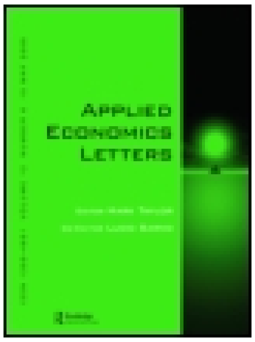

Applied Economics Letters

ISSN: 1350-4851 (Print) 1466-4291 (Online) Journal homepage: http://www.tandfonline.com/loi/rael20

Savings-investment cointegration in panel data

KEUN-YEOB OH , BONG-HAN KIM , HONG-KEE KIM & BYUNG-CHUL AHN

Applied Economics Letters, 1999, **6**, 477–480

Savings–investment cointegration in panel data

KEUN-YEOB OH, BONG-HAN KIM*, HONG-KEE KIM‡ and
BYUNG-CHUL AHN§

*Chung-Nam National University, Korea and *Inje University, ‡Han-Nam University and §Yeung-Nam University*

Received 10 September 1998

Existing cointegration tests for the savings–investment model are limited because of low testing power. In this paper the savings–investment correlation is re-examined using a panel cointegration test by which the power seems to be improved greatly. A cointegration relationship is obtained between the two variables with panel data, and the savings retention coefficient is far from zero. This seems to be consistent with results based on traditional regression methods. Thus, it is concluded that cointegration techniques do not provide the solution to the savings–investment puzzle.

I. INTRODUCTION

According to Feldstein and Horioka (1980) (hereafter FH), the relationship between national savings and domestic investment can be used as a measure of international capital mobility. If capital is perfectly mobile between countries, then investors don't care which country they are investing in. The crucial factor that concerns investors is the rate of return. Thus, with perfect world capital mobility, domestic saving is not necessarily related to domestic investment. Savings in each country respond to worldwide opportunities for investment, while the worldwide pool of capital finances investment in each country. Conversely, if international capital mobility is low, then incremental savings tend to be invested in the country of origin.

From this conjecture, FH assess the relationship between savings and investment by estimating regression equations of savings rates on investment rates, using data from the OECD countries. Their results show that the regression coefficient (the so-called savings retention coefficient) is close to 1, which indicates that most of the incremental savings tend to remain in the country where the savings have occurred. The paper by Feldstein and Horioka has led to a large body of research that supports their finding that there is a high correlation between domestic savings and investment. This result was not what many researchers expected, because they believed that capital was highly mobile across the borders of the OECD countries. For this reason we call their finding 'The Savings Investment Puzzle' (often called the 'Feldstein–Horioka Puzzle').

There are two ways to analyse the FH coefficient. The first is to use cross-sectional data and the second is to use time-series data. This paper re-examines the relationship between the two variables using time-series data. When we deal with time-series data, it is natural to check whether the data are stationary. If the data are non-stationary, we need to investigate the cointegration relationship between savings and investment.

Miller (1988), Gulley (1992) and Bodman (1995) explained capital mobility using the cointegration relationship between savings and investment. If there is cointegration between the two variables, the authors regard capital as highly immobile internationally. With no cointegration, capital is regarded as highly mobile. Various cointegration testing methods show no cointegration relationship between savings and investment using recent data for the US and for other countries. The authors argued that this is evidence of a high degree of capital mobility.

The results of these authors differed greatly from those of previous researchers who did not consider the non-stationarity of the data. Some researchers now consider the FH puzzle to be solved. They insist that the approach of previous researchers was incorrect, since the non-stationarity property of the data was not considered. They argue that if we considered the non-stationarity of the data and used cointegration techniques, then the results would meet our expectations of a high degree of international capital mobility between OECD countries. There would no longer be a puzzle.

Is this argument reasonable? We think it may not be. What was it that made the recent results using the cointegration approach differ from previous results using the 'traditional' approach? Which results are more reliable? This paper focuses on this econometrics problem.

