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Panel data model comparison for empirical saving-investment relations

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Panel data model comparison for empirical saving-investment relations

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Panel data model comparison for empirical saving-investment relations

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June 2006

Abstract: The low capital mobility among OECD countries, signalled by a high saving-investment (SI) relation and known as the Feldstein-Horioka puzzle, has triggered a lively discussion in the empirical literature. In this paper, we compare between, pooled, time and country dependent specifications of the SI relation via cross-validation criteria. It is found that the country dependent model is best performing among the four. Secondly, error correction models are uniformly outperformed by static panel models. Thirdly, via scatter diagrams of cross section specific estimates we observe a different time evolution of SI relations for developed and developing economies.

Keywords: Saving-investment relation, Feldstein-Horioka puzzle, model comparison
JEL Classification: C33, E21, E22

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1 Introduction

By means of a between regression for OECD countries Feldstein and Horioka (1980), henceforth FH (1980), document a strong correlation linking domestic investment and saving, which is argued to be at odds with capital mobility. The so-called "Feldstein Horioka puzzle" (FH puzzle) has provoked a lively discussion of actual mobility of the world's capital supply, and of the relation between domestic saving and investment (SI). Numerous empirical specifications have been employed to evaluate the SI relation. A time-dependent SI relation is firstly investigated by Sinn (1992). Country specific SI relations are considered by Obstfeld (1986), Miller (1988), Afxentiou and Serletis (1993), Tesar (1993) and Alexakis and Apergis (1994). In addition, according to a potential cointegration relation linking saving and investment, error correction models (ECMs) have been applied to investigate the dynamics of domestic investment (Jansen 1998, Pelgrin and Schich 2004).

In the empirical literature, however, cross model comparisons have not been provided yet. Since estimates of the SI relation are likely model dependent, comparisons of the latter might be crucial for a characterization of capital mobility by means of diagnosed correlation features of domestic saving and investment. One purpose of this paper is to undertake a systematic comparison of between, pooled, time dependent and country dependent specifications of the SI relation. As a further direction of model selection we also distinguish the scope of static and dynamic models addressing the SI relation. Throughout, we rely on cross-validation techniques (Allen 1974) for model comparison.

Most empirical contributions to the debate on the FH puzzle concentrate on one or two specific cross sections such as OECD members, EU countries, the Euro area, large or less developed economies. As a second purpose of this paper, we investigate a set of specific (partly overlapping) cross sections, and a general cross section sampled from all over the world and containing as many economies as possible conditional on data availability. The latter is one of the largest cross sections that has been considered to analyze the SI relation. Distinguishing numerous specific cross sections will be useful to relate the SI relation e.g. to the degree of market integration or the state of development. The large cross section promises a global view on descriptive features of the correlation between domestic saving and investment. As a third contribution of this paper, we provide scatter diagrams which can illustrate quantitatively panel heterogeneity of the SI relation in both the time and cross sectional dimension.

Annual data spanning the period 1971 to 2002 is analyzed. From static model performance we derive that the best performing parametric description of the SI relation is cross section specific. Contrasting static and dynamic (error correction) model formalizations we find no hint at the necessity of a dynamic model specification. Scatter diagrams reveal that the SI relation of developed and developing economies have experienced a rather different time evolution when comparing it against some global average. As such, SI relations might be also subject to other economic conditions and policies than capital mobility.

The remainder of the paper is organized as follows: In the next Section we briefly sketch some core empirical contributions provoked by FH (1980). In Section 3 we introduce model selection criteria and the considered panel data models. The data is described in Section 4. Empirical results obtained from the model comparison are provided in Section 5. Section 6 summarizes briefly our main findings and concludes. More detailed information on the investigated (cross sections of) economies is given in the Appendix.

2 Econometric approaches to measure the SI relation

Econometric attempts to solve the FH puzzle might be divided in two categories, namely the use of different sample information and of alternative econometric model specifications. In the following we briefly sketch the latter categories.

2.1 Sample selection

Harberger (1980), Murphy (1984) and Obstfeld (1986) show empirically that large countries are likely to have high SI relations. For a large economy, the world interest rate and many goods prices are more likely endogenous. Then, a shortfall in domestic saving may drive up both the world's as well as the domestic interest rate. As a result, a large countries' domestic investment decreases. Thus, although capital flows are mobile for the large country, it is likely to show a high SI relation. In contrast, most developing countries are small and cannot influence the world interest rate. Therefore, the corresponding SI relation is lower for developing countries. Murphy (1984) demonstrates that between regression estimates reduce to 0.59 for 10 small OECD countries, and remain as high as 0.98 for 7 large OECD economies. It turns out that particularly the US, Japan and the UK have a dominant impact on the between estimate. By means of time series models for 7 OECD countries Obstfeld (1986) also demonstrates that the measured SI relation is increasing in country size. Focussing on the difference between the saving and investment ratio, Harberger (1980) shows that the latter as a fraction of the investment ratio has a lower absolute value and less variability for OECD countries in comparison with developing economies. As the opposite to the large country effect, Dooley, Frankel and Mathieson (1987) and Mamingi (1994) have found that the SI coefficient is smaller for developing economies in comparison with OECD countries. Dooley et al. (1987) show that between regression estimates are smaller for 48 developing economies than for 14 OECD countries. Using time series data for 58 developing countries, Mamingi (1994) obtains an estimated SI relation which is smaller than the corresponding OECD based measure.

Moreover, the SI relation is found to be lower among members of the EU or the Euro area. Owing to informational and institutional links, financial flows should be larger within the EU than among OECD countries. Feldstein and Bachetta (1991) show that 9 EU countries experienced a sharp decline in the SI relation in the 1980s, while 14 non-EU OECD countries did not. Similarly, Artis and Bayoumi (1992) find for the 6 core economies of the European Monetary System an insignificant SI relation over the period 1981 to 1988. Blanchard and Giavazzi (2002) document that the SI relation estimated from pooled regression models declines in case the investigated cross section changes from OECD to the EU or the Euro area. In addition, it is diagnosed to decline over time. According to Blanchard and Giavazzi (2002) the SI relation for the Euro area diminishes to 0.14 when using annual data over the period 1991 to 2001.

