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LONG RUN EQUILIBRIUM RELATIONSHIP BETWEEN INWARD FDI AND PRODUCTIVITY

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By constructing a panel dataset from nine OECD countries for the period 1971-1999 and adopting up-to-date panel cointegration estimation methods, the paper shows the robustness of long run positive relationship between inward foreign direct investment and productivities of host countries. Especially, with group mean fully modified OLS, the estimation model allows common time dummies to control possible cross-sectional dependence and also allows heterogeneous cointegrating vectors for the members of cross section. The paper also confirms the long run equilibrium relationship between domestic knowledge stocks and productivities in G7 countries.

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1. INTRODUCTION

Barriers to the cross border capital movements have been steadily removed. Especially, foreign direct investment (FDI) has been rapidly increased since the establishment of World Trade Organization (WTO) (UNCTAD, 2003). The benefits of inward FDI to the host countries on their capital formation, employment, exports, and technology are generally considered to dominate the potential costs of foreign controls of local factors of production. Accordingly, most host countries have liberalized their FDI regulations to attract foreign investment since the early 1980s.

One of the most important benefits from inward FDI from the perspective of host countries would be the prospect of gaining access to advanced know-hows and technologies of multinational corporations (MNCs). These benefits often take the form of various types of externalities, in which case they are referred to as knowledge

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spillover. For instance, local firms may improve their productivity as a result of their imitation of technologies retained by MNCs, or hire workers trained by MNCs.[1]

Accordingly, FDI has been regarded as an important channel for international knowledge transfer. A series of empirical studies also support it. For instance, Branstetter (2000), using data on patent citations between Japanese investing firms and American indigenous firms, shows that FDI is a significant channel for knowledge spillover, both from investing firms to indigenous firms and from indigenous firms to investing firms. Hanel (2001) approximates the knowledge stock of foreign subsidiaries in 19 Canadian industries as being proportional to the share of sales accounted for by those subsidiaries. His estimation results also indicate that foreign knowledge stocks contribute to Canadian productivity growth although the estimated effect of FDI from one of his main models is statistically significant only at a 15% significance level. Van Pottelsberghe and Lichtenberg (2001), using panel data on 13 member countries of the Organization for Economic Cooperation and Development (OECD) from 1971 to 1990, investigate whether inward and outward FDI, as well as imports, are effective in the international diffusion of knowledge. The results from their OLS estimation show that significant knowledge spillover take place through both imports and outward FDI. However, according to their study, the stock of foreign knowledge embodied in incoming FDI has no significant effect. In contrast, Lee (2006) show that international knowledge spillovers through inward FDI are significant and robust, using panel data from 16 OECD countries for the period 1981-2000. Unlike Van Pottelsberghe and Lichtenberg (2001), Lee (2006) uses estimation methods reflecting up-to-date developments in non-stationary panel data econometrics.

This paper also aims to find empirical evidence supporting the positive effect of inward FDI on the productivities of host countries. Especially, this paper focuses on identifying the long run positive relationship between inward FDI and productivities of host countries by applying up-to-date panel cointegration estimation methods to the quite long period data from nine countries. For this, we construct the panel data set for the period 1971-1999. In fact, an empirical investigation into knowledge spillover effects cross national borders was first attempted by Coe and Helpman (1995) that found evidence of significant spillover of the R&D results through import flows. Using twenty years data of twenty two countries, they also claim to estimate a long run equilibrium relationship among the variables by assuming their estimation models as the panel cointegration models but they fail to provide the appropriate evidence that justifies such assumption. Furthermore, the conventional OLS estimation method applied to those cointegration models by them has proved to have a serious flaw. The shaky basis of this estimation strategy is mainly due to the limited development of panel data econometrics at the time of their article.

[1] Blomström and Kokko (1998) provide a good survey of previous studies on the issues related to such spillover effects from the MNCs.

