# International Capital Mobility and its Policy Implications for Asia-Pacific Economies

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This paper investigates the savings-investment relationship, also known as the Feldstein-Horioka puzzle, for 28 Asia-Pacific countries from 1960 to 2006. It utilizes recently developed panel cointegration techniques to test and estimate the long-run equilibrium relationship between savings and investment. Investment and savings rates are found to have unit roots and to be cointegrated, based on five different panel unit root tests and three types of panel cointegration tests. The estimated coefficients on the savings rate, employing CCR, DOLS, and FMOLS techniques, exhibit a declining trend over subsample periods including the structural break for the Asian financial crisis in 1997-98. This suggests that international capital mobility in the Asia-Pacific economies increased substantially in the 1990s and 2000s. Moreover, the magnitude of the estimated savings-retention coefficients is much smaller than that reported by Feldstein and Horioka.

**Key words:** capital mobility, Feldstein-Horioka puzzle, panel unit root, panel cointegration

**JEL classification:** F3, E2, C3

## I. Introduction

The mega-trend of globalization, integration, and securitization of international financial markets, spurred by the rapid development of information technology and the opening of markets, has accelerated competition across national borders and has fundamentally changed domestic financial policy. Korea's financial markets were completely opened

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following the Asian currency crisis in 1997-98, after a partial opening in 1996 with OECD membership and the introduction of foreign investors into its securities markets in 1992. Increasing capital mobility due to the opening of domestic financial markets in Korea has led to more efficient allocation of financial resources and more volatility of financial variables such as securities prices, interest rates, and exchange rates.

In a seminal work, Feldstein and Horioka (1980) argue, based on cross-sectional regressions, that changes in domestic investment are very sensitive to changes in domestic savings for OECD countries. In the literature, empirical evidence for this "Feldstein-Horioka puzzle"—industrialized countries with high capital mobility show high savings-retention coefficients, implying low capital mobility—has been conflicting.

For example, Christopoulos (2007), using a panel cointegration test based on Johansen's maximum likelihood approach, finds that savings and investment rates for a panel of OECD countries over the period 1950-1992 are cointegrated. He construes the result as implying that the Feldstein-Horioka hypothesis should be accepted. In contrast, Narayan and Narayan (2010), employing a residual-based panel cointegration test, could not establish any evidence of a cointegrating relationship between savings and investment for a panel of G7 countries from 1971 to 2002. They interpret their finding as suggesting that capital in the G7 countries is highly mobile, contrary to the Feldstein-Horioka puzzle, since no long-term relationship exists between savings and investment.

This paper investigates international capital mobility, focusing on the savings-investment correlation or Feldstein-Horioka puzzle from 1960 to 2006 for 28 Asia-Pacific economies—Australia, Bangladesh, Bhutan, Brunei, Cambodia, China, Fiji, Hong Kong, India, Indonesia, Japan, Korea, Macao, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Vanuatu, and Vietnam. The study is based on macroeconomic data extracted from the *World Bank's World Development Indicators 2008*.

This study differs from other studies on the savings-investment nexus in the following respects. First, it contributes to the literature on international capital mobility by enhancing the power and accuracy of inference and estimation using the most recent econometric techniques combined with more expanded panel datasets over time and space (including more time series and cross-section countries) to derive policy implications. Second, it explores the relationship for 28 Asia-Pacific countries in a panel cointegration framework. While there has been a plethora of research on industrialized OECD countries, comparable studies on developing Asia-Pacific countries in a panel cointegration framework have been relatively rare and have included only a few countries.

Third, the study utilizes an extensive variety of panel cointegration tests encompassing both residual-based (Kao, 1999; Pedroni, 2004) and maximum likelihood-based tests (Fisher-type—Johansen, 1995), and estimation methods such as CCR (canonical cointegrating regression), DOLS (dynamic ordinary least squares), and FMOLS (fully modified ordinary least squares) developed by various authors to enhance the credibility of the empirical results. To date, researchers have used only one or two test procedures to investigate the savings-investment relationship, mostly for samples of OECD countries. Some authors, like Christopoulos (2007), argue that maximum likelihood-based tests are superior to the residual-based panel cointegration tests. Another contribution of this paper is that it does provide estimates of the savings-retention coefficient based on three distinct types of panel cointegration estimation procedures, while many authors, including Christopoulos (2007) and Narayan and Narayan (2010), do not furnish the coefficient estimates and report only panel cointegration test results.

