International capital mobility: Evidence from panel cointegration tests

John Thornton
Olumuyiwa S Adedeji
International capital mobility: Evidence from panel cointegration tests

Olumuyiwa Adedeji, John Thornton

Fiscal Affairs Department, International Monetary Fund, 700 19th Street N.W., Washington DC 20431, USA

Received 21 December 2006; received in revised form 11 July 2007; accepted 6 August 2007

Available online 15 August 2007

Abstract

Panel cointegration techniques applied to pooled data for 50 developed and developing economies for the period 1970–2000 indicate that savings and investment are non-stationary and cointegrated, that there are marked differences in saving–retention ratios between different country groups, and that retention ratios have fallen.

© 2007 Elsevier B.V. All rights reserved.

Keywords: Feldstein–Horioka approach; Panel unit roots; DOLS panel cointegration

JEL classification: F31;F32

1. Introduction

The Feldstein and Horioka (1980) claim that capital was relatively immobile remains controversial. They based this claim on the results of cross-section regressions of investment and savings ratios across 16 OECD countries for the 1960–74 period, reasoning that saving and investment would be perfectly correlated in a closed economy but should be unrelated in an open economy since saving could seek out the highest global returns. How economists have responded to the Feldstein–Horioka puzzle has been reviewed thoroughly by Coakley et al. (1998), who conclude that while the savings–investment association is generally accepted, there remains a considerable debate about whether it is informative about capital mobility.¹

2. Panel estimation of the Feldstein–Horioka regression

In this note, we focus on the savings–investment association over the period for a panel of 50 developed and developing economies, and separately for data panels of different groups of countries that might be expected to have broadly similar characteristics.² We exploit recent advances in panel cointegration techniques that make it possible to estimate consistently the long-run association between variables and examine whether the cointegration coefficients (savings–retention ratios) have changed over time.³

The first step is to analyze the time series properties of the data in order to determine the persistence of the pooled savings and investment rates. Panel unit root tests have been

¹ Other explanations for the high correlation include: (i) that the endogeneity of saving implies that other (exogenous) factors could produce a high correlation even if capital is mobile, such as the procyclicality of saving and investment, population growth, productivity and other shocks, the presence of a non-traded consumption good, and the government’s reaction to current account imbalance; (ii) country size effects whereby, for example, an increase in national saving in a large country would reduce the world interest rate leading to an increase in domestic investment; and (iii) that the cross-section regressions capture the unit coefficient implied by the current account solvency condition constraint and not the degree of capital mobility. See Coakley et al. (1998).

² The countries in the different groups are as follows: OECD: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Luxemburg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and the United States; Asia: China, Hong Kong, Indonesia, India, Japan, Korea, Sri Lanka, Malaysia, Pakistan, Philippines, Singapore and Thailand; Latin America: Argentina, Bolivia, Brazil, Chile, Columbia, Mexico, Panama, Paraguay and Uruguay. The data source is the Penn World Tables (version 6.1) and the data are annual for the period 1970–2000.

³ Much of the empirical literature employs country-by-country time series analyses of the integration and cointegration properties of savings and investment series, which employs techniques that often are of low power in small samples and does not take advantage of information across countries.
developed on the same principles that underlie the conventional ADF test. Their most valuable feature is the degree of homogeneity that they allow. We use the panel unit root test proposed by Levin et al. (2002) (LLC), which allows for heterogeneity of the intercepts across members of the panel, and by Im et al. (2003) (IPS), which allows for heterogeneity of the intercepts as well as in the slope coefficients; both of them are constructed by averaging individual augmented Dickey–Fuller (ADF) (Dickey and Fuller, 1979) t-statistics across cross-section units.

The LLC test is of the null hypothesis that each individual time series in the panel is integrated versus the alternative hypothesis that all individual time series are stationary and is determined by the conventional step-down procedure. The null of $H_0: \delta=0$ under the assumption that $\delta_i=\delta$ for all $i$ is tested against the alternative hypothesis, $H_1: \delta<\delta_i$ for all $i$. The test is based on a technique that removes autocorrelation as well as deterministic components.