The development of panel data econometrics has been striking recently. Pedroni (1999) and Kao (1999) propose methods for testing cointegration of panel data that are more appropriate and powerful than those used by Coe and Helpman (1995). Various estimation methods for panel cointegration model have also been proposed. Although the OLS estimator is (super)consistent even under panel cointegration, it has a second order asymptotic bias so that its standards errors are not valid. In order to construct valid t-statistics, several alternative estimation procedures such as Fully Modified OLS (FMOLS) estimation and Dynamic OLS (DOLS) estimation have been designed. Kao and Chiang (2000) show that the conventional OLS estimator has a non-negligible bias in small sample under panel cointegration. They conduct Monte Carlo experiments to compare small sample properties of particular forms of panel FMOLS and DOLS estimators, pooled the data along the within-dimension. For these specific versions of within-dimension panel FMOLS and DOLS estimators, Monte Carlo results illustrate that the FMOLS does not improve over the OLS and that the DOLS has superior small sample properties. On the other hand, Pedroni (2001) points out that the within-dimension panel FMOLS and DOLS estimators proposed by Kao and Chiang (2000) could suffer from serious small sample size distortions. According to Pedroni (2001), the point estimates from such estimators are also difficult to interpret economically when the cointegrating vectors are heterogeneous as is likely to be the case for the present applications since such estimators do not represent the average long run relationship. Pedroni (2000) suggests the group mean panel Fully Modified (FM) estimator as a superb alternative. According to Pedroni (2000, 2001), the group mean panel FM estimator, pooled the data along the between-dimension, exhibits relatively minor size distortions in small samples in contrast to the within-dimension estimators including ones suggested by Kao and Chiang (2000). Furthermore, unlike within-dimension estimators, between-dimension estimators allow heterogeneous coefficients for individual members of cross section instead of imposing common slope coefficients. This is an important advantage for the analysis of country panel data because there is no reason to believe that the cointegrating vectors are homogenous across countries. Moreover, the point estimates for the between-dimension estimator can be interpreted as the mean value for the cointegrating vectors, which is not true for the within-dimension estimators. Regarding the studies of international knowledge spillovers, Kao, Chiang and Chen (1999) and Lee (2006) apply within-dimension panel FMOLS and DOLS estimators while Lee (2005) uses the group mean panel Fully Modified (FM) estimator. Based on these up-to-data panel data econometrics, this paper will demonstrate the existence and magnitude of long run equilibrium relationship between inward FDI and productivities of host countries.

The paper is organized as follows; chapter 2 explains data sources and the construction of variables. The results of panel unit root tests and panel cointegration tests on the data are provided in chapter 3. Based on these tests, a panel cointegration model is proposed and the results of consistent estimations are also provided in chapter 3. Chapter 4 summarizes the main results of the paper.

2. DATA

The productivity of a host country is measured in terms of total factor productivity (TFP) in the manufacturing sector. TFP in the manufacturing sector is estimated under the assumption that the production technology is Cobb-Douglas and that the output elasticities of production factors are time-invariant over the sample period. Accordingly, the output elasticity of labor services is calculated using the average share of labor income over the sample period. The estimates of value-added, fixed capital stock, labor service employed and labor income share in the manufacturing sector are based on the STAN database compiled by OECD. The estimates of domestic R&D capital stocks are based on R&D investment data from the OECD's Science and Technology database. R&D investments influencing TFP include not only business sector R&D expenditures but also the R&D expenditures of research institutes and universities. Physical capital and domestic R&D capital stocks are calculated according to a perpetual inventory model. A depreciation rate of 10% is used to estimate physical capital stocks, while a 20% rate is applied to calculate R&D capital stocks. As the economic life cycle of a technology becomes shorter, the depreciation rate of R&D capital is set to be much higher than that of physical capital. However, this setting is not a crucial one and using various alternative combinations of depreciation rates does not substantially change the main results of the paper.

Foreign R&D stocks embodied in inward FDI are constructed by applying the method suggested by Van Pottelsberghe and Lichtenberg (2001):

$$S_{i,t}^{f}=\sum_{j\neq i}\left(F_{ij,t}\cdot\frac{S_{j,t}^{d}}{K_{j,t}}\right)=\sum_{j\neq i}\left(w_{ij,t}^{f}\cdot S_{j,t}^{d}\right),\quad w_{ij,t}^{f}=\frac{F_{ij,t}}{K_{j,t}}\,, \tag{1}$$

where $S_{i,t}^{f}$ is the estimate of foreign R&D capital stocks that are embodied in the inward FDI of country *i* accumulated at the end of year *t*. The term $F_{ij,t}$ denotes the flow of FDI from country *j* to country *i*. The term $K_{j,t}$ denotes country *j*'s gross fixed capital formation in the manufacturing sector in year *t*. We would prefer to use stock data for FDI rather than flow data, but missing data and inconsistent data methods between countries make the measurement of FDI stock difficult. To avoid problems of volatile and incomplete flow data, four-year moving averages are used, as in Van Pottelsberghe and Lichtenberg (2001).

Data on inward FDI are obtained from two sources. For the period 1981-1999, the OECD's International Direct Investment database provides appropriate raw data. For the period 1971-1980, we resort to the data compiled by Van Pottelsberghe and Lichtenberg (2001). In fact, Van Pottelsberghe and Lichtenberg (2001) also constructed their FDI data based on the old database compiled by OECD. But the current OECD database no longer provides the inward FDI data before 1980 to the public. Since we adopt the same methodology and the same database as those of Van Pottelsberghe and Lichtenberg (2001) in constructing the data for the period 1981-1999, the compatibility problem that might be present in combining different data set should be minimized.