2.2 Competing panel based estimators

In comparison to sample selection, however, it is less clear which estimator is most appropriate to signal capital (im)mobility. Proceeding from an equilibrium model of saving, investment, net foreign investment and the real domestic interest rate, Feldstein (1983) argues that estimates of the SI coefficient from between regressions provide a reliable basis to evaluate the hypothesis of perfect international capital mobility. Murphy (1984), Obstfeld (1986), Feldstein and Bachetta (1991) and Tesar (1991) estimate the SI relation via between regressions.

On the other side, Miller (1988), Afxentiou and Serletis (1993) and Alexakis and Apergis (1994) have argued for cross section specific regressions which are to be preferred in the light of potential cointegration linking domestic saving and investment. In case saving or investment ratios were nonstationary it is unclear what cross sectional averages entering a between regression actually measure. Another common argument for a cross section specific SI relation is that the latter is likely heterogenous across economies. In case of cross sectional heterogeneity between regressions have attached the risk of providing biased results owing to model misspecification. Corbin (2001) argues that a high SI relation estimated from between regressions could be seen as a statistical artefact that goes back to (neglected) country specific effects. He shows that the fixed effect and random effect estimator of the SI relation are smaller in comparison with the pooled and between estimator. Using mean group estimates (Pesaran and Smith 1995) in a nonstationary and heterogeneous panel, Coakley, Fuertes and Spagnolo (2001) obtain an estimated SI relation which is insignificantly different from zero for 12 OECD countries over the period from 1980 to 2001. Obstfeld (1986), Miller (1988), Afxentiou and Serletis (1993), Tesar (1993) and Alexakis and Apergis (1994) evaluate country specific SI relations. Feldstein (1983) allows a country specific constant in pooled regressions. Amirkhalkhali and Dar (1993) permit inter-country variation in both the constant and the slope parameter in panel regressions, which are estimated by means of error component models (Swamy 1970, Swamy and Mehta 1975).

Between or pooled regressions are typically understood to address the long run SI relation, which is not affected by the business cycle. As pointed out by Sinn (1992), between regressions might deliver biased results against capital mobility observing that the long run SI relation could be determined by the intertemporal budget constraint. For the latter reason Sinn (1992) estimates time dependent SI relations from cross-sectional regressions. Nevertheless, the evidence offered by time varying SI relations for 23 OECD countries over a sample period from 1960 to 1988 does not overcome the finding of a puzzling high SI relation.

Summarizing the panel based responses to the initial contribution by FH (1980) it turns out that the FH puzzle is quite robust over a substantial portfolio of applied panel data models. Comparisons of alternative panel data modeling frameworks, however, are rare and if available, not very comprehensive or systematic and based on in-sample fitting criteria.

2.3 Error correction models

Recently, panel error correction models (ECMs) have been put forth as a dynamic framework to address the FH puzzle from an econometric perspective. This avenue of empirical research is based on a potential cointegrating relation between the saving and investment ratio. Coakley, Kulasi and Smith (1996) argue that saving and investment as a share of GDP appear to be $I(1)$ in OECD economies and the current account balance as a share of GDP might be $I(0)$. Coakley and Kulasi (1997) find by means standard cointegration tests (Kremers, Ericsson and Dolado 1992, Johansen 1991) that the saving and investment ratio are cointegrated in major OECD countries. Conditional on ΔS^*_{it}, a single-equation ECM for the SI relation has the following form:

$$\Delta I^*_{it} = \alpha_i + \lambda_i(I^*_{i,t-1} - \eta_i S^*_{i,t-1}) + \beta_i \Delta S^*_{it} + e_{it}, \quad i = 1, \ldots N, \quad t = 1, \ldots T, \tag{1}$$

where $\overline{I^*_i} = 1/T \sum_{t=1}^{T} I^*_{it}$, $\overline{S^*_i} = 1/T \sum_{t=1}^{T} S^*_{it}$, $I^*_{it} = I_{it}/Y_{it}$ and $S^*_{it} = S_{it}/Y_{it}$, with I_{it}, S_{it} and Y_{it}, $t = 1, \ldots, T$, denoting gross domestic investment, gross domestic saving and gross domestic product (GDP) in time period t and country i, respectively. Moreover, Δ is the first difference operator, e.g. $\Delta I^*_{it} = I^*_{it} - I^*_{i,t-1}$. Restricting $\eta_i = 1$, Jansen (1998) tests the short run SI relation for OECD countries by means of coefficient estimates $\hat{\beta}_i$. He argues that β_i reflects limited capital mobility and country-specific business cycle influences. By comparison, Pelgrin and Schich (2004) interpret the error correction coefficient, λ_i, as an indicator of capital mobility. They view capital mobility as the ease with which a country can borrow or lend to run prolonged current account imbalances in the short to medium term. Thus, the higher the capital mobility, the lower is the adjustment speed of investment to its long run equilibrium level implied by the one-to-one cointegrating relation linking S^*_{it} and I^*_{it}. Implementing a panel ECM for 20 OECD countries over the sample period 1960 to 1999 with three alternative specifications of cross sectional heterogeneity (dynamic fixed effects, mean group and pooled mean group estimation) Pelgrin and Schich (2004) find that the estimated error correction coefficient, $\hat{\lambda}_i$, is negative and significantly different from zero. In addition, a time dependent evaluation reveals that $\hat{\lambda}_i$ comes closer to zero over time, which is consistent with a presumption of increasing capital mobility. Furthermore, the estimated cointegration parameter, $\hat{\eta}_i$, is found to differ only insignificantly from unity, thereby implying a binding long run solvency constraint.