This study attempts to solve the Feldstein-Horioka puzzle employing recently developed panel cointegration techniques to test and estimate the long-run equilibrium relationship between savings and investment. The empirical analysis is performed in four steps. First, conventional univariate unit root tests are conducted to find the order of integration of the savings and investment rate series for individual countries. Second, five types of panel unit root tests are employed to confirm the nonstationarity of the series in a panel system consisting of all the countries. Third, three types of panel cointegration tests (Johansen, 1995; Kao, 1999; Pedroni, 2004) are used to establish a cointegrating (long-term equilibrium) relationship between domestic savings and investment rates. Fourth, three types of panel cointegration estimation techniques (CCR, DOLS, and FMOLS) are utilized to obtain estimates on the savings-retention (or Feldstein-Horioka) coefficient. This estimation is performed for different subsample periods to find evidence for the extent and magnitude of changes in capital mobility over time.

The remainder of this paper is organized as follows. In Section 2, the regression models for empirical analysis are specified, and panel unit root and cointegration testing and estimation techniques for econometric analyses are explained. Section 3 provides data descriptions and empirical results. In Section 4, the findings are recapitulated and the contributions of this paper are presented.

## II. Model and Econometric Framework

### A. Model Specification

This paper employs data on 28 Asia-Pacific countries to evaluate the connection between the domestic savings rate and the domestic investment rate. In a world economy with perfect capital mobility, there should be no correlation between domestic savings and domestic investment. In contrast, if capital mobility is low and domestic savings are primarily invested in the country of origin, there should be high correlation between domestic savings and domestic investment rates.

To explore the relationship between savings and investment rates, the following equation is applied to heterogeneous panel data:

$$\left(\frac{I}{Y}\right)_{it} = \alpha + \beta\left(\frac{S}{Y}\right)_{it} + \varepsilon_{it},\ \mathrm{i} = 1, \ldots, \mathrm{N};\ \mathrm{t} = 1, \ldots, \mathrm{T} \qquad (1)$$

where $(I/Y)_{it}$ is the ratio of gross domestic investment to gross domestic product (GDP) in country $i$ at time $t$, $(S/Y)_{it}$ is the corresponding ratio of gross domestic savings to GDP, and $\varepsilon_{it}$ is a disturbance term. The equations above are a panel version of Feldstein and Horioka's (1980) cross-sectional equations. They use cross-section data and present results in average ratios for the entire period as well as for subperiods. However, using cross-sectional equations has been criticized for causing various problems ranging from estimation bias to the loss of valuable information in data.

The above savings-investment equation may be represented as the following standard panel regression equation:

$$y_{it} = \alpha + \beta x_{it} + u_{it},\ u_{it} = \mu_i + v_{it},\ \mathrm{i} = 1, \ldots, \mathrm{N};\ \mathrm{t} = 1, \ldots, \mathrm{T} \qquad (2)$$

where $y_{it}$ is the dependent variable $(I/Y)_{it}$, $\alpha$ is the intercept term for the common effects of time series and cross section, $\beta$ is the savings-retention coefficient, $x_{it}$ is the explanatory variable $(S/Y)_{it}$, and the error term $u_{it}$ is composed of unobservable individual specific effects $\mu_i$ and the disturbance term $v_{it}$, which are error components, so this can be called an error components model.

### B. Panel Cointegration Tests and Estimation

The cointegration methodology as applied to time series data was first introduced in the 1980s (e.g., Engle & Granger, 1987; Johansen, 1988, 1991, 1992a, 1992b, 1995;

Johansen & Juselius, 1990, 1992). In the early 1990s, cointegration techniques were extended to apply to panel data. There has been much research on panel cointegration since the late 1990s. Excellent surveys on nonstationary panels, panel cointegration, and dynamic panels are presented in Baltagi (2008, Chapter 12), Baltagi and Kao (2000), and Banerjee (1999), among others.

A panel unit root and cointegration approach has many benefits compared to a conventional time series approach. First, by pooling time series and cross sections, the finite sample power of the test is significantly improved. Conventional unit root tests, such as the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, are widely reported to have low power performance when the time-series sample size is small. Levin and Lin (1992, 2002), Im, Pesaran, and Shin (1997, 2003), and others demonstrate that the power of unit root tests using panel data is substantially improved over univariate testing procedures. Mark and Sul (2001), and Pedroni (1997, 1999, 2004) also report power improvement of the panel cointegration approach. Second, pooling time series and cross sections (using panel data) may provide more useful information on the nature of the economic system of equations for a group of countries or institutions, than individually analyzing a single equation for each country or institution.

