shown different impacts of the Internet on different areas. The Internet does provide convenience to some aspects of work; however, it may also differ in the effect on the research productivity if viewed in different fields. The existing studies help me understand the effect of Internet. Nevertheless, each of them suffers from some weakness, such as a small data set and so on. With the invention of broad band, high speed Internet and many other different apparatus, the application of the Internet now is different from what it was ten year ago. As the technological progress continues, the impact of the Internet may be changing. In my study, using the more up-to-date data and a larger sample size with new information, I try to uncover some factors that may affect the pattern of knowledge flows and may find new relationships between Internet applications and knowledge flows.

CHAPTER 3

ECONOMIC MODEL

3.1 A Simple Production Function

Since the cost of finding publication information from further away has fallen due to the invention of the Internet, scholars can be informed of what other scholars have already done easily. An approach similar to that of Depken and Ward (2009) also applies here. I assume that the production process is presented by $f(x_1, x_2, \dots, x_n)$; x represents the amount of various inputs which would affect the output of production function. Then the researcher's pseudo-profit function is the total revenue minus the total cost. Now that researchers face an optimization problem -- researchers' objective functions are to maximize a shadow profit function:

$$\prod = pf(x_1, x_2, \dots, x_n) - \sum_{t=1}^{N} w_t x_t$$

Let w_t be the input costs researchers face and is rewarded according to some shadow price of output, p. The shadow price, by definition, is the change in the objective value of the optimal solution of an optimization problem obtained by relaxing the constraint by one unit. Here it refers to the change in the value to a researcher of a paper due. When maximizing the pseudo-profit function using the first order condition, I have:

$$\frac{p * \partial f(x_1, x_2, \dots, x_n)}{\partial x_1} = w_1$$

$$\frac{p * \partial f(x_1, x_2, \dots, x_n)}{\partial x_2} = w_2$$

$$\frac{MP1}{MP2} = \frac{p_T * \frac{\partial f(x_1, x_2, \dots, x_n)}{\partial x_1}}{p_T * \frac{\partial f(x_1, x_2, \dots, x_n)}{\partial x_2}} = \frac{w_1}{w_2}$$

Let x_1 be the process of searching for reading and incorporating an article into one's research from the messages provided from distantly far away, then the function will have marginal benefit of MP_1 and cost (w_1). Let x_2 be the process of searching for reading and incorporating an article into one's research from local such that it would have marginal benefit of MP_2 and cost (w_2). If the access to journals from far away becomes easier, w_1 will decrease, but w_2 will has no change, I expect the researcher to make more use of articles available from far away thus increase geographic scale of articles cited. This would involve a scale effect and substitution effect—with more resources available on line, scholars are able to find reference information depending on the quality of the paper instead of being limited by location. As a result, the citations the home country would decrease and references are more likely to be from worldwide. (Figure 3).

3.2 Input Costs

Hypothesis 1: The Internet reduces the cost of learning of more distant knowledge.

Since the Internet creates an easier way of checking reference information—making the cost of finding research output the same no matter where the author is, I propose that it would lead to growth of research output over time. The quantity and quality of research would increase with more resources available online using the same budget constraint. Cardoso, Guimaraes and Zimmermann (2010) found that "Europe is catching up with North-American levels of production, both because it has been delivering more outputs and because it managed to have more of its journals considered in international databases that track academic work in economics around the world." Thus I can expect that the there exists positive effect of Internet on the knowledge spillover.

Another potential change that may have happened that is the value of research output, which can be represented by the shadow price p_T, may have changed over time. However, even if the shadow price of the research output changes overtime, it would not affect my results. At any point of time, the optimal decision is made according to the relative cost of search and P_t

is cancelled out which means that the change in the shadow price will not affect the choice of decision.

3.3 Normal goods

Hypothesis 2: Research in Economics is a normal good.

As income increases, more research and higher quality is demanded. Money will be spent on research inputs with the hope that investigations can find the key factors that can affect the movement of long run economy. Since researchers can have more funding available and in order to be competitive in getting the funding, more inputs will be devoted to research. One aspect for the demand for research is the demand for higher quality research. Higher quality research often requires more up-to-date knowledge inputs from all sources. Consequently, researchers with more funds available to them should have make more references during their research since they are trying to figure out what others have already done worldwide.

3.4 Market Efficiency

Hypothesis 3: A more open economy improves labor market mobility and might imply more communication between countries in higher education. A more open economy is related to market efficiency, and thus higher labor market mobility. In the economics profession, there is anecdotal evidence of more academics taking positions in countries other than their country of origin. At the same time, market liberalization will also increase cooperation in education to provide better service to students, thus contribute to the knowledge spillover.

CHAPTER 4

ECONOMETRIC MODEL

4.1 Empirical Model

The main purpose of our study is to examine the impact of country-level factors on the geographic flow of knowledge over time. Our measures of knowledge flows are derived from the geographic dispersion of the cited material. I assume that authors that cite more broadly or cite more often from more distant sources obtain broader information flows. When more authors in a country tend to cite the research conducted in other countries more often, scholars in that country will become more integrated into the global flow of research findings, and also into the global profession.

The regression model I am using in the paper expresses academic citation concentration in a country in the field of economics as functions of several variables. In line with earlier researchers, Jaffe and Trajtenberg's (1998) finding suggests that patent inventors tend to cite more to other patents whose inventors reside in the same country. "It appears that a large part of knowledge is highly localized." "The effect of pure distance, past the country border, is rather smaller" (Peri, 2002). All of these suggest that distance between countries would be one important factor in determining knowledge flows. However, I don't use distance information in my analysis. This is because distances between countries are constant over time. In the fixed country effect model I employ, distance is subsumed by country dummy variables. In my specifications, fixed factors account for the impact of distance together with all the other country level fixed factors such as culture difference and political affiliations which are constant over time but are different across countries. Another factor that should be taken into consideration is the lagged effect of our independent variables. I suspect that the impacts of income, economic openness, Internet applications and higher education expenditures in one period affect citation

flows over a number of periods. This implies that the lags of these independent variables will also have significant impact on the citation spillover. For example, scholars need to collect information about what other people have already written on the research topic. Consequently, new Internet applications in previous years will impact a publication's citations in the following years. One appropriate way of dealing with this problem will be incorporating lagged terms of the independent variables in the regression.

$$\mathrm{citation_{it}} = \mathrm{f(X_{i,t}, X_{i,t-1}, X_{i,t-2}, X_{i,t-3}, X_{i,t-4,} \ldots D_i)}$$

"i" identifies countries and "t" represents year; "citation" pertains to one of our two dependent variables; Xs represent different independent variables; Ds refers to country dummy variables which control for time-invariant country-specific factors.

