What determines the relation between domestic saving and investment? - a new look at the Feldstein-Horioka puzzle

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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 both theoretical and empirical literature. For diverse panel data models applied to estimate the SI relation a systematic model comparison has not been delivered yet. In this paper, we compare firstly between, pooled, time dependent and country dependent specifications of the SI relation via cross-validation (CV) criteria. It is found that the country dependent SI model is best performing among the four. Secondly, according to CV criteria, error correction models formalizing adjustment dynamics of domestic investment are uniformly outperformed by static panel model specifications. Thirdly, to uncover the determinants of the long-run SI relation, we apply bivariate functional coefficient models for a variant of the pooled regression. Macroeconomic state variables such as openness, the age dependency ratio, government current and consumption expenditures are found to have a significant impact on the SI relation.

Keywords: Saving-investment relation, Feldstein-Horioka puzzle, functional coefficient models, model comparison
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1 Introduction

Numerous macroeconometric studies have been addressing the link between an economies' domestic investment and saving. By means of a between regression for OECD countries Feldstein and Horioka (1980), henceforth FH (1980), document a strong correlation linking the latter variables, which is argued to be at odds with capital mobility. Following FH (1980) one would expect that under perfect capital mobility the correlation between a country's saving and investment ratio should be small. As such the diagnosed high correlation is in contrast to established theoretical frameworks in open economy macroeconomics and also to the believe that capital markets have experienced substantial liberalization. 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.

On the one side, economists have tried to identify economic forces governing the high SI relation. For instance, Obstfeld (1986) argues that both saving and investment respond to shocks in the population or productivity growth. Coakley, Kulasi and Smith (1996) and Taylor (2002) demonstrate that long-run solvency constraints might cause the high SI relation. On the other side, econometricians have tried to use other more flexible (panel) regressions 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 both, the theoretical as well as the econometric literature, a high correlation between domestic saving and investment, has been related e.g. to an economies' state of development or alternative regimes of market integration. To address such issues from an econometric perspective it is natural to employ alternative cross sections for panel data modeling. In comparison to sample selection, however, it is less clear which estimator or which particular panel data specification is most convenient to signal capital (im)mobility. Static as well as dynamic (error correction) panel data models have been employed to evaluate the SI relation. 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. The first 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.

Apart from the state of development or market integration a set of other macroeconomic factors has been considered as potential determinants of the SI relation or, similarly, the current account balance (Debelle and Faruqee 1996, Milesi-Ferretti and Razin 1998, Chinn and Prasad 2000). Addressing the potential of factor dependence

FH (1980) failed to explain the strong SI relation with economic influences as, for instance, the degree of openness, country size, etc. As the second contribution of this paper we adopt the idea of factor dependence characterizing the SI relation. After underscoring the prevalence of panel heterogeneity we follow a new semiparametric approach to illustrate the determinants of the SI relation. The latter is derived as a bivariate generalization of functional coefficient models (Cai, Fan and Yao 2000) that exploits sample information over both dimensions of the investigated data panels. Moreover, it allows a separation of long- and short-run factor impacts on the SI relation.

We analyse annual data spanning the period 1971 to 2002 for various (partly overlapping) cross sections characterizing the world economy, developing countries, the OECD, the EU and the Euro area. From model comparison we obtain that the investment and saving ratios are likely stationary and, thus, do not further pursue within a framework of error correction specifications. From static model performance we derive that the most convenient parametric description of the SI relation is cross section specific. Moreover, we agree with recent contributions documenting a decreasing trend of empirical SI relations. To identify potential determinants of the SI relation the formalized semiparametric model is suitable to cope with cross sectional heterogeneity, time and factor dependence. It allows to separate deterministic from measurable economic conditions characterizing the empirical SI relation over time. From the functional coefficient models, an economies' degree of openness, its age dependency ratio and government current and consumption expenditures are identified to have a significantly negative influence on the SI relation in the long run. Besides, countries with high GDP (measuring the effect of country size) are more likely to have a high SI relation. According to these results, it might be inappropriate to consider the SI relation merely as a measure of capital mobility upon which strategies of monetary or fiscal policy are developed.