It is now well known that unit root tests have very low testing power. Therefore, if we use these tests for cointegration

1350–5851 © *1999 Routledge*

analysis, the procedure may give rise to erroneous results. In our paper, we employ a panel data approach to examine the relationship between domestic savings and investment. Panel analysis can provide very dramatic improvement in the power of unit root tests, by increasing the number of observations. In the economics literature, a number of researchers have turned to panel data methods, partly inspired by Levin and Lin (1992; hereafter LL). For example, Oh, (1996), Wu (1996) and Papell (1997) use panel unit root tests for the study of exchange rates.

We use panel data to test whether the saving rates are cointegrated with the investment rates in the long term. We recently discovered that Coakley and Kulasi (1996) have also dealt with the FH problem using panel data. They use the methods of Im *et al.* (1995), and their results are quite similar to ours.

II. FELDSTEIN–HORIOKA ANALYSIS

A time-series version of the Feldstein-Horioka equation can be written as

$$(I/Y)_t = a + b\ (S/Y)_t + u_t \qquad (1)$$

Here I is domestic gross investment, S is national savings and Y is GDP. In Equation (1), b is called the 'savings retention coefficient'. A large value (near one) for b would imply that capital is likely to be immobile across national borders. On the other hand, if international capital markets are closely interrelated and capital is perfectly mobile between countries, then b would be close to zero. We will call b the FH coefficient.

A panel version of Equation 1 is as follows.

$$(I/Y)_{it} = a + b\ (S/Y)_{it} + u_{it} \qquad (2)$$

Here, we have additional subscripts i to t, indicating each country.

III. PANEL APPROACH FOR NON-STATIONARY DATA

We make use of a panel version of the 'Engle–Granger two-step method' for cointegration tests. The first step is to apply OLS to Equation 2 and to compute the time-series of the residuals from the regression. The second step is to apply unit root tests to the residuals by using the ADF (augmented Dickey–Fuller) test. This differs from single time-series data methods in that we pool the series of the residuals from several individuals.

Levin and Lin (1992), Im *et al.* (1995), Pedroni (1995, 1996), and Maddala and Wu (1997) developed methods for such non-stationary panel data. We used LL's statistic in our inference because it is the simplest to use. LL and other authors show that the power of the test increases greatly when using panel data. For example, if we apply unit root tests on data from a single country, when the AR(1) coefficient is 0.9 then the power is below 10%, even when $t = 100$, but the power increases to 90% when we use data from seven countries (see Levin and Lin, 1992).

It is well known that when implementing the Engle–Granger two-step method for testing cointegration, the critical values are different from those in the usual ADF unit root tests. This arises because the estimation in the first step creates some bias in the tests. Fortunately, we don't have this bias in panel cointegration (Pedroni, 1995, 1996). For example, Pedroni showed that the critical values for the statistic are the same, whether we use original data or estimated residuals. This property is very different from the usual single cointegration test.

In actual tests, we use two-step Monte-Carlo simulation results to obtain critical values, because the number of observations is finite and finite sample properties differ from asymptotic properties. We report the critical values for the cointegration tests from this simulation.

IV. TESTS AND RESULTS

Panel unit root tests with the data

All the data are obtained from the IFS CD-Rom (June 1996) data set. Our data cover the period from 1957 to 1995 for seven industrialized countries.

For a preliminary test, we implemented the unit root tests for individual data using the ADF test, using various time-lag terms. We could not reject the null hypothesis of unit roots in the savings rate and investment rate data. (We do not report these results to save space.)