Regarding the ECM specification in (1) it is worthwhile to point out that the conditional single equation ECM only offers efficient estimation or inference in case domestic saving is weakly exogenous, i.e. it does not respond to lagged current account imbalances (Johansen 1992). Weak exogeneity of S_{it} is, however, neither tested by Jansen (1998) nor by Pelgrin and Schich (2004). As a more fundamental caveat of cointegration modeling, it is worthwhile mentioning that standard unit root tests are not constructed for variables which are bounded by construction, as e.g. $S^*_{i,t-1}$ or $I^*_{i,t-1}$. Unit root tests are formalized to distinguish between stationary processes and processes driven by stochastic trends. Since the latter can grow or decrease to any level, the notion of nonstationary saving and investment ratios is to some extent counterintuitive. The latter issue is addressed by Herwartz and Xu (2006). They show that the ratio of domestic saving, domestic investment and current account imbalances to the GDP are bounded nonstationary for most OECD economies via unit root tests for bounded variables (Cavaliere 2005). Given this evidence, we refrain from viewing (1) as derived from a system of cointegrating variables. Rather we will focus on its empirical performance in comparison with static panel based formalizations of the SI relation, since error correction dynamics might also be formalized for stationary variables or bounded nonstationary variables.

3 Model selection

From the review of empirical approaches followed to investigate the SI relation, it is apparent that a wide portfolio of econometric specifications has been employed. Somewhat surprisingly, the relative merits of competing model classes have not yet been provided in a systematic and comprehensive fashion. In this section, model specifications and cross validation (CV) techniques applied for model comparison are introduced.

Basically we classify empirical models into three categories: The class of static models comprises basic panel specifications formalized to explain domestic investment ratios conditional on saving ratios. A second class of models is given in terms of first differences of the latter ratios. Owing to the feature that changes of domestic investment ratios are used as dependent variables one may regard this model class as 'weakly dynamic'. More general dynamic patterns will be formalized in a third class comprising ECM type models. Comparing the first two model categories is informative to uncover potential mean reverting features of the saving and investment ratio since differencing stationary time series will likely involve a loss in accuracy of fit. In the opposite case of nonstationary ratios, a model in first differences is suitable to guard against spurious regressions. Since taking first differences of I^*_{it} will also remove individual effects, a comparison of model estimates in levels vs. changes of investment ratios will shed light on the prevalence of individual effects as a characteristic of investment ratios. Comparing the second and third model class ('weakly dynamic' models against ECMs) is helpful to distinguish cointegrating features from scenarios of independent (bounded) stochastic trends governing S^*_{it} and I^*_{it}.

3.1 Cross validation criteria

In principle, model comparison may follow some optimization of in-sample criteria (log-likelihood estimates, model selection criteria, (adjusted) R^2, etc.) or out-of-sample performance. Since in-sample features of alternative panel data models often only allow more or less trivial rankings according to the number of explanatory variables (pooled regression, between regression, within regression, allowance of cross-section specific or time dependent parameters, etc.), it is a-priori more tempting to base model evaluation on some measure of out-of-sample performance. To obtain criteria for model comparison we will employ cross-validation (CV) techniques (Allen 1974, Stone 1974, Geisser 1975). The latter are seen as an out-of-sample based means to distinguish the relative merits of competing models that is not trivially affected by outstanding factors as e.g. the number of model parameters. CV techniques are widely used in applied non- and semiparametric modeling. In the following we provide a brief outline of the implementation of cross validation methods used in this study.

To discriminate panel based estimators at an aggregated level we use the following CV criterion:

$$cv_{(mod)} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}|y_{it} - \hat{y}_{it}(mod)|. \tag{2}$$

In (2) 'forecasts' $\hat{y}_{it}(mod)$ for some dependent variable of interest (the investment ratio, say) are based on so-called leave one out or jackknife estimators, i.e.

$$\hat{y}_{it}(mod) = x'_{it}\underline{\hat{\boldsymbol{\beta}}}_{mod,it}, \tag{3}$$

with $\underline{\hat{\boldsymbol{\beta}}}_{mod,it}$, being an estimated parameter vector that is obtained from a particular model, $y_{it} = x'_{it}\underline{\hat{\boldsymbol{\beta}}}_{mod,it} + e_{it}$, after removing the it-th pair of dependent and explanatory variables from the sample. The particular model representations entering CV based comparisons will be given in detail below. Apart from model comparison by means of absolute forecast errors we will also provide CV criteria derived from squared forecast errors, i.e.

$$cv^2_{(mod)} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(y_{it} - \hat{y}_{it}(mod))^2. \tag{4}$$

3.2 Model specifications

An unrestricted static representation of the relationship between domestic investment and saving may be given as

$$I^*_{it} = \alpha_{it} + \beta_{it} S^*_{it} + e_{it}. \tag{5}$$

The empirical implementation of the relation in (5) will, generally, require some restrictions on the parameters α_{it} and β_{it} which could be formalized in the time dimension, the cross section dimension or both. Following these lines we consider four settings for the choice of the latter parameters: In the first two places we estimate the model parameters by means of pooled and between regressions, abbreviated and formalized as

$$pol: \quad I^*_{it} = \alpha + \beta S^*_{it} + e_{it}, \tag{6}$$
$$bet: \quad \overline{I^*_i} = \alpha + \beta \overline{S^*_i} + \overline{e}_i, \tag{7}$$

respectively. As two main competitors of these highly restricted regression designs we regard the parameters of the model in (5) to be either time specific or to vary over the cross section, i.e.

$$tim: \quad I^*_{it} = \alpha_t + \beta_t S^*_{it} + e_{it}, \tag{8}$$
$$cro: \quad I^*_{it} = \alpha_i + \beta_i S^*_{it} + e_{it}. \tag{9}$$

A major purpose of this paper is to determine a family of econometric models that is most suitable in explaining actual investment ratios. Error correction models have been introduced as an alternative venue to investigate the SI relation. To characterize the scope of ECM models we proceed in two steps.

