Testing the validity of the Feldstein-Horioka puzzle for Australia

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Abstract
This paper presents an investigation into the relationship between investment and savings in Australia over the period 1960-2007. Using four time series techniques our results reveal that the Feldstein-Horioka puzzle exists in a weak form with a lower saving retention coefficient. Granger Causality tests illustrate that savings Granger cause investment both in the short and long runs. Our results suggest Australia could effectively adopt policies that focus on increasing investment through increasing domestic savings

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1. Introduction

Low capital mobility among OECD countries, signified by a high saving-investment (S-I) correlation and known as the Feldstein-Horioka (henceforth F-H) puzzle, has set off a vigorous debate in the empirical literature. The S-I relationship is important because it has implications for taxation rates and for policies that seek to affect international capital mobility; at the same time there is no doubt that capital accumulation, savings and investment are important stimuli for growth (Coakley *et al*., 2004; Rao *et al*., 2009).

Feldstein and Horioka (1980) present estimates of the following equation for 16 OECD countries over the sample period 1960-1974:

$$ITY_{it} = \alpha_i + \beta_i STY_{it} + \varepsilon_{it} \tag{1}$$

where $ITY =$ ratio of investment to income, $STY =$ ratio of saving to income, *i* and *t* are country and time subscripts respectively and $\varepsilon_{it} \sim N(0,\sigma)$ for all *i* and *t*. Their saving retention estimate (β) is within the range of 0.85 and 0.95, indicating low capital mobility in the sample of countries.

A comprehensive review of the relevant literature is presented by Apergis and Tsoumas (2009) who conclude that the majority of the empirical studies oppose the original strong results of F-H although the correlation exists in a weaker form.

To shed light on country-specific time-series studies, Felmingham and Cooray (2006) utilize an error correction model to examine Australian data and found a long run S-I relationship and imperfect capital mobility. Estimations of the S-I relation by Cooray and Felmingham (2008) suggest that Australia could successfully adopt policies that focus on increasing investment through increasing domestic savings, but this finding is in contrast to Schmidt (2003) who found that investment in Australia is strongly exogenous and therefore policies that aim to increase investment through savings are unlikely to be successful.

The objective of this paper is to re-examine the F-H hypothesis using a comprehensive set of four powerful, time-series econometric techniques in an attempt to identify the relative stability of results and the causal relationship between S-I for Australia using data for the period 1960-2007. Section 2 provides a brief history of the F-H puzzle. Section 3 presents details of the methodologies employed and section 4 details the empirical results. The implications of the results are considered in a brief concluding section.

2. Brief Survey on F-H Puzzle

There is a vast literature that presents investigations into the F-H puzzle using cross-section, time-series or panel data estimation methods; however the results are not consistent.[1] For instance, Hussein (1998) employs Dynamic Ordinary Least Squares (DOLS) techniques to estimate the S-I relationship for a sample of 23 OECD countries using data for the period 1960-1993 and obtain results which imply that capital mobility is remarkably high in the majority of

[1] See Apergis and Tsoumas (2009) for a comprehensive survey.

the sample countries.[2] Amirkhalkhali *et al.* (2003) examine the S-I deficit relationship within the context of a random coefficients model for 19 OECD countries over the period 1971-1999 and find that the S-I correlation is present but the crowding out effect appears to weaken in the 1990s at the same time that the degree of capital mobility appears to increase. Sinha and Sinha (2004) examine the short and long run relationships between S-I for 123 countries using an error correction framework and show that there is evidence for capital mobility for only 16 countries, and most of these are developing countries. Hoffmann (2004) uses a bivariate cointegrated VAR model and finds that the long run capital mobility in UK and US are remarkably stable and high over the mid 19th century up to the early 1990s.

Pelgrin and Schich (2008) apply panel error correction techniques to data for 20 OECD countries from 1960 to 1999 and find a long run S-I relationship with an increase in the persistency of the deviations from this long run relation, which suggests that capital mobility has increased. Grier *et al*. (2008) use data from 1947-2007 to examine the relationship between S-I in the USA using Bai and Perron (1998, 2003) techniques to test for structural breaks. They found a positive relationship in the short run that has weakened considerably over time in terms of magnitude and statistical significance but find no cointegration between S-I in the long run.

Early studies on the F-H puzzle with an Australian focus include Obstfeld (1986) who pools time-series observations to estimate the F-H relationship for 7 developed countries and finds β to be as low as 0.2 for Australia for the period 1960-1984. However, when Coakley *et al*. (1994, 1995) extend the sample period from 1960-1992 they obtain a value for β of about 0.6. Georgopoulos and Hejazi (2005) emphasize, however, that there should be a home bias, and that this bias should be falling through time.