The remainder of the paper is organized as follows: In the next Section we briefly state the FH puzzle and sketch some core theoretical and empirical contributions provoked by FH (1980). In Section 3 we initiate our empirical analysis by highlighting that the empirical SI relation has seen some weakening over more recent time periods. In Section 4 we provide a systematic comparison of static vs. dynamic models formalizing the SI relation. The best performing model is characterized by marked panel heterogeneity. For the latter we also illustrate that empirical SI relations might be driven by measurable economic factors. Given that the link between domestic saving and investment is likely heterogeneous over the panel members and time as well as factor dependent we introduce a semiparametric approach to evaluate the SI relation in Section 5. We derive the new framework from univariate functional coefficient models, and discuss briefly model representation, implementation and inferential issues. Empirical results obtained from the latter venue of modeling are provided in Section 6. Section 7 summarizes briefly our main findings and concludes. More detailed informations on the investigated countries and definitions of variables are given in the Appendix.

2 The relation between domestic saving and investment

In this section we briefly state the FH puzzle. Moreover, we give a short overview of the most important theoretical and empirical contributions on the SI relation triggered by FH (1980).

2.1 Feldstein Horioka puzzle

FH (1980) argue that if capital were mobile, domestic investment would not depend on domestic saving but the world saving, and domestic saving could seek out globally the highest return. Under perfect mobility of capital one would expect a small if any correlation between domestic saving and investment. By contrast, immobility of capital would imply a one-to-one relationship between domestic saving and investment.

To investigate the saving-investment (SI) relation FH (1980) make use of a between regression

$$\overline{I_i^*} = \alpha + \beta \overline{S_i^*} + e_i, \quad i = 1 \dots N, \tag{1}$$

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}, $t = 1, \dots, T$, denoting gross domestic investment, gross domestic saving and gross domestic product (GDP) in time period t and country i, respectively. Estimating regression (1) for 16 OECD countries with annual data from 1960 to 1974, FH (1980) obtain

$$\overline{I_i^*} = \underset{(0.018)}{0.035} + \underset{(0.074)}{0.887} \overline{S_i^*} + \widehat{e}_i, \tag{2}$$

with standard errors given in parentheses underneath the parameter estimates. The estimated impact of the average saving ratio on the average investment ratio, 0.887, is not significantly different from unity. The degree of explanation offered by (2) is 0.91. FH (1980) interpret the high SI relation as evidence for capital market segmentation among the considered OECD economies.

The initial responses to the FH puzzle, which replicate between regressions with different samples of OECD countries, have shown that the result in FH (1980) is quite robust. Although the estimated SI relation has declined over time, it remained large and significantly different from zero. A few contributions, however, argue that the FH puzzle has disappeared, such as Artis and Bayoumi (1992), Coakley, Fuertes and Spagnolo (2001) and Blanchard and Giavazzi (2002) for the EU and Euro area. The academic debate on the FH puzzle may be divided into two categories. While economists have been trying to give alternative theoretical interpretations of an empirically high SI relation, econometricians have reconsidered the SI relation using alternative model representations and/or estimation techniques. The latter categories are briefly sketched in the following.

2.2 Economic models explaining a high SI relation

From the viewpoint of economic theory, firstly, general equilibrium models have been constructed that allow a high SI relation in response to exogenous shocks under high or perfect capital mobility. By means of a life-cycle model Obstfeld (1986) demonstrates that, given a rise in the population growth rate, both the saving and the investment ratio increase. Mendoza (1991) constructs a real-business-cycle model of a small open economy with moderate adjustment costs and small variability and persistence of technological shocks. The latter turns out to be consistent with a positive correlation between domestic saving and investment, although financial capital is perfectly mobile.

Secondly, the stationarity of the current account balance implied by the long-run budget constraint (solvency constraint) could induce a high SI relation. By construction, saving minus investment equals the current account balance. Thus, a close SI relation might reflect stationarity of the current account. Introducing a market determined risk premium on borrowing, Coakley et al. (1996) show that the long-run solvency constraint implies a stationary current account. For the case of a simple Solovian economy with stochastic growth, Taylor (2002) demonstrates that stationarity of the current account is a sufficient condition for the long-run intertemporal budget constraint to hold. In this vein of economic models a high SI association reflects the solvency constraint, but not necessarily capital immobility.