This study allows heterogeneity in individual specific fixed effects across countries by use of nonstationary, dynamic panel testing procedures. It applies panel unit root and cointegration testing and estimation methods to research on international capital mobility and thereby improves the power performance of the relevant estimation and inference procedures. If the existence of unit roots in the various panel data series is proved by panel unit root tests, the existing studies that do not consider panel unit roots can suffer from reduced confidence in their estimation and inference results, due to the spurious regression problem (Granger & Newbold, 1974).[1] Entorf (1997) finds similar spurious regression phenomena and misleading inference results in panel data models. Kao (1999) and Phillips and Moon (1999) derive the least squares dummy

1. The spurious regression problem occurs when regression analyses are carried out for the I(1) (integrated process of order one) variables that follow mutually independent (uncorrelated) integrated processes (nonstationary time series processes with unit roots). In this case, there is a risk that the two variables seem to have a close relationship, since the regression coefficients are significantly different from zero, $R^2$ values are high, and the estimated residuals show high positive autocorrelation. A spurious or dubious regressional relationship emerges, even though the regression coefficients, t-statistics, and $R^2$ values must all be 0 under the null hypothesis, because the two integrated processes are originally independent so that the covariance between their error terms is 0. In the case of spurious regression, the correct result, that there is no relationship between the two variables, can be obtained by performing regression analysis using differenced data instead of level variables.

variable estimator and asymptotic distributions of various conventional statistics for spurious regression panel data models.

In the presence of panel unit roots, it is necessary to estimate the regression equation by panel cointegration techniques such as CCR, DOLS, and FMOLS, based on panel cointegration tests. Panel unit root tests can be categorized into tests assuming a common unit root process across cross sections and those positing individual unit root processes. Levin, Lin, and Chu (2002), Breitung (2000), Hadri (2000), and Harris and Tzavalis (1999) all postulate that there is a common unit root process across cross sections. Im, Pesaran, and Shin (2003), Choi (2001), and Maddala and Wu (1999) propose panel unit root tests that allow for individual unit root processes, so that the persistence parameter (autocorrelation coefficient) may vary across cross sections. Among these, only Hadri's (2000) panel unit root test has the null hypothesis of no unit root, similar to the single series unit root test of Kwiatkowski, Phillips, Schmidt, and Shin (1992). All other panel unit root tests have the null of unit roots. All the researchers above corroborate the fact that panel unit root tests have a greater power than conventional single-series unit root tests by Monte Carlo simulations.

Kao (1999), McCoskey and Kao (1998), and Pedroni (1999, 2004) have proposed panel cointegration tests. Kao (1999) presents residual-based tests for cointegration regression in panel data. He constructs DF (Dickey-Fuller) and ADF tests for the null of no cointegration. McCoskey and Kao (1998) propose a residual-based Lagrange multiplier (LM) test for the null of cointegration in panel data. They find that the empirical sizes of the LM-FMOLS and LM-DOLS are close to the true size even in small samples. In the model that McCoskey and Kao (1998) use, both intercepts and slope coefficients may vary across cross-sectional units, as in Im, Pesaran, and Shin (1997, 2003) and Pedroni (1999, 2004).

Pedroni (1999, 2004) examines the properties of residual-based tests for the null of no cointegration for dynamic panels in which both the short-run dynamics and the long-run slope coefficients are permitted to be heterogeneous across individual members of the panel. He considers both pooled within dimension tests and group mean between dimension tests. He shows that the limiting distributions of the tests are normal and free of nuisance parameters. He derives seven test statistics for the null of no cointegration in heterogeneous panels with multiple regressors. He demonstrates that following appropriate standardizations, each of the seven statistics above will be distributed as standard normal when both the time series and cross-sectional dimensions of the panel grow large.

Kao and Chiang (2000) study the asymptotic distributions for OLS, FMOLS, and DOLS estimators in cointegrated regression models of panel data. Their Monte Carlo simulation results show that the OLS estimator has a non-negligible bias in finite samples, the FMOLS estimator does not improve over the OLS estimator in general, and the DOLS outperforms both the OLS and FMOLS estimators. Pedroni (2000, 2004) also presents independent estimation methods of the panel cointegration model using FMOLS. This study estimates the panel regression model of the savings- investment equation, utilizing CCR, DOLS, and FMOLS techniques, after properly considering the panel unit root test results on the data variables. Due to space limitations, technical details of specific panel cointegration tests and estimation procedures have been omitted from the paper. Readers may refer to the papers summarized above for technical details.

