WHAT ARE COUNTRY-LEVEL DETERMINANTS OF ECONOMIC RESEARCH PRODUCTIVITY?

by

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ABSTRACT

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Economics research productivity is an emerging concern because it determines education system's quality and it can help improve economic welfare. This study seeks to investigate country-level determinants of research productivity in the Economics discipline. The main variables of interest are the use of the Internet and personal computers, economic openness and higher education. I hypothesize that Internet and PC use can lower the collaboration cost and searching cost resulting in increased marginal productivity from Internet adoption and positive cross productivity effects. Therefore, if people can access Internet more, their productivity will increase. In addition, economic openness, especially greater labor mobility, increases the degree of competition in the academic labor market. In particular, successful professors have become better able to move between institutions that offer better opportunities regardless of whether they are domestic or foreign, public or private. Competition among academics generally takes the form of increased research and publication effort. This paper uses fixed effect model, distributed lag models and robust standard errors to adjust the estimated errors. It shows that there are significant effects of economic openness, study abroad, and Internet adoption on the economic research productivity. However, these effects vary across different groups of countries. Study abroad and Internet have most significant joint effects in developing countries while it has no discernable effect in developed countries. Trade and FDI, good proxies for economic openness, do have significant effects. There also are significant effects from economic openness, study abroad, personal computer use and higher education on academic concentration.

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CHAPTER 1

INTRODUCTION

1.1 Summary of the thesis

Economic research productivity is important because it helps determine an educational institution's quality in Economics discipline and can help promote policies conducive to economic welfare. This research looks for the determinants of economic research productivity using a panel data of 29 countries from 1975 to 2006. Table A.1 demonstrates a general upward trend in publishing outside of the US. This thesis tries to uncover some of the mechanisms related to why this trend has occurred. I explore the importance of such factors as the level of the country's Internet and personal computer use, economic openness, income, higher education, educational inputs, and international academic exchanges. I hypothesize that Internet and personal computer use, economic openness, and study abroad will have positive relationships with economic research productivity; and that market liberalization can help countries increase productivity due to enhancing labor mobility. The paper also shows that there is a decrease in "research market's concentration" due to higher competition in professional labor market, higher education and study abroad.

1.2 Contribution of the thesis

A wealth of factors has been identified which contribute to increased research productivity. Several studies have tried to examine the relationship between research. productivity and researcher age (Gonzalez-Brambila and Veloso, 2007), gender and marriage (Mary Frank Fox, 2005), collaboration (Lee and Bozeman, 2005; Defazio, Lockett and Wright, 2008; Sooryamothy and Shrum, 2007; Agrawal and Godfarb, 2008), funding (Jacob and Lefgren, 2007); institutional factors (Dundar and Lewis, 1998) and Information and Communication Technology application (ICT) (Hamermesh and Oster, 1998; Barjak, 2006; Depken and Ward, 2009). Most of these examine research productivity in many different disciplines and at the institutional or personal level. This paper examines the country-level determinants of research productivity in just Economics field. The data include both developed countries and developing countries for a long period (32 years) so we can see the different effects of those determinants in different countries.

1.3 Organization of the thesis

The thesis is organized as follows: a review of relevant literature is in chapter two. Chapter three provides explanations on basic economic theories such as normal goods, labor mobility, human capital and simple production function apply to the investigation. The econometric model and hypothesized results are in chapter four. Chapter five describes the data collected for the analyses. Chapter six reports the results from the empirical model and chapter seven is the conclusion of my thesis.

CHAPTER 2

LITERATURE REVIEW

To the extent that research productivity is important for economic development, understanding the determinants of research productivity also becomes important. Several studies have tried to examine the relationship between research productivity and age; gender; marriage status; collaboration; funding; institutional factors such as number of faculties, graduate students and size of graduate programs; Information and Communication Technology (ICT) appliances; and international factors such as the use of the English language, countries' convergence in economic and modern educational standards. However, the results are not always consistent because they use different methods for different data sources that cover different time periods.

2.1 Literature on Age, Gender and Marriage Status

Researchers might start doing research early (when they are still young), but researching experience and publishing do not come immediately. At the time they mature, they gain knowledge, experience and professional relationships that can help them to increase their research output. Gonzalez-Brambila and Veloso (2007) confirm a quadratic relationship between a researcher's age and his productivity by using a data set of Mexican researchers in the Mexican National System of Researchers (SNI) from

1991 to 2002. They analyzed the dynamics of productivity over the life cycle and explore differences across disciplines described as “Exact Sciences:” Biology and Chemistry, Health Sciences, Social and Humanities, Agricultural Sciences and Biotechnology, and Engineering. Their estimators include the Negative Binomial fixed effects model, the Conditional Maximum Likelihood Estimation (CMLE) proposed by Hausman, et al. (1984), and the Non-Linear Least Square Method proposed by Turner and Mairesse (2003). They show that there is great heterogeneity across disciplines. Researchers are found to be productive, in terms of publishing, between 30 and 79 years old, reaching a peak of 1.76 papers per year by the time they are 53 years old.

Mary Frank Fox (2005) used the data from a national mail survey conducted in the U.S in 1993-1994 of 1,215 full-time, tenured or tenure track faculty in doctoral-granting departments in computer science, chemistry, electrical engineering, microbiology, and physics. The dependent variable, publication productivity, is the number of papers published or accepted for publication in refereed journals within the three years before the survey. Her study takes into account different types of publications, time lags, period of time, self-reported data. She found out that there is a significant gender difference (p=.008). In the three-year period before the survey, women published or had accepted for publication, 8.9 papers versus 11.4 for men. For women, the relationship between marriage and productivity varies by type of marriage: second and later compared with first marriage, and occupation of spouse. Women in subsequent marriages have higher productivity than women in first marriages. This relates to their greater likelihood to be married to another scientist with marriage to a scientist having a positive effect on productivity.

2.2 Literature on Collaboration

Collaboration is viewed as playing an important role in enhancing productivity both through sustaining the process of knowledge creation and as a means to increase the division of tasks and to achieve scale economies in research activity (Katz and Martin, 1997) and (Adams et al., 2005). Lee and Bozeman (2005) analyzed a sample of 443 U.S. academic scientists affiliated with either National Science Foundation or Department of Energy research centers. Productivity measures in this study were taken directly from the curriculum vitae of the individuals. Because characteristics of individual and the working environment are endogenously correlated to both collaboration and productivity, they used the two-stage-least-squares (2SLS) analysis to examine the mediating effect of collaboration on publishing productivity. The findings indicate that the simple number of peer-reviewed journal papers is strongly and significantly associated with the number of collaborators, after controlling for other moderating variables such as age, rank, grant, gender, marital status, family relations, citizenship, job satisfaction, perceived discrimination, and collaboration strategy. However, when productivity is measured by 'fractional count', dividing the number of publications by the number of authors, number of collaborators is not a significant predictor of publishing productivity.

If the collaboration cost is lowered due to better ICT applications, we can expect to see increasing research productivity of collaborators with ICT adoption. Agrawal and Godfarb (2008) found that Binet (an early version of Internet) adoption improved medium-ranked universities' research productivity because it increased research collaboration between U.S universities and specialization of research tasks. Without the World Wide Web and the browser functions, Binet still allowed communication via email, access to remote file archives, use of Listserv, file transfer protocol (FTP), and compatibility with other operating systems such as UNIX. Agrawal and Godfarb collected publication data (16,495 papers) from seven electrical engineering journals over the 11-year period 1981-1991 and identified 270 U.S universities for their interesting. Those universities were classified into three tiers, with 90 universities in each: Tier 1 (high research orientation), Tier 2 (medium research orientation), or Tier 3 (low research orientation). They used universities' official websites and latitude and longitude data from the US Geological Survey for determine the distance between institution pairs and Cyber Geography Research, for a record of Bitnet connections. OLS regressions are applied to see that Bitnet facilitate collaboration across institutions, especially between certain types of institutions, namely top tier-middle tier pairs that were co-located. Besides, the Bitnet Effect varies with institution quality and distance between institutions. That means second-tier schools significantly increased their collaboration rates with co-located top-tier schools after Bitnet connection.

However, the process can be different for developing countries. Duque, et al. (2005) collected the data from scientists at universities and research institutes in Karalla (n= 303), Kenya (n= 315) and Ghana (n= 300) during the period 2000-2002. They examined the relationship between collaboration and productivity, controlling for other factors and whether the Internet can reduce problems associated with collaboration in developing areas: Africa, Asia and Latin America. The results suggested that the collaborative benefits of new ICTs are not realized in developing areas. Scientists from Karalla are the most productive, have the best access to email and report the fewest problems in their research—they are also the least collaborative. At the other extreme, Kenyan scientists are the least productive, have difficulty with email access and report the most research problems, but they manage to collaborate a great deal. If both institutional and locational context are controlled for, the association between collaboration and productivity was quite limited. They conclude that it is not collaboration alone that causes research problems, but poverty, corruption and family obligations.