While involving many lagged X values on the right-hand side, the consideration of parsimonious parameterization would lead me to reformulate the equation by introducing lagged values of dependent variable (Y) among the regressors. The relationship is shown in the following process:

$$Y_{i,t} = \alpha + \beta X_{i,t} + \gamma_1 Y_{i,t-1} + \varepsilon_{it}$$

$$Y_{i,t} - \gamma_1 Y_{i,t-1} = \alpha + \beta X_{i,t} + \varepsilon_{it}$$

Use of the lag operator, it turns into

$$Y_{i,t}(1 - \gamma_1 L) = \alpha + \beta X_{i,t} + \varepsilon_{it}$$

$$Y_{i,t} = \theta + \frac{\beta X_{i,t}}{1 - r_1 L} + u_{i,t}$$

$$Y_{i,t} = \theta + \beta X_{it} + \gamma_1 \beta X_{i,t-1} + {\gamma_1}^2 \beta X_{i,t-2} + \cdots + u_{i,t}$$

Thus, the dynamic models for the panel data, which includes observations from 22 countries from 1985 to 2006, are as following:

$$HHI_{it} = \alpha + \beta HHI_{it-1} + \gamma INCOME_{it} + \delta_1 OPEN\_ECON_{it} + \delta_2 INTERNET_{it} + \delta_3 HIGHER\_EDUCATION_{it} + \delta_4 COUNTRY_t + \delta_5 STUDY\_ABROAD_{It} + \varepsilon_t$$

$$Dom_{Citation_{it}} = \alpha + \beta Dom_{Citation_{it-1}} + \gamma INCOME_{it} + \delta_1 OPEN_{ECON_{it}} + \delta_2 INTERNET_{it} + \delta_3 HIGHER_{EDUCATION_{it}} + \delta_4 COUNTRYDUMMY_t + \delta_5 STUDY\_ABROAD_{It} + \varepsilon_t$$

4.2 Tests of Hypothesis

I use two dependent variables. The first is Herfindahl-Hirschman Index (HHI), which is the sum of the squares of citations made to different institutions. For example, suppose there are three schools in the sample, and in 1990, 15% of citations made in USA were to school1 and 5% to school 2 and 80% to school 3, HHI for USA in 1990 can be computed as:

$$HHI_{USA1990} = (15\%)^2 + (5\%)^2 + (80\%)^2 = 0.9125$$

Lower HHI values represent a broader rate of citation to different institutions. In our panel data, for each country and year, I calculate a unique value for the HHI that ranges between 0 and 1.

The second dependent variable is the percentage of citations made from the research conducted in the home country (Domestic Citation Rate), which ranges between 0 and 1. To explain it explicitly, let me use one example. For instance, domestic citation rate for USA in 1990 would be percentage of references that are from USA for those articles published by authors in USA in 1990. The HHI and the domestic citation rate are two variables I used to capture the broadening of citation patterns over time.

I test the first hypothesis, that Internet technology increased the breadth of citations, with two variables, the number of Internet users per 100 in a country and the number of personal computer users per 100 in a country. The Internet users variable is perhaps the better measure but it is more likely measured with more error than the number of personal computer users. In both cases, the variables refer to the total population of a country and not to the academic population that has traditionally been more computer literate.

The GDP per capita and unemployment rate are used in the model to test the second hypothesis. According to this hypothesis, GDP per capita is expected to have a negative effect on citation breadth and unemployment rate is expected to have a positive impact. Higher GDP

per capita implies that the average income per capita is higher. As such, government can spend more money to support higher education. Then with more funding available, researchers have better conditions for doing research and have higher possibility of citing more papers published from many other countries.

Alternatively, I can use more direct measures of research inputs derived from changes in the number of students in higher education and the expenditures per student. The number of faculty researchers is roughly proportional to the number of students. With more faculty, more research is produced, but perhaps not of any better quality. As expenditures per student rise, the main university cost, faculty salaries rise. Higher salaries attract higher quality faculty who publish higher quality research that requires greater breadth in knowledge from multiple sources.

In order to test the third hypothesis on openness, I used foreign direct investment (FDI, trade (sum of import and export) and an economic openness index as explanatory variables. We expect these variables to have negative impact on citation breadth. A more direct measure of openness relates to scholarly exchanges across countries. In order to control for this, I use variables measuring participation in the “ERASMUS” program and the number of US visa holders for scholarly exchanges. I expect knowledge flows to be less localized due to increased communication between countries in the academic field.

CHAPTER 5

DATA

5.1 Dependent Data

5.1.1 HHI

I use data on citation information for published papers, which have been collected from the Institute for Scientific Information (ISI). ISI contains Social Science Citation Index (SSCI) which have reference information for all articles published in 174 journals from 1975-2006 in the field of economics. This database includes detailed information about the authors of papers, publication years, residence of institutional affiliation of the author, the name of journal in which the articles are published, the issue of the journal, beginning page of the article in the journal and the detailed reference information a paper made to other papers. To control for journal quality, the sample of journals used was limited to the pool of 66 journals that were indexed by ISI continuously throughout the sample period.

Each paper published contains two parts of information. The first part is what I named "HEADER" contains information about the citing paper itself, including the name of different authors, title of the paper, journal name, issue and volume of the journal, publication year, beginning page, and a unique identification number "UT". The second part is what I called "REF". It contains simple reference information for each article. Ultimately, I created "REF" to include only the unique identifiers, "UT" values, of the citing and cited articles. Different references coming from the same article contain the same identification number denoted as "CITING-UT". Different articles citing the same article contain the same identification number

denoted as “CITED-UT”. Together, these two files allow me to obtain detailed information for any two pair of articles involved in a citation.

The following description describes how I generate information from the reference: reshape and parse out the information in the REF. First, I obtained title of the journal cited, publication year, name of the authors, and the volume Issue number and page of the journal. Second, this information was parsed and standardized for misspellings. Third, this information on cited articles was merged back to the header information to obtain the unique identifier of the cited work. This allows me to trace the cited information in the later period back to the more detailed information on an earlier publication. Since ISI provides location information about the authors of each of the articles included, it also makes possible for me to trace the country and institution of the authors included during the citation process.

To make sure that it correctly merged the reference information back to “Header”, I use standardized journal name, publication year, the name of the first author, issue of the journal, page and so on. In order to standardize the name of journal, I need to change each record manually to have the name of the journal the same as the information in the “Header” to have a higher successful merge rate. Due to the limitation of knowledge and the existence of typos, the rate of merging is not perfect.

Thus I create a usable sample in which the “header” has detailed article information and a unique “UT” and a “ref” that links unique identifiers by citing and cited “UT” values. Now, I can merge “ref” to obtain detailed information for both cited and citing articles. Unfortunately for my purposes, many articles cite to material not indexed by ISI or it cites to material prior to my sample period. This missing citation problem is more severe for articles published earlier in the sample. To address this issue, I limit my analysis to articles published after 1985 so that 10 years will have elapsed from when I can obtain cited article information.

So far I have generated a panel dataset which includes all the HHI for each country in each year. Take HHI for France in 2003 for example, for each record, I generate a weighted value which is equal to 1 divided by the product of the total number of authors in the reference paper and the total number of authors in the citing articles. Then, I generate a variable “a” which is the sum of all the weighted value as long as they are in the same publication year, cited by the same country and from the same place. At the same time, I generate another new variable “b” which is the sum of weight which are from the same publication year and are cited by the same country. The value of HHI is the sum of squared ration of a/b. In figure 4, 5 and 6, I have some graphs of HHI values for some large data countries.

5.1.2 Domestic Citation

One of the interesting issues is to what extent the authors cite previous articles published from the same countries the authors are from (I refer to this as the domestic citation rate). Similar studies have been done to analyze domestic citation among the patent spillover. As stated by Bronwyn H. Hall, Adam B. Jaffe and Manual Trajtenberg (2001) “Presumably citations to patents that belongs to the same assignee represent transfers of knowledge that are mostly internalized, whereas citations to patents of ‘others’ are closer to the pure notion of (diffused spillovers)”.