## III. Empirical Analysis

### *A. Data*

This analysis is based on annual macroeconomic data from 28 Asia-Pacific countries—Australia, Bangladesh, Bhutan, Brunei, Cambodia, China, Fiji, Hong Kong, India, Indonesia, Japan, Korea, Macao, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Vanuatu, and Vietnam—over the 1960-2006 period. The data on domestic savings and investment rates (gross domestic savings and gross capital formation, each as a percentage of GDP) were extracted from the *World Bank's World Development Indicators 2008.*

Table 1 displays the descriptive statistics of the investment and savings rate series for 28 countries. The average investment and savings rates are 24.5 percent and 21.1 percent, respectively; their maximum values are 70.2 percent and 68.3 percent, respectively. The standard deviation (showing the degree of dispersion from the mean) for the savings rate is greater (by 54 percent) than that for the investment rate. Also reported are Jarque-Bera statistics for testing whether the series are normally distributed. Under the null hypothesis of a normal distribution, the Jarque-Bera statistic is distributed as $\chi^2$ with 2 degrees of freedom. The reported p-values are the probability that a Jarque-Bera statistic exceeds (in absolute value) the observed value under the null hypothesis. A small probability value leads to the rejection of the null hypothesis of a normal distribution. For the investment and savings rate series above, the hypothesis of normal distribution at the 1 percent significance level is rejected. As expected, the investment and savings rate series of 28 Asia-Pacific countries are far from a normal distribution.

**Table 1. Descriptive Statistics of the Variables for 28 Asia-Pacific Countries (1960-2006)**

| | Investment rate (I/Y) | Savings rate (S/Y) |
|---|---|---|
| Mean (average) | 24.50 | 21.08 |
| Median | 23.25 | 20.95 |
| Maximum | 70.23 | 68.33 |
| Minimum | 4.35 | -73.99 |
| Standard deviation | 9.18 | 14.13 |
| Skewness | 0.90 | -0.35 |
| Kurtosis | 5.01 | 5.48 |
| Jarque-Bera ($\chi^2$) | 321.96 (0.00**) | 285.20 (0.00**) |
| Number of observations | 1,059 | 1,033 |

Source: World Bank, *World Development Indicators 2008*, 2008.
Notes: Numbers in parentheses denote marginal significance levels (p-values). ** denotes significance at 1%. Jarque-Bera is a test statistic for whether the series is normally distributed. Under the null hypothesis of a normal distribution, the Jarque-Bera statistic is distributed as $\chi^2$ with 2 degrees of freedom. A small probability value leads to the rejection of the null hypothesis of a normal distribution. For the investment and savings rate series above, the hypothesis of normal distribution at the 1% significance level is rejected.

### *B. Empirical Results*

As discussed earlier, this analysis is performed in four steps. First, conventional univariate unit root tests are conducted to find the order of integration of the savings and investment rate series for individual countries. Second, five types of panel unit root tests are employed to confirm the nonstationarity of the series in a panel system of the entire countries. Third, three types of panel cointegration tests (Johansen, 1995; Kao, 1999; Pedroni, 2004) are used to establish a cointegrating (long-term equilibrium) relationship between domestic savings and investment rates. Fourth, three types of panel cointegration estimation techniques—CCR, DOLS, and FMOLS—are utilized to obtain estimates on the savings-retention (or Feldstein-Horioka) coefficient. This estimation is performed for different subsample periods to find evidence for the extent and magnitude of changes in capital mobility over time.

This section reports the results of panel unit root and cointegration tests on the variables, and estimation of the savings-investment equation by CCR, DOLS, and FMOLS.

Table 2 exhibits the results of univariate unit root tests on the savings and investment rates of 28 individual countries from 1960 to 2006. It presents the results of three