In the third place a high SI relation may be due to a government targeting the current account balance. Artis and Bayoumi (1992) argue that the current account balance was an important target for monetary policy in the 1970s, but not in the 1980s. This policy change appears to correspond to a reduction in the SI relation among OECD countries in the 1980s.

Finally, the goods market, not the capital market, may be seen as the binding constraint linking domestic saving and investment. From this perspective, Tesar (1993) demonstrates that a model with stochastic fluctuations in the output of non-traded goods is consistent with a high SI association. In case non-traded goods account for a significant share of total output, consumer preferences over traded and non-traded goods and over the intertemporal allocation of consumption may introduce low cross-country correlations of aggregate consumption and an optimal portfolio biased towards claims on domestic output. Describing the so–called consumption correlations puzzle (Backus, Kehoe and Kydland 1992) and the home-bias portfolio puzzle (French and Poterba 1991), the latter effects are in line with a high SI relation. Comparably, Obstfeld and Rogoff (2000) demonstrate that moderate transactions costs of international trade may cause a substantial difference in real interest rates in spite of full financial market integration. In turn, real interest rate differentials might give rise to a high SI relation.

2.3 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.

2.3.1 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.

2.3.2 Competing panel based estimators

To relate the SI relation to the state of development or market integration it is natural to specify alternative cross sections for panel data models. In comparison to sample selection, however, it is less clear which estimator is most convenient 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 the saving and investment ratios, I_{it}^* and S_{it}^*, were nonstationary it is unclear what cross sectional averages $\bar{I}_i^*$ and $\bar{S}_i^*$ entering a between regression actually measure. Another common argument for a cross section specific SI relation is that the latter is heterogenous across economies. In case of cross sectional heterogeneity between regressions have attached the risk of providing spurious 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 et al. (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.

2.3.3 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 et al. (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:

$$\Delta I^*_{it} = \alpha_i + \lambda_i(I^*_{i,t-1} - \eta_i S^*_{i,t-1}) + \beta_i \Delta S^*_{it} + e_{it}, \quad i = 1, \ldots N, \quad t = 1, \ldots T, \qquad (3)$$

where α_i is a constant and 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 at 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 (3) 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 in the present framework, one should also take into account that standard cointegration and, in particular, unit root tests are not constructed for variables measured as ratios like I^*_{it} or S^*_{it}. 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. For the interpretation of the ECM in (3), however, the cointegration assumption is not really crucial, since error correction dynamics might also be formalized for stationary variables. In the light of the difficulties with unit root testing for bounded variables we refrain from viewing (3) 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.

3 Preliminary analyses

Having reviewed theoretical and empirical approaches to modeling the SI relation, this section is thought to introduce the data used for the empirical analyses. In addition, we provide first views at empirical features of the SI relation which are characteristic for our investigated (set of) cross sections. In the following we first give some information on the data and motivate the use of alternative cross sections. Stylized features of the empirical SI relation, as e.g. its downward trending behavior, will be illustrated by means of standard between regressions as in FH (1980) and time dependent regressions as adopted by Sinn (1992) or Blanchard and Giavazzi (2002).

3.1 The data

In the empirical literature on the SI relation, most authors concentrate on one or two specific cross sections such as OECD members, EU countries, the Euro area, large or less developed economies. In this paper, we investigate a set of specific 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 analyse the SI relation. Distinguishing numerous specific cross sections will be useful to reconsider former analyses relating 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 and its underlying determinants.

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.

3.2 Time dependence of the SI relation

3.2.1 Between regressions

Implementing the between regression in (1) with annual data covering the period 1971 to 2002, we obtain the results shown in panel A of Table 1. Between regression estimates are significantly positive in all cross sections except E11 and E14. Excluding the two latter cross sections from model comparison between regressions offer degrees of explanation between 52% (O26) and 83% (O15). Following the arguments in FH (1980) a significantly positive SI relation in W97 is not surprising. Some patterns of capital market segmentation are likely over a group of 97 economies sampled from all over the world. From a global perspective capital mobility is limited ’on average’. For E14 and E11, the coefficient estimates are insignificant and thereby confirm the EU and Euro effect. Capital mobility is high among EU countries and even higher in the Euro area. In F16, both the estimated SI relation (0.62) and the degree of explanation (0.58) are smaller for the period 1971 to 2002 compared to the result given in (2) for the period 1960 to 1974. The latter finding is consistent with the presumption that capital mobility has increased over time. Furthermore, it could be shown that the estimated SI relation becomes insignificant in F16 if Japan, the UK and the US are excluded, thereby signalling a large country effect.