I calculate the domestic citation rate in the following way:

$$\text{Domestic citation rate} = \frac{\text{the number of references that comes from the citing country}}{\text{total number of citations that are made from the citing country}}$$

In my sample, 42.93% of citing articles are made from countries other than USA. In the attachment, figure 3 shows how the fractions of domestic citations change from 1985 to 2006 for each country. As we can see, for most of the countries, domestic citation rate fluctuates at

the beginning of my sample, which may be due to the fewer number of matched citations going into the calculation in the early years. But the series declines in the latter years together with the increasing number of total number of citations matched. When I check the graph for USA which, comparing with other countries, always contains larger total number of citations made, the series is relatively stable and declines over time. Also for countries which have a lower domestic-citation rate, the series appear to be stable and fluctuate in a small oscillation. All of these indicate that the scale of knowledge spillover increases with time.

5.2 Independent Data

GDP per capita: the country's GDP divided by the total population in the country. (It is based on 2000 international dollar) The data are from the World Development Indicators (WDI) publications and WDI Online database of the World Bank. Unemployment rate: unemployment happens when one person has no job but he or she has been actively looking for jobs in the past four weeks. These two variables are used to measure the income level of the country.

The Internet user variable is the ratio of Internet users to the total number of population. The PC user variable is the ratio of personal computer users to the total number of population. These statistics are obtained based on response to an annual questionnaire which ITU sends to the communication agency.

Higher education enrollment is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level. I also use the higher education expenditures to measure the effects of higher education on citation reference. This is the public current spending on education divided by the total number

of students by level, as a percentage of GDP per capita. It includes government spending on educational institutions (both public and private), education administration as Ill as subsidies for private entities (students/households and other private entities). (From the World Bank)

Foreign Trade: It is calculated as a percentage of GDP and it is the sum of total value of exports and imports divided by GDP. It includes both goods and service. FDI: is defined as the investment of foreign assets into domestic structures, equipment, and organizations. It contains four parts, for example it is the sum up of equity capital, reinvestment of earning, other long-term capital, short and term capital. Economic Freedom of the World Index: the definition of Economic Freedom is “Individuals have economic freedom when property they acquire without the use of force, fraud, or theft is protected from physical invasions by others and they are free to use, exchange, or give their property as long as their actions do not violate the identical rights of others. An index of economic freedom should measure the extent to which rightly acquired property is protected and individuals are engaged in voluntary transactions.” (James Gwartney and Robert Lawson et al. Economic Freedom of the World: 1996 Annual Report) .It is retrieved from the Frazier Institute’s “Economic Freedom of the World” and contains five area of freedom: size of Government: index, Property Rights index, Monetary freedom, freedom to trade internationally and Labor Freedom index. Each category uses a scale from 0 to 10, where “10” represents the maximum freedom and the overall score is just average value of the five indexes mentioned above.

U. S Visa holder: Two types of visa holders (F1 and J1) are included in our sample. According to US Immigration Support, F-1 Student Visa Eligibility requires holders to pursue an academic program in an institution recognized by the United States government. The foreign students must be a full time student and part-time is not allowed. Similarly, J-1 Exchange Visitor Visa holders are those people who are “coming to the United States as a student, scholar, trainee, teacher, professor, research assistant, medical graduate, or international visitor who are

participating in a program of studies, training, research, or a cultural enrichment program that is specifically designed by the United States Department of State, through its Bureau of Educational and Cultural Affairs". The data is retrieved from US Department of Justice's statistical yearbook of the immigration and naturalization service from 1985 to 2006. The value is calculated by ratio of the total number of people who hold F1 and J1 VISA to the total number of population in that country. I believe that the number of these two types of the visa holder represents the "Americanization" of the academy in countries where those visa holders are from. Since the US is so dominant in Economic research, it would have some impact on the spillover of knowledge.

ERAMUS: According to the information provided by the Wikipedia, the European Region Action Scheme for the Mobility of University Student (ERASMUS) program, established in 1987 for the purpose of "achieving a significant increase in the number of students […] spending an integrated period of study in another member state"(Council of the European Communities, 1987), are currently having more than 4,000 higher education institutions across 31 countries and over 2.2 million students have already taken part. "To participate in the Erasmus program students must be studying for a degree or diploma at a tertiary-level institution and must have completed their first year" (Wikipedia). Also, Matthias Parey and Fabian Waldinger (2010) showed that "ERAMUS scheme has a strong effect on the students' decision to go abroad" by showing that "the probability of studying abroad is low and flat before ERAMUS is introduced, and increases strongly for those students affected by the availability of ERMUAS scholarships." So I also believe that ERAMUS would also affect the pattern of citation in those European countries.

I retrieve the number of ERAMUS outgoing students from 1987 to2006 from the website of European commission in education and training system. It is the ratio of the number of ERAMUS students to the total population in one particular country.

CHAPTER 6

EMPIRICAL RESULTS AND IMPLICATIONS

6.1 Empirical results from using HHI as dependent variable

My estimation of knowledge flows characterized by HHI is presented in appendix A. The OLS parameter estimates are reported in the first two columns of table A1. The different number of asterisks indicates statistical significance at 10%, 5%, and 1% significance level with robust standard error in the parenthesis. The estimates show that HHI in the previous year is positively related with HHI in current year. Many coefficients are shown to be significant. However, without controlling for the time invariant effect, the interpretation is of little meaning. The coefficients are biased and inconsistent. Also, the P-value from Breusch-Pagan test is equal to 0.00, which is less than the alpha=0.01, so I can conclude that there is a heteroskedasticity which may be affecting hypothesis tests.

Column 3 and 4 show the estimation results when I use year dummy variables and country dummy variables to control the time invariant effects and country invariant effects and use robust standard error to control for heteroskedasticity. Lagged HHI still has significant impact on HHI while US-VISA is having a positive effect and being significant at 1% significance level. The coefficient of US-VISA goes against my hypothesis. One explanation is that I am using US-VISA to approximate the impact of study abroad on HHI. However, the HHI is mainly from the field of economics. The main independent variables, PC and Internet, exhibit different trend which is also disagree with our assumption. When test the existence of the correlation between variables, I found that “VIF” for most variables is greater than 10, signifying the

existence of multicollinearity between variables. Except that, all the other variables are statistically insignificant. The interpretation of the coefficient for lagged HHI can be: if HHI in previous year increase by 1 percentage point, HHI in current year is going to increase by 0.298 percentage point.

PC and INTERNET are correlated with each other (the correlation between the two is larger than 0.9), including both variables at the same time may cause some bias in my regression, I report regressions which include only one of two variables at a time. Also, I drop GDP per capita and Unemployment and use only higher education expenditure as my proxy for income. As we know, the best variable that captures the income level of the scholars is salaries; higher education expenditure can be a better alternative we can use as proxy than GDP per capita and unemployment rate. I report these specifications in table A2. When including year dummy variables, Internet and PC are statistically insignificant and the sign of coefficient goes opposite which is not true according to my hypothesis. However, excluding year dummy variables from my regression as shown in column 2 will give us a different scenario. If I include PC in my estimation,, the coefficient is -.015 and highly statistically significant. In column 3, Internet, as the only proxy for the application of internet, is statistically significant. The interpretation of the coefficient is straightforward: Internet usage increases by 1 percentage point, HHI decreases by 0.008 percentage point which confirms the hypothesis 1.