**Table 2. Univariate Unit Root Tests for Individual Countries**

| Country | Investment rate | | | Savings rate | | |
|---|---|---|---|---|---|---|
| | ADF | PP | ADF-GLS | ADF | PP | ADF-GLS |
| Australia | -2.68 (0.09) | -2.55 (0.11) | -2.01 (0.05*) | -2.20 (0.21) | -2.14 (0.23) | -1.40 (0.17) |
| Bangladesh | -0.93 (0.77) | -0.92 (0.77) | -0.13 (0.90) | -0.59 (0.86) | -1.21 (0.66) | -0.61 (0.54) |
| Bhutan | 2.45 (0.99) | -1.73 (0.40) | -1.34 (0.19) | -1.91 (0.32) | -1.12 (0.69) | -1.05 (0.31) |
| Brunei | -0.84 (0.78) | -1.05 (0.71) | -0.93 (0.37) | -1.07 (0.70) | -1.07 (0.70) | -1.19 (0.25) |
| Cambodia | -1.80 (0.37) | -1.64 (0.45) | -1.55 (0.13) | -0.99 (0.74) | -1.54 (0.50) | -1.88 (0.10) |
| China | -1.47 (0.54) | -1.41 (0.57) | -1.52 (0.14) | -0.11 (0.94) | -0.06 (0.95) | 0.29 (0.77) |
| Fiji | -2.75 (0.07) | -2.75 (0.07) | -2.77 (0.01**) | -3.04 (0.04*) | -3.01 (0.04*) | -3.11 (0.003**) |
| Hong Kong | -3.64 (0.01**) | -2.47 (0.13) | -3.68 (0.001**) | -2.59 (0.10) | -2.35 (0.16) | -1.87 (0.07) |
| India | 0.78 (0.99) | 0.88 (0.99) | 1.29 (0.21) | 0.32 (0.98) | -0.05 (0.95) | 1.20 (0.24) |
| Indonesia | -2.04 (0.27) | -2.04 (0.27) | -1.34 (0.19) | -1.69 (0.43) | -1.69 (0.43) | -1.26 (0.21) |
| Japan | -0.63 (0.85) | -0.63 (0.85) | -0.59 (0.56) | -0.07 (0.95) | -0.40 (0.90) | -0.69 (0.49) |
| Korea | -2.71 (0.08) | -2.74 (0.07) | -1.18 (0.24) | -2.39 (0.15) | -2.80 (0.07) | -0.51 (0.62) |
| Macao | -1.98 (0.29) | -1.50 (0.52) | -2.06 (0.05) | -0.64 (0.84) | -0.67 (0.84) | -0.36 (0.72) |
| Malaysia | -1.96 (0.30) | -2.10 (0.25) | -1.44 (0.16) | -1.22 (0.66) | -1.03 (0.74) | -1.06 (0.29) |
| Mongolia | -2.08 (0.25) | -2.22 (0.21) | -1.27 (0.22) | -2.13 (0.24) | -2.05 (0.27) | -2.18 (0.04*) |
| Myanmar | -3.32 (0.02*) | -3.42 (0.02*) | -3.29 (0.002**) | -3.67 (0.01**) | -3.75 (0.01**) | -3.71 (0.001**) |
| Nepal | -3.06 (0.04*) | -1.17 (0.68) | -0.43 (0.67) | -2.71 (0.08) | -2.66 (0.09) | -1.52 (0.14) |
| New Zealand | -2.53 (0.12) | -2.59 (0.11) | -2.55 (0.02*) | -4.21 (0.003**) | -2.68 (0.09) | -3.47 (0.002**) |
| Pakistan | -3.62 (0.01**) | -3.92 (0.004**) | -1.54 (0.13) | -1.84 (0.36) | -1.68 (0.43) | -1.64 (0.11) |
| Papua New Guinea | -4.30 (0.002**) | -2.10 (0.25) | -2.03 (0.05*) | -1.83 (0.36) | -1.94 (0.31) | -1.50 (0.14) |
| Philippines | -1.69 (0.43) | -1.91 (0.33) | -1.48 (0.15) | -2.00 (0.29) | -1.87 (0.34) | -1.93 (0.06) |
| Singapore | -1.93 (0.32) | -2.00 (0.28) | -1.03 (0.31) | -2.85 (0.06) | -2.10 (0.25) | -1.52 (0.14) |
| Solomon Islands | -2.50 (0.13) | -2.45 (0.14) | -2.67 (0.02*) | -4.78 (0.01**) | -2.99 (0.07) | -3.94 (0.01**) |
| Sri Lanka | -2.08 (0.25) | -2.20 (0.21) | -1.19 (0.24) | -3.19 (0.03*) | -2.92 (0.05*) | -3.16 (0.003**) |
| Thailand | -2.68 (0.09) | -2.24 (0.19) | -1.34 (0.19) | -1.78 (0.39) | -1.78 (0.39) | -0.48 (0.63) |
| Tonga | -1.84 (0.35) | -1.84 (0.35) | -1.67 (0.11) | -4.90 (0.001**) | -4.90 (0.001**) | -3.73 (0.001**) |
| Vanuatu | -1.50 (0.51) | -1.50 (0.51) | -1.58 (0.14) | -2.99 (0.06) | -1.89 (0.33) | -1.95 (0.07) |
| Vietnam | -2.99 (0.06) | -0.66 (0.84) | -0.70 (0.50) | -0.43 (0.89) | -0.35 (0.90) | -0.40 (0.70) |

Notes: Numbers in parentheses denote MacKinnon's (1996) one-sided p-values. * and ** denote significance at 5% and 1%, respectively. GLS = generalized least squares. ADF-GLS statistics are from Elliott, Rothenberg, and Stock's (1996) DF-GLS tests.

different unit root tests: ADF, PP (Phillips & Perron, 1988), and ADF-generalized least squares (Elliott, Rothenberg, & Stock, 1996). The null hypothesis of unit root is not rejected for most countries at conventional significance levels, except for a few cases—the savings rates of Fiji, Myanmar, New Zealand, Solomon Islands, Sri Lanka, and Tonga, and the investment rates of Hong Kong, Myanmar, Pakistan, and Papua New Guinea. Although savings and investment rate series for most countries seem to have unit roots, we need to be sure about the nonstationarity of the variables by conducting panel unit root tests, which are more powerful than conventional univariate tests.