Panel unit root tests are used to check whether these results from the unit-root test arise due to low testing power. Table 1 reports panel unit root test results using data for the seven OECD countries. Critical values are obtained from simulation. The individual specific fixed-effects model in LL is used because the savings rates and investment rates have non-zero

Table 1. *Panel unit root tests results for the pooled seven countries' data*

Variables	Lags	$\hat{\rho}^*$	t_ρ	1% critical value	5% critical value
Saving rates	1	–0.1650	–5.0960	–5.37	–4.88
	2	–0.1558	–4.3662	–5.39	–4.82
	3	–0.1404	–3.6832	–5.19	–4.82
	4	–0.1519	–3.7514	–5.23	–4.72
	5	–0.1490	–3.4913	–5.22	–4.67
Investment rates	1	–0.1862	–4.8167	–5.37	–4.88
	2	–0.0635	–3.8480	–5.39	–4.82
	3	–0.1631	–3.6407	–5.19	–4.81
	4	–0.1777	–3.7436	–5.23	–4.72
	5	–0.1448	–2.9319	–5.22	–4.67

The absolute t-values are smaller than critical values in all cases. This indicates that even the panel tests cannot reject the null hypothesis of non-stationarity of the data.

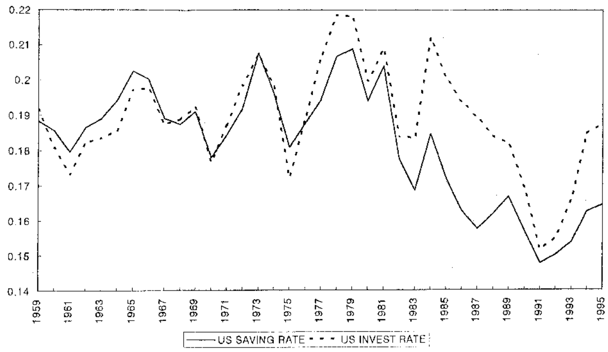

Fig. 1. *Saving and investment rate in US*

means. In our table, it can be seen that the absolute *t*-values are smaller than the critical values in all cases. This indicates that even the panel tests cannot reject the null hypothesis of the non-stationarity of the data. The savings rate and investment rate data are non-stationary. These results are consistent with those of previous papers.

Hypothesis 3
This is simply that the other two hypotheses are both correct.

Cointegration tests using individual data
In this section we report cointegration test results. First, we graph the US data in Figure 1. (Graphs for other countries are omitted.) At first glance, the savings rates and the investment rates seem to move together. But what do the cointegration tests tell us? We implemented a cointegration test for Equation 1.

Table 2 reports 1973–1995 data results only. (The results for 1957–1995 are not reported, but they are very similar to the results in this table.) For most countries we obtain no cointegration. These results are consistent with those in previous papers. We see that absolute *t*-values are smaller than critical values.

The problem now face is low testing power. Even when we appear to obtain a no-cointegration relationship, we cannot conclude that there is no cointegration. The no-cointegration relationship could arise due to the low power of the tests.

Cointegration tests using panel data
Table 3 shows the results of panel cointegration tests for Equation 2. The 1973–1995 data were used. When we use the seven countries' data together, the tests reject the null hypothesis at the 1% and 5% significance levels. This is quite different from the results obtained using individual time-series data cointegration tests, but is consistent with results from traditional regression methods. We conclude, therefore, that the individual cointegration technique does not provide a solution to the FH puzzle.

Size of savings retention coefficient
Finally, from panel regression, we obtain the size of the FH coefficient (*b* in the equation). We find that the estimate of *b*

Table 2. *Results of cointegration tests for individual data*

Lags	Country	$\hat{\rho}^*$	t_ρ	1% critical value	5% critical value
1		–0.3946	–1.5671	–3.65	–2.87
2		–0.5649	–1.8289	–3.46	–2.69
3	US	–0.7610	1.9414	–3.33	–2.64
4		–0.5127	–1.0553	–3.31	–2.49
5		–0.1058	–0.2013	–3.51	–2.59