Table A.3 shows the regression result when I use total number of publications to control for heteroskedasticity in the regression. PC and Internet shows the same impact as in the previous table. In the absence of time dummy variables, economic freedom of the world index shows up to be highly significant and the coefficient is equal to -0.003 which confirms with our intuition that a open economy has positive impact on the spillover of knowledge across country.

In table A.4, I exclude China from our regression as I suspect that observations from China are outliers that would bias our result as showed in the above graph. When excluding China from our regression, the Economic Freedom Index becomes statistically significant and the absolute value of the magnitude of coefficient almost increases by a factor of three. The effect of VISA becomes insignificant. More importantly, the sign of GDP per capita changes from positive to negative showing that China does create bias in our regression.

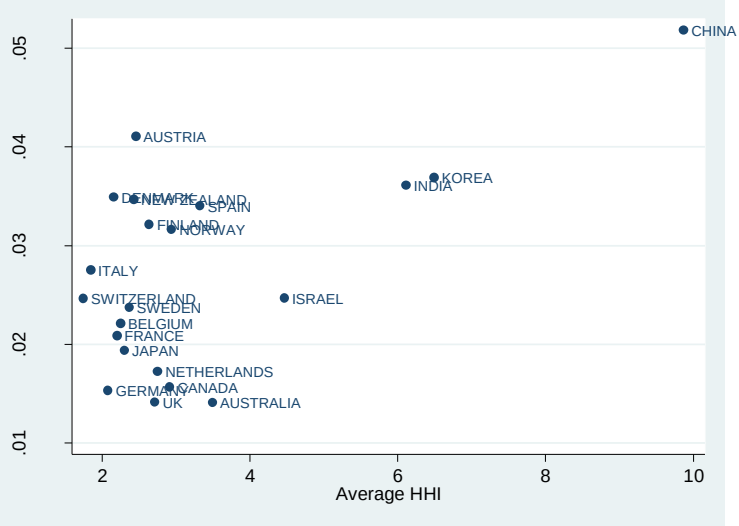

Figure 1: Average GDP Growth Rate and Average HHI

6.2 Results from using domestic citation rate as dependent variable

I now turn to using domestic citation rate as dependent variable as an alternative way to check whether these country-level factors will have the same impact on the knowledge spillover.

Using similar method as in Table A1, I find that by controlling time invariant effect and year invariant effect, significance level in the coefficient changes obviously. Comparing column 2 and 4, higher education index changed from highly significant to insignificant and the magnitude of the coefficient changed greatly from -0.66 to -0.22. PC and Internet are

insignificant. However, when adding lagged Self-citation in the regression, the lagged term is insignificant in affecting Self-citation.

The model in Table B.2 is similar to table A2, and the estimation results are quite similar. The lagged Self-Citation is significant in impacting Self-Citation at 10% significance level. The estimates reveal a negative and significant relationship between Erasmus and self-citation rate which is agree with my assumption.

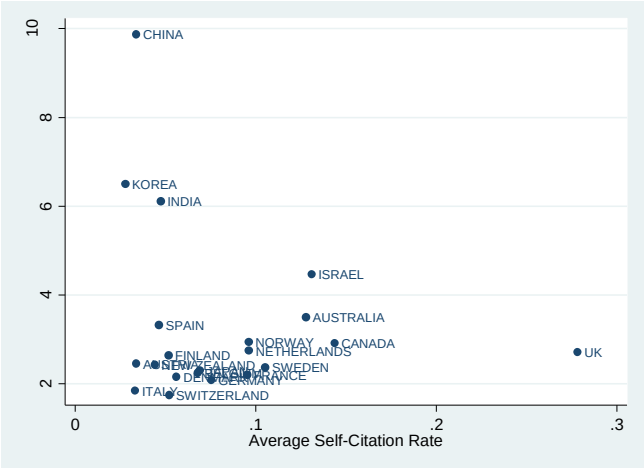

Figure 2: Average GDP Growth Rate and Average Domestic Citation Rate

In table B3, I check the different impacts in the models when excluding China for our sample. I notice that after excluding China, the magnitude of coefficient of the lagged form of self-citation increases from 0.107 to 0.135 and its significance level increases from of 90% to 95%. The impact of Economic Freedom Index remains the same; the unemployment rate is less significant and has positive effect. However, while GDP per capita remains statistically insignificant, the absolute value of its coefficient doubles.

6.3 Stationary Test

Under the assumption of Gauss-Markov theorem, the regression series are either stationary or deterministic such that the Ordinary Least Square Estimators are consistent. By using the Augmented Dickey Fuller Test and the DF-GLS Test to test for existence of unit root, I find that my dependent variable HHI is not a stationary process for some countries before de-trending. Also results from the unit root tests for the regressors imply that they are not stationary processes. Thus, a more powerful test for my analysis would be to transform all the variables into stationary processes and then test the relations between the deviations of the variables. However, according to the economic theories, I expect that the trend in the dependent variable is correlated with trends in the independent variables which can be called co-integration, thus making the use of OLS an appropriate method. As we can see tables in appendix C the HHI for CANADA is not a stationary process even after detrending or first differencing, implying that it is a I(2) process. However, the time periods of my sample may not be long enough and my test results suffer from lower power problems. Further investigation may be necessary to verify my results.

CHAPTER 7

CONCLUSION

This paper is an attempt to use the citation information to capture the flow of knowledge and thus identify casual effects on the change in citation patterns. Using fixed effect models, I find that wider application of Internet increases citation breadth across countries in the field of economics under some specific conditions; Economic openness is one important factor that would affect the citation flows; I also notice that citation patterns in the past are having significant impact on citations in the next year even after I use country dummy variables. This may imply the existence of school of thought which is stated as researchers tend to cite from places where they have similar school of thought. However, due to the limitation of institution level of independent data, I am unable to test the existence of it. Further study may be required to check whether it exists or not. Also my study is limited in the field of economics; further research can extend the study to the other fields to check whether internet has impact on other fields of study. Another possible extension of research may be on the role of physical distance (or economic distance) in the flow of knowledge. Factor model analysis seems a promising tool for the extension as it can effectively capture the cross-sectional dependence across countries.