Table 3 presents the results of five distinct panel unit root tests, such as Levin, Lin, and Chu's (2002) t*, Breitung's (2000) t, Hadri's (2000) Z, Im, Pesaran, and Shin's (2003) W, and Maddala and Wu's (1999) ADF-Fisher $\chi^2$ statistics. Among these, Levin, Lin, and Chu's, Breitung's, and Hadri's tests are based on the common unit root process assumption that the autocorrelation coefficients of the tested variables across cross sections are identical. However, IPS and ADF-Fisher $\chi^2$ tests rely on the individual unit root process assumption that the autocorrelation coefficients vary across cross sections.

All four panel unit root tests except for Hadri's (2000) have the null hypothesis of unit roots, while Hadri's test posits the null of no unit roots (stationarity). All five distinct panel unit root tests in Table 3 confirm that both the savings and investment rates of 28 countries have unit roots and are thus nonstationary.

**Table 3. Panel Unit Root Tests for Savings and Investment**

| | Tests assuming a common unit root process | | | Tests assuming individual unit root processes | |
|---|---|---|---|---|---|
| Series name | LLC t*-stat: $H_0$: Unit root | Breitung t-stat: $H_0$: Unit root | Hadri Z-stat: $H_0$: No unit root | IPS W-stat: $H_0$: Unit root | ADF-Fisher $\chi^2$: $H_0$: Unit root |
| Investment rate | -0.52 (0.30) | -0.99 (0.16) | 15.52 (0.00**) | 1.29 (0.90) | 46.13 (0.82) |
| Savings rate | 3.25 (0.99) | -0.32 (0.37) | 9.67 (0.00**) | -0.27 (0.39) | 58.93 (0.37) |

Notes: Numbers in parentheses denote marginal significance levels (p-values). * and ** denote significance at 5% and 1%, respectively. All four panel unit root tests above except for Hadri's (2000) have the null hypothesis of unit roots (nonstationarity), while Hadri's test posits the null of no unit roots (stationarity).

Table 4 reports the results of panel cointegration tests for the same countries and years. It shows three different kinds of panel cointegration tests such as residual-based tests of Kao (1999) and Pedroni (2004), and maximum likelihood-based Fisher-type Johansen's (1995) tests. Some authors, like Christopoulos (2007), argue that using likelihood-based tests is superior to the residual-based panel cointegration tests. The

**Table 4. Panel Cointegration Tests for Savings and Investment**

| Panel cointegration tests | Statistics | Equation: (I/Y) = f (S/Y) |
|---|---|---|
| Pedroni ($H_0$: no cointegration) | Panel $\nu$ (nu) | 1.53 (0.06) |
| | Panel $\rho$ (rho) | -6.33 (0.00**) |
| | Panel PP | -5.26 (0.00**) |
| | Panel $\rho$ ADF | -5.79 (0.00**) |
| | Group (rho) | -2.50 (0.01**) |
| | Group PP | -3.98 (0.00**) |
| | Group ADF | -4.65 (0.00**) |
| Kao ($H_0$: no cointegration) | ADF t | -4.63 (0.00**) |
| Johansen-Fisher (hypothesized number of CEs: 0) | Trace test<br>Maximum-eigenvalue test | 120.1 (0.00**)<br>107.8 (0.00**) |
| Johansen-Fisher (hypothesized number of CEs: at most 1) | Trace test<br>Maximum-eigenvalue test | 62.54 (0.26)<br>62.54 (0.26) |

Notes: $H_0$ = null hypothesis, CE = cointegrating equation. Numbers in parentheses denote marginal significance levels (p-values). ** denotes significance at 1%.

null hypothesis of all three tests is no cointegration. Pedroni's six out of seven statistics for heterogeneous panels and Kao's ADF t statistics indicate the possibility of a cointegrating (or long-run equilibrium) relationship between savings and investment rates. In particular, Johansen's trace and maximum-eigenvalue tests suggest the existence of one cointegrating equation between domestic savings and domestic investment.

