The Measurement of International Capital Mobility Using Panel Cointegration Estimators

Hongkee Kim*

This paper investigates the Feldstein-Horioka coefficients for OECD country group, Latin country group and Asian country group using the recently developed several nonstatioanry panel cointegration techniques. The savings and investment rates are nonstationary and cointegrated in panel. The estimated FH coefficients using panel FMOLS and DOLS estimators have significantly declined for the second sub-period of 1980-98, comparing with those for the first sub-period of 1960-79 for all three country groups. In addition, the FH coefficient using the panel cointegration estimator in FH original samples (16 OECD countries) decreases drastically for the sub-periods of 1975-98 (0.10-0.35), though it is a little smaller (0.59-0.83) than that of original FH (0.88) for 1960-74. These estimated FH coefficients are consistent with the recognitions that international capital flows have increased significantly after the 1980s. The FH coefficient using panel cointegration estimator is considered to have important information about international capital mobility.

Keywords: Feldstein-Horioka puzzle, International capital mobility, Panel cointegration estimator

JEL Classification: F31, F32, F36

I. Introduction

It is generally accepted that high capital mobility across countries is one of most important driving forces for economic globalization.

*Professor, Department of International Economics, College of Economics and Business, Hannam University, Ojung-dong, Taeduk-ku, Taejon 306-791, South Korea, (Tel) +82-42-629-7597, (Fax) +82-42-636-5879, (E-mail) hongkee@mail.hannam.ac.kr. I am grateful to Reter Pedroni for his helpful comments and providing programs.

Increasing capital mobility across countries would enhance the economic efficiency of allocation. However, abrupt international capital movement may destabilize economies and cause financial crises, as seen in the 1997 Asian crisis. Safely speaking, international capital mobility may increase the probability of financial crisis. Therefore, many efforts have been made to measure how mobile international capital is.

There are several ways to investigate the degree of international capital mobility.[1] One is to investigate the relationship between savings and investment. Feldstein and Horioka (1980, hereafter FH) propose that an increase in savings in one country causes an increase in resources for investment across countries in the case of perfect capital mobility. Therefore, the correlation between savings and investment would be zero under perfect international capital mobility. On the contrary, an increase in savings in one country leads to an increase in investment in that country if capital is not mobile across countries, which results in high correlation of savings and investment. FH regressed investment rates on savings rates using the averaged cross-section data of 16 OECD countries for the period of 1960-74. They find that the regression coefficient is very large, which is unexpected in light of the supposed belief that international capital is highly mobile. After their seminal paper, many empirical researches have been done, for different periods and different countries. But the results have been similar to those of FH.[2]

Some of these studies focus on the time series aspects of the data. Savings and investment rates usually turn out to be nonstationary. It is well known that one should avoid a spurious regression problem by checking the cointegration relationship when the time series data are nonstationary. However, the traditional cointegration technique has the problem of low power. In order to improve the power of the test, the number of observations (span of data) should be extended. However, it is not easy to find data for a very long time span, with some exceptional cases.[3] Furthermore, expansion of the time horizon might cause the regime-shift

[1]These include checking interest parity condition and examining the international consumption correlation.

[2]See Coakley *et al.* (1998).

[3]Taylor (1996) uses the data of savings and investment rate for 12 countries over the period of 1850-1992.

problem. The panel data are a good alternative to power problem.

This paper estimates the FH coefficients from data by country group for OECD, Asian countries and Latin American countries, using recently developed *nonstationary panel techniques*. In doing so, we will check how the FH coefficient changes and compare sizes of the FH coefficient between country groups and between periods. In addition, we can evaluate the FH puzzle in terms of international capital mobility.

This paper is distinct from other research in several respects. First, it applies the recently developed nonstationary panel techniques to the relationship between savings and investment. Furthermore, this paper uses not only the within group but also the between-group estimator, which is powerful for dealing with heterogeneity across countries and over time. Pedroni (2000) proposes a panel cointegration estimator that is efficient in controlling for heterogeneity which is very common in the saving-investment relationship with panel data. Our paper exploits Pedroni's FMOLS (fully modified OLS) and Kao's DOLS (dynamic OLS) to deal with the heterogeneity problem. Finally, this paper is distinct from existing papers in the sense that this study compares the FH coefficient between country groups and periods rather than for individual countries.

The paper is organized as follows. Section II briefly reviews the literature on the savings and investment relationship, mainly focusing on the panel analysis. Section III introduces the nonstationary panel techniques for empirical works. The data and empirical results are presented and interpreted in Section IV, and the final section contains the summary and conclusions.