2.3 Literature on Funding

Defazio, Lockett and Wright (2008) used a panel of 294 researchers in 39 EU research networks over 15 years to analyze the effectiveness of collaborative structures on research productivity when funding is a moderating factor. EU-funded research networks require researchers to collaborate as a condition for securing research funding. Their choice of the Arellano-Bond estimator for dynamic panel data was driven by the opportunity to specifically control for the issues of heterogeneity and endogeneity that could affect scientific production. They concluded that during the period of funding, collaboration did not lead to an increase in research production. On the other hand, in the post-funding period, the impact of collaboration on productivity is positive and significant though the number of collaborations decreases within the network.

Jacob and Lefgren (2007) used OLS and the regression discontinuity method for all applications (unsuccessful as well as successful) to the National Institutes of Health (NIH) from 1980 to 2000 for postdoctoral training grants (F32s)[1] and standard research grants (R01s)[2] in order to estimate the impact of receiving an NIH grant on subsequent publications and citations. The findings show that receipt of either an NIH postdoctoral fellowship or research grant leads to about one additional publication over the next five years. The estimates represent about 20 and 7 percent increases in research productivity for F32 and R01 recipients respectively. Nevertheless, NIH research grants have at most a small effect on the research productivity of the marginal applicants.

Adams (2009) use panel data covering 110 top U.S universities and 12 main science fields during 1981-1999 to report that there is convergence in the world's science and engineering and a falling U.S. share. And much of the slowdown in publication is located in public universities. This is mainly because of a slower growth of financial resources, which in turn cause a deceleration in the growth of research output in public universities and university fields falling into the middle 40 percent and bottom 40 percent of their disciplines. The faster growth of mostly federal research funding for public universities is cancelled out by the slower growth in tuition and state appropriations. Even if public and private universities obtain similar percentage

[1] The Ruth L. Kirschstein National Research Service Award for Individual Postdoctoral Fellows (F32)

[2] The National Institute of Health Research Project Grant Program (R01)

increase in scientific papers and citation weighted papers from equal (percentage) increases in R&D, graduate students and current funds, there are still the differences in growth of research output between them. Compensation in private universities rises almost one percent a year faster than in public universities. Moreover, wages are flat across professorial rank in public universities, whereas they rise noticeably with rank in private universities. As a consequence, he finds (conjectures?) that top scientists want to move from public to private universities. This leads to a slower growth of research in public universities as well.

2.4 Literature on Institutional Factors

Dundar and Lewis (1998) exploited National Research Council data in 1993 on ninety of the US's research universities programs in the four broad fields of the biological sciences, engineering, the physical sciences and mathematics, and the social and behavioral sciences. They examine the relationship between academic research productivity and institutional factors such as department size, number of students of the departments, annual research spending, institutional library expenditure, quality of computing facilities, number of teaching assistants, etc. They deduced that academic research productivity is closely associated with program faculty size but at a diminishing rate. This is due to an increased opportunity for collaboration and reinforcement. Having more full professors and larger percentage of departmental faculty working on research can enhance research productivity. In addition, departments located in private universities generally have higher research productivity.

2.5 Literature on Information and Communication Technology

One of the most discussed factors is the development of ICTs. Hamermesh and Oster (1998) used all coauthored articles in three major economics journals from 1970-79 and 1992-96 to consider the direct impact of high technology on the research productivity by altering patterns of coauthoring of articles in economics. They held constant each individual's base-line productivity in looking for distance effects. Thus, their method shows how much a particular co-authorship adds to the individual productivity of the members of the team. The study hypothesized that there is significant growth in the percentage of distance co-authorships (who are not in the same metropolitan area) due to greatly lowering communication costs. However, the productivity (in terms of subsequent citations) of distant-coauthored relationships is lower relative to closed-coauthored relationships. Moreover, there is no decline in their relative disadvantage between 1970s and 1990s. This can be explained by the argument that high technology is used as a consumption rather than investment good. Vasileiadou and Vliegenthart (2009) also concur in their findings: "the positive impact of internet use on research productivity is limited and may only be relevant when collaborative endeavors suffer coordination problems. At the same time, meetings prove the most important predictor of research productivity."

Nevertheless, Barjak's (2006) findings point in another direction. He collected data on more than 1,400 scientists from five academic disciplines in 2003 (astronomy, chemistry, computer science, economics, and psychology) and seven European countries in order to investigate the relationship between internet use and research productivity in the context of other influences: age, gender, recognition, career motivation and the size of the collaboration network. The control variables included dummies for country, discipline, gender and type of organization of the respondent. The research productivity of scientists was measured on the basis of the self-reported number of publications during the years 2001 and 2002 (working papers, journal articles, book chapters, monographs, conference presentations, reports, others). The findings indicate that scientists who communicate more in general and via e-mail produce more publications, regardless of the form of publication. Scholars with personal homepages “without full text paper” publish more than those who do not have personal homepages, but less than those who feature full text papers or hyperlinks to these papers on their homepages. The use of peers’ web pages and the websites of other institutions correlates with the number of working papers; the number of journal articles correlates with the use of library sites and electronic journals; the number of conference presentations correlates with all information sources except for library sites. The writing of book chapters is correlated with the use of on-line information sources.

Depken and Ward (2009) focused their attention on, JSTOR, a new tool available to academic researchers in the mid 1990s. JSTOR is a large scale Internet-based searchable achieve of articles published in hundreds of journals over the past century or more. They analyze the effects of JSTOR access on both researchers’ inputs (references) and outputs (published articles) by using JSTOR’s own records of journals archived and institutions’ access arrangements and ISI’s Social Science Citation Index database for the economics discipline from 1975 through 2006. The results indicate that

JSTOR access lowers researcher costs to finding, reading, benefiting from and ultimately referring to achievable papers. In addition, scholars at institutions with JSTOR access tend to produce more articles but not necessarily more future citations.

2.6 Literature on International Factors

Borghans and Cörvers (2009) capture and explain the changes in the structure of research and higher education in Europe by comparing the developments in research in several European countries in different research areas using a long time series, specially the case of economics research and the case of the Netherlands. Higher education started to grow substantially around 1960, when research and higher education increased in its international orientation, and gradually transformed to the American standard. They argue that the cost and benefits of the size of the market, communication cost, the transferability of knowledge between countries and financial regulations are determinants in decision to study domestically or internationally. In fact, there is a trend toward international cooperation because of cheaper travel possibilities, European integration, the use of email and the Internet, and the change of language used in research from the national language to English. Smaller language areas made this transformation earlier while there are also clear timing differences between research fields.[3] The convergence of country specific habits and institutions towards the global (US) standards has further facilitated the internationalization of research and higher

[3] "Sciences and medicine tend to switch to English first, followed by economics and social sciences, while for law and arts only the first signs of such a transformation are currently observed." Borghans and Cörvers (2009)

education in Europe. They also suspect that an increase in the size of the home research market would have an opposite effect.

The existing studies help us to understand the relationship of productivity and many factors like gender, funding, marriage status, program size, market size, collaboration, professional compensations, IT tools and communication cost at both individual as well as institutional level. Nevertheless, they suffer from some weak points, such as the small datasets and datasets that are often self-reported over a short time period. It is likely to be the case that developed countries' scholars have better facilities to do research than developing countries. Likewise, elite schools can have more funding to support researchers. In this study, we use a sample that is more up-to-date (1975-2006) with cross-country variation (30 countries including both developed and developing countries). We control for variables at national level such as GDP per capita, FDI, trade, unemployed people, the openness of the economy, internet use, higher education student population, U.S nonimmigrant professional visa holders from Europe and Erasmus exchange students program in Europe. We try to uncover the factors that have significant affects on economic research productivity using a panel estimator. We expect that ICT and economic openness can help increase the national research productivity in the economic discipline.

CHAPTER 3

ECONOMIC MODEL

Research is conducted with individuals affiliated with various institutions for a variety of reasons. My sample of journal articles is dominated by research performed by academics at universities but also includes work by scholars at research institutions like National Institution of Economic and Social Research (NIESR) in England, Organization for Economic Cooperation and Development (OECD) in France and President's Council of Economic Advisors (CEA) in U.S. In the research industry, researchers or research institutions are suppliers; consumers might be students, organizations and governments. The researcher labor market rewards top researchers financially but can also offer non-pecuniary benefits to a successful research career such as prestige, travel, resources and consulting opportunities.

In addition, I assume that the research market is monopolistically competitive. It means that there are few barriers to entry and exit. The market's concentration depends on factors such as fixed costs, economy of scale and the degree of product differentiation. For example, the lower the fixed costs, the more academic institutions and researchers can join the market. The decreasing marginal cost of doing research due to economy of scale attracts more institutions enter the research market. Also the lesser the degree of research differentiation because of the convergent inputs' quality, the more research institutions there will be in market equilibrium.