First, we evaluate general panel models as formalized in (5) to explain the changes of investment ratios rather than their levels. The corresponding unrestricted panel representations read as

$$\Delta I^*_{it} = \alpha_{it} + \beta_{it} \Delta S^*_{it} + e_{it}. \tag{10}$$

Note that although not indicated by our notation the parameters α_{it}, β_{it} and error terms e_{it} differ across (5) and (10). As when implementing (5) we will provide CV measures for pooled, between, time and cross section specific regressions of ΔI^*_{it} on ΔS^*_{it}. In a second step, the 'weakly dynamic' model in (10) will be augmented with (alternative representations of) lagged error correction terms. To be explicit we compare the following model versions by means of CV criteria:

$$ecm1: \quad \Delta I^*_{it} = \alpha_i + \lambda_i (I^*_{i,t-1} - \eta_i S^*_{i,t-1}) + \beta_i \Delta S^*_{it} + e_{it}, \tag{11}$$
$$ecm2: \quad \Delta I^*_{it} = \alpha_i + \lambda_i (I^*_{i,t-1} - S^*_{i,t-1}) + \beta_i \Delta S^*_{it} + e_{it}, \tag{12}$$
$$ecm3: \quad \Delta I^*_{it} = \alpha_i + \lambda_i (I^*_{i,t-1} - S^*_{i,t-1}) + e_{it}, \tag{13}$$

All ECM specifications in (11) to (13) can be derived from the model in (1) introduced by Pelgrin and Schich (2004) and formalize cross sectional parameter dependence. Whereas the general model in (11) allows the parameter η_i to enter unrestrictedly, (12) and (13) make use of the restriction $\eta_i = 1$ implying that the current account imbalance impacts on the investment ratio.

Regarding the model portfolio in (6) to (9) one may also consider time varying ECMs for the completeness of model comparison. Although time variation may, in principle, also apply for error correction dynamics we refrain from formalizing time dependent ECM models for two reasons: First, CV criteria estimated for the model class in (10) will show that time dependence is likely not an important feature of the parametric description of ΔI^*_{it}. Secondly, in the light of recent work on threshold cointegration (Balke and Fomby 1997) it is likely that time variation in λ_i is better conditioned upon economic states rather than presuming deterministic time shifts of model parameters.

3.3 Leave one out forecasts

The determination of CV measures for the representation of changes of the investment ratio may follow the same lines as discussed for the level representation. To allow cross model comparison, however, jackknife forecasts of ΔI^*_{it} have to be transformed to forecasts for the level variables I^*_{it}. Since $\hat{I}^*_{it} = \Delta\hat{I}^*_{it} + I^*_{it-1}$, CV estimates comparing $\hat{I}^*_{it}$ and I^*_{it} are equal to those obtained from a comparison of $\Delta\hat{I}^*_{it}$ and ΔI^*_{it}. For the purpose of informationally equivalent model comparison we compute CV criteria for the level of the investment ratio using the model family in (10) and recursive forecasts $\hat{I}^*_{it-1}$, $t = 2, \ldots, T$, initialized with the first observation I^*_{i1}. Note that CV estimates for the latter model family are generally obtained over samples covering one observation less in comparison with the level representation in (5).

4 The data

We investigate the SI relation with seven alternative (partly overlapping) cross sections using annual data from 1971 to 2002 drawn from the World Development Indicators CD-Rom 2004 published by the World Bank. These cross sections are composed as follows:

1) The first and most comprehensive sample covers 97 countries from all over the world (W97), for which most observations of the saving and investment ratio from 1971 to 2002 are available. For 6 countries data for 2002 are not available. These missing values are estimated by means of univariate autoregressive models of order 1 with intercept. Although data for Sao Tome and Principe and Lesotho are published, these two countries are not included owing to an outstandingly high negative saving

ratio prevailing over quite a long period. A list of all 97 countries contained in W97 is provided in the Appendix.

2) All OECD countries except Czech Republic, Poland, Slovak Republic and Luxembourg comprise the second cross section and is denoted with O26. The first three countries are not included due to data nonavailability. Luxembourg is often excluded in empirical analyses of the SI relation owing to presumably peculiar determinants of its savings.

3) The third sample we consider covers 14 major countries of the European Union (E14), which are the O26 countries without Australia, Canada, Hungary, Iceland, Japan, Korea, Mexico, New Zealand, Norway, Switzerland, Turkey and the US. Contrasting this subgroup with O26 may reflect the EU effect on the SI relation.

4) As the fourth cross section 11 Euro area economies excluding Luxembourg (E11) are investigated. E11 differs from E14 by exclusion of Denmark, Sweden and the UK. In the Euro area, there is no exchange rate risk and financial markets should be more integrated in comparison with the remainder of the EU.

5) To offer a 'complementary' view at the link between market integration and the SI relation, we investigate a fifth cross section defined as O26 minus E11. Here we focus on weaker forms of market integration and try to isolate their impact on the SI relation.

6) Conditioning the SI relation on the state of economic development has become an important avenue to solve the FH puzzle. Therefore we analyze a sixth cross section that collects less developed economies. The latter is obtained as W97 minus O26 and denoted in the following as L71.

7) Finally, for completeness and to improve on the comparability of our results to FH (1980) we will also consider the cross section employed in their initial contribution (F16). The latter comprises 16 OECD countries namely O26 excluding France, Hungary, Korea, Mexico, Norway, Portugal, Spain, Switzerland and Turkey.

5 Results

5.1 Model comparisons

Cross-validation results are documented in Table 1. The panels A, B, and C of the Table show the CV estimates for models specified in levels, first differences and ECM model versions, respectively. Apart from giving raw CV measures (cv and cv^2) we also show scale invariant normalized results ($\widetilde{cv}$ and $\widetilde{cv^2}$). For the purpose of normalization, CV estimates from cross section specific model formalizations are set to unity. All models describing ΔI_{it}^* share the same benchmark model for normalization such that an immediate contrasting of 'weakly dynamic' models as (10) and ECMs is feasible. Cross comparison of the model families given in (5) and (10) is feasible by regarding (non-normalized) absolute CV estimates obtained from the benchmark (cross section specific) models.

5.1.1 Static panel models

Concentrating on the model family (5) the overall evidence is that country specific panel models provide the most suitable framework to investigate the SI relation. This model class uniformly yields smallest CV estimates over all cross sections. For the largest cross section (W97) we find that for both normalized CV criteria all remaining modeling approaches perform similarly poor in comparison with cross section specific modeling. It turns out that the second best models, time specific regressions ($\widetilde{cv}$) and the pooled regression ($\widetilde{cv^2}$), are about 40% and 83% in excess of the corresponding estimates obtained from cross section specific regressions. The CV results are also remarkable in the sense that time dependent regressions which allow a relatively large number of model parameters, namely 64 ($T = 32$), perform similar to the highly restricted pooled regression models encountering only two parameters. With regard to the relative performance of the cross section specific regression against between regression say, mean absolute forecast errors ($\widetilde{cv}$) for the latter are between 16% (O15) and 69% (E11) worse. In sum, the latter results underscore the likelihood of panel heterogeneity.