II. Literature Review

Feldstein and Horioka (1980) use the following cross section regression model to check the relationship between savings and investments.

$$IR_i = \alpha + \beta SR_i + \varepsilon_i \tag{1}$$

where IR_i and SR_i denote the domestic investment rate and domestic savings rate of country i, respectively. Their estimates of

β turn out to be high, which is opposite to the supposed belief that capital is mobile across countries in modern times. The high correlation between savings and investment is be known as the FH puzzle. The β is called the savings retention coefficient or the FH coefficient. There are several papers arguing that the FH coefficient may not be informative about international capital mobility, on the basis that the FH coefficient could be high even under perfect capital mobility in their theoretical model.[4] However, there have been a large number of studies on the FH coefficient in light of international capital mobility. Here we will put focus on a survey on research using panel data.

Krol (1996) argues that one might obtain a wrong inference about capital mobility if the time averaged data for savings and investment are used. He postulates that estimates of the FH coefficient using time averaged cross-section data would be high, due to intertemporal budget constraints. He assumes that the high FH coefficient is derived from a country's intertemporal budget constraint, rather than from a low international capital mobility. Krol uses annual panel data to avoid this problem and he controls business cycle and country size effects. His estimates of the FH coefficients are 0.2-0.16, which is much smaller than previous results. He argues that the panel regression removes the business cycle and country size effects, so his results imply that international capital mobility is large during the period.

Jansen (2000) argues that the low coefficients Krol (1996) obtained are derived from the inclusion of Luxembourg in the regression data. He shows that the estimated correlation coefficients are almost the same as previous other estimates when Luxembourg is excluded. However he argues that declining savings and investment correlation after 1973 is related with increasing capital mobility across countries. Coiteux and Olivier (2000) show that the short-run coefficient for savings is low, while the long-run coefficient for savings is high in a panel error correction form, supporting Jansen's view. They interpret this result as an evidence that international capital is very mobile in the short run, but not in the long run.

Coakley *et al.* (2001) estimate FH coefficients for 12 OECD countries, using group mean panel estimator techniques in order to

[4]See Coakley *et al.* (1998) for a recent review about the FH puzzle.

avoid the problems of panel unit roots and cointegration testing.[5] They suppose that saving and investment are nonstationary and the evidences on cointegration are weak or mixed. Their mean group estimate is only 0.33 while the cross section estimate was 0.68. They conclude that the mean group estimator could give a solution to the FH puzzle.

Ho (2002) is an interesting paper using panel cointegration. He examines the saving-investment relationship by applying the within-dimension DOLS and FMOLS of Kao and Chiang (2000) for 20 OECD countries. He shows that DOLS outperforms FMOLS. His FH coefficients tend to be below 0.47.

Most previous papers use traditional panel data, as reviewed above. They have a disadvantage in the sense that they do not account for much of dynamics regardless of whether they are time averaged or not. In the cases where traditional panels do account for dynamics, they do it in a very limited way. Specifically, they assume that the dynamics are the same for all members of the panel.

Ho uses nonstationary panel data as examined above. But his paper has several shortcomings. One is that he used the 'within-dimension panel cointegration estimator' rather than the 'between-dimension panel cointegration estimator.'[6] The within-dimension panel test statistics constrain the alternative coefficients to be the same across members, which is inconvenient for testing for heterogeneous cross-country panel data. Another problem is that he used OLS estimates as a first step for obtaining the FMOLS estimator, which might cause the large size distortion.[7]

The next section explains the panel cointegration techniques to be used to examine the correct savings and investment relationship, overcoming the previous mentioned problems.

[5]The mean group estimator can be calculated by the average of OLS estimate of each member.

[6]According to Pedroni (2000, 2001), for heterogeneous cross-section data, the group-mean estimator is much more useful than the within-group estimator in the sense that test statistics constructed using group mean estimators are designed to test the null hypothesis, so that the values under alternative hypotheses are not constrained to be the same.

[7]To reduce size distortion, the initial value in FMOLS should be a value under the null hypothesis or a theory-based derived value.

III. Empirical Methods

A. Panel Unit Root and Panel Cointegration

It is well known that traditional unit root tests or cointegration tests (*e.g.*, ADF or residual-based cointegration tests) involve the low power problem for nonstationary data. The panel data is a good alternative for increasing the number of observations, and hence the power of the tests. Levin, Lin, and Chu (2002, hereafter, LLC) and Quah (1994) initiated study on the panel unit root tests. Quah (1994) studies a standard unit root test in panels with homogenous dynamics and homogeneous disturbances. LLC studies the more practical unit root in panels with heterogeneous dynamics, fixed effects, and an individual-specific determinant trend. More recently, Im, Pesaran, and Shin (1997, hereafter IPS) and Maddala and Wu (1999) propose a between-group panel unit root test, which permits a heterogeneous autoregressive root under the alternative hypothesis. We use the panel unit root test of LLC and IPS. LLC test has an alternative hypothesis that all members have homogeneous unit roots, whereas IPS has an alternative that at least some of members have a heterogeneous unit root.