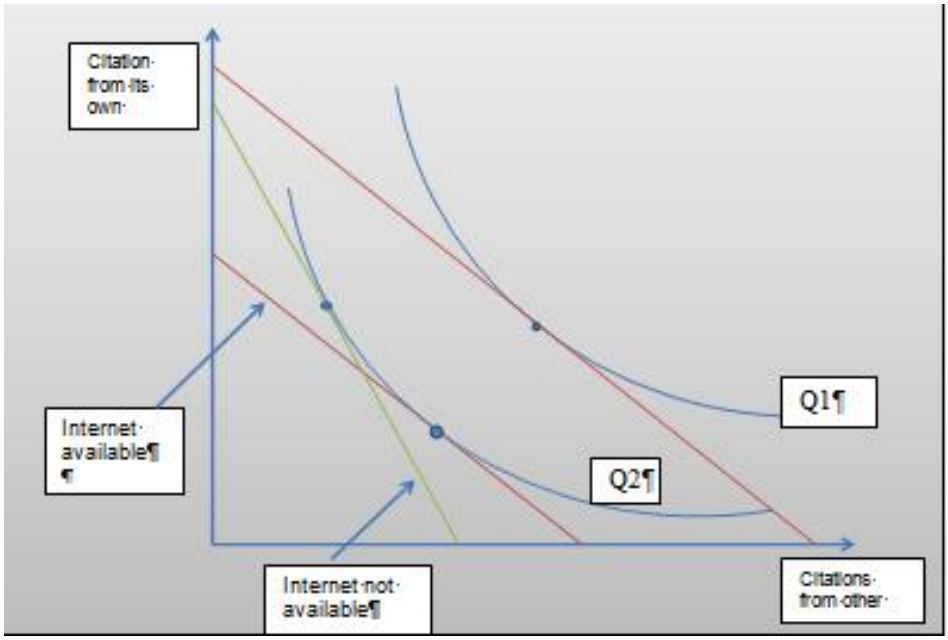

Figure 3: The Impact of Internet on Citation Pattern

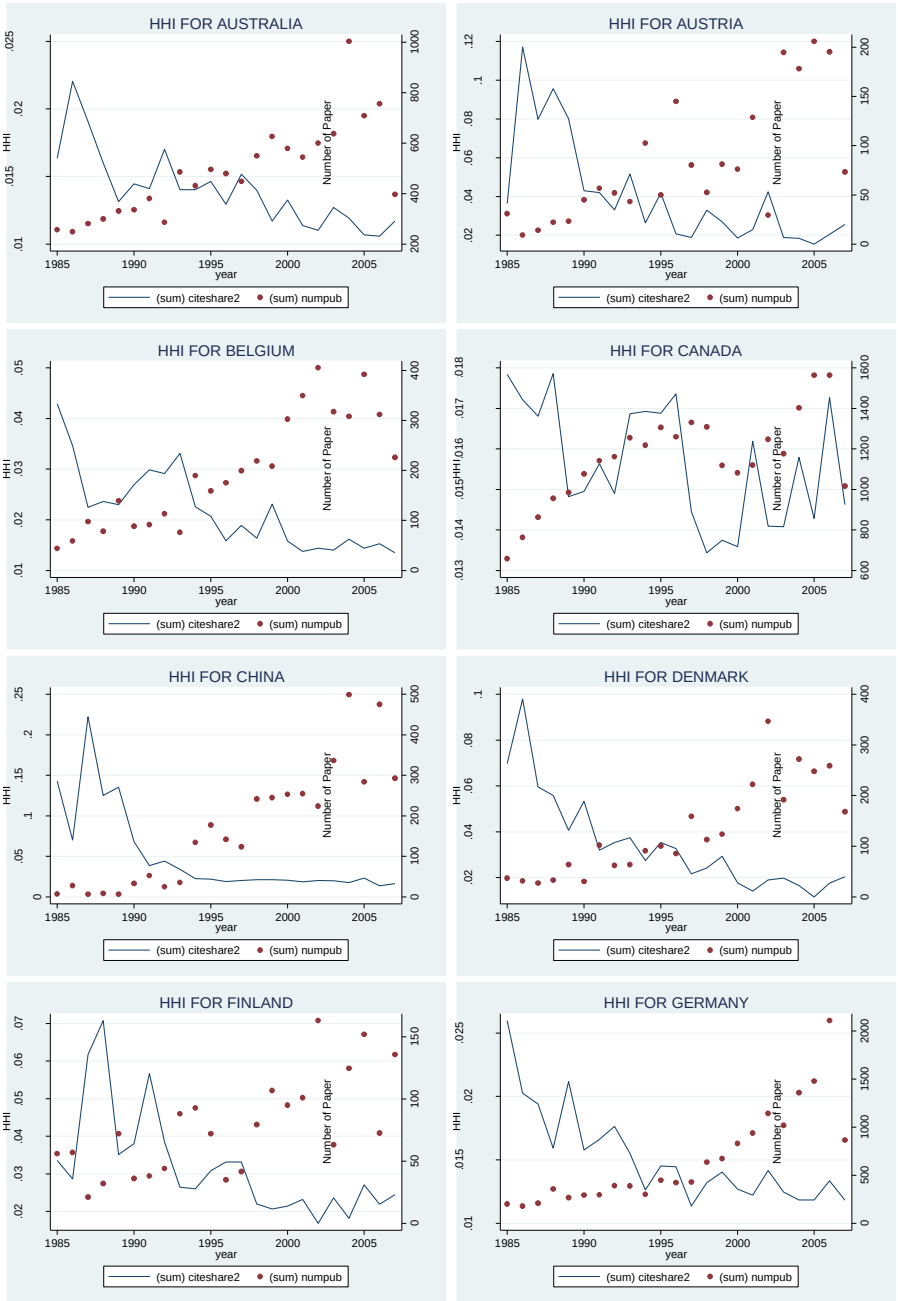

Figure 4: Trend of HHI and Total number of Citations made 1

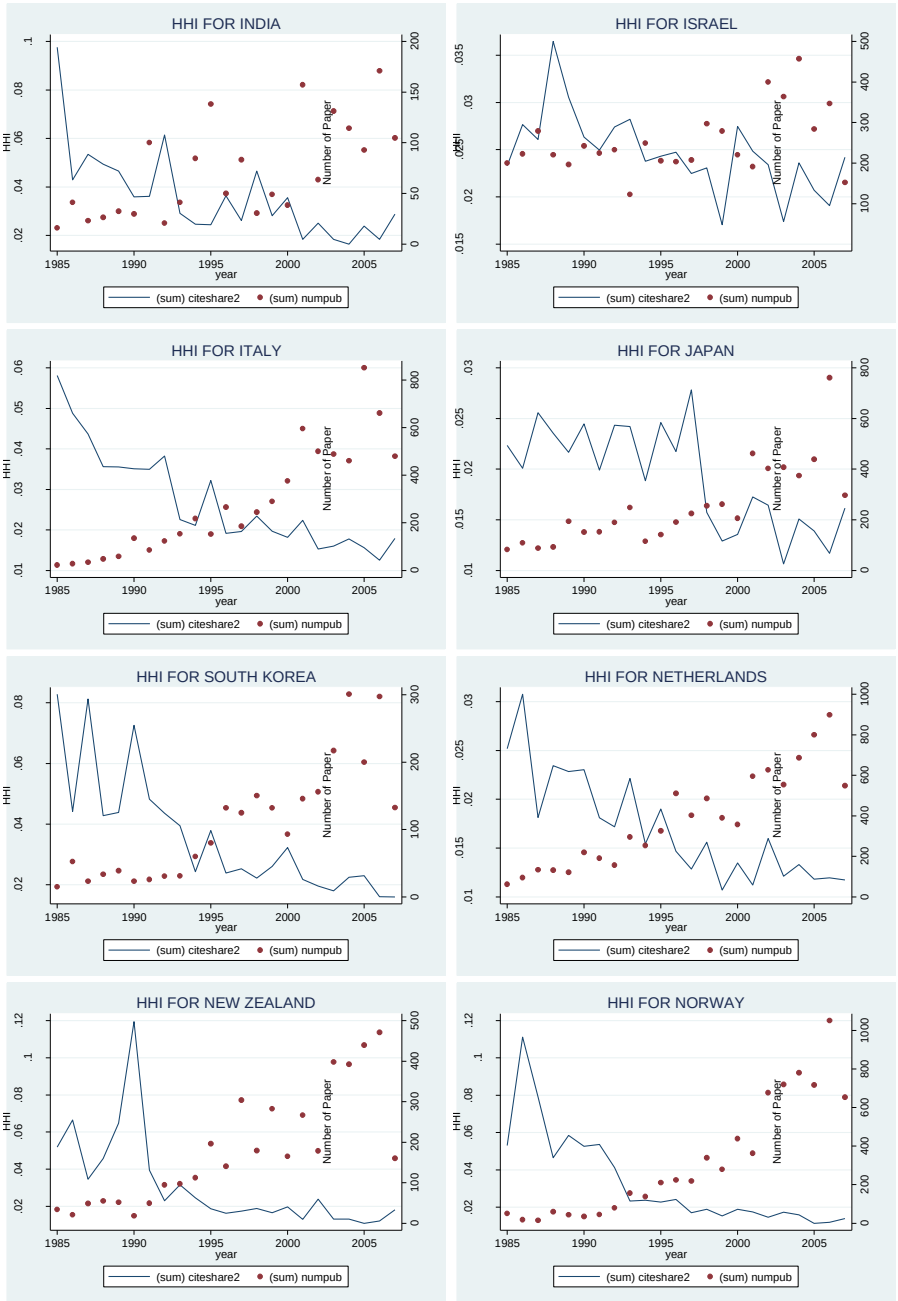

Figure 5: Trend of HHI and Total number of Citations made 2

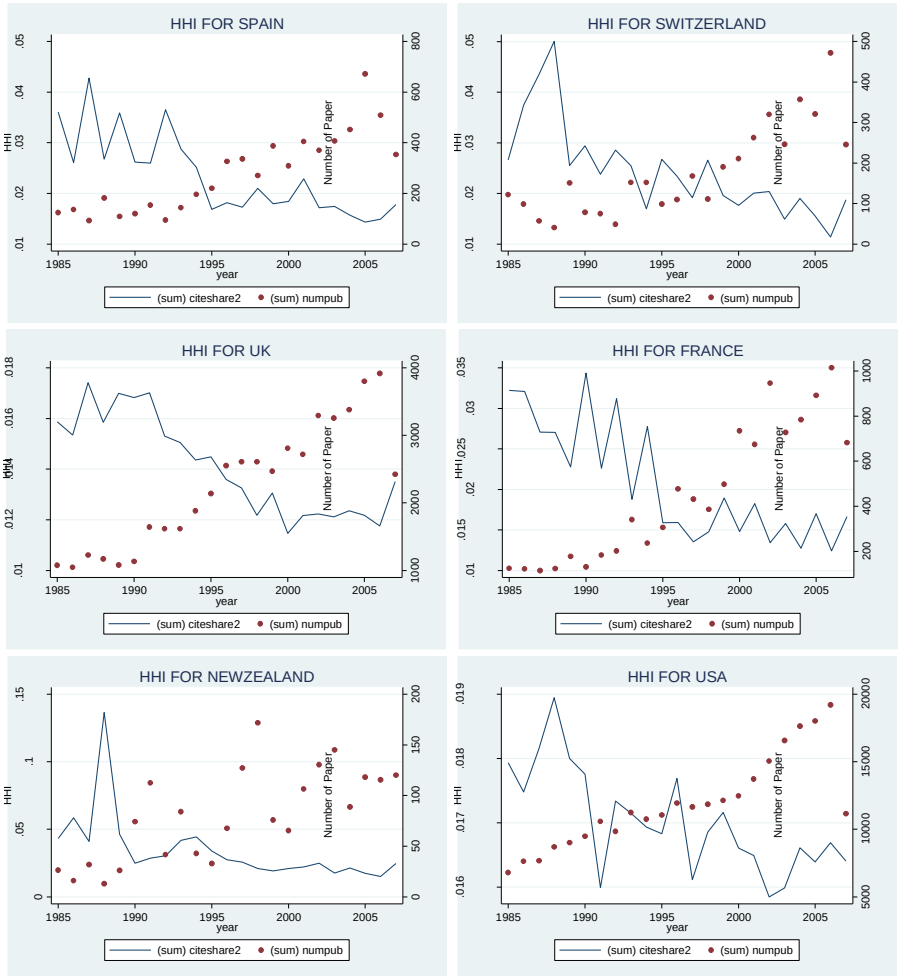

Figure 6: Trend of HHI and Total number of Citations made 3

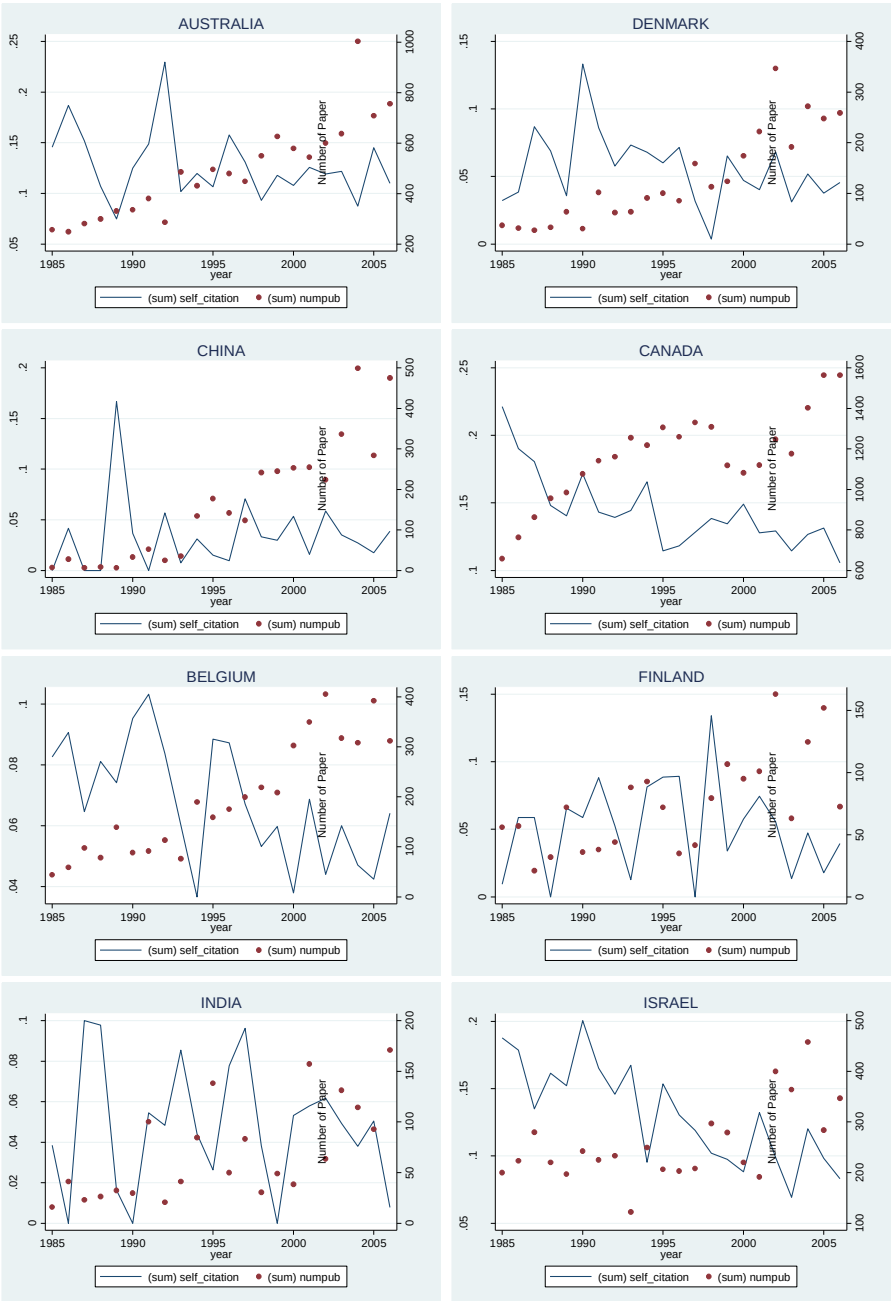

Figure 7: Trend of Domestic Citation Rate and Total Number of Citation Made 1

Figure 8: Trend of Domestic Citation Rate and Total Number of Citation Made 2

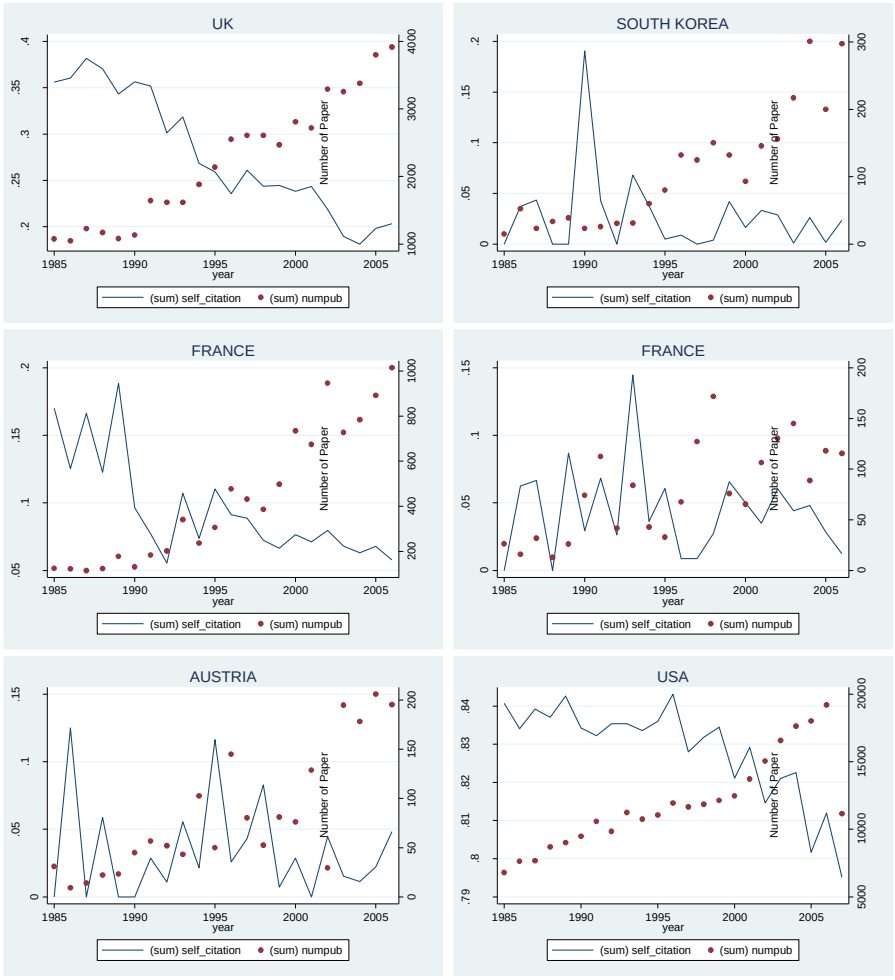

Figure 9: Trend of Domestic Citation Rate and Total Number of Citation Made 3

APPENDIX A

REGRESSION RESULTS FOR HHI

Table A.1 OLS estimation and fixed effect models with all variables

VARIABLES	(1) OLS WITHOUT LAG	(2) OLS WITH LAG	(3) FE WITHOUT LAG	(4) FE WITH LAG
Erasmus	0.396*** (0.149)	0.188 (0.116)	0.077 (0.299)	0.080 (0.234)
US visa	-0.020 (0.018)	-0.010 (0.015)	0.263*** (0.079)	0.192* (0.105)