5.1.2 Static vs. weakly dynamic models

As mentioned comparing the model families in (5) and (10) sheds light on the potential of mean reversion as a characteristic of domestic investment and saving ratios. Moreover, such a comparison hints at the prevalence of individual effects in (5) which are removed by differencing. For both model families cross section specific model formalizations uniformly outperform the remaining panel based estimation schemes, i.e. between regression, time specific and pooled modeling. For F16, E14 and E11 both CV measures (cv and cv^2) yield only small numerical differences when comparing the performance of cross section specific regressions for the levels and first differences of the domestic investment ratio. For all remaining cross sections, however, CV estimates are clearly in favor of a specification explaining the investment ratio rather than its changes. Concentrating e.g. on mean absolute forecast errors, cross section specific panel approaches to changes of the investment ratio yield cv estimates that are between 13% (O26) and 38.8% (L71) worse than corresponding statistics obtained for the level representation.

5.1.3 Error correction dynamics

Although model representations of changes of the investment ratio have been outperformed by level representations it is still interesting to address the issue of potential error correction dynamics. Comparing normalized CV estimates in Panels B and C of Table 1, we find that none of the ECM model versions closely approaches the cross section specific 'weakly dynamic' model $\Delta I_{it} = \alpha_i + \beta_i \Delta S^*_{it} + e_{it}$. The latter results are the more surprising when recalling that the first three ECM versions are formalized conditional on the cross section member. Overall mean absolute forecast errors obtained from cross section specific ECMs are between 15% (E11, model $ecm1$ given in (11)) and 74% (F16, model $ecm3$ (13)) larger than the benchmark presuming absence of error correction dynamics. The latter results are also at odds with a presumption of cointegration linking the ratios of domestic saving and investment over GDP. In case of cointegration just regressing ΔI^*_{it} on ΔS^*_{it} would suffer from statistical inefficiency owing to the neglection of the long run equilibrium relationship. Since saving minus investment approximates the current account the latter result is consistent with the finding of Herwartz and Xu (2006) that current account imbalances measured as a ratio to GDP is bounded nonstationary and, thus, saving and investment are not cointegrated.

5.2 Panel heterogeneity

On the one hand, contrasting various empirical specifications of the SI relation the static, cross section specific model in (9) offers outstanding jackknife forecasting accuracy. Apart from its significance it is of interest to uncover the quantitative degree of cross sectional heterogeneity. On the other hand, it is also shown in the empirical literature (Sinn 1992, Blanchard and Giavazzi 2002) that the correlation between domestic saving and investment has experienced some weakening over time. The latter is often regarded as an indication of improved financial market integration. In this subsection, we address the panel heterogeneity via a consideration of subperiod specific estimates. We separate the sample information into two equally sized subperiods, covering 1971 to 1986 and 1987 to 2002, respectively. To visualize panel heterogeneity we scatter cross section specific estimates obtained from the model in (9) for the first against the second subsample. Scatter plots are provided for the nonoverlapping cross sections L71 and O26 on the one hand, and O15 and E11 on the other hand. To provide some 'overall' measure all graphs also comprise subperiod specific mean group estimates $\frac{1}{N}\sum_{i=1}^{N}\hat{\beta}_i$ (Coakley, Fuertes and Smith 2001). It is worthwhile pointing out that using between estimates instead of the latter averages would obtain very similar graphical results. To facilitate the interpretation of estimation results mean group estimators are derived from W97 (O26) when contrasting cross section specific estimates of L71 and O26 (O15 and E11) in the upper (lower) panels of Figure 1.

Under cross sectional homogeneity one would expect the $\hat{\beta}_i$, $i = 1, \ldots, N$, to scatter in some small neighborhood of the mean group estimates. Obviously the latter feature cannot be retrieved from Figure 1 thereby revealing some quantitatively substantial parameter variation. The magnitude of the latter variation is similar for both considered subperiods.

In the sprit of the initial argument put forth by Feldstein and Horioka (1980), one would expect that owing to its higher degree of financial market integration cross sectional estimates obtained for developed economies tend to cluster in some area below the W97 averages. Surprisingly, we obtain exactly the opposite result according to which the majority of O26 economies show a slope estimate being above the global SI relation for both subperiods. The latter result might be partially due to the large country effects which are well established with reference to single economy as the UK, Japan or the US (Murphy 1984). Given that our results are characteristic for a majority of OECD members, however, one may argue that empirical SI relations are also subject to some other influences than capital mobility or country size. Furthermore, more integrated financial markets do not necessarily lead to a high capital flow since these only provide the possibility of borrowing or lending abroad but do not imply the willingness to make use of such financing or investment. The latter argument can be related to other macroeconomic puzzles, such as, for instance, the consumption correlations puzzle (Backus, Kehoe and Kydland 1992) and the home-bias portfolio puzzle (French and Poterba 1991).

Moreover, in comparison with developed economies (O26) the relative position of SI relations estimated for developing economies (L71) against the global perspective is by far more unstable. Numerous developing economies change their relative position against the W97 average SI relation over time. Significant fractions (about one fifth) of the L71 cross section show SI relations exceeding the W97 mean group measure in the first subperiod while falling below the latter quantity in the second subperiod and vice versa. The marked time heterogeneity of 'relative' SI relations calls for a further analysis of potential links between the SI relation and economic conditions or policies. Increasing trade openness, for instance, might lead to a deceasing SI relation. Governments targeting the current account imbalance can cause an increasing SI relation (Artis and Bayoumi 1992). Besides, the stable low SI relation for some developing economies in both subperiods might be addressed to the fact that some of them are market borrowers while others are depending solely on official financing.