Recently, more attention has been paid to the cointegration test and estimation in the panel model. Several researches have done by Kao (1999), and Pedroni (2004). Kao (1999) proposes two types of panel cointegration test on the basis of the DF and ADF.

One of the most troublesome questions in panel data is how to tackle heterogeneous short run dynamics and heterogeneity across numbers, because the heterogeneity problem seems to be prevalent in panel data. We use the cointegration test of Pedroni (2004) to handle heterogeneity problems.[8] As a general form, the following type of regression will be considered.

$$IR_{it} = \alpha_i + \delta_i + \beta_i SR_{it} + e_{it} \qquad i = 1,2,3,\cdots,N, \; t = 1,2,3,\cdots,T \tag{2}$$

This formulation allows for considerable heterogeneity: a heteroge-

[8]Pedroni (2004) proposes seven residual based tests for the null of cointegration. Four are based on pooling the residuals of the regression for the panel within group and the other three are based on pooling the residuals for the between group.

neous slope coefficient (β_i), fixed effect (α_i) and time dummy (δ_t). Time dummy is intended to capture any disturbances that are common across different members of panel, such as global disturbances and international business cycles. Under the null of no cointegration, the panel of estimated residuals, $\hat{e}_{it}$ is nonstationary, whereas it is stationary, under the alternative of cointegration.

Pedroni (2004) shows that group PP and group ADF panel cointegration tests have a relatively high power for the number of members and number of time observations that are relevant to this research. So we will explain the two group mean panel cointegration test statistics on which focus will be put in the empirical work. The group mean pp statistic is given as

$$z_{GPP} = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \hat{L}_{11i}^{-2} \hat{e}_{it-1}^{2}\right)^{-1/2} \sum_{t=1}^{T} (\hat{e}_{it-1} \Delta \hat{e}_{it-1} - \hat{\lambda}_i) \tag{3}$$

where $\hat{e}_{it}$ is the estimated residual from equation (2) and $\hat{L}_{11i}^{2}$ is the estimated long run variance for $\Delta\hat{e}_{it}$. Similarly, $\hat{\lambda}_i$ is the familiar nonparametric serial correction term in the Phillips-Perron estimator. For the parametric group ADP panel test, we set $\hat{\lambda}_i = 0$ and $\hat{L}_{11i}^{2}$ is replaced by the simple contemporaneous variance of the residuals from the ADF autoregression of $\hat{e}_{it}$. Asymptotic distribution for both group PP and group ADF is standard normal when standardized in a specific form.

B. The FMOLS and DOLS Panel Cointegration Estimator

Now, how can the cointegration vector be estimated? Generally there are two estimation methods for panel cointegration such as panel FMOLS and panel DOLS estimator. Pedroni (2000) proposes two types of the fully modified OLS (FMOLS) panel cointegration estimator. One is the within group (or dimension) FMOLS and the other is the between group (or group mean) FMOLS. He also shows that the between-group FMOLS suffers much less from small sample size distortion than within-group estimators and allows for a more flexible alternative hypothesis.[9] In addition, the between group FMOLS has an advantage for point estimate in the sense

[9]The within group FMOLS is asymptotically unbiased, but has a large size distortion. Thus it is not recommended for point estimation.

that it can be interpreted as the mean value of the cointegration vector.

The within group panel FMOLS estimator (WFM) for Equation (2) is given by

$$\hat{\beta}^*_{WFM} = [\sum_{i=1}^{N}\sum_{t=1}^{T}(SR_{it}-\bar{SR}_i)^2]^{-1}[\sum_{i=1}^{N}(\sum_{t=1}^{T}(SR_{it}-\bar{SR}_{it})IR^*_{it}-\hat{\lambda}_i)] \tag{4}$$

The group mean panel FMOLS estimator ($\hat{\beta}_{GFM}$) can be written by

$$\hat{\beta}_{GFM} = \frac{1}{N}\sum_i \left[\frac{\sum_{t=1}^{T}(SR_{it}-\bar{SR}_i)IR^*_{it}-T\hat{\gamma}_i}{\sum_{t=1}^{T}(SR_{it}-\bar{SR}_i)^2}\right] \tag{5}$$

where $(IR)^*_{it}=(IR_{it}-\bar{IR}_i)-(\hat{\Omega}_{21i}/\hat{\Omega}_{22i})\Delta SR_{it}$, $\hat{\gamma}_i=\hat{\Gamma}_{21i}+\hat{\Omega}^0_{21i}-(\hat{\Omega}_{21i}/\hat{\Omega}_{22i})(\hat{\Gamma}_{22i}+\hat{\Omega}^0_{22i})$. Here $\hat{\Omega}_i=\hat{\Omega}^0_i+\hat{\Gamma}_i+\hat{\Gamma}'_i$ is the estimated long run covariance matrix of the stationary vector consisting of the estimated residuals from the cointegration regression and the differences in savings rate. $\hat{\Omega}^0_{21i}$ is the long-run covariance between the stationary error terms (e_{it} in Equation (2)) and the unit root autoregressive disturbances. $\hat{\Omega}^2_{22i}$ is the long-run covariance of the differences in savings rates. $\hat{\Gamma}_i$ is a weighted sum of the autocovariances and a bar over these letters denotes the mean for i members.[10] The associated t-statistics for the within group and the between-group FMOLS estimator are standard normal as T and N approach infinity.[11]