FDI	-0.087 (0.095)	-0.066 (0.065)	0.093 (0.079)	0.040 (0.075)
Trade	-0.010*** (0.003)	-0.005* (0.003)	-0.028* (0.015)	-0.012 (0.014)
Economic Freedom of the World Index	-0.005*** (0.002)	-0.002* (0.001)	-0.004 (0.004)	-0.003 (0.004)
Higher Education Expenditure	0.250** (0.119)	0.102 (0.117)	0.054 (0.152)	0.025 (0.162)
Higher Education students	-0.445*** (0.076)	-0.244*** (0.070)	-0.546* (0.293)	-0.266 (0.212)
Unemployment Rate	-0.124*** (0.026)	-0.071*** (0.022)	0.005 (0.035)	-0.014 (0.032)
GDP/cap	-0.669*** (0.193)	-0.307** (0.139)	0.280 (0.685)	0.133 (0.712)
PC	-0.039*** (0.010)	-0.025*** (0.009)	0.019 (0.017)	0.007 (0.017)
Internet	0.021*** (0.007)	0.013** (0.007)	-0.008 (0.014)	-0.000 (0.013)
Year Dummy			X	X
Country Dummy			X	X
Lagged HHI		0.460*** (0.070)		0.298*** (0.095)
Constant	0.089*** (0.011)	0.045*** (0.010)	0.056 (0.035)	0.040 (0.038)
Observations	372	356	372	356
R-squared	0.401	0.531	0.572	0.593

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A.2 the impact of Internet and PC on fixed effect model