Contrasting cross sectional estimates for O15 and E11 against the O26 mean group, descriptive features of parameter estimates $\hat{\beta}_i$ are more in line with the traditional view of the SI relation as corresponding to capital mobility. Five out of 11 economies entering the currency union show a link between domestic saving and investment which is above the O26 average for the first subperiod whereas it is less than the latter for the second subperiod. Accordingly, these economies experience an increased participation in international financing over time. For the likely more heterogeneous subgroup O15 we diagnose that 9 out of 15 economies show SI relations with relative positions changing in both directions.

6 Conclusion

In this paper we investigate the relation between domestic saving and investment for seven cross sections covering the sample period 1971 to 2002. Cross-validation criteria are applied to compare different specifications of the SI relation. We find that the country-dependent SI model is the best performing model compared to the between, pooled and time-dependent specifications of the SI relation. Comparing error correction models formalizing adjustment dynamics of domestic investment with static panel models, the former is outperformed by the latter in terms of CV criteria.

Panel heterogeneity is illustrated by scatter diagrams comparing selected cross sectional estimates against some average measures. Descriptive features of empirical SI relations are markedly different when contrasting developing (L71) vs. developed economies (O26) or cross sections showing an a-priori different degree of market integration as O15 and E11. This evidence supports the view that the SI relation might be also subject to other economic forces than capital mobility.

Interpreting the empirical SI relation as a summary measure for economic conditions or policy strategies it is tempting to uncover the economic forces (dis)connecting domestic saving and investment. We regard the latter issue as an area of future research. From model comparison results provided in this paper it appears natural to investigate conditional features of the SI relation in the framework of static cross sectional model formalizations.

Appendix: List of countries included in W97

1	DZA-Algeria	33	DEU-Germany	65	NZL-New Zealand
2	ARG-Argentina	34	GHA-Ghana	66	NER-Niger
3	AUS-Australia	35	GRC-Greece	67	NGA-Nigeria
4	AUT-Austria	36	GTM-Guatemala	68	NOR-Norway
5	BGD-Bangladesh	37	GUY-Guyana	69	PAK-Pakistan
6	BRB-Barbados	38	HTI-Haiti	70	PRY-Paraguay
7	BEL-Belgium	39	HND-Honduras	71	PER-Peru
8	BEN-Benin	40	HKG-Hong Kong, China	72	PHL-Philippines
9	BWA-Botswana	41	HUN-Hungary	73	PRT-Portugal
10	BRA-Brazil	42	ISL-Iceland	74	RWA-Rwanda
11	BFA-Burkina Faso	43	IND-India	75	SAU-Saudi Arabia
12	BDI-Burundi	44	IDN-Indonesia	76	SEN-Senegal
13	CMR-Cameroon	45	IRL-Ireland	77	SGP-Singapore
14	CAN-Canada	46	ISR-Israel	78	ZAF-South Africa
15	CAF-Central African Republic	47	ITA-Italy	79	ESP-Spain
16	CHL-Chile	48	JAM-Jamaica	80	LKA-Sri Lanka
17	CHN-China	49	JPN-Japan	81	SUR-Suriname
18	COL-Colombia	50	KEN-Kenya	82	SWZ-Swaziland
19	ZAR-Congo, Dem. Rep.	51	KOR-Korea, Rep.	83	SWE-Sweden
20	COG-Congo, Rep.	52	KWT-Kuwait	84	CHE-Switzerland
21	CRI-Costa Rica	53	LUX-Luxembourg	85	SYR-Syrian Arab Republic
22	CIV-Cote d'Ivoire	54	MDG-Madagascar	86	THA-Thailand
23	DNK-Denmark	55	MWI-Malawi	87	TGO-Togo
24	DOM-Dominican Republic	56	MYS-Malaysia	88	TTO-Trinidad and Tobago
25	ECU-Ecuador	57	MLI-Mali	89	TUN-Tunisia
26	EGY-Egypt, Arab Rep.	58	MLT-Malta	90	TUR-Turkey
27	SLV-El Salvador	59	MRT-Mauritania	91	UGA-Uganda
28	FJI-Fiji	60	MEX-Mexico	92	GBR-United Kingdom
29	FIN-Finland	61	MAR-Morocco	93	USA-United States
30	FRA-France	62	MMR-Myanmar	94	URY-Uruguay
31	GAB-Gabon	63	NPL-Nepal	95	VEN-Venezuela, RB
32	GMB-Gambia, The	64	NLD-Netherlands	96	ZMB-Zambia
				97	ZWE-Zimbabwe

References

Afxentiou, P. C. and Serletis, A. (1993). International capital mobility and the long run investment and saving in canada, *Economia-Internationale* **46**: 147–167.

Alexakis, P. and Apergis, N. (1994). The Feldstein-Horioka puzzle and exchange rate regimes: evidence from cointegration test, *Journal of Policy Modeling* **16**: 459–472.

Allen, D. M. (1974). The relationship between variable selection and data augmentation and a method for prediction, *Technometrics* **16**: 125–127.

Amirkhalkhali, S. and Dar, A. A. (1993). Testing for capital mobility: A random coefficients approach, *Empirical Economics* **18**: 523–541.

Artis, M. and Bayoumi, T. (1992). Global capital market integration and the current account, *in* M. Taylor (ed.), *Money and Financial Markets*, Cambridge, MS and Oxford: Blackwell, pp. 297–307.

Backus, D., Kehoe, P. and Kydland, F. (1992). International real business cycles, *Journal of Political Economy* **100**: 745–775.

Balke, N. S. and Fomby, T. B. (1997). Threshold cointegration, *International Economic Review* **38**: 627–645.

Blanchard, O. and Giavazzi, F. (2002). Current account deficits in the euro area. the end of the feldstein horioka puzzle?, *MIT Department of Economics Working Paper 03-05*.

Cavaliere, G. (2005). Limited time series with a unit root, *Econometric Theory* **21**: 907–945.

Coakley, J., Fuertes, A.-M. and Smith, R. (2001). Small sample properties of panel time-series estimators with i(1) errors, *Birkbeck College Discussion Paper 3/2001*.

Coakley, J., Fuertes, A.-M. and Spagnolo, F. (2001). The Feldstein-Horioka puzzle is not as bad as you think, *Working paper*.

Coakley, J. and Kulasi, F. (1997). Cointegration of long span saving and investment, *Economics Letters* **54**: 1–6.