Next, the DOLS panel cointegration estimator of the FH coefficient is considered. Kao and Chiang (1997) apply dynamic OLS (DOLS) to panel cointegration estimation. The original DOLS of Kao is the within group estimator. Mark and Sul (1999) propose a kind of panel DOLS estimator and show that it can improve the small sample performance. Kao and Chiang's type of panel DOLS

[10]Interested readers can refer to Pedroni (2000, 2001) for more details.

[11]The associated t-statistics for the within group and the between-group FMOLS estimator takes the form as follows:

$$t_{\hat{\beta}^*_{WFM}}=(\hat{\beta}^*_{FMi}-\beta)(\sum_{i=1}^{N}\hat{\Omega}^{-1}_{22i}\sum_t(SR_{it}-\bar{SR}_i)^2)^{1/2},\ t_{\hat{\beta}^*_{GFM}}=(1/\sqrt{N})\sum_{i=1}^{N}(\hat{\beta}^*_{FM.i}-\beta)(\hat{\Omega}^{-1}_{11.i}\sum_t(SR_{it}-\bar{SR}_i)^2)^{1/2}$$

where β is a value under the null hypothesis.

estimator is unweighted estimator and Mark and Sul's panel DOLS is weighted estimator. Pedroni (2001) proposes the between group DOLS estimator which is a little different from Kao and Chiang (1997). The panel DOLS regression can be set up as follows:

$$IR_{i,t} = \alpha_i + \delta_t + \beta_i SR_{i,t} + \sum_{k=-Ki}^{Ki} \gamma_{ik} \Delta SR_{i,t-k} + u^*_{i,t} \qquad (6)$$

The within group panel DOLS (WDOLS) and the group mean panel DOLS (GDOLS) estimators are given as follows:[12]

$$\hat{\beta}^*_{WDOLS} = [(\sum_{i=1}^{N} \sum_{t=1}^{T} Z_{i,t} Z'_{i,t})^{-1} (\sum_{n=1}^{N} \sum_{t=1}^{T} Z_{i,t} \tilde{IR}_{i,t})]_1 \qquad (7)$$

$$\hat{\beta}^*_{GDOLS} = [\frac{1}{N} \sum_{i=1}^{N} (\sum_{t=1}^{T} Z_{i,t} Z'_{i,t})^{-1} (\sum_{t=1}^{T} Z_{i,t} \tilde{IR}_{i,t})]_1 \qquad (8)$$

where Z_{it} is the $2(K+1)*1$ vector of regressors $Z_{it} = (SR_{it} - \bar{SR}_i, \Delta SR_{it-k}, \cdots, \Delta SR_{it+k})$, $\tilde{IR}_{it} = IR_{it} - \bar{IR}_i$. A bar over a letter denotes a mean and the subscript 1 outside the brackets indicates the first elements of the vector used to obtain the pooled slope coefficient. The associated t-statistic for the group-mean estimator has a standard normal distribution, as T and N approach infinity, as in the FMOLS estimator.[13]

IV. Empirical Results

The data used in this paper are taken from the International Financial Statistics of the IMF and World Development Indicator of World Bank. The data are annual and cover the period from 1960 to 1998 for 21 OECD countries, 11 Asian countries and 16 Latin America countries.[14]

[12] Pedroni (2001) can be referred to for more detail.

[13] The associated t statistic can be expressed as the following:

$$t_{\hat{\beta}^*_{GDOLS}} = (1/\sqrt{N}) \sum_{i=1}^{N} (\hat{\beta}^*_{D,i} - \beta)((1/\hat{\sigma}_i^2) \sum_t (SR_{i,t} - \bar{SR}_i)^2)^{1/2},$$

where $\hat{\sigma}_i^2$ is the long run variance of the residuals from the DOLS regression and $\hat{\beta}^*_{D,i}$ is the conventional DOLS estimator.