The results of this study appear to contradict those of Narayan and Narayan (2010), who could not find evidence of a cointegrating relationship between savings and investment for G7 countries using only Pedroni's (1999) methodology. However, Christopoulos (2007), using Johansen's panel cointegration tests, found that savings and investment for a panel of OECD countries from 1950 to 1992 are cointegrated. Since this study employs both Johansen's and Pedroni's tests as well as others, its results may provide more persuasive and conclusive evidence on the issue. This study also provides estimates of the savings-retention coefficient based on three distinct panel cointegration estimation procedures (CCR, DOLS, and FMOLS), while many authors, including Christopoulos (2007) and Narayan and Narayan (2010), do not furnish the coefficient estimates due to technical restrictions on panel cointegration estimation, and only report panel cointegration test results.

Table 5 shows savings-retention coefficient ($\beta$) estimates as a measure of capital mobility using three types of panel cointegration estimation techniques: CCR, DOLS,

**Table 5. Panel Cointegration Estimation of the Savings-Retention Coefficient**

| | 1960-2006 | 1960-1979 | 1980-1997 | 1998-2006 |
|---|---|---|---|---|
| CCR | 0.31<br>(7.70; 0.00**) | 0.51<br>(8.35; 0.00**) | 0.32<br>(5.83; 0.00**) | 0.12<br>(1.56; 0.12) |
| DOLS | 0.32<br>(7.65; 0.00**) | 0.51<br>(7.56; 0.00**) | 0.32<br>(5.57; 0.00**) | 0.10<br>(1.11; 0.27) |
| FMOLS | 0.31<br>(7.84; 0.00**) | 0.50<br>(8.59; 0.00**) | 0.32<br>(5.87; 0.00**) | 0.12<br>(1.66; 0.10) |

Notes: ** denotes significance at 1%. Numbers in parentheses represent t-ratios (t) and marginal significance levels (p = p-value) from the cointegrating regressions. Figures in the table are organized in the order of coef (t; prob) = coefficient estimate (t-ratio; p-value). The standard errors used in the calculations of the t-statistics in all the tables are panel heteroskedasticity consistent standard errors of the White (1980) type. The estimation results for the panel cointegrating regressions with no time trend and with a linear time trend were almost identical, and thus only one result is presented.

and FMOLS. The estimation results are presented for the entire 47-year sample period (1960-2006) and subsample periods of 1960-79, 1980-97, and 1998-2006. The rationales for the categorization of subsamples are the substantial increase in international capital mobility in the 1980s and the 1997-98 Asian currency crisis. The estimation results of CCR, DOLS, and FMOLS are very similar for all the sample periods. There is a downward trend in the savings-retention coefficient estimates over the subsample periods. For example, the DOLS estimates fall from 0.51 for 1960-1979 to 0.32 for 1980-1997 and to 0.10 for 1998-2006. This implies that international capital mobility in the 28 Asia-Pacific countries almost quintupled from 1960 to 2006. The CCR and FMOLS estimates also show a similar trend, with a quadruple increase in capital mobility over the same period. Although the savings-retention coefficient estimates for 1998-2006 are only marginally significant[2] at around 10 percent, their declining trend is quite obvious. The increase in international capital mobility from 1998 to 2006 may be partly due to the acceleration of capital market liberalization measures taken by Korea and other countries as part of the reform policy recommended by the International Monetary Fund after the Asian currency crisis in 1998.

2. This low significance may have come from the data problem that a smaller number of annual observations is available for 1998-2006 than for other subperiods. We should distinguish between insignificant estimates of the savings retention coefficient and no cointegration. The existence of cointegration between savings and investment has already been proven by the results of the panel cointegration tests reported in Table 4. Hence, the insignificant estimates only mean that the coefficient is estimated with high standard errors due to the data shortage problem for the 1998-2006 subperiod.

Feldstein and Horioka (1980) found that the savings-retention coefficient estimates range from 0.89 (using gross savings and investment) to 0.94 (with net savings and investment) from 1960 to 1974 for 16 OECD countries. In contrast to common beliefs, we see that even for the similar period of 1960-1979, Asia-Pacific countries showed much higher capital mobility (lower coefficient estimates) than OECD countries. This result may arise from differences in estimation methods, such as cross-section average vs. panel cointegration estimation, or from intrinsic differences in data between developed OECD countries and developing Asian countries. Considering the superior power performance and accuracy of panel cointegration estimation procedures compared to cross-section average estimation, it is possible to conclude that capital mobility was higher than expected and showed a rapidly increasing trend in the 28 Asian countries over the 1960-2006 period.