Lags	Country	$\hat{\rho}^*$	t_ρ	Country	$\hat{\rho}^*$	t_ρ
1		–0.3978	–2.3883		–0.3962	–2.8037
2		–0.5045	–2.7802**		–0.2857	–1.7143
3	UK	–0.5593	–2.6234	Japan	–0.3403	–1.8592
4		–0.5564	–2.1867		–0.1764	–0.9412
5		–0.6742	–2.3292		–0.2266	–1.1694
1		–0.2522	–1.4477		–0.0542	–0.5821
2		–0.3282	–1.8739		–0.0193	–0.1903
3	Canada	–0.3873	–2.0186	Germany	–0.0492	–0.4466
4		–0.3959	–1.8226		–0.0822	–0.6484
5		–0.3242	–1.3278		–0.0197	–0.1362
1		–0.5795	–2.1243		–0.3946	–1.5671
2		–0.5919	–1.7370		–0.5649	–1.8289
3	Italy	–0.5162	–1.2176	France	–0.7610	–1.9414
4		–0.4658	–0.9217		–0.5127	–1.0552
5		0.0584	0.1037		–0.1058	–0.2013

** Indicates rejection of no-cointegration at the 5% significance level. For most countries, we obtain no cointegration.

Table 3. *Cointegration tests results for panel data*

Lags	$\hat{\rho}^*$	t_ρ	1% critical value	5% critical value
1	–0.2776	–5.2198	–2.96	–2.20
2	–0.3053	–5.1551	–2.88	–2.19
3	–0.3074	–4.6658	–2.90	–2.15
4	–0.3032	–4.1839	–2.90	–2.12
5	–0.2344	–3.0125	–2.82	–2.12

When we use seven countries' data together, the tests reject the null hypothesis of no-cointegration at the 1% and 5% significance levels.

is 0.7849 (with a *t*-value of 23.6), which is far from zero. This figure indicates that domestic investment is sensitive to domestic savings, which is consistent with the results of FH and with other traditional approaches.

V. CONCLUSION

The existing cointegration tests for the FH model are limited due to the problem of low testing power. This misleads some researchers to conclude that results from these tests have solved the FH puzzle.

In this paper we re-examined the puzzle using a panel co-integration test by which the power seems to be improved greatly. We obtained a cointegration relationship with panel data, with an FH coefficient that was far from zero. This is consistent with results based on traditional regression methods. Thus we conclude that cointegration techniques do not provide a solution to the FH Puzzle. The puzzle might be solved through some theoretical model. For example, Baxter and Crucini (1993) showed that substantial positive savings–investment correlations are a robust implication of the basic model, even with complete contingent claims markets.

REFERENCES

Baxter, M. and Crucini, M.J. (1993) Explaining saving/investment correlations, *American Economic Review*, **83**, 416–36.

Bodman, P. (1995) National saving and domestic investment in the long term, *International Economic Journal*, **9**, 37–60.

Coakley, J. and Kulasi, F. (1996) Cointegration of saving and investment. Discussion Paper 96–04, Center for International Capital Markets at London Guildhall University.

Feldstein, M. and Horioka, (1980) Domestic saving and international capital flows, *The Economic Journal*, **90**, 317–23.

Gulley, O.D. (1992) Are saving and investment cointegrated? Another look at the data, *Economics Letters*, **39**, 55–58.

Im, K.-S., Pesaran, M.H. and Shin, Y. (1995) Testing for unit roots in dynamic heterogeneous panels. DAE Working Paper No. 9526, University of Cambridge.

Levin, A. and Lin, C.-F. (1992) Unit root test in panel data: asymptotic and finite sample properties. UCSD, Discussion Paper 92–23.

Maddala, G.S. and Wu, S. (1997) A comparative study of unit root tests with panel data and a new simple test. The Ohio State University.

Miller, S.M. (1988) Are saving and investment cointegrated?, *Economic Letters*, **27**, 31–4.

Oh, K.-Y. (1996) Purchasing power parity and unit root test using panel data, *Journal of International Money and Finance*, **15**, 405–18.

Papell, D.H. (1997) Searching for stationarity: purchasing power parity under the current float, *Journal of International Economics*, **43**, 313–32.

Pedroni, P. (1995) Panel cointegration; asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Indiana University.

Pedroni, P. (1996) Fully modified OLS for heterogeneous cointegrated panels and the case of purchasing power parity. Indiana University.

Wu, Y. (1996) Are real exchange rates non-stationary? Evidence from a panel data test, *Journal of Money Credit and Banking*, **24**, 54–63.