[14] The OECD country group consists of 21 countries excluding Mexico and Korea. Asia country group consist of India, Indonesia, Japan, Korea,

TABLE 1
UNIT ROOT TESTS FOR PANEL DATA OF SAVINGS RATE AND INVESTMENT RATE

Method	Savings Rate				Investment Rate			
	LLC		IPS		LL		IPS	
	No trend	Trend	No trend	Trend	No trend	Trend	No trend	Trend
T value								
OECD	-1.66	-1.83	-3.69	-3.92	-1.54	-3.13	-3.20	-5.82
Asia	0.58	0.53	-1.33	-1.08	-0.92	-1.79	-2.09	-3.18
Latin	-1.43	-2.44	-1.57	-2.33	-2.14	-2.12	-3.10	-3.83
Panel Critical Value								
5%	-1.99	-2.23	-1.90	-2.52	-1.99	-2.23	-1.90	-2.52
1%	-2.68	-2.94	-2.04	-2.67	-2.68	-2.94	-2.04	-2.67

Note: The null hypothesis is that all individual series are nonstationary.

TABLE 2
PANEL COINTEGRATION TESTS BY COUNTRY GROUP

Country Group	Within Group		Between Group	
	Panel pp stat	Panel ADF stat	Panel *t* stat	Panel ADF stat
OECD				
Raw	-1.27	-1.83	-1.15	-2.54
Time Mean	-2.02	-3.10	-1.87	-3.81
Asia				
Raw	-3.40	-3.57	-3.02	-3.60
Time Mean	-3.40	-3.73	-3.07	-3.56
Latin				
Raw	-5.21	-5.27	-5.57	-5.99
Time Mean	-6.74	-6.66	-7.61	-7.87

Note: The test statistic has asymptotic standard normal distribution.

We check whether the panel data series have unit roots using the LLC and IPS tests. Table 1 shows that results of the panel unit roots test are a little different depending on the panel unit root test. The null of panel unit root for savings rate cannot be rejected, except in OECD country group using IPS method. The null of panel

Malaysia, Myanmar, Pakistan, the Philippines, Singapore, Sri Lanka, and Thailand. Latin country group includes Argentina, Bolivia, Brazil, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Paraguay, Peru and Venezuela.

unit root for investment rate using LLC cannot be rejected whereas the null in the case of time dummy using IPS can be rejected in OECD country group. However the saving and investment rates are assumed to have a panel unit root as in other papers.[15]

Table 2 shows the results of panel cointegration. We use the within group and between group PP and ADF tests to check whether the panel data are cointegrated. The cases of cointegration tests are divided into raw data and time mean data. The results of the test statistic indicate that the null hypothesis of no cointegration can be rejected at a reasonable significance level for all countries, except in the raw data in OECD using the group PP. Even in that case, the group ADF statistic shows that the savings and investment rates are cointegrated. Therefore, the savings and investment rates appear to be cointegrated at a reasonable significance level for all three country-groups.

Finally, we estimate the cointegrating vector using five methods: panel FMOLS (the within dimension and the group mean) and DOLS (the weighted and unweighted within dimension and the group mean). We consider two cases: with and without time. A time dummy is usually included to check for simultaneous or common effects across countries. In general, savings and investment rates can be affected by international business cycle or global shocks. Therefore, a time dummy is desirable to be included in order to control for international business cycle effects or other common shocks. Therefore we will put focus on the case with a time dummy for each period.[16]

Table 3 shows the estimate of the FH coefficient by periods and by country groups, using the between group and within-group panel cointegration estimation technique. We can find overall noticeable empirical results. Firstly, FH coefficients have declined significantly in the second sub-period of 1980-98 relative to the first sub-period of 1960-79 for all country groups. For example, the FH coefficients using the between group estimator decrease from 0.7 in the first sub-period to 0.4 in the second sub-period.

Secondly, the FH coefficients of the between group methods are generally smaller than those of the within group methods. The FH coefficients vary depending on whether the time dummy is included

[15]Ho (2002) can be referred to.

[16]The case without time dummy is also reported for a comparison.