3.1 Normal goods

A variety of simple economic theories apply to the understanding of the key determinants of research productivity. First, I propose that higher education and academic research are normal goods. As incomes in an economy increase, there is increased demand for higher education and for research effort in higher education. This would lead to more spending for education and more university degrees. The increase in academic research comes from both an increase in faculty sizes required by increased student populations but also from an increased demand for higher quality education. Remler and Pemar (2009) stated that research quality is a proxy for hard-to-measure teaching quality and barriers to entry. "Researchers more effectively teach higher order skills and therefore increase student human capital more than non-researchers"[4]. As a result, the demand for research increases because domestic schools want to compete with foreign institutions and attract future students, who are willing to pay higher expenditure for better colleges. The demand curve for research shifts rightward causing research output to increase. The higher price in the research market can be attributed to higher levels of compensation for productive researchers.

[4] Remler and Pemar (2009), "Why do institutions of higher education reward research while selling education?" NBER working paper.

In addition, the demand curve shifting rightward will increase the number of research done, then decrease the average total cost of doing research. Consequently, more research institutions are entering the market in order to gain profit. As a result, the market's concentration is reduced. I will test for an increase in research output and a decrease in market's concentration due to lower unemployment rates, higher GDP per capita, expenditure per higher education student and higher education school enrollment.

3.2 Labor Mobility

Economic openness, especially greater labor mobility, increases the degree of competition in the academic labor market. In particular, professors have become better able to move between institutions with better benefits regardless of whether the institution is domestic or foreign, public or private. Competition in this labor market generally takes the form of increased research and publication effort. Established researchers would have to compete with new productive colleagues in order to keep their positions, or gain the financial rewards and non-pecuniary benefits. This mitigates the moral hazard problem under which academics who were insulated from competition were able to shirk on research effort. Non-productive researchers, who had pursued consumptive goals, now would be more exposed to the risk that they could be passed over. In many places, this risk has increased over time unless researchers increase their productivity.

Moreover, greater labor mobility increases competition in the labor market then decrease the average salary. In other words, in opened economy, labor supply shifts rightward then the number of researchers increase and the "price" of average researchers decrease. The lower fixed cost of research institutions will lure more institutions into the research market. Therefore, economic openness helps to reduce the market's concentration. Economic openness might be evidenced by measures of foreign direct investment (FDI) and international trade and by measures of economic freedom.

3.3 Human Capital

In the academic setting, a more open market also related to more chances for students to study abroad, greater use the standardized language of scholarship (English), more exposure to other education systems and to approaches from many different areas. Thus, human capital is accumulated. Cörvers (1996) discusses four effects of human capital on labor productivity: the "worker effect", the "allocative effect", the "diffusion effect" and the "research effect." First of all, researchers with more knowledge and experiences are assumed to be more efficient in working with the resources at hand. Therefore the production possibility curve shifts outward. Second, the allocative effect points to the greater efficiency of higher quality researchers in allocating all input factors to the research process among researchers. Third, the diffusion effect stresses that researchers who go to higher education at higher ranking schools or go abroad are more able to adapt to up-to-date information and technological change in order to increase their research productivity as well as affect other colleagues positively. Fourth, the research effect refers to the role of higher quality researchers as an important input factor in general research and development (R&D) activities. R&D, in turn, is a key factor for technological progress and productivity growth. In fact, researchers can improve their own quality through studying in U.S (still the dominant research country for Economics) and joining exchange student programs such as ERASMUS[5] in Europe because of English fluency, foreign culture experience, foreign relationships, possibly a more open mind and exposure to a greater variety of knowledge approaches.

As the number of people who study abroad increases, there are more high quality researchers. Different institutions, either domestic or foreign, can have similar research output's quality. Because the degree of research differentiation is small, there will be more institutions in the pool. In conclusion, the research market's concentration is decreasing if studying abroad is increasing.

3.4 Simple Production Function

Finally, the effect of the Internet can be understood using a simple research production function approach. Let $q= f(x_{1,} x_{2,} x_{3....} x_N)$, where q represents the amount of research produced including dimensions of both quantity (e.g., number of articles) and quality (e.g., citations to articles). The factors of production, x, represents inputs such as computers, library access, modernized labs, funding for researchers, and number of

[5] A European student exchange program, "European Region Action Scheme for the Mobility of University Students"

researching hours, availability of research assistants and the number of collaborators. The marginal productivity of an input is the additional output that can be produced by employing one more unit of that input while holding all other inputs constant or the first order partial derivative of output with respect to an input, $\partial q/\partial x_i$. We might expect diminishing marginal productivity for any factor or the second order partial derivatives are negative. However, the cross partial derivatives or the cross productivity effects should be positive. This is because of a strong assumption that marginal productivities diminish "rapidly enough" to compensate for any possible negative cross productivity effects. [6]

I propose that a technical improvement such as Internet with all of its applications, such as JSTOR (Depken and Ward, 2009), eTorrent, Google, Wikipedia, etc., can increase the growth of output over time. This is because Internet can lower the collaboration cost and searching cost. For example, individuals can collaborate with each other via email messages, which are faster and more convenient than traditional mail or fax (Agarwal and Goldfarb, 2008). The Internet is becoming the on-line library which has almost up-to-date information in many different disciplines, but does not occupy any "real estate." Searching and documenting online are often easier and more efficient relative to conventional methods with papers and bookshelves. Therefore, we expect a positive marginal productivity from Internet adoption and positive cross productivity effects. That implies that if people can access Internet more, their productivity will increase.

[6] Snyder and Nicholson, "Microeconomic Theory, basic principles and extensions" (10th edition).

Ajay and Goldfarb (2008) suggested that the reduction in communication costs associated with ICT applications (Bitnet) lead to a broadening of the institutions participating in the production of high quality research, perhaps due to the benefits of specialization and gains from trade through cross-university collaboration. Then the market's concentration is decreasing.

CHAPTER 4

ECONOMETRIC MODEL

4.1 Empirical Model

The goal of our study is to determine which factors have affected research productivity and research market's concentration at country-level. Chief among our hypotheses are whether Internet and PC use and economic openness are significant factors. Positive effects of ICT and economic openness on research output would indicate that Internet infrastructure investment and market openness might increase research productivity in economics. Negative effects of ICT and economic openness on research market's concentration would indicate that ICT and economic openness helps to decrease research market's concentration.

The regression models below express academic publications and research market's concentration as functions of several variables, where the subscripts i and t pertain to specific countries and years, respectively. I use a fixed country effect to control for some unobservable differences across different countries related to culture or politics. Thus, the coefficients of the independent variables are identified by changes that occur over time. Moreover, developed and developing countries might have different error term's variance for different observations. Therefore, I suspect there exits heteroskedasticity problem, then I use robust standard errors to adjust the estimated errors.

In fact, economic openness, study abroad, ICT, income and higher education might have lagged effects on economic research productivity and on research concentration. For example, a rise in “permanent” income is likely to have an effect on consumption for higher education, which is distributed over a number of future time periods. Similarly, study abroad might take long time before students return and apply what they have learnt. Moreover, there is a tendency for a research institution to have the similar research productivity from year to year. I incorporate inter-temporal persistence effects by including the lagged endogenous variable with one year lag as an independent variable. The empirical results without one year lag are in the Appendix A. The specification below allows for lag dependency in research output and the contribution of other countries characteristics in explaining economic research output

$$\mathrm{Research}_{it} = \mathrm{f}(\mathrm{RESEARCH}_{i,t-1}, \mathrm{X}_{i,t-1}, \mathrm{D}_t)$$

where $\mathrm{Research}_{it}$ and $\mathrm{RESEARCH}_{i,t-1}$ stand for current and lagged research output for country i. The lagged dependent variable accounts for a dynamic component in economic research productivity. The term $\mathrm{X}_{i,t-1}$ contains a set of lagged country characteristics such as income, economic openness, studying abroad, Internet and higher education And the D_t terms are year dummies. The linear dynamic panel data models for economic research productivity and research concentration take the forms

$$\ln(\text{Research}_{it}) = \alpha_0 + \delta\text{RESEARCH}_{i,t-1} + \alpha_1\text{INCOME}_{i,t-1} + \alpha_2\text{ECON}_{\text{OPEN}\ i,t-1}$$
$$+ \alpha_3\text{STUDY}_{\text{ABROAD}\ i,t-1} + \alpha_4\text{INTERNET}_{i,t-1} + \alpha_5\text{EDU}_{\text{HIGHER}\ i,t-1}$$
$$+ \alpha_6\text{DUMMY}_{\text{YEAR}} + \mu$$

$$\text{Concentration}_{it} = \beta_0 + \theta\text{CONCENTRATION}_{i,t-1} + \beta_1\text{INCOME}_{i,t-1} + \beta_2\text{ECON}_{\text{OPEN}\ i,t-1}$$
$$+ \beta_3\text{STUDY}_{\text{ABROAD}\ i,t-1} + \beta_4\text{INTERNET}_{i,t-1} + \beta_5\text{EDU}_{\text{HIGHER}\ i,t-1}$$
$$+ \beta_6\text{DUMMY}_{\text{YEAR}} + \varepsilon$$

4.2 Hypothesized result

Research: My key variable of interest is the Weighted Impact Factor (WIMP). It is the number of the publications in peer-reviewed economics journals in year t by authors whose affiliations are in country i. For articles with multiple authors, each author's country receives a pro rata weighted share of the article. Moreover, articles are weighted by the publishing journal's impact factor, the ratio of incoming citations to outgoing citations. Thus, this measure of research combines elements of both quantity of publications and quality of publications.