For the purpose of analyzing the cyclical and trend behaviour of the S-I relationship for Australia, Felmingham and Cooray (2006) utilize spectral analysis and find a long run relationship between the two variables. In relation to capital mobility, their results based on an error correction model, show that imperfect capital mobility exists, and their more recent work (Cooray and Felmingham, 2008) argues that Australia could successfully adopt policies that focus on increasing investment through increasing domestic savings. However these results are in contrast to Schmidt (2003) who finds that investment is strongly exogenous and so policies that aim to increase investment through domestic savings are unlikely to be successful for Australia.

It is unlikely that complete stability will exist in empirical tests of the F-H puzzle in a changing and less than perfectly competitive dynamic international economic environment. Nevertheless given the uncertainty caused by contradictory results generated using a variety of econometric techniques, time periods and samples, this paper seeks to identify the stability of causal relationship between S-I for Australia across econometric techniques using data for the period 1960-2007.

3. Methodologies

Hendry's well known General to Specific (GETS) technique consists of a broad dynamic lag structure between the dependent and explanatory variables with the cointegrating equation

[2] This finding is supported by Coakley *et.al* (2004) who used mean group estimator techniques to estimate F-H for 12 OECD countries over the period 1980-2000. Their results show that high capital mobility exists in these countries.

comprising lagged levels and first differences of the variables. Using standard variable deletion tests, the general unrestricted model is reduced into a parsimonious dynamic adjustment model while ensuring that the residuals satisfy the underlying classical assumptions.

Engle and Granger (1987) (EG) developed a two-step technique to estimate long and short run equations. The first stage is to estimate the cointegrating equation and the residuals from the cointegrating equation are then used to estimate the short run dynamic model.

The Phillip and Hansen's (1990) Fully Modified Ordinary Least Squares (FMOLS) is also a single equation estimation technique. We used the Parzen lag window to estimate the cointegrating equations. Following Rao (2006) we start with smaller lag lengths and increase the size while keeping an eye on the estimated elasticities. The specific lag length is confirmed when there are no significant changes in the implied coefficients.

Johansen's (1988) contribution to multivariate cointegration tests, frequently referred to as the Johansen Maximum Likelihood (JML) test,[3] can be applied to justify that the regressors are exogenous. The first stage is to determine the order of the VAR, and then to test for the existence of cointegrating vector(s). Rejection of the null of no cointegration can be obtained through the eigenvalue and trace test statistics. Identification is tested by regressing the lagged error correction model (ECM) normalized on respective variables.

JML offers a more unified framework for estimating and testing cointegrating relationships in the context of ECMs. Granger causality tests can be applied to both long and short run situations with the one period lagged error correction term being derived from the long run cointegrating equation. In each case the dependent variable is regressed against past values of itself and past values of other variables together with the lagged error correction term. Significance of the lagged error correction term in respective equations will determine the causality relationship.

4. Results

The two variables of interest are *ITY*, which is gross domestic investment as a share of GDP (IFS, 2008), and *STY*, which is gross domestic savings as a share of GDP (IFS, 2008).

We test for the presence of a unit root in our variables using the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests. These results are reported in Table 1. The ADF tests are applied to both levels and their first differences with an intercept and trend. The ADF and PP statistics for the level variables do not exceed the critical values (in absolute terms), but when we take the first difference of each of the variables the ADF and PP statistics are higher than the respective critical values (in absolute terms) suggesting the level variables are $I(1)$ and their first differences are stationary.

{Table 1 about here}

4.1 Alternative Estimates

The alternative time series techniques are employed to examine the validity of F-H puzzle for Australia. We estimate equation (1) with GETS, EG, FMOLS and JML techniques for the whole

[3] This technique is sometimes also referred as the Vector Error Correction Method (VECM) or the Error Correction Method (ECM).

sample 1960-2007 and for two sub-samples, 1960-1980 and 1981-2007. We selected the sample break date of 1980 because of the substantial financial reforms and liberalization undertaken in the early 1980s in Australia and many other developed economies. The financial reforms have resulted in substantial gains such as increases in bank profits, new financial products and services and a decline in average costs. For a review of financial reforms in Australia, see Edirisuriya and O'Brien (2001), Sathye (2001), Sturm and William (2002) and Edirisuriya (2006).

GETS, EG, FMOLS and JML estimates of equation (1) are presented in Table 3. The null hypothesis of the savings retention coefficient, β, is that it should be equal to zero for complete capital mobility. The dummy variable (DUM) captures the effects of financial sector reforms and liberalization and it is expected that the sign of DUM should be positive because financial reforms improve the quantity and quality of financial services and trigger more opportunities for investment and savings.