As shown in Tables 2-5, the domestic savings and investment rate series are integrated of order one, individually and in a panel system of 28 countries, by conventional univariate and five panel unit root tests. The maximum likelihood-based panel cointegration tests of Johansen (1995), and residual-based tests of Kao (1999) and Pedroni (2004) provide evidence suggesting that there is one cointegrating relationship between savings and investment rates. The estimates of the savings -retention coefficient as a measure of capital mobility by three types of panel cointegration methodologies—CCR, DOLS, and FMOLS—all indicate a downward trend in the coefficient, implying increasing capital mobility for the 28 Asia-Pacific countries over the 1960-2006 period.

The magnitude of the estimated coefficients is much smaller, ranging from 0.10 to 0.51, than those (0.89-0.94) reported by Feldstein and Horioka (1980). In contrast to the data on developed OECD countries in Feldstein and Horioka (1980), the panel data in this paper include rapidly growing high-performance Asian countries: China, Hong Kong, India, Indonesia, Korea, Malaysia, Singapore, Thailand, and Vietnam. Higher levels of marginal productivity of capital and greater demand for foreign capital for growth in these rapidly developing economies may have contributed to higher capital mobility and greater foreign investment than in industrialized OECD countries with lower yields from capital.

## IV. Concluding Remarks

This study uses the most recent econometric techniques combined with more expanded panel datasets over time and space (including more time series and cross-section countries) to derive policy implications, using a panel cointegration framework. Similar studies on Asia-Pacific developing countries have been relatively rare and have focused on fewer countries. This study uses a variety of panel cointegration tests encompassing both residual-based (Kao, 1999; Pedroni, 2004) and maximum likelihood-based tests (Fisher-type—Johansen, 1995), and the CCR, DOLS, and FMOLS estimation methods. Most other studies to date have used only one or two tests to examine the savings-investment correlation, and most have focused on OECD countries. This study bases estimates of the savings-retention coefficient on three distinct panel cointegration estimation procedures, while many studies have been limited to reporting panel cointegration test results.

This study finds investment and savings rates to be nonstationary and cointegrated, based on five different panel unit root tests (Levin, Lin, & Chu, 2002; Breitung, 2000; Hadri, 2000; Im, Pesaran, & Shin, 2003; Maddala & Wu, 1999) and three types of panel cointegration tests (Johansen, 1995; Kao, 1999; Pedroni, 2004). The residual-based panel cointegration tests of Pedroni (2004) and Kao (1999) all indicate rejection of the null hypothesis of no cointegration at conventional significance levels, implying the existence of panel cointegration. Moreover, Johansen's (1995) maximum likelihood-based panel cointegration tests using trace and maximum-eigenvalue statistics provide evidence for the existence of one cointegrating relationship in the savings-investment equation.

In this study, the estimated coefficients on the savings rate utilizing CCR, DOLS, and FMOLS techniques all display a declining trend over subsample periods including the structural break for the Asian financial crisis in 1997-98. According to Feldstein and Horioka (1980), a lower savings- retention coefficient signifies higher capital mobility, since it indicates lower correlation between domestic savings and domestic investment. This study found that capital mobility in the Asia-Pacific economies almost quadrupled from the 1960s to the 2000s. According to the estimation results, international capital mobility in the Asia-Pacific countries significantly increased in the 1990s and 2000s.

Empirical findings of this paper may be summarized as follows.

1. The domestic savings and investment rate series are integrated of order one (nonstationary), individually and in a panel system of 28 countries. The maximum likelihood-based panel cointegration tests of Johansen (1995), and residual-based tests of Kao (1999) and Pedroni (2004) provide evidence suggesting that there is one cointegrating relationship between savings and investment rates.
2. The estimates of the savings-retention coefficient as a measure of capital mobility by three types of panel cointegration methodology—CCR, DOLS, and FMOLS—all indicate a declining trend in the coefficient, implying increasing capital mobility for the 28 Asia-Pacific countries from 1960 to 2006.

3. The magnitude of the estimated coefficients is much smaller, ranging from 0.10 to 0.51, than those (0.89-0.94) reported by Feldstein and Horioka (1980), who did not consider the nonstationarity of data and the resulting spurious regression problem.

This study draws on data from rapidly growing, high-performance Asian countries such as China, Hong Kong, India, Indonesia, Korea, Malaysia, Singapore, Thailand, and Vietnam. Higher levels of marginal productivity of capital and greater demand for foreign capital for growth in these rapidly developing economies may have contributed to higher capital mobility and greater foreign investment than in industrialized OECD countries with lower yields from capital. This has a policy implication that properly utilizing foreign capital to supplement insufficient domestic savings is a wise growth strategy for developing economies.

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