TABLE 3

PANEL COINTEGRATION ESTIMATIONS BY COUNTRY GROUP

Period				1960-98	1960-79	1980-98
OECD	Time Dummy	Between Group	FMOLS	0.47 (12.35)	0.82 (18.32)	0.38 (10.78)
			DOLS	0.53 (11.63)	1.19 (19.85)	0.32 (12.29)
		Within Group	FMOLS	0.32 (1.67)	0.71 (2.71)	0.23 (0.98)
			DOLS (un)	0.32 (1.32)	1.08 (2.75)	0.26 (1.12)
			DOLS	0.46 (12.84)	0.80 (19.95)	0.71 (29.43)
	No Time Dummy	Between Group	FMOLS	0.78 (20.84)	0.83 (21.95)	0.62 (9.75)
			DOLS	0.85 (20.63)	0.90 (16.30)	0.71 (8.55)
		Within Group	FMOLS	0.54 (2.59)	0.71 (3.26)	0.27 (1.03)
			DOLS (un)	0.63 (2.52)	0.78 (3.03)	0.33 (1.18)
			DOLS	0.89 (21.43)	0.79 (20.92)	0.39 (8.19)
Asia	Time Dummy	Between Group	FMOLS	0.57 (17.02)	0.61 (14.85)	0.38 (6.26)
			DOLS	0.62 (18.64)	0.76 (16.11)	0.41 (7.22)
		Within Group	FMOLS	0.52 (3.98)	0.64 (4.59)	0.41 (1.53)
			DOLS (un)	0.52 (3.76)	0.69 (4.53)	0.46 (1.91)
			DOLS	0.73 (23.86)	0.63 (17.41)	0.51 (0.81)
	No Time Dummy	Between Group	FMOLS	0.70 (21.70)	0.68 (17.84)	0.37 (6.34)
			DOLS	1.02 (26.25)	0.76 (18.82)	0.44 (1.60)
		Within Group	FMOLS	0.65 (5.28)	0.77 (6.21)	0.34 (1.20)
			DOLS (un)	0.67 (5.56)	0.79 (6.64)	0.44 (1.60)
			DOLS	0.81 (32.77)	0.71 (21.11)	0.28 (6.63)
Latin	Time Dummy	Between Group	FMOLS	0.60 (19.83)	0.54 (14.65)	0.43 (13.66)
			DOLS	0.66 (20.21)	0.54 (16.64)	0.40 (13.97)
		Within Group	FMOLS	0.61 (4.35)	0.72 (4.39)	0.58 (3.61)
			DOLS (un)	0.69 (4.28)	0.77 (4.88)	0.67 (4.35)
			DOLS	0.66 (18.99)	0.76 (20.91)	0.59 (17.67)
	No Time Dummy	Between Group	FMOLS	0.66 (18.63)	0.93 (24.92)	0.28 (8.30)
			DOLS	0.72 (19.80)	1.33 (37.89)	0.17 (7.54)
		Within Group	FMOLS	0.71 (4.62)	0.84 (4.37)	0.51 (2.82)
			DOLS (un)	0.78 (5.07)	0.88 (4.85)	0.54 (3.13)
			DOLS	0.75 (20.62)	0.89 (26.90)	0.31 (10.40)
Other Panel Results	Corbin (2001): The between panel: 1.06 (1973-92) The within panel: 0.74 (1973-92) Krol (1996): 0.16 (1962-90) Coitex and Olivier (2000): 0.634 (1960-95) Jansen (2000): 0.57 (1960-90) Ho (2001): DOLS 0.47 (1961-97) FMOLS: 0.84 (1961-97)					

Notes: 1. DOLS (un) denotes unweighted DOLS estimator.
2. ( ) denotes the t-value for zero coefficient. As explained in section III, asymptotic distribution of t statistic is standard normal as T and N go to infinity.

or not. As mentioned above, the time dummy is used to control for the common effects. The differences of the FH coefficients vary across country groups. In OECD country group, FH coefficients with the time dummy are much smaller than those without the time dummy, whereas FH coefficients with time dummy in Latin country group are smaller than those without the time dummy. In Asia country group, the FH coefficients are almost same. It is expected that a more closely interconnected country groups have smaller FH coefficient with a time dummy than without time dummy. Therefore it is natural that OECD country group has a much smaller estimated FH coefficient with the time dummy than without time dummy.

Next we will examine how HF coefficients have changed over periods for each country group. First we will investigate the case of OECD country group. The group mean FMOLS estimate of the FH coefficient is 0.47, while the DOLS estimate is 0.53, for the entire period. Both FH coefficients by within group FMOLS and unweighted DOLS are 0.32 and the weighted DOLS are 0.46. These estimates are much smaller than those in other papers, which are reported for comparison. However, the coefficient is still significantly nonzero with either method.[17] Now, we consider two sub-periods (1960-79, and 1980-98).[18] The FH coefficients using group mean FMOLS and DOLS are is 0.38 and 0.32 respectively for the period 1980-98, whereas they are 0.82 and 1.19 for 1960-79. It is noticeable that the FH coefficients have declined significantly during the second sub period. The HF coefficients using the between group FMOLS and weighted DOLS estimator for the second sub-period are much smaller (0.38 and 0.32) and the null of zero FH coefficients can still be rejected. However, the HF coefficients by the between group FMOLS and DOLS are 0.23 and 0.26, which are not significantly different from zero for the second sub period.

Next we will investigate FH coefficients in Asian country group. The group mean FMOLS estimate of the FH coefficient is 0.54, while the DOLS estimate is 0.62, for the entire period. These estimates are not different from those in other papers. The

[17]Pedroni (2000) shows that the between-group FMOLS estimator has less size distortion than any other feasible estimator.