Concentration: This is one of my two dependent variables. It is the concentration of research market in country i in year t. It is the sum of the squared of all institutions' shares in the market. It is from 0 to 1. The higher it is, the more concentration in the market.

INCOME: This is measured using Gross Domestic Products (GDP) per capita and unemployment rate. GDP per capita is derived from Purchasing Power Parity (Constant 2000 international dollar). Countries with higher GDP per capita and lower unemployment rate might spend more money for higher education and increased research productivity. Its coefficients are expected to be positive for GDP per capita and negative for unemployment rate. Rich countries also often have less concentrative market, then GDP's coefficient is expected to be negative and unemployment rate's is positive.

ECON_OPEN: This includes Foreign Direct Investment (FDI), trade and the economic openness index. I hypothesize a positive effect on research because countries with high exports and imports and that have more foreign investment usually have more open economies and higher economic openness index. These could also be related to more mobile labor market conditions. In addition, it is possible to use direct measure openness from EFW. Besides, economic openness will decrease the research market's concentration because of more competition; its coefficient is supposed to be negative.

STUDY_ABROAD: Engaging in studies abroad is an indicator of researcher integration into the larger research community. This contains the percentage of students who pursuit higher education abroad (within Europe) in general higher education students and number of people go to U.S for professional reasons such as conferences, seminars or professional visitor exchanging. Studying abroad with all advantages of better education systems, broaden knowledge, English fluency and foreign relationships can increase researchers' productivity. I expect a positive relationship between these measures and academic research. However, a negative relationship of study abroad and market concentration is expected due to lower degree of research differentiation among research institutions.

INTERNET: This is one of the main explanatory variables of interest. The Internet can reduce collaboration and communication cost. It also stocks huge amount of up-to-date information for researchers. So it has positive and significant effect on research productivity while it has negative effect on market concentration.

HIGHER EDUCATION: Increasing expenditure for higher education students might help more students to pursue higher education or go to better either domestic or foreign schools. Countries with accelerating higher education (post-secondary school) enrollments have larger pools from which researchers will emerge. Moreover, because the faculty demand is derived from the demand for higher education, the number of higher education students likely proxies for the number of academic researchers. The coefficients for research output are expected to be positive. In addition, the increasing number of researchers will lower the average cost of doing research, then attract more research institutions. So the coefficients for concentration are negative.

CHAPTER 5

DATA

The focus of this analysis is the role of industry institutional changes on research productivity. As such, the country and year is the appropriate unit of observation because institutional arrangements can vary across countries but tend to be more homogeneous within a country. Moreover, the data are usually only available at the country level. Country level data for this paper is collected from a variety of sources. Published article information is from the Institute for Scientific Information (ISI). Country openness measures are from annual surveys Economic Freedom of the World (EFW) by the Fraser Institute. General macroeconomic measures are from the World Bank's World Economic Indicators. Student international travel information come from the European Region Action Scheme for the Mobility of University Students Program (ERASMUS program) and U.S Department of Justice Data on visas issued.

5.1 Article Information

Research productivity is measured by the number, and quality, of published research articles in the Economics field. Article information was obtained from ISI's Social Science Citation Index (SSCI) data on all articles published (over 44,000) in 79 top economics journals during the period 1975-2006. For each article, the location of the institutional affiliation of the authors was obtained so that a count of articles published by country and year could be made. If authorship spans multiple countries, each country is assigned a pro rata share of authorship. Rather than focus on raw counts of articles, however, we weight each article based on the journal's "impact factor," a measure of the quality of the journal in which it appears. The impact factor is the ratio of citations to a journal to references made by a journal. The US is excluded from the analysis because it represents about 60% of all research output over the period. Less developed countries also are excluded from the analysis because their economic research outputs tend to be low and sporadic. In all, we analyze 30 countries' economic research output from 1975 to 2006.

And because I'm interested in the relative changes among countries' research productivity then I use the research output share of countries as my dependent variable. It is a country's impact factor weighted economic publications share of total worldwide. A country's share might be higher because it increases faster than other countries' or it might decrease more slowly than other countries. It is not necessary to conclude that the economic research productivity increase or decrease when the share goes up or down respectively.

The Herfindahl-Hirschman Index (HHI) of a country is used to measure the concentration of research across institutions in a country. The HHI of country equals sum of the squares of the shares of individual institutions' research output..A lower value for the HHI indicates that research output is more diffuse across institutions in the country.

Table A.1 and graph 1 show the increasing trend of countries' economic research output share and decreasing trend of institutional concentration over time.

5.2 The World Development Indicators

General macroeconomic variables come from the World Development Indicators (WDI) publications and WDI Online database of the World Bank. These measures include GDP per capita (based on Purchasing Power Parity), foreign trade, FDI and the number of unemployed people. GDP per capital is an approximation of the value of goods produced per person in the country, equal to the country's GDP divided by the total number of people in the country. It is converted to thousands of constant 2000 international dollar. Foreign Direct investment (FDI) is net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. FDI is divided by total GDP in order to get the percentage of GDP. FDI is calculated in billion of current U.S dollars. Trade includes merchandise trade and trade in services. The trade is as percentage of GDP. Unemployed people are all those who are not employed during a specified reference period but are available for work and have taken concrete steps to seek paid employment or self-employment.

Higher education is formal, non-compulsory, education that follows at the university level. Higher education student index in this paper is the number of higher education students per 100 people. It equals the net number of higher education students divided by population and multiplied with 100. In our data, there are some missing data from 1975 to lately 1980. We use the average value for missing data because we assume that the higher education enrollment increases gradually over the time. Expenditure per higher education student is the net amount of money spending for a higher education student. It is calculated in thousands of constant 2000 international dollars.

The number of Internet user per 100 people in the country equals the total number of Internet subscribers is divided by population and multiplied with 100. Internet user statistics are based largely on responses to an annual questionnaire that the International Telecommunication Union (ITU) sends to government telecommunication agencies. For most developed and larger developing countries, Internet user data are based on methodologically sound user surveys conducted by national statistical agencies or industry associations. These data are either provided directly to the ITU by each country, or the ITU does the necessary research to obtain the data. For countries where Internet user surveys are not available, the ITU uses average multipliers to estimate the number of users per subscriber.

Internet subscribers include people who pay for access to the Internet (dial up, leased line, and fixed broadband). The number of subscribers measures all those who are paying for Internet use, including the so-called “free Internet” used by those who pay via the cost of their telephone call, those who pay in advance for a given amount of time (prepaid), and those who pay for a subscription (either flat-rate or volume-per-usage based). Number of personal computers (PCs) per 100 people is the number of self-contained computers used per 100 people.

5.3 Economic Freedom of the World

Economic freedom is defined as the freedom to produce, trade and consume any goods and services acquired without the use of force, fraud or theft. This is embodied in the rule of law, property rights and freedom of contract, and characterized by external and internal openness of the markets, the protection of property rights and freedom of economic initiative. Data from the Frazier Institute's "Economic Freedom of the World" allows for a general index and disaggregating into five areas.

The areas are: Size of Government: Expenditures, Taxes, and Enterprises; Legal Structure and Security of Property Rights; Access to Sound Money; Freedom to Trade internationally; and Regulation of Credit, Labor, and Business. First, the Size of Government index includes general government consumption spending as a percentage of total consumption, transfers and subsidies as a percentage of GDP, government enterprises and investment and top marginal tax rate. Second, Legal Structure and Security of Property Rights index is from the process of judicial independence, impartial courts, protection of property rights, military interference in rule of law and the political process, integrity of the legal system, legal enforcement of contracts and regulatory restrictions on the sale of real property. Third, Access to Sound Money considers money growth, standard deviation of inflation and inflation and freedom to own foreign currency bank accounts. Fourth, taxes on international trade, regulatory trade barriers, size of trade sector relative to expected, black-market exchange rates and international capital market controls are used to get Freedom to Trade Internationally index. Finally, the Regulation of Credit, Labor, and Business talks about credit market regulations, labor market regulations and business regulations.

The construction of the index published in Economic Freedom of the World is based on three important methodological principles. First, objective components are always preferred to those that involve surveys or value judgments. Second, the data used to construct the index ratings are from external sources such as the International Monetary Fund, World Bank, and World Economic Forum that provide data for a large number of countries. Third, transparency is present throughout. The total index is simply the summation of all five major-area index. However, the available data is available only at five-year intervals for the period 1975 to 2006. For this period, I linearly interpolate annual values within five year intervals. The result for the Economic Freedom of the World index without one year lag is in the Appendix B.