### Table 1
Panel unit root tests for saving and investment ratios, 1970–2000

<table>
<thead>
<tr>
<th>Countries</th>
<th>Period</th>
<th>Saving–retention ratio</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (50 countries)</td>
<td>1970–2000</td>
<td>0.716</td>
<td>19.950</td>
</tr>
<tr>
<td>OECD*</td>
<td>1970–2000</td>
<td>0.507</td>
<td>9.076</td>
</tr>
<tr>
<td>Asia</td>
<td>1970–2000</td>
<td>0.732</td>
<td>7.929</td>
</tr>
<tr>
<td>Latin America</td>
<td>1970–2000</td>
<td>0.642</td>
<td>6.420</td>
</tr>
<tr>
<td>Africa</td>
<td>1970–2000</td>
<td>0.454</td>
<td>6.737</td>
</tr>
</tbody>
</table>

Because of the limited number of observations, the results for the sub-period 1986–2000 should be interpreted with caution.

* Excludes Mexico, Korea and Japan, which are included in the samples for Asia and Latin America, and excludes Cyprus and because of limited data availability.

### Table 2
Panel cointegration test, 1970–2000

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SAF</td>
<td>DF-rho</td>
<td>PC1</td>
</tr>
<tr>
<td>OECD*</td>
<td>DF-t</td>
<td>PC2</td>
</tr>
<tr>
<td>Africa</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a $P$-values are in parenthesis.

b The DF test statistics are analogous to the parametric Dickey–Fuller test for non-stationary time series. The DF-rho and DF-t statistics assume strict exogeneity of the regressors with respect to errors and no autocorrelation. DF-rho* and DF-t* statistics are based on endogenous regressors. These tests depend on consistent estimates of the long-run variance-covariance matrix to correct for nuisance parameters once the limiting distribution has been found. The ADF test is analogous to the Augmented Dickey–Fuller test for non-stationary time series.

c PC1 and PC2 are the non-parametric Phillips–Perron tests.
The panel specification for the IPS test takes the form:

$$\Delta y_{it} = \alpha_{0i} + \alpha_{1i} t + \beta_{1i} + \delta y_{it-1} + \sum_{j=1}^{p_i} \beta_{ji} \Delta y_{it-j} + \epsilon_{it}$$

(2)

where \(P_i\), \(\alpha_{0i}\), and \(\alpha_{1i}\) are as in Eq. (1) and \(\theta_i\) represents the time dummies used to account for cross-sectional correlation that could result from common shocks affecting all countries in the panel in the period. The null of \(H_0: \delta_i = 0\) for all \(i\) (i.e., all series have a unit root) is tested against the alternative \(H_1: \delta_i < 0\) for \(i=1,2,\ldots, N_i\) and \(\delta_i = 0\), for \(i=N_i+1, N_i+2,\ldots, N\). On the assumption that the \(N\) cross-section units are independently distributed, the \(t\)-statistic can be computed as an average of the individual ADF \(t\)-statistics such that:

$$t_{NT}(p, \rho) = \frac{\sum_{i=1}^{N} t_{iT}(p_i, \rho)}{N}$$

(3)

where \(t_{iT}(p_i, \rho)\) is the \(t\)-statistic for testing \(\delta_i = 0\) in each individual ADF regression. In a further step, the above \(t\)-bar statistic is standardized so that it converges to a standard normal distribution, as \(N\) increases. A key strength of the IPS test is that \(\delta_i\) is allowed to differ across countries and only a fraction of panel members is required to be stationary under the alternative hypothesis.

The results of the LLC and IPC tests are reported in Table 1. It shows that the null of the unit roots for the panel data for the savings and investment series cannot be rejected by both the LLC and the IPS tests for the panel of all countries or for the panels of country groups. Therefore, we can implement a test for panel cointegration between savings and investment.