We estimate the general dynamic equation in GETS with a lag length of four periods for the entire sample and with three lags for sub-periods. The EG cointegrating equation is estimated with Ordinary Least Squares and provides estimates of the cointegrating equation in the first stage. FMOLS estimates are obtained with the parzen lag window and a lag length of zero for the whole period and zero and four for the two sub-periods respectively. In JML, the order of the VAR is five for whole period and one for the sub-periods and the eigenvalue and trace tests indicate that there is cointegration between S-I, see Table 2 for these results.

{Table 2 about here}

We estimate the JML cointegrating equation using (un)restricted intercepts and no trends.[4] The results show similarity in the estimates of β across the four techniques. For brevity Table 3 only contains the estimates of β and DUM. The estimated results of β using all four techniques are consistent and slightly above 0.5 for the whole period. The magnitude of β is lower for the later sub-period, suggesting that international capital mobility has increased slightly. DUM has the expected positive sign and is significant in most tests.

{Table 3 about here}

In developing the appropriate Error Correction Models for the short run, we adopted the GETS approach in the second stage. The short run equations are only estimated for whole period. The cointegrating equations from Table 3 are used to formulate the respective error correction terms (*ECT*). This second stage equations are estimated with OLS in which ΔITY_t is regressed on its lagged values, the current and lagged values of ΔSTY_t and the lagged *ECT* from the cointegrating vectors of EG, FMOLS and JML. We use lags up to four periods and after employing variable deletion tests we obtain the parsimonious versions present in Table 4.

It is worth noting that all the estimated coefficients are significant at conventional levels, except the intercept in EG, FMOLS and JML. The coefficient of the lagged *ECT* is significant at 5% level with the expected negative sign, and serves as a negative feedback mechanism in the

[4] For the whole period and the first sub-period we employ the restricted intercept and no trend option and the unrestricted intercept and no trend option for the second sub-period. Only these options gave us meaningful results.

equations. The X^2 statistics indicate that there is no serial correlation (X^2_{sc1}), functional form misspecification (X^2_{ff}), non-normality (X^2_n) or heteroskedasticity (X^2_{hs}) in the residuals.

{Table 4 about here}

4.2. The Granger Causality Tests

The existence of cointegration implies Granger causality but it does not indicate the direction of causality. We employ JML modelling to assess the direction of causation. If the variables are cointegrated then equations should be estimated with JML rather than a VAR as in a standard Granger causality test and we follow Engle and Granger (1987) by estimating a JML model for Granger causality as follows:

$$\Delta ITY_t = \upsilon + \sum_{i=1}^{p} \lambda_i \Delta ITY_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta STY_{t-1} + \pi_1 ECT_{t-1} + \varepsilon_{1t} \tag{2}$$

$$\Delta STY_t = \upsilon + \sum_{i=1}^{p} \gamma_i \Delta STY_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta ITY_{t-1} + \pi_2 ECT_{t-1} + \varepsilon_{2t} \tag{3}$$

where ECT_{t-1} is the lagged error correction term derived from the long run cointegrating relationship and ε_{1t} and ε_{2t} are the serially independent random errors. In each case, the dependent variable is regressed against past values of itself and past values of other variables. The JML based Granger causality test is applied in both the short run and long run. The results are presented in Table 5.

{Table 5 about here}

In the short run the investment ratio is insignificant at the 5% level in the savings ratio equation implying that the investment ratio does not Granger cause the savings ratio in the short run. However, the savings ratio is significant at the 5% level in the investment ratio equation, implying that there is a bi-directional causality running from savings ratio to investment ratio. The long run results suggest that the coefficient of ECM_{t-1} is significant at the 5% level with the expected negative sign in the investment ratio equation, which implies that in the long run the savings ratio Granger causes the investment ratio.

Our results suggest that the endogeneity problem is limited because the savings ratio is only weakly exogenous, and this is in contrast to the results of Schmidt (2003) who found that investment in Australia is strongly exogenous. Therefore we reach the opposite conclusion and suggest that policies which aim to increase investment through domestic savings are likely to be successful.

5. Conclusion

We have attempted to estimate the savings retention coefficient (β) and determine the causality relationship between S-I for Australia over the 1960-2007 period using GETS, EG, FMOLS and

JML. The β coefficient is identified to be slightly larger than 0.5 and statistically significant over the entire time period and appears to be falling when we compare sub-periods. This implies that the F-H puzzle exists in a weaker form with a lower saving retention coefficient. The effects of the 1980s financial reforms and liberalization on investment are also significant but only temporary.