3. ESTIMATION MODEL AND RESULTS

A basic estimation equation is built on the estimation model of Coe and Helpman (1995) and is given as follows.

$$\log \frac{A_{i,t}}{A_{i,95}} = \alpha_i + \beta_1 \log \frac{S^d_{i,t}}{S^d_{i,95}} + \beta_2 G \log \frac{S^d_{i,t}}{S^d_{i,95}} + \beta_3 \log \frac{S^f_{i,t}}{S^f_{i,95}} + \varepsilon_{i,t}\ ,$$
$$i = 1,...,9,\ t = 71,...,99\ . \tag{3}$$

G is the dummy variable equal to one for the G7 countries, and equal to zero for other small countries. Consequently, β_2 measure the magnitude of the difference between the G7 countries and the non-G7 countries in the effects of corresponding variables. $A_{i,t}$ is the manufacturing TFP of country *i* in year *t*.

Equation (3) estimates the effects of domestic and foreign R&D capital stocks on manufacturing TFP. It transforms all variables into index values (1995=1) to free them from the units of measurement. Denoting the indexed variables by corresponding small letters, Equation (3) can be presented as follows.

$$\log a_{i,t} = \alpha_i + \beta_1 \log s^d_{i,t} + \beta_2 G \log s^d_{i,t} + \beta_3 \log s^f_{i,t} + \varepsilon_{i,t}\ ,\quad i = 1,...,9,\ t = 71,...,99\ . \tag{4}$$

In this case, each estimated coefficient represents the elasticity of the manufacturing TFP index (1995=1) with respect to the index of each independent variable (1995=1). As long as the estimated coefficients are correctly interpreted and used, the transformation of all variables into unit-free index values facilitates a clearer analysis of the results. This is because each country’s data should be pooled for a single estimation equation even though they have country specific elements in their measurement and compilation.

To estimate the Equation (4) as a panel cointegration model, we first need to check the non-stationarity of the variables considered in the model. Table 1 shows the results of panel unit root tests suggested by Hadri (2000). The tests of Hadri (2000) have clear advantages over the tests suggested by Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2002) in that Hadri (2000) tests the null hypothesis of stationarity while for the other tests the unit root is the null hypothesis to be tested. Unlike traditional unit root tests, we need to show that the variables are non-stationary to apply cointegration model to those variables. Therefore appropriate null hypothesis should be the stationarity of variable. The results indicate that both dependent and explanatory variables are non-stationary at 1% significance level for various test specifications provided by Hadri (2000).

Table1. Panel Unit Root Test [a]

	Homo	Hetero	SerDep
$\log a_{i,t}$	18.517	15.558	4.478
$\log s_{i,t}^{d}$	23.435	27.047	4.097
$\log s_{i,t}^{f}$	13.088	19.19	3.941

[a] Hadri (2000) tests the null hypothesis of stationarity. Tests are based on fixed effects model. Test statistic is distributed as standard normal under the null. The error process is assumed to be homoskedastic across the panel (Homo), or heteroskedastic across units (Hetero). Serial dependence in the disturbances can also be taken into account (SerDep). The null hypothesis of stationarity is rejected with 1% significance level for each variable we considered in the model regardless of test specifications. Tests are based on STATA procedures that can be found in the Statistical Software Components (SSC) archive.

Accordingly, to ascertain that the regression of the model is not spurious, the results of panel cointegration tests need to be checked. Table 2 provides the results of four panel cointegration tests suggested by Kao (1999) and the results of seven panel cointegration tests suggested by Pedroni (1999).

The first three tests by Kao (1999) clearly indicate that the model is panel cointegrated with 1% significance level. The last one by Kao (1999) also supports the panel cointegrated model with 5.4% probability value. On the other hand, only two tests of Pedroni (1999), Group t-statistics and panel t-statistics reject the null of no cointegration with 5% significance level. But we should note that these are the two most powerful, given our sample size, according to Pedroni's (2004) Monte Carlo simulations although Pedroni (1999) proposes seven panel cointegration test statistics. For the panel data with the number of cross section units being about 20 and the number of time units being about 30, the empirical powers of panel and group t-statistics are roughly twice as large as the other test statistics according to Pedroni (2004).