The next step is to test whether savings and investment are cointegrated. The available techniques for panel cointegration tests are in essence an application of the Engle and Granger (1987) cointegration analysis. As in the analysis of single time series, these approaches test the residuals from the estimation for stationarity. Kao (1999) and Pedroni (2004) provide different statistics for this purpose, both of which assume homogenous slope coefficients across countries.

Kao (1999) tests the residuals \(\hat{e}_{it}\) of the OLS panel estimation by applying DF- and ADF-type tests:

$$\hat{e}_{it} = \rho_{a-1} + \epsilon_{it}$$

(4)

and

$$\hat{e}_{it} = \rho_{a-1} + \sum_{j=1}^{p} \phi_j \Delta \hat{e}_{it-j} + \epsilon_{it}.$$  

(5)

The null hypothesis of no cointegration, \(H_0: \rho = 1\), is tested against the alternative hypothesis of stationary residuals, \(H_1: \rho < 1\). Kao presents five DF and ADF types of cointegration tests in the panel data, the asymptotic distributions of which converge to a standard normal distribution \(N(0,1)\). The test statistics are \(DF_{a0} \times \beta\), \(DF_{a}\) and ADF, which are for cointegration with the endogenous regressors, and \(DF_{a0}\) and \(DF_{a}\) which are based on assuming strict endogeneity of the regressors. Building on the assumption that regressors are strictly exogenous, Pedroni (2004) suggests a Phillips–Perron-type test, which implies less strict assumptions with respect to the distribution of the error terms than do the DF and ADF tests, and provides two test statistics, \(PC_1\) and \(PC_2\), which converge to a standard normal distribution. Table 2 shows the outcomes of the cointegration tests between savings and investment rates. The results indicate that the null hypothesis of no cointegration between saving and investment ratios can be rejected at conventional significance levels for the panel of all countries and for the panels of country groups.

Finally, we use the dynamic ordinary least squares (DOLS) developed by Kao and Chiang (2001) to estimate the long-run cointegrating vector between saving and investment.\(^4\) This estimator is designed for non-stationary panels and corrects the standard pooled OLS for serial correlation and endogeneity of regressors that are normally present in long-run economic relationships. The estimates of the savings–retention ratio by period are reported in Table 3. There are several striking results. First, for the pool of all countries the retention ratio for the full sample period is relatively high (0.72) and broadly in line with the original Feldstein–Horioka result, though it declines over the sample period (from 0.8 to 0.64). Second, there are marked differences in retention ratios between country groups, with the lowest being for the OECD group (0.51) and, perhaps surprisingly, the African group (0.54), which seems likely to reflect the impact of non-market flows (foreign aid); and the highest being for the Asian group (0.73). Finally, for all country groups the retention ratio declined markedly over the sample period, with the decline most marked in the OECD and African country groups (from 0.63 to 0.3 and from 0.58 to 0.14, respectively), and least marked in the Latin American group (0.69 to 0.65). In all cases, the coefficients on the retention ratios are statistically significant. These results are similar to those from some recent studies using similar techniques. For example, Ho (2002) reports a savings–retention coefficients of 0.47 (DOLS) for a data panel of 20 OECD countries, and Kim et al. (2005) report a coefficient of 0.76 in 1960–1979 falling to 0.42 during 1980–1998 for a panel of 11 Asian countries. In their survey of the empirical literature, Coakley et al. (1998) summarize the cross-section coefficients as being around 0.62. Our results could be interpreted as indicating that capital has been mobile generally, that it has been very mobile in the OECD countries, and that it has increased substantially in recent years.

3. Conclusions

Applying recently developed panel cointegration techniques to a pool of 50 developed and developing economies for the period 1970–2000, we find that: (i) savings and investment are non-stationary and cointegrated series; (ii) that there are marked differences in saving–retention ratios between different country groups, with ratios lowest in the OECD and African economies; and (iii) that in all country groups retention ratios fell markedly

\(^4\) Kao and Chiang (2001) demonstrate the superiority of the dynamic OLS estimator with respect to OLS and full modified OLS in estimating panel regressions.
in the second half of the sample period. These results are consistent with international capital mobility having increased considerably over time.

References