Coakley, J., Kulasi, F. and Smith, R. (1996). Current account solvency and the Feldstein-Horioka puzzle, *Economic Journal* **106**: 620–627.

Corbin, A. (2001). Country specific effect in the Feldstein-Horioka parodx: a panel data analysis, *Economics Letters* **72**: 297–302.

Dooley, M., Frankel, J. and Mathieson, D. J. (1987). International capital mobility: What do saving-investment correlations tell us?, *IMF Staff Papers* **34**: 503–529.

Feldstein, M. (1983). Domestic saving and international capital movements in the long run and the short run, *European Economic Review* **21**: 129–151.

Feldstein, M. and Bachetta, P. (1991). National saving and international investment, *in* D. Bernheim and J. Shoven (eds), *National Saving and Economic Performance*, Chicago: University of Chicago Press, pp. 201–226.

Feldstein, M. and Horioka, C. (1980). Domestic saving and international capital flows, *Economic Journal* **90**: 314–329.

French, K. and Poterba, J. (1991). Investor diversification and international equity markets, *American Economic Review* **81**: 222–226.

Geisser, S. (1975). The predictive sample reuse method with applications, *Journal of the American Statistical Association* **70**: 320–328.

Harberger, A. C. (1980). Vignettes on the world capital market, *American Economic Association* **70**: 331–337.

Herwartz, H. and Xu, F. (2006). Reviewing the sustainability/stationarity of current account imbalances with tests for bounded integration, *Economics Working Paper 2006-07*, Christian-Albrechts-University of Kiel.

Jansen, W. J. (1998). Interpreting saving-investment correlations, *Open Economies Review* **9**: 205–217.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models, *Econometrica* **59**: 1551–1580.

Johansen, S. (1992). Cointegration in partial systems and the efficiency of single-equation analysis, *Journal of Econometrics* **52**: 389–402.

Kremers, J., Ericsson, N. and Dolado, J. (1992). The power of cointegration tests, *Oxford Bulletin of Economics and Statistics* **54**: 325–348.

Mamingi, N. (1994). savings-investment correlations and capital mobility in developing countries, *The World Bank Policy Research Working Paper 1211.*

Miller, S. M. (1988). Are saving and investment cointegrated?, *Economics Letters* **27**: 31–34.

Murphy, R. G. (1984). Capital mobility and the relationship between saving and investment rates in oecd countries, *Journal of International Money and Finance* **3**: 327–342.

Obstfeld, M. (1986). Capital mobility in the world economy: Theory and measurement, *Carnegie-Rochester Conference Series on Public Policy* **24**: 55–104.

Pelgrin, F. and Schich, S. (2004). National saving-investment dynamics and international capital mobility, *Working Paper 2004-14*, Bank of Canada.

Pesaran, M. H. and Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels, *Journal of Econometrics* **68**: 79–113.

Sinn, S. (1992). Saving-investment correlations and capital mobility: On the evidence from annual data, *Economic Journal* **102**: 1162–1170.

Stone, M. (1974). Cross-validation choice and assessment of statistical predictions, *Journal of the Royal Statistical Society B* **36**: 111–147.

Swamy, P. (1970). Efficient inference in a random coefficient regression model, *Econometrica* **38**: 311–323.

Swamy, P. and Mehta, J. (1975). Bayesian and non-bayesian anaylsis of switching regressions and of random coefficient regression models, *Journal of the American Statistical Association* **70**: 593–602.

Tesar, L. L. (1991). Savings, investment and international capital flows, *Journal of International Economics* **31**: 55–78.

Tesar, L. L. (1993). International rsik-sharing and non-traded goods, *Journal of International Economics* **35**: 69–89.