5.4 U.S Visa Holders

Borghans and Cörvers (2009) suggest that following the American model of higher education has enhanced research productivity. As they note, it is difficult to measure "Americanization" of the educational system. A proxy variable I use is student travel to the US. The numbers of nonimmigrant professional visa holders (F1 and J1 classes) are collected from the U.S Department of Justice's statistical yearbooks of the immigration and naturalization service from 1975 to 2006. F1 visas are reserved for non-immigrants wishing to pursue academic studies and/or language training programs, and are given only through academic institutions. Vocational education is not included in F-1 visa. A J-1 visa is a non-immigrant visa issued by the United States to exchange visitors participating in programs that promote cultural exchange. They can be alien physician, educational care, camp counselor, internship, student, work, travel, teacher, trainee and flight training, government visitor, international visitor, professor and research scholar, specialist. We use these data with a purpose to examine the effect of Americanization on other countries' research productivity through American standards spread and English using. The U.S visa holders per 100 is the number of U.S visa holders from a country divided by the country's population then multiplied with 100.

5.5 ERASMUS program

The European Region Action Scheme for the Mobility of University Students (ERASMUS) is a European student exchange program established in 1987. ERASMUS's specific objectives are to improve the quality and to increase the volume of student and teaching staff mobility throughout Europe; to improve the quality and increase the amount of multilateral cooperation between higher education institutions in Europe; to improve and increase cooperation between higher education institutions and enterprises and to spread innovation and new pedagogic practice and supports between universities in Europe. By 2006, 150,000 European students have studied abroad via the ERASMUS program. We use the student mobility and the teacher mobility data from 1987 to 2006 retrieved directly from website of European commission's education and training database, in order to check how labor mobility, which often comes with economic openness, can determine the research productivity. The data includes the numbers of incoming and outgoing European students as well as teachers categorized by host countries and home countries per year. We use the number of ERASMUS student per 100 people. It equals number of ERASMUS student divided by population then multiplied with 100.

After matching these data sources by countries and year, we got a usable sample of 928 observations of 29 countries over 32 years (from 1975 to 2006). Table A.1 shows two groups of developed and developing countries and their economic research output over time. Table A.2 shows the description of dependent and independent variables. Economic research outputs, numbers of ERASMUS students, U.S visa holders, Internet subscribers and regulation of credit, labor and business have 928 observations. Other than that, because of missing value, there are different numbers of observations. ERASMUS exchange student program did not start until 1987, so before 1987 the value of ERASMUS students is zero. Besides, ERASMUS program is just for European countries, then for non-European countries the value is also zero. PC use data started from 1980. Internet started from 1990. Before that time, the value is zero.

CHAPTER 6

EMPIRICAL RESULTS AND IMPLICATIONS

This chapter interprets the results acquired through the different models used in the research and implication of the result. Table A.3 in the Appendix A contains the estimates for the joint effects of all variables with one year lag: last year's research output share, Internet users, the number of PC, trade, FDI, study abroad, higher education students, expenditure per higher education student, GDP per capita and unemployment rate on a country's research output for different groups of countries. The long run joint effects are in table A.4. Table A.5 shows the regression result of ICT adoption. Table A.6 is the estimated effects of economic openness (trade and FDI). Table A.7 is the result of study abroad. The estimated effects of higher education on economic research productivity are in table A.8. Table A.9 contains the regression results of various variables' effect on domestic institutional concentration (HHI). The long run effects on research concentration are in table A.10.

6.1 The Joint Effects on Economic Research Output Share

Because different countries have different economic conditions, education systems and research productivity, then I divide 29 countries in 2 groups in Table 3:

developed countries and developing countries in order to see the different effects on economic research productivity. The long run effects are in Table A.4. Recall that all independent variables are lagged one year.

Unemployment rate has a negative effect on economic research in both developed and developing countries. In short run, if unemployment rate increases 1%, next year research output share will decrease 0.003%. But in long run, research output share goes down 0.006%.

GDP per capita and FDI have negative effects on economic research output. They are significant at 10% in developing countries. It might be the case that FDI flowing in the private sector creates more jobs and attracts more people working in the private sector than doing research. Therefore, their income increases but research output decreases. Besides, trade has negative effect on economic research output in developed countries, but positive in developing countries. If trade increases 1%, research output next year will decrease 0.002% in developed countries, and go up 0.01% in developing countries. Without other independent variables, FDI still has negative effect but trade has positive effect. Their effects are nearly doubled in the long run.

Personal Computer (PC) use has positive effect in developed countries, and negative effect in developing countries. If the number of PCs increases 1%, research output share next year will increase 0.002% in developed countries and decrease 0.01% in developing countries. In contrast, Internet has negative effect in developed countries but positive and significant at 10% in developing countries. A possible interpretation is that personal computers are used more efficiently in developed countries, but are used as “toys” more than tools in developing countries. However, the Internet helps people in developing countries access to more up-to-date information and new technological changes from abroad. As a result, their research output will be improved. In other specifications omitting other independent variables, Internet and PC use have positive effects on economic research output as expected. The long run effects are approximately two times larger than the short run effects.

The numbers of higher education students and expenditure per higher student have positive effects on economic research output. If expenditure per higher education student rises $1,000, then research output goes up 0.002% in short run and 0.004% in long run. A 1% increase in number of higher education students leads to 0.03% increase in research output in short run and 0.06% increase in long run. Without other independent variables, higher education still has positive effect on economic research output.

Study abroad in European countries or in U.S has negative effect on economic research output in developed countries but positive and significant at 10% in developing countries. In developing countries, if U.S visa holders increase 1%, research output increases 3.74% in short run, and 7.48% in long run. If Erasmus students increase 1%, research output rises 15.16% in short run and 30.32% in long run. In developed countries, study abroad might be a negative proxy for domestic education quality. When domestic education quality is low, students would rather study abroad than in their home countries. Alternatively, students who studying abroad are willing to stay abroad, not come back to their home countries.

6.2. The Joint Effects on Institutional Concentration

Table A.9 shows the regression results for research concentration and Table A.10 includes long run joint effects in developed countries and developing countries.

The unemployment rate effect on research concentration is positive and significant at 10%. If unemployment rate increases 1%, research concentration next year will decrease 0.006 in short run and 0.008 in long run. GDP per capita has negative and significant at 5% effect in developed countries and positive and significant (5%) in developing countries. The effect of GDP per capita does not change much in long run. However, in developing countries, if GDP per capita increases $1,000, research concentration goes up 0.07 in short run, and 0.083 in long run. It might be the case that when the average individual income rises, fixed costs in research industry grow up then some research institutions get out of the research market.

PC use has a negative effect on concentration in both developed and developing countries. The effect is significant at 5% in developed countries. If PC usage increases 1%, research concentration next year will decrease 0.003 in developed countries and 0.008 in developing countries. The effect is the same in long run for developed countries but higher (0.01) for developing countries. However, Internet has positive and significant (10%) effect in developed countries, and negative in developing countries. So in developing countries, Internet adoption helps decrease communication and search costs, and, thus, improves marginal productivity more in lower tier institutions. But in developed countries, some elite schools often have excellent scholars who are more productive so they take more advantages of Internet than researchers in low ranking institutions. Therefore Internet access actually increases their research productivity faster than researchers at low ranking institutions and, thus, increases the concentration in research market.

FDI has negative a effect while trade has positive effect in both developed and developing countries. If FDI increases 1%, research concentration next year will decrease 0.0005 in developed countries and 0.02 in developing countries. In long run, the research concentration decreases 0.0006 in developed countries and 0.024 in developing countries. If trade increases 1%, research concentration also increases 0.0004 in developed countries and 0.003 in developing countries. It might be because the labor diversity, which comes along with labor mobility in opened economies, increases the degree of research output differentiation in research market. As a result, research concentration will be higher.

The number of higher education students has a negative effect on economic research output. Expenditure per higher education student also has negative and significant (5%) effect. If the fraction higher education students increase 1%, research concentration next year will decreases 0.01 in developed countries and 0.03 in developing countries. If expenditure per higher education student increases $1,000, then research concentration will decrease 0.006 in developed countries and 0.010 in developing countries. In long run, the effects are approximately the same.

Study abroad in U.S and in European countries has negative effects on research concentration in both developed and developing countries as expected. The long run effects are higher than the short run effects. This is consistent with human capital accumulated along study abroad helping increase researchers' productivity more so at lower tier institutions.