[18]The period is divided into before and after 1980, because many developing countries as well as developed countries removed capital controls in the 1980s.

TABLE 4

PANEL COINTEGRATION ESTIMATIONS FOR THE ORIGINAL FH SAMPLES

Period			1960-98	1960-74	1975-98
Time Dummy	Between Group	FMOLS	0.39 (8.91)	0.59 (10.84)	0.29 (8.37)
		DOLS	0.48 (8.52)	0.83 (17.78)	0.35 (12.97)
	Within Group	FMOLS	0.27 (1.43)	0.51 (2.41)	0.11 (0.52)
		DOLS (un)	0.23 (1.00)	0.67 (3.64)	0.10 (0.51)
		DOLS	0.42 (9.52)	0.48 (15.12)	0.65 (26.98)
Feldstein and Horioka	Feldstein and Horioka (1980): 0.887 (11.98): 1960-74 Feldstein (1983) 0.796 (0.11): 1960-79				

Note: ( ) denotes the t statistic.

coefficients are significantly nonzero with either method. Now, we look at the results of two sub-periods (1960-79, and 1980-98). The FH coefficient using the between group FMOLS is 0.38 for the period 1980-98, whereas it is 0.61 for 1960-79. The between group DOLS estimate also decreases from 0.76 in the first period to 0.41 in the second period. The estimated coefficients (0.38, 0.41) for the period 1980-98 are much lower than previous results, although they are still significantly different from zero. The FH coefficients using the within dimension methods have similar sizes. But the FH coefficients are insignificant for the second sub-period as in the case of OECD country group.

Finally we will take a close look at the results in Latin America Country group. The FH coefficient of the between group FMOLS and DOLS are 0.60 and 0.66 respectively for the entire period. The FMOLS estimate decreases from 0.54 in the first sub-period to 0.43 in the second period, while the between group DOLS estimate also decreases from 0.54 in the first sub-period to 0.40 in the second sub-period. The FH coefficients using the within group methods are relatively large (0.58, 0.67 and 0.59) in the second sub-periods.

We observe that the FH coefficient significantly reduces for the second sub-period in all three country-groups. The above FH coefficients for the second sub-period are smaller than those in other researches.[19] Furthermore it is noted that several FH

[19]Coakley *et al.* (1998) write a survey paper that summarizes the cross-section coefficients (above 0.62, except one case) and time series

coefficients using the within dimension method in OECD country group and Asia country group are insignificant for the second period.

We will examine the FH coefficients for the same sample for which Feldstein and Horioka estimated, in order to check if the FH coefficient implies the degree of international capital mobility. The results are reported in Table 4. The FH coefficient by the group mean methods ranges from 0.59 to 0.83, which is a little smaller than original FH coefficient (0.88). In contrast, the FH coefficient is 0.29-0.35 for the period of 1975-98, which declined significantly relative to that for the previous period. These values are smaller than those for the periods of gold standard system.[20] Moreover the estimates by the within group FMOLS and unweighted DOLS are not significantly different from zero. These facts imply that the FH coefficient has an important information about international capital mobility.

Therefore a decrease in the FH coefficients using the panel cointegration estimators for the period of 1980-98 is likely to tell us that international capital mobility increased from the FH perspective. Moreover the within group FMOLS and DOLS estimators in OECD and Asian country group have insignificant zero values for the second sub-period, which implies that capital is perfectly mobile across these countries.

V. Conclusion

This paper studies the FH coefficients in OECD country group, Asian country group and Latin country, using recently developed several panel cointegration methods: the between group and within group FMOLS and DOLS estimators It is found that the savings and investment rates in panel data are non-stationary and cointegrated. The FH coefficients using the between group and within group FMOLS and DOLS significantly decreases in the second sub-period of 1980-98. The estimated FH coefficient after

coefficients (above 0.6, except in rare cases). The FH coefficient using panel data are as follows: Corbin (2001): 1.06-0.74 (1973-92), Coitex and Olivier (2000): 0.634 (1960-95), and Jansen (2000): 0.57 (1960-90).

[20]Corbin (2001) estimated the FH coefficients traditional stationary panel methods for the gold standard system (0.40-0.43).

1980 is almost the same as for the period using the gold standard system, when capital is considered highly mobile between advanced countries. Moreover, it is found that some estimates of the FH coefficients are not different from zero for the second sub-period as in OECD and Asia country groups, which implies perfect capital mobility according to FH.

The drastic reduction in the estimated FH coefficient using panel cointegration might be consistent with the recognitions that the capitals are mobile across countries due to the advances in telecommunication technology, evolutionary financial techniques and the globalized financial markets. Therefore FH coefficient using the nonstationary panel technique is a good measure for degree of international capital mobility.