VARIABLES	(1) COUNTRY DUMMY WITH PC & INTERNET	(2) COUNTRY DUMMY WITH PC	(3) COUNTRY DUMMY WITH INTERNET	(4) YEAR DUMMY AND COUNTRY DUMMY WITH PC & INTERNET
Lagged HHI	0.341***	0.340***	0.354***	0.289***
	(0.079)	(0.079)	(0.079)	(0.086)
ERASMUS	-0.321	-0.335	-0.428*	-0.049
	(0.233)	(0.232)	(0.239)	(0.189)
US visa	0.150*	0.152*	0.150*	0.196**
	(0.077)	(0.077)	(0.077)	(0.099)
Economic Freedom of the World Index	-0.008**	-0.008***	-0.009***	-0.003
	(0.003)	(0.003)	(0.003)	(0.004)
Higher Education Expenditure	0.147	0.142	0.114	0.060
	(0.210)	(0.210)	(0.205)	(0.182)
Higher Education students	-0.158	-0.149	-0.142	-0.098
	(0.150)	(0.149)	(0.147)	(0.139)
PC	-0.025**	-0.015***		0.002
	(0.010)	(0.004)		(0.014)
Internet	0.008		-0.008***	-0.001
	(0.006)		(0.002)	(0.010)
Country Dummy	X	X	X	X
Year Dummy				X
Observations	370	370	381	370
R-squared	0.558	0.557	0.554	0.589

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.3 models using total number of publication to correct heteroskadasticity