CHAPTER 7

SUGGESTION FOR FUTURE RESEARCH AND CONCLUSION

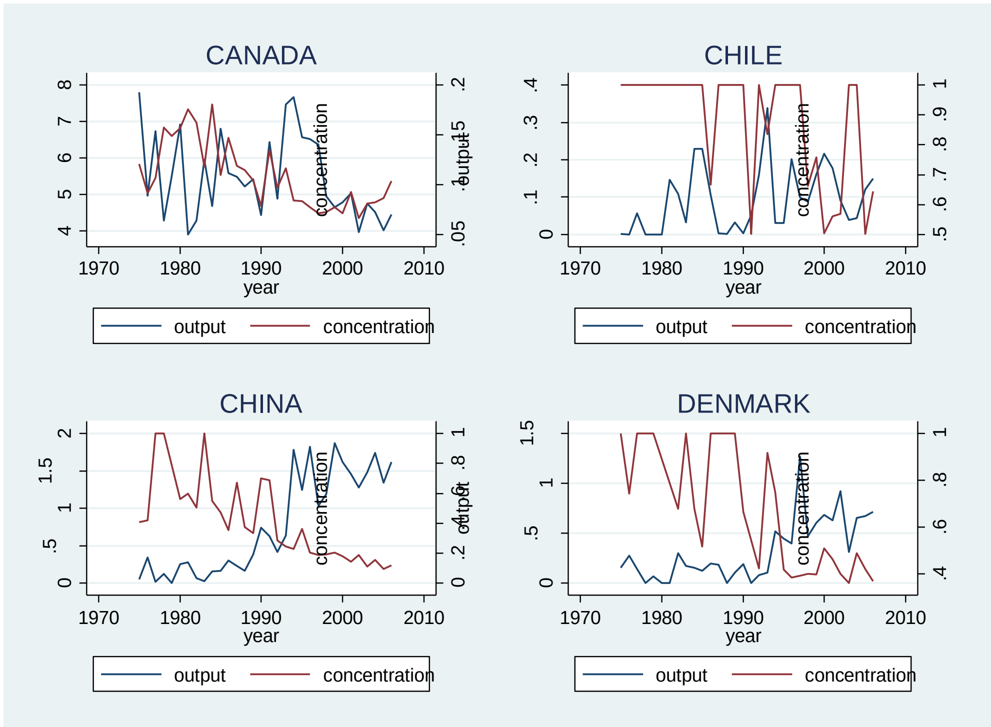
7.1. Conclusion

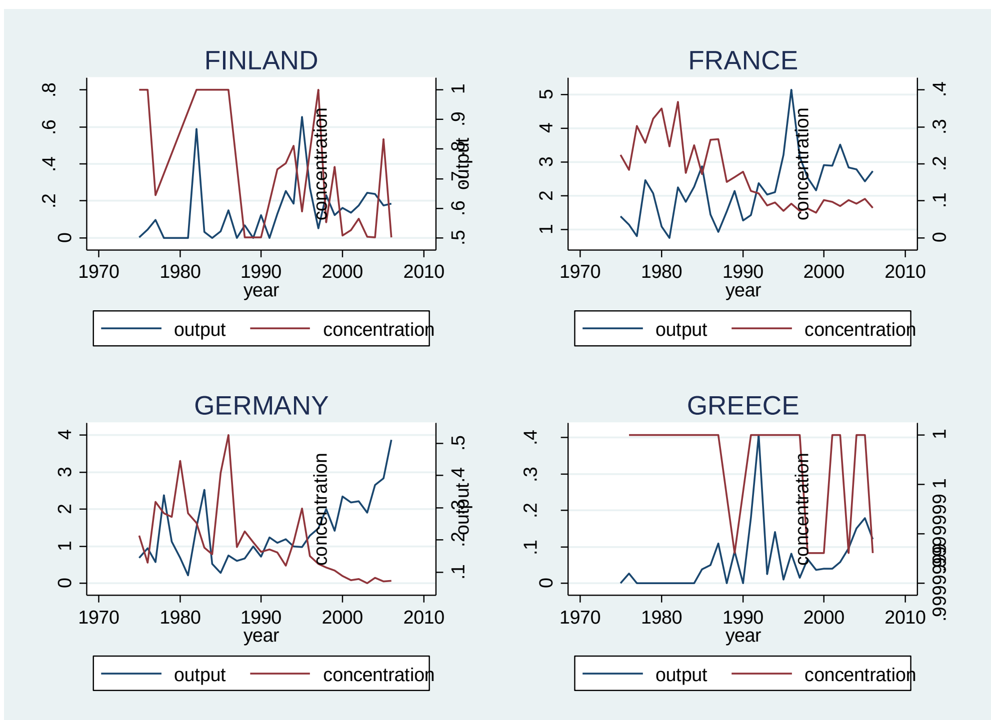
Using the panel data of 29 countries in 32 years with fixed effect, distributed lag models and robust standard errors, this paper has the interesting results that Internet adoptions and economic openness, which often goes with labor mobility, and study abroad opportunities will increase a country's economic research output share. These effects are especially significant in smaller and less developed countries or developing countries such as China, India or Turkey, etc, but not for all developed countries. Moreover, FDI (as a proxy for economic openness), number of higher education students, expenditure for higher education students and PC use are associated with decreasing research concentration within a country. Study abroad also appears to have a negative impact on concentration. The unemployment rate is not always a significant effect for different countries, but normally developed countries have lower unemployment rate and higher research output share. GDP per capita has negative effect on economic research productivity. It might be because that development of private sector attracts more people working in private sector than doing research, therefore it increases average individual income and then increases fixed costs in research market. So when GDP per capita increases, research output decreases and research concentration grows up. In long run, those effects are often larger than short run effects.

7.2. Suggestion For Future Research

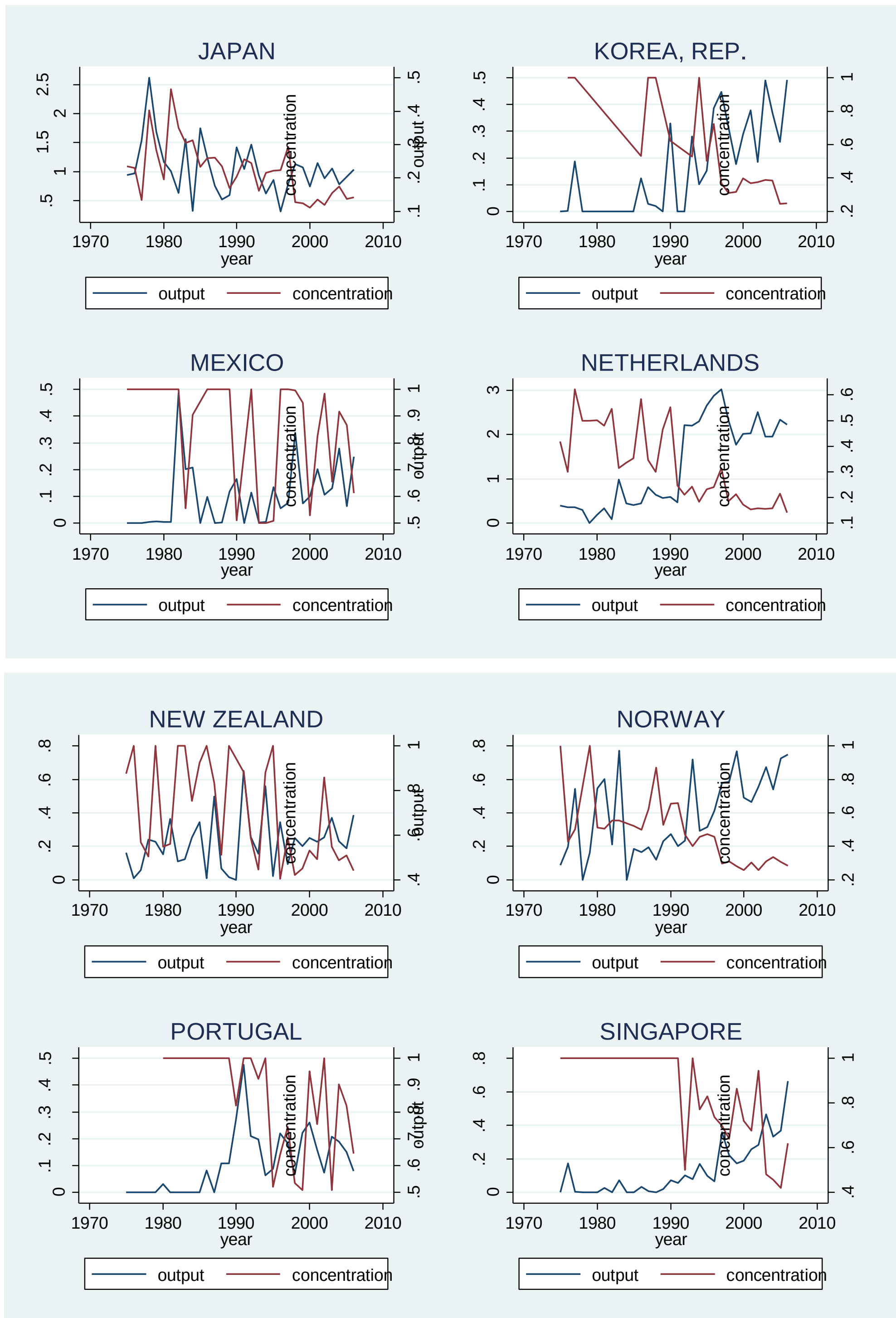
I suspect there are different effects of economic openness, study abroad and ICT adoption between developed and developing countries. Developing countries can gain instant benefit from Internet and study abroad while economic openness often takes longer time. However, I have more developed countries than developing countries in my data so the result can be biased even I use fixed effect and use robust standard error. One could collect data about more developing countries and replicate what I did to see if the conclusion still holds. The Internet and PCs data I use is the number of Internet subscribers and PC numbers is not collected by academic institutions. It might make a total difference if future studies have institutions' Internet and PCs data. The U.S visa holders in my data also are the numbers of F1 and J1 visas in all disciplines, not only Economics so it might affect my result. Besides, it has lagging and leading effect that I suspect but did not control in this paper. I should use numbers of exchanged teachers in Erasmus program than use number of exchanged students, but there is not enough data. Moreover, I dropped many authors in the data because I could not track their institutions so the research output share might have a little change.