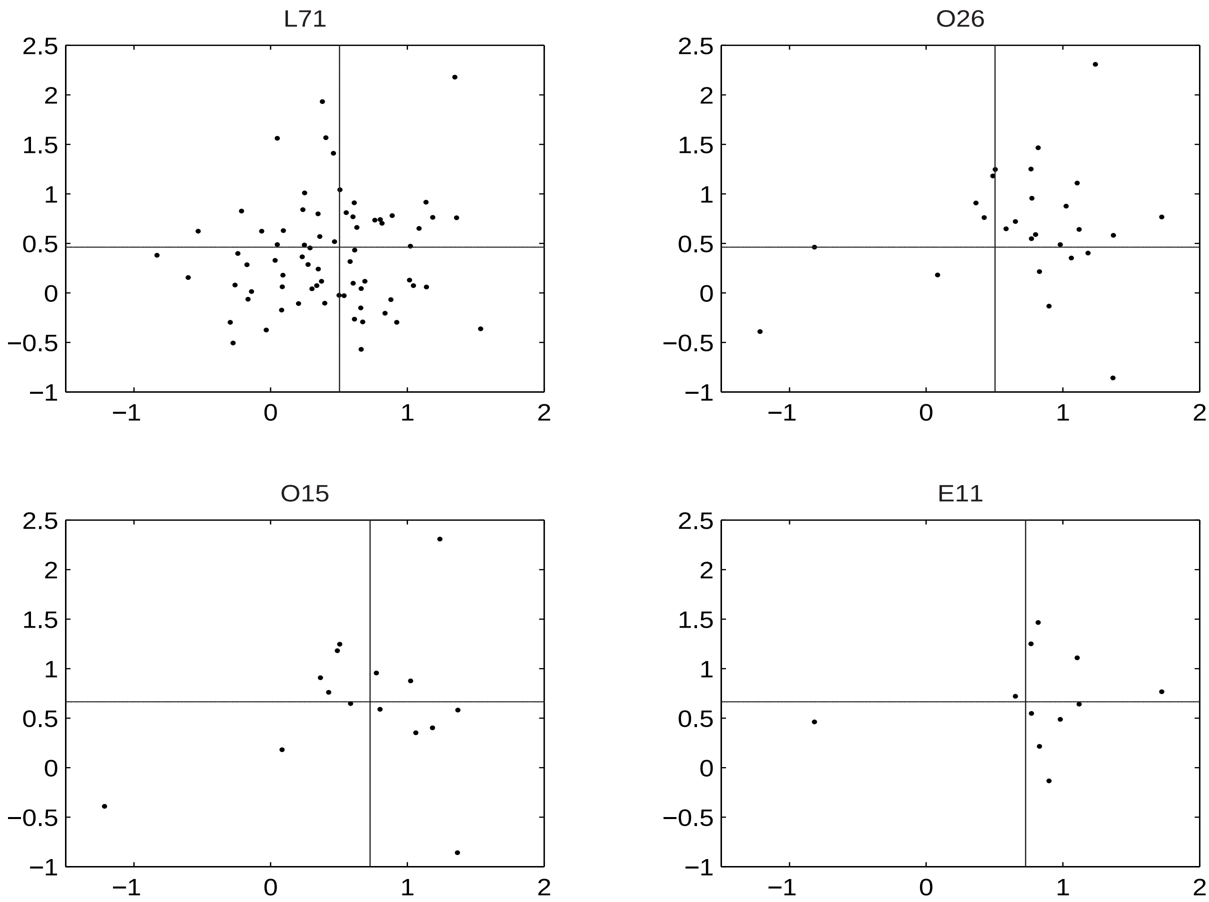

Figure 1: Scatter plots of country specific SI estimate $\hat{\beta}_i$ in (9) from the first subperiod (1971-1986) on the x-axis against second subperiod (1987-2002) estimates on the y-axis. Vertical and horizontal lines correspond to mean group estimates for W97 (O26) in the upper (lower) panels.

Table 1: **Panel model comparison**

Model	cv	cv^2	$\widetilde{cv}$	$\widetilde{cv^2}$	cv	cv^2	$\widetilde{cv}$	$\widetilde{cv^2}$	Model	cv	cv^2	$\widetilde{cv}$	$\widetilde{cv^2}$
	Panel A: Static				Panel B: Dynamic				Panel C: ECM				
Cross-Section: W97													
bet	4.46	38.06	1.40	1.85	6.18	65.32	1.45	1.68	*ecm*1	5.74	74.46	1.34	1.91
pol	4.47	37.68	1.41	1.83	5.94	60.71	1.39	1.56	*ecm*2	5.90	73.60	1.38	1.89
tim	4.44	38.66	1.40	1.88	6.50	79.51	1.52	2.04	*ecm*3	5.40	58.71	1.26	1.51
cro	3.17	20.59	1.00	1.00	4.27	38.89	1.00	1.00					
Cross-Section: L71													
bet	4.99	46.39	1.39	1.84	6.65	75.65	1.34	1.54	*ecm*1	6.73	94.82	1.35	1.93
pol	4.99	45.75	1.40	1.81	6.37	69.49	1.28	1.41	*ecm*2	6.76	91.03	1.36	1.85
tim	5.04	47.72	1.41	1.89	7.15	94.65	1.44	1.92	*ecm*3	5.96	69.54	1.20	1.41
cro	3.58	25.24	1.00	1.00	4.97	49.23	1.00	1.00					
Cross-Section: O26													
bet	2.87	14.45	1.38	1.83	3.33	19.26	1.41	1.80	*ecm*1	3.02	18.85	1.29	1.77
pol	2.87	14.48	1.38	1.83	3.09	16.31	1.31	1.53	*ecm*2	3.53	25.98	1.50	2.43
tim	2.66	12.23	1.28	1.55	3.31	20.16	1.41	1.89	*ecm*3	3.85	29.15	1.64	2.73
cro	2.08	7.90	1.00	1.00	2.35	10.67	1.00	1.00					
Cross-Section: O15													
bet	2.51	11.94	1.16	1.36	3.72	22.46	1.43	1.72	*ecm*1	3.54	24.80	1.36	1.89
pol	2.52	11.93	1.17	1.35	3.80	24.27	1.46	1.85	*ecm*2	4.12	34.57	1.59	2.64
tim	2.62	11.55	1.21	1.31	4.81	39.88	1.85	3.05	*ecm*3	4.27	36.64	1.64	2.80
cro	2.16	8.81	1.00	1.00	2.60	13.09	1.00	1.00					
Cross-Section: F16													
bet	2.55	11.61	1.43	1.99	2.47	9.69	1.37	1.69	*ecm*1	2.42	11.52	1.34	2.00
pol	2.61	11.53	1.46	1.98	2.55	12.02	1.42	2.09	*ecm*2	2.84	16.13	1.58	2.81
tim	2.34	9.85	1.30	1.69	2.94	15.71	1.63	2.73	*ecm*3	3.13	17.50	1.74	3.04
cro	1.79	5.82	1.00	1.00	1.80	5.75	1.00	1.00					
Cross-Section: E14													
bet	3.05	15.26	1.55	2.32	2.82	13.82	1.46	2.08	*ecm*1	2.30	10.22	1.20	1.54
pol	2.99	14.59	1.52	2.22	2.79	14.67	1.45	2.21	*ecm*2	2.68	13.37	1.39	2.02
tim	2.66	12.24	1.35	1.86	2.76	12.28	1.43	1.85	*ecm*3	3.15	17.43	1.64	2.63
cro	1.97	6.58	1.00	1.00	1.92	6.63	1.00	1.00					
Cross-Section: E11													
bet	3.30	17.96	1.69	2.70	3.02	15.94	1.49	2.16	*ecm*1	2.32	10.75	1.15	1.46
pol	2.94	14.63	1.51	2.20	2.90	16.36	1.44	2.22	*ecm*2	2.72	14.26	1.35	1.94
tim	2.72	12.17	1.39	1.83	3.52	20.09	1.74	2.73	*ecm*3	3.28	18.95	1.62	2.57
cro	1.96	6.65	1.00	1.00	2.02	7.37	1.00	1.00					

The table shows absolute and normalized CV criteria. In panels A (models in levels) and B (models in first differences), the considered implementations of panel models are the between (*bet*), pooled (*pol*), time (*tim*) and cross section specific (*cro*) regression. Smallest CV estimates are normalized to unity. Results obtained in Panel C are for the ECMs where the CV estimates are normalized in the way that the corresponding CV estimates for the cross-section dependent regression in first differences is equal to unity.