VARIABLES	(1) COUNTRY DUMMY WITH PC & INTERNET	(2) COUNTRY DUMMY WITH PC	(3) COUNTRYDUMMY WITH INTERNET	(4) YEAR DUMMY AND COUNTRY DUMMY WITH PC & INTERNET
Lagged HHI	0.378***	0.383***	0.376***	0.363***
	(0.037)	(0.037)	(0.036)	(0.039)
Erasmus	-0.149	-0.137	-0.171*	-0.119
	(0.093)	(0.093)	(0.090)	(0.104)
US visa	0.004	0.003	0.004	0.026
	(0.014)	(0.014)	(0.014)	(0.019)
Economic Freedom of the World Index	0.003***	-0.003***	-0.003***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Higher Education Expenditure	-0.063	-0.059	-0.067*	-0.057
	(0.039)	(0.039)	(0.038)	(0.040)
Higher Education students	-0.066	-0.067	-0.073	-0.023
	(0.077)	(0.077)	(0.075)	(0.086)
PC	-0.002	-0.006***		0.001
	(0.003)	(0.001)		(0.005)
Internet	-0.003		-0.004***	0.003
	(0.002)		(0.001)	(0.005)
Year Dummy				X
Country Dummy	X	X	X	X
Observations	370	370	381	370
R-squared	0.668	0.667	0.672	0.680

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.4 the impact of China on the models

VARIABLES	(1) Without China	(2) with China
Lagged HHI	0.298***	0.342***
	(0.083)	(0.074)
ERASMUS	-0.408*	-0.128
	(0.236)	(0.271)
US visa	0.048	0.115*
	(0.030)	(0.066)
Economic Freedom of the World Index	-0.007**	-0.002
	(0.003)	(0.005)
GDP/cap	-0.711	0.591
	(0.523)	(1.038)
Unemployment Rate	-0.033	-0.012
	(0.030)	(0.033)
Internet	-0.001	0.009
	(0.008)	(0.010)
Country Dummy	X	X
Year Dummy	X	X
Observations	400	421
R-squared	0.624	0.593

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX B

REGRESSION RESULT FOR DOMESTIC CITATION RATE

Table B.1 OLS regression and fixed effect model with all the variables

VARIABLES	(1) OLS WITHOUT LAG	(2) OLS WITH LAG	(3) DUMMY WITHOUT LAG	(4) DUMMY WITH LAG
Erasmus	-6.269***	-2.406***	-0.950	-0.824
	(0.886)	(0.604)	(0.776)	(0.738)
US visa	1.118***	0.442***	-0.158	-0.057
	(0.0942)	(0.094)	(0.115)	(0.121)
FDI	-0.167	0.014	-0.327*	-0.246
	(0.234)	(0.237)	(0.173)	(0.178)
TRADE	0.0342***	0.010	0.039	0.0256
	(0.0101)	(0.008)	(0.034)	(0.0354)
Economic Freedom of the World Index	-0.00128	-0.002	-0.0121*	-0.0131*
	(0.00454)	(0.003)	(0.007)	(0.007)
Higher Education Expenditure	0.503**	0.263	0.339	0.277
	(0.204)	(0.172)	(0.279)	(0.310)
Higher Education Index	-1.582***	-0.660***	-0.210	-0.290
	(0.339)	(0.218)	(0.453)	(0.466)
Unemployment Rate	0.315***	0.098	0.227**	0.149
	(0.0983)	(0.076)	(0.112)	(0.110)
GDP/cap	0.438	0.405	-0.370	-0.444
	(0.741)	(0.503)	(1.347)	(1.448)
PC	-0.0479	-0.027	-0.065*	-0.050
	(0.0342)	(0.028)	(0.039)	(0.040)
Internet	-0.0122	-0.003	-0.009	-0.012
	(0.0236)	(0.017)	(0.033)	(0.032)
Country Dummy			X	X
Year Dummy			X	X
Lagged domestic citation rate		0.574***		0.090
		(0.067)		(0.067)
Observations	372	356	372	356
R-squared	0.508	0.686	0.802	0.800

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B.2: the impact of Internet and PC on fixed effect model

VARIABLES	(1) PC without Year Dummy	(2) Internet without Year Dummy	(3) PC and Internet without Year	(4) Internet with Year
Lagged domestic citation rate	0.098*	0.102*	0.098*	0.107*
	(0.058)	(0.058)	(0.059)	(0.061)
Erasmus	-1.267**	-1.249**	-1.274**	-1.224*
	(0.614)	(0.622)	(0.618)	(0.672)
US visa	0.001	0.006	0.002	-0.020
	(0.120)	(0.122)	(0.120)	(0.123)
Economic Freedom of the World Index	-0.013***	-0.016***	-0.013***	-0.014**
	(0.005)	(0.005)	(0.005)	(0.006)
Higher Education Expenditure	0.491*	0.458*	0.489*	0.428
	(0.274)	(0.274)	(0.271)	(0.292)
Higher Education students	0.260	0.300	0.264	0.245
	(0.266)	(0.258)	(0.270)	(0.303)
Internet		-0.021***	-0.004	-0.033
		(0.008)	(0.020)	(0.021)
Country Dummy	X	X	X	X
Year Dummy				X
PC	-0.034***		-0.029	
	(0.013)		(0.031)	
Observations	370	381	370	381
R-squared	0.780	0.777	0.780	0.785

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B.3: the impact of China on the models

VARIABLES	(1) Without China	(2) with China
Lagged domestic citation rate	0.135**	0.107*
	(0.063)	(0.061)
ERASMUS	-0.501	-0.614
	(0.661)	(0.677)
US-VISA	-0.036	-0.064
	(0.089)	(0.091)
Index of Economic Freedom	-0.011*	-0.0117*
	(0.006)	(0.006)
GDP/cap	-0.212	-0.549
	(1.594)	(1.499)
Unemployment	0.181*	0.193**
	(0.097)	(0.098)
Internet	-0.009	-0.017
	(0.019)	(0.019)
Country Dummy	X	X
Year Dummy	X	X
Observations	400	421
R-squared	0.786	0.778

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX C

RESULT OF DF TEST BEFORE AND AFTER DETRENDING

Table C.1 ADF test for HHI in Canada

Augmented Dickey-Fuller test for unit root			Number of obs =	17
Interpolated Dickey-Fuller				
Test	1% Critical	5% Critical	10% Critical	
Statistic	Value	Value	Value	
Z(t)	-1.314	-3.750	-3.000	-2.630

Table C.2 ADF test for HHI in Canada after detrending

Augmented Dickey-Fuller test for unit root			Number of obs =	17
Interpolated Dickey-Fuller				
Test	1% Critical	5% Critical	10% Critical	
Statistic	Value	Value	Value	
Z(t)	-1.151	-3.750	-3.000	-2.630
MacKinnon approximate p-value for Z(t) = 0.6943				

Table C.3 ADF test for HHI in Canada after first differencing

Augmented Dickey-Fuller test for unit root			Number of obs =	17
Interpolated Dickey-Fuller				
Test	1% Critical	5% Critical	10% Critical	
Statistic	Value	Value	Value	
Z(t)	-1.655	-3.750	-3.000	-2.630
MacKinnon approximate p-value for Z(t) = 0.4545				

Table C.4 ADF test for HHI in Canada after second differencing

Augmented Dickey-Fuller test for unit root			Number of obs =	17
Interpolated Dickey-Fuller				
Test	1% Critical	5% Critical	10% Critical	
Statistic	Value	Value	Value	
Z(t)	-8.210	-3.750	-3.000	-2.630
MacKinnon approximate p-value for Z(t) = 0.0000				

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