Graph 1: Trend of Economic Research Output and Institutional Concentration 1

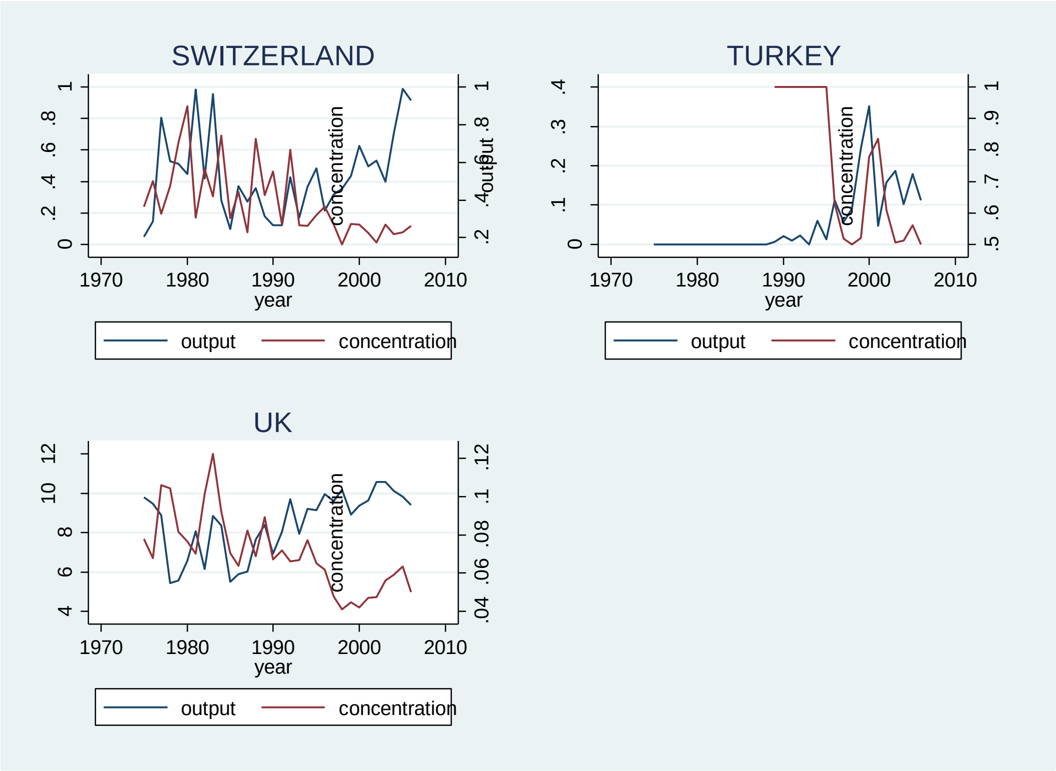




Graph 2: Trend of Economic Research Output and Institutional Concentration 2



Graph 3: Trend of Economic Research Output and Institutional Concentration 3



APPENDIX A

REGRESSION RESULTS FOR ECONOMIC RESEARCH OUTPUT AND INSTITUTIONAL CONCENTRATION

Table A.1: Economic Research Output Share over the World

Country	1975-1982	1983-1990	1991-1998	1999-2006
Developed countries				
AUSTRALIA	2.28	1.88	1.60	1.49
AUSTRIA	0.23	0.20	0.38	0.34
BELGIUM	1.00	1.52	1.10	0.94
CANADA	5.55	5.45	6.37	4.53
DENMARK	0.12	0.14	0.41	0.65
FINLAND	0.10	0.05	0.22	0.18
FRANCE	1.50	1.79	2.76	2.79
GERMANY	1.02	0.89	1.28	2.43
GREECE	0.02	0.04	0.12	0.09
IRELAND	0.06	0.06	0.10	0.18
ITALY	0.07	0.25	0.97	1.15
JAPAN	1.32	1.02	0.90	0.96
NETHERLANDS	0.25	0.61	2.26	2.10
NORWAY	0.30	0.25	0.42	0.62
SPAIN	0.04	0.66	1.34	1.73
SINGAPORE	0.03	0.03	0.15	0.35
SWEDEN	1.06	0.89	0.75	1.17
SWITZERLAND	0.49	0.33	0.31	0.64
UK	7.50	7.20	9.22	9.81
Less developed and developing countries				
ARGENTINA	0.08	0.03	0.04	0.08
CHILE	0.04	0.08	0.13	0.13
CHINA	0.14	0.27	1.09	1.56
INDIA	0.25	0.29	0.22	0.18
ISRAEL	4.41	4.12	2.04	1.64
KOREA, REP.	0.05	0.06	0.22	0.33
MEXICO	0.06	0.10	0.09	0.15
NEW ZEALAND	0.17	0.16	0.29	0.26
PORTUGAL	0.01	0.07	0.19	0.17
TURKEY		0.01	0.05	0.17
US	71.93	71.56	64.94	63.05

Table A.2: Description of Variables

Variable	Description	Obs	Mean	Std. Dev.	Min	Max	Begin year	End year
Economic research output	Impact factor weighted publications share	928	1.10	1.90	0.00	10.59	1975	2006
HHI	Herfindahl-Hirschman Index (Institutional Concentration)	818	0.49	0.32	0.04	1.00	1975	2006
ERASMUS	ERASMUS student per 100 higher education students	928	0.01	0.01	0.00	0.08	1987	2006
U.S visa	U.S visa holders per 100 people	928	0.05	0.05	0.00	0.44	1975	2006
FDI	Foreign Direct Investment (billion dollars)	928	2.30	4.94	-15.09	92.67	1975	2006
Trade	Trade as percentage of GDP	902	62.59	41.72	9.01	456.65	1975	2006
EFW	Economic Freedom of the World index	923	6.60	1.09	3.40	8.80	1975	2006
Trade freedom	Freedom to trade index	923	7.19	1.27	2.20	9.60	1975	2006
Regulation	Regulation of Credit, labor and business	928	5.88	1.04	3.00	8.80	1975	2006
Higher education students	Number of higher education student per 100 people	865	2.75	1.36	0.05	6.90	1975	2006
Higher education expenditure	Expenditure per higher education student (thousand dollars)	641	6.20	4.35	0.35	23.39	1975	2006
GDP/cap	GDP per capita (thousand dollars)	783	16.48	9.40	0.25	51.86	1980	2006
Unemployed	Unemployment rate	709	7.18	3.91	1.58	23.88	1975	2006
PC	Number of Personal Computer per 100 people	915	12.50	19.03	0.00	94.34	1980	2006
Internet	Number of Internet users per 100 people	928	10.52	20.10	0.00	85.90	1990	2006

Table A.3: The Joint Effects on Economic Research Output

(Dependent variable is economic research output share)

	(1) 29 countries	(2) Developed Countries	(3) Developing Countries
last-year research output	0.53	0.46	0.50
	(0.07)***	(0.07)***	(0.14)***
unemployment rate	-0.003	-0.02	-0.03
	(0.01)	(0.01)	(0.02)
GDP/cap	-0.002	-0.02	-0.13
	(0.01)	(0.01)	(0.07)*
PC use	0.01	0.002	-0.01
	(0.003)	(0.004)	(0.01)
Internet	-0.004	-0.002	0.02
	(0.003)	(0.003)	(0.01)*
FDI	-0.004	-0.002	0.03
	(0.003)	(0.002)	(0.02)*
Trade	0.01	-0.002	0.01
	(0.01)	(0.003)	(0.01)
Higher education expenditure	0.002	0.007	0.03
	(0.01)	(0.02)	(0.04)
Higher education students	0.03	0.05	0.13
	(0.04)	(0.07)	0.14
Erasmus	0.54	-2.53	15.16
	(2.31)	(2.78)	(8.17)*
US visa	-1.42	-0.43	3.74
	(0.69)**	(0.83)	(1.75)*
R-sqd (within)	0.41	0.42	0.67
Observations	553	369	184

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table A.4: The Long Run Joint Effects on Economics Research Output

(Dependent variable is economic research output share)

	(1) 29 countries	(2) Developed Countries	(3) Developing Countries
unemployment rate	-0.006	-0.037	-0.060
GDP/cap	-0.004	-0.037	-0.260
PC use	0.021	0.004	-0.020
Internet	-0.009	-0.004	0.040
FDI	-0.009	-0.004	0.060
Trade	0.021	-0.004	0.020
Higher education expenditure	0.004	0.013	0.060
Higher education students	0.064	0.093	0.260
Erasmus	1.149	-4.685	30.320
US visa	-3.021	-0.796	7.480

Table A.5: The Estimated Effect of ICT adoption

(Dependent variable is economic research output share)