Table 2. Panel Cointegration Test [a]

Test	Standardized Statistics	P-value
Kao (1999)		
DF_Rho Test	-2.8254	0.002***
DF_*t*_Rho Test	-5.8151	0.000***
DF_Rho_Star Test	-8.0607	0.000***
DF_*t*_Rho_Star Test	-1.6042	0.054*

Pedroni (1999)		
Panel ν-stat	0.8177	0.793
Panel ρ-stat	0.2084	0.583
Panel t-stat (non-parametric)	-0.5374	0.295
Panel t-stat (parametric)	-1.9901	0.023**
Group ρ-stat	1.3009	0.903
Group t-stat (non-parametric)	-0.1027	0.459
Group t-stat (parametric)	-2.2055	0.014**

[a] The null hypothesis of no cointegration is tested. *, **, *** indicate the parameters that are significant at 10%, 5%, 1% probability level respectively.

Table 3 summarizes the estimation results. First, the results from all the model specifications show that there exists a significant long run equilibrium relationship between domestic R&D stock and productivity in G7 countries. We also note that the magnitudes of estimated coefficients are the same up to one decimal point. However, in non-G7 countries, such relationship is not significant for all the model specifications except the OLS estimation. We will not pursue the relationship between domestic R&D stocks and productivity in further detail as our focus is on the relationship between inward FDI and productivities of host countries.

Table 3. Estimation Results [a]

	(1)	(2)	(3)	(4)
$\log s_{i,t}^{d}$	0.0074***	0.0063	0.0022	-0.0127
	(0.002)	(0.221)	(0.696)	(0.449)
$G\log s_{i,t}^{d}$	0.2929***	0.2689***	0.2310***	0.2698***
	(0.000)	(0.000)	(0.000)	(0.000)
$\log s_{i,t}^{f}$	0.0164***	0.0343***	0.0207****	0.0144**
	(0.000)	(0.000)	(0.000)	(0.017)

Notes: (1) OLS Estimation, (2) The Fully-Modified OLS Estimation, (3) The Dynamic OLS Estimation (1 lead and 1 lag), (4) Group-mean Fully-Modified OLS Estimation.

[a] The dependent variable is log (total factor productivity), indexed as 1995=1. *, **, *** indicate the parameters that are significant at 10%, 5%, 1% probability level respectively. In parenthesis, *p*-values are given.

The second and the third column show that the results of within-dimension panel DOLS and FMOLS estimation suggested by Kao and Chiang (2000) confirm the positive long run relationship between inward FDI and productivities of host countries. From the first column, we note that the similar result can be obtained from the OLS estimation. The final column shows the results from the group mean between-dimension FM estimation suggested by Pedroni (2000). As was explained in the previous section, this estimator has several advantages over within-dimension estimators. The RATS procedure written by Pedroni allows us to control possible cross-sectional dependence by including common time dummies. In estimation, we include such common time dummies as cross-sectional dependence is likely to be present in our application. This between-dimension estimator allows heterogeneous cointegrating vectors for each members of cross section and therefore provides interpretable results when cointegrating vectors are believed to be heterogeneous as is very likely the case for the present analysis. The results show that the robustness of long run equilibrium relationship between inward FDI and productivities of host countries. Note that the magnitude of the estimated coefficient is the smallest with the group mean FM estimation.

4. CONCLUSION

This paper carried out empirical studies on the long run equilibrium relationship between inward FDI and productivities of host countries by applying up-to-date panel cointegration estimation methods to the quite long period data from nine countries.

For this, we constructed the panel data set for the period 1971-1999 by combining two datasets. These two dataset are quite compatible because they are based on the same database compiled by OECD and they are also constructed using the same methodology suggested by Van Pottelsberghe and Lichtenberg (2001). We first tested non-stationarity of the variables considered in the model using panel unit root tests suggested by Hadri (2000). The tests of Hadri (2000) have clear advantages in our analysis over the conventional panel unit root tests in that the tests of Hadri (2000) set the null hypothesis of stationarity. The test results indicated that both dependent and explanatory variables were clearly non-stationary. Subsequently, we checked whether the estimation model was panel cointegrated. For the sake of robustness, we used eleven test statistics, four suggested by Kao (1999) and seven by Pedroni (1999). From these, we showed that we could estimate long run equilibrium relationships among variables using panel cointegration models.

The estimation results from all the model specifications showed that there was a significant and robust long term equilibrium relationship between inward FDI and productivities of host countries. Especially, the group mean FM estimation suggested by Pedroni (2000), which allows common time dummies to control possible cross-sectional dependence and also allows heterogeneous cointegrating vectors for each members of cross section, indicated the robustness of long run equilibrium relationship between inward FDI and productivities of host countries.

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