Further improvements in capital mobility may be difficult as Australia is a highly open economy with a stable ratio of current account balances to GDP over longer periods. Financial reforms may play an influential role in improving international capital mobility. Our Granger causality tests reveal that both in short and long run, the savings ratio Granger causes investment ratio. With this finding, and in line with Cooray and Felmingham (2008), we argue Australia could effectively adopt policies that focus on increasing investment through increasing domestic savings.

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Table 1: Results of ADF and PP Unit Root Tests

Variables	ITY	ΔITY	STY	ΔSTY
ADF Statistic	1.100 [2]	5.816 [1]	1.669 [0]	5.821 [1]
PP Statistic	2.387 [4]	7.230 [5]	1.638 [2]	4.276 [4]

Notes: The ADF and PP critical values at 5%, respectively, are 3.516 and 3.519. The lag lengths for ADF and PP are in parenthesis.

Table 2: JML Cointegration Tests

	Eigenvalue			Trace		
	Test Statistic	95%	90%	Test Statistic	95%	90%
1960-1980						
r = 0	16.2132	15.8700	13.8100	26.3480	20.1800	17.8800
r <= 1	7.5300	9.1600	10.1348	9.7906	19.2200	17.1800
1981-2007						
r = 0	24.380	14.8800	12.9800	28.7316	17.8600	15.7500
r <= 1	4.3423	8.0700	6.5000	4.3423	8.0700	6.5000
1960-2007						
r = 0	15.8700	14.678	13.8100	20.9633	20.1800	17.8800
r <= 1	6.2852	9.1600	7.5300	6.2852	9.1600	7.5300

Table 3: Alternative Estimates of β

	GETS	EG	FMOLS	JML
1960-2007				
β	0.568	0.531	0.544	0.503
	(5.56)*	(12.30)*	(12.80)*	(3.27)*
DUM	0.811	0.808	1.303	0.737
	(1.75)**	(1.18)	(2.00)*	(2.15)*
1960-1980				
β	0.827	0.579	0.691	0.790
	(2.88)*	(5.95)*	(6.02)*	(2.10)*
1981-2007				
β	0.625	0.533	0.649	0.641
	(3.02)*	(2.73)*	(3.47)*	(4.43)*
DUM	0.852	0.323	0.132	1.628
	(1.84)**	(2.34)*	(2.45)*	(1.89)**

Note: β is the savings retention coefficient. *DUM* captures the effects of financial reforms and is constructed 1 in 1980-85 and zero otherwise. The significance at 5% and 10% levels are * and **, respectively.

Table 4: Short run Adjustment Equations: 1960-2007

	GETS	EG	FMOLS	JML
Intercept	12.864 (5.26)*	0.014 (0.11)	0.011 (0.08)	0.010 (0.08)
λ	-0.306 (2.71)*			
STY_{t-1}	0.568 (5.56)*			
ECT_{t-1}		-0.432 (3.42)*	-0.340 (3.03)*	-0.326 (2.95)*
ΔITY_{t-1}	0.331 (2.73)*	0.411 (3.42)*	0.381 (3.19)*	0.371 (2.95)*
ΔSTY	0.373 (4.01)*	0.393 (4.27)*	0.343 (3.84)*	0.362 (3.96)*
ΔSTY_{t-3}	-0.191 (2.05)*	-0.198 (2.13)*	-0.209 (2.23)*	-0.210 (2.24)*
DUM	0.811 (1.76)**			
Adjusted R^2	0.574	0.674	0.560	0.654
SEE	0.129	0.090	0.080	0.096
X^2_{sc}	0.171 (0.68)	0.015 (0.90)	0.010 (0.92)	0.024 (0.88)
X^2_{ff}	1.272 (0.26)	1.485 (0.22)	1.668 (0.20)	0.841 (0.36)
X^2_{n}	0.913 (0.63)	0.845 (0.66)	0.361 (0.84)	0.208 (0.90)
X^2_{hs}	0.064 (0.80)	0.055 (0.81)	0.074 (0.79)	0.134 (0.71)

Notes: Absolute *t*-ratios are in the parentheses. * and ** indicate statistical significance at the 5% and 10% confidence levels respectively. λ is the speed of adjustment. The *DUM* is part of the cointegrating equations in EG, FMOLS and JML and therefore it is not included again in the short run equations.

Table 5: Results of Granger Causality Tests

Dependent Variable	ΔSTY_t	ΔITY_t	ECM_{t-1}
ΔSTY_t	-	0.663 (1.11)	0.277 (1.06)
ΔITY_t	0.315 (2.91)*	-	-0.430 (2.58)*

Notes: * indicates statistical significance at the 5% confidence level