	(1)	(2)
Last year research output	0.52 (0.05)***	0.51 (0.05)***
Internet per 100	-0.001 (0.003)	0.001 (0.003)
PC per 100	0.006 (0.004)	0.0003 (0.003)
Dummy Year		X
R-sqd (within)	0.30	0.32
Obs	893	893

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table A.6: The Estimated Effect of Economic Openness

(Dependent variable is economic research output share)

	(1)	(2)
Last year research output	0.51 (0.07)***	0.50 (0.07)***
FDI	-0.005 (0.005)	-0.006 (0.004)
Trade	0.009 (0.005)*	0.01 (0.01)
Dummy Year		X
R-sqd (within)	0.31	0.33
Obs	873	873

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table A.7: The Estimated Effect of Study Abroad

(Dependent variable is economic research output share)

	(1)	(2)
Last year research output	0.51 (0.06)***	0.51 (0.06)***
U.S visa	-0.21 (0.69)	-0.54 (0.50)
ERASMUS	7.60 (3.25)**	5.63 (3.93)
Dummy Year		X
R-sqd (within)	0.31	0.33
Obs	899	899

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table A.8: The Estimated Effect of Higher Education

(Dependent variable is economic research output share)

	(1)	(2)
Last year research output	0.56 (0.08)***	0.56 (0.08)***
Higher education expenditure	0.01 (0.004)**	0.01 (0.01)
Higher education students	0.03 (0.03)	0.02 (0.04)
Dummy Year		X
R-sqd (within)	0.37	0.40
Obs	608	608

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table A.9: The Joint Effect on Research Concentration

(Dependent variable is economic research concentration)

	(1) 29 countries	(2) Developed Countries	(3) Developing Countries
last-year research concentration	0.20	0.13	0.16
	(0.05)***	(0.07)*	(0.10)
unemployment rate	0.006	0.006	0.003
	(0.003)*	(0.004)	(0.009)
GDP/cap	0.002	-0.01	0.07
	0.005	(0.005)**	(0.03)**
PC use	-0.001	-0.003	-0.008
	(0.001)	(0.001)**	(0.009)
Internet	0.001	0.001	-0.001
	(0.001)	(0.001)*	(0.004)
FDI	-0.001	-0.0005	-0.02
	(0.001)	(0.0008)	(0.01)
Trade	-0.0003	0.0004	0.003
	(0.001)	(0.001)	(0.005)
Higher education expenditure	-0.01	-0.006	-0.01
	(0.004)**	(0.004)	(0.04)
Higher education students	-0.02	-0.01	-0.03
	(0.01)	(0.01)	(0.08)
Erasmus	0.51	-0.30	-5.68
	(1.14)	(1.18)	(4.27)
US visa	-0.69	-0.36	-1.72
	(0.32)**	(0.33)	(1.68)
R-sqd (within)	0.37	0.49	0.41
Observations	493	342	151

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table A.10: The Long Run Joint Effects on Research Concentration

(Dependent variable is economic research concentration)

	(1) 29 countries	(2) Developed Countries	(3) Developing Countries
unemployment rate	0.008	0.007	0.004
GDP/cap	0.003	-0.011	0.083
PC use	-0.001	-0.003	-0.010
Internet	0.001	0.001	-0.001
FDI	-0.001	-0.0006	-0.024
Trade	0.0004	0.0005	0.004
Higher education expenditure	-0.013	-0.007	-0.012
Higher education students	-0.025	-0.011	-0.036
Erasmus	0.638	-0.345	-6.762
US visa	-0.863	-0.414	-2.048

APPENDIX B

REGRESSION RESULTS FOR ECONOMIC RESEARCH OUTPUT AND INSTITUTIONAL CONCENTRATION (WITHOUT ANY LAG)

Table B.1: Regression Results For Economic Research Output (without any lag)

(Dependent variable is economic research output share)

Research output	(1) 29 countries	(2) Developed Countries	(3) Developing Countries	(4) EU
ERASMUS	2.56	-2.89	36.89	-1.83
	(5.12)	(6.20)	(12.86)***	(6.20)
US visa	-1.36	0.40	8.36	-1.69
	(1.11)	(1.53)	(3.53)**	(1.13)
FDI	-0.007	0.001	0.01	-0.01
	(0.004)*	(0.004)	(0.01)	(0.004)**
Trade	0.005	-0.02	0.01	0.003
	(0.01)	(0.01)*	(0.01)	(0.01)
EFW	-0.27	0.50	-0.14	-0.60
	(0.24)	(0.42)	(0.2)	(0.50)
Higher education student	0.09	0.02	0.11	0.07
	(0.14)	(0.17)	(0.15)	(0.17)
Higher education expenditure	0.02	0.005	-0.005	-0.03
	(0.04)	(0.04)	(0.06)	(0.05)
GDP/cap	-0.03	-0.04	-0.27	-0.01
	(0.02)	(0.02)	(0.10)**	(0.03)
unemployed	-0.04	-0.07	-0.04	-0.05
	(0.02)*	(0.04)*	(0.02)	(0.03)*
PCper100	0.004	0.005	0.002	0.01
	(0.007)	(0.007)	(0.02)	((0.01)
Internet per 100	-0.0001	0.002	0.02	0.003
	(0.007)	(0.01)	(0.01)	(0.01)
R-sqd (within)	0.14	0.25	0.53	0.26
Observations	565	377	188	376

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table B.2: The Estimated Effect of ICT adoption (without any lag)

(Dependent variable is economic research output share)

	(1)	(2)	(3)	(4)	(5)	(6)
Internet per 100	0.004 (0.006)	0.006 (0.003)*			0.01 (0.01)	0.001 (0.005)
PC per 100			0.001 (0.005)	0.008 (0.004)**	-0.003 (0.006)	0.01 (0.01)
Dummy Year	X		X		X	
R-sqd (within)	0.07	0.03	0.08	0.04	0.08	0.04
Obs	928	928	915	915	915	915

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table B.3: The Estimated Effect of Economic Openness (without any lag)

(Dependent variable is economic research output share)

	(1)	(2)	(3)	(4)
FDI	-0.01	-0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)**	(0.01)**
Trade	0.02	0.02	0.02	0.02
	(0.01)	(0.01)**	(0.01)	(0.01)*
EFW	-0.22	-0.01		
	(0.19)	(0.16)		
Freedom of Trade			-0.18	-0.10
			(0.10)*	(0.07)
Regulation			-0.02	0.10
			(0.17)	(0.18)
Dummy Year	X		X	
R-sqd (within)	0.12	0.07	0.12	0.09
Obs	897	897	897	897

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table B.4: The Estimated Effect of Higher Education, Study Abroad and Income

(without any lag)

(Dependent variable is economic research output share)

	(1)	(2)	(3)	(4)	(5)
ERASMUS	11.70				3.27
	(7.52)				(5.56)
U.S visa	-2.01				-1.46
	(1.11)*				(1.11)
Higher education students		0.02		0.07	0.05
		(0.11)		(0.12)	(0.12)
Higher education expenditure		0.02		0.04	0.02
		(0.02)		(0.03)	(0.03)
GDP/cap			-0.01	-0.02	-0.02
			(0.02)	(0.02)	(0.02)
Unemployed			-0.03	-0.04	-0.04
			(0.02)	(0.02)**	(0.02)**
Dummy Year	X	X	X	X	X
R-sqd within	0.10	0.08	0.09	0.11	0.11
Obs	928	626	709	589	589

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table B.5: The Regression Result for Institutional Concentration (without any lag)

(Dependent variable is Herfindahl-Hirschman Index)

	(1) 29 countries	(2) Developed Countries	(3) Developing Countries	(4) EU
ERASMUS2	0.89	-0.23	-5.22	2.12
	(1.02)	(0.93)	(3.40)	(1.24)*
USvisa2	-0.95	-0.86	-1.30	-0.56
	(0.34)***	(0.42)**	(1.43)	(0.47)
FDI2	0.0002	-0.001	0.01	-0.0002
	(0.001)	(0.001)	(0.01)	(0.001)
Trade	-0.001	0.0001	-0.001	-0.002
	(0.001)	(0.001)	(0.004)	(0.001)
EFW	0.02	0.03	0.01	0.06
	(0.03)	(0.05)	(0.03)	(0.05)
Higher education students	-0.04	-0.02	-0.01	-0.05
	(0.02)*	(0.02)	(0.07)	(0.03)*
Higher education expenditure	-0.02	-(0.01)	0.01	-0.02
	(0.01)***	(0.004)***	(0.03)	(0.01)***
GDPper_cap2	0.001	-0.01	0.04	-0.002
	(0.01)	(0.01)*	(0.02)	(0.01)
Unemployed	0.01	0.01	0.01	0.01
	(0.003)**	0.004	(0.01)	(0.004)**
PCper100	.000945	-0.002	-0.001	-0.0004
	(0.001)	(0.001)	(0.01)	(0.002)
Internet100	.0000687	0.002	0.004	0.002
	(0.002)	0.001	(0.004)	0.002
R-sqd within	0.37	0.50	0.38	0.48
Obs	526	360	166	352

Robust standard errors in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

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