(*Received 28 July 2004; Revised 18 October 2004*)

References

Bayoumi, T. "Saving-Investment Correlations: Immobile Capital, Government Policy or Endogenous Behavior?" *IMF Staff Papers* 37 (1990): 360-87.

Coakley, J., Kulasi, F., and Smith, R. "Current Account Solvency and the Feldstein-Horioka Puzzle." *Economic Journal* 106 (No. 436 1996): 620-7.

Coakley, J., Kulasi, F., and Smith, R. "The Feldstein and Horioka Puzzle and Capital Mobility: A Review." *International Journal of Finance and Economics* 3 (No. 2 1998): 169-88.

Coakley, J., Fuertes, A. M., and Smith, Ron. "Small Sample Properties of Panel Times Series Estimators with I(1) Errors." http://papers.ssrn.com/sol3/papers.cfm, 2001.

Coakley, J., Fuertes, A. M., and Spagnolo, F. "The Feldstein-Horioka Puzzle Is not as Bad as You Think." http://papers.ssrn.com/sol3/papers.cfm, 2001.

Coiteux, M., and Olivier, S. "The Saving Retention Coefficient in the Long Run and in the Short Run: Evidence from Panel Data." *Journal of International Money and Finance* 19 (No. 4 2000): 535-48.

Corbin, A. "Country Specific Effect in the Feldstein-Horioka Paradox: A Panel Data Analysis." *Economics Letters* 72 (No. 3

2001): 297-302.

Feldstein, M., and Horioka, C. "Domestic Saving and International Capital Flow." *Economic Journal* 90 (No. 358 1980): 314-29.

Ho, Tsung-wo. "The Feldstein-Horioka Puzzle Revisited." *Journal of International Money and Finance* 21 (No. 4 2002): 555-64.

Im, K. S., Pesaran, M. H., and Shin, Y. C. Testing for Unit Roots in Heterogeneous Panels. Discussion Paper, University of Cambridge, 1997.

Jansen, W. J. "International Capital Mobility: Evidence from Panel Data." *Journal of International Money and Finance* 19 (No. 4 2000): 507-11.

Kao, C. "Spurious Regression and Residual-Based Tests for Cointegration in Panel Data." *Journal of Econometrics* 90 (1999): 1-44.

Kao, C., and Chiang, M. H. "On the Estimation and Inference of a Cointegrated Regression in Panel Data." *Advances in Econometrics* 15 (2000): 179-222.

Kim, H. K., Oh, K. Y., and Jeong, C. W. "Panel Cointegration Results on International Capital Mobility in Asian Economies." *Journal of International Money and Finance*. Forthcoming, 2004.

Krol, R. "International Capital Mobility: Evidence from Panel Data." *Journal of International Money and Finance* 15 (No. 3 1996): 467-74.

Levin, A, Lin, C. F., and Chu, C. S. J. "Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties." *Journal of Econometrics* 108 (No. 1 2002): 1-24.

Maddala, G. S., and Wu, S. "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test." *Oxford Bulletin of Economics and Statistics* 61 (Special Issues 1999): 631-52.

Mark, M., and Sul, Donggyu. A Computational Simple Cointegration Vector Estimation for Panel Data. The Ohio State University, Department of Economics Working Papers, 2002.

Moon, H. R., and Phillips, P. C. B. A Reinterpretation of the Feldstein-Horioka Regression from a Nonstationary Panel Viewpoint. Mimeograph, Yale University, 1998.

Obstfeld, M. International Capital Mobility in the 1990s. NBER Working Paper, No. 4534, 1993.

Pedroni, P. "Fully Modified OLS for Heterogeneous Cointegrated

Panels." *Advances in Econometrics* 15 (2000): 93-130.

_________. "Purchasing Power parity Tests in Cointegrated Panels." *Review of Economics and Statistics* 83 (No. 4 2001): 723-41.

_________. "Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests, With an Application to the PPP Hypothesis." *Econometric Theory* 20 (No. 3 2004): 597-625.

Phillips, P. C. B., and Moon, H. "Linear Regression Limit Theory for Nonstationary Panel Data." *Econometrica* 67 (No. 5 1999): 1057- 111.

Philips, Peter, and Ouliaris, S. "Asymtotic Properties of Residual Based Tests for Cointegration." *Econometrica* 58 (No. 1 1990): 165-93.

Quah, D. "Exploiting Cross Section Variation for Unit Root Inferences in Dynamic Panel Data." *Economic Letters* 44 (1994): 1353-7.

Taylor, A. M. International Capital Mobility in History: The Saving and Investment Relationship. NBER Working Paper, No. 5743, 1996.

Tesar, L. L. "Saving, Investment and International Capital Flows." *Journal of International Economics* 31 (Nos. 1-2 1991): 55-78.