Given the weakened evidence in favor of a large or even significant SI relation in more recent sample in comparison with FH (1980), it is sensible to check the robustness of the previous between regression results by means of two equally sized sub-samples, covering the periods 1971 to 1986 and 1987 to 2002, respectively. Between regression results obtained for these two subperiods are documented in panels B and C of Table 1. It can be seen that the estimated SI relation has decreased in all cross sections. This evidence points to some variation of the SI relation and, moreover, is consistent with the generally improving integration of capital and goods markets. Furthermore, the between estimates are insignificantly different from zero in E14 and E11 for both subperiods. Although the SI relation in OECD economies (O26, F16, O15) is still significantly different from zero, it is much smaller for the more recent period. As a consequence, the degree of explanation achieved by between regressions for the second subset is lower than for the first, and varies between 26% (F16) and 68% (O15) when E11 and E14 are excluded. It is worthwhile mentioning that as an alternative to between regressions pooled regression models deliver results which are qualitatively identical to those reported for the between regressions. We do not provide pooled estimates in detail for space considerations.

In the light of the latter results one may conjecture that the FH puzzle is not such a big puzzle anymore when concentrating on more recent time windows. In a similar vein, using data for 12 OECD countries from 1980 to 2001, Coakley et al. (2001) show the insignificance of the SI relation by means of nonstationary panel models. Blanchard and Giavazzi (2002) also document a small SI relation in a pooled regression for the EU area using the sample period 1991 to 2001. From a statistical as well as economic viewpoint, however, potential time variation of the SI relation provokes some subsequent issues. With regard to statistical aspects it is not clear in how far conclusions offered by (misspecified) time homogeneous econometric models are spurious or robust under respecification of the model. From an economic perspective it is tempting to disentangle the economic forces behind the observed decreasing trend in the SI relation. With regard to the latter aspect it is of particular interest to separate deterministic time features from measurable economic factors driving the SI relation. The next paragraph will underscore that the SI relation is likely not homogenous within the two subsamples considered so far but time varying throughout.

3.2.2 Time dependent SI relations

Given that between regression estimates of the SI relation decrease over the two subperiods, it is tempting to address the issue of time variation in some more detail. For this purpose, we employ a sequence of (time specific) cross sectional OLS regressions proposed by Sinn (1992) or Blanchard and Giavazzi (2002):

$$I^*_{it} = \alpha_t + \beta_t S^*_{it} + e_{it}, \quad i = 1 \ldots N. \tag{4}$$

Time varying slope estimates, $\widehat{\beta}_t$, $t = 1971, \ldots, 2002$, obtained from model (4) for the three non-overlapping cross sections (L71, O15 and E11) are shown in Figure 1 jointly with corresponding 95% confidence intervals. Eyeball inspection confirms that the SI relation has decreased over time in all cross sections. It has declined from around 0.8 to 0.2 in O15 (similarly in O26 and F16) from 0.39 to 0.18 in L71 (W97) and from 0.5 to zero in E11 (E14). Regarding E14 and E11 our results are in line with Blanchard and Giavazzi (2002). A sharp reduction of $\hat{\beta}_t$ between 1975 and 1980 is found for F16, E14 and E11. This evidence might be due to the fact that many industrialized economies experienced current account deficits in this period. The latter might mirror the effects of oil price shocks in the late 1970s. According to Sachs (1981), however, changes in investment opportunities rather than oil price changes dominated the medium-run behavior of current accounts in the 1970s.

4 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. Model selection issues will become a core part of this section. After identifying a model family describing the data better than rival specifications we try to uncover potential determinants of the SI relation.

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 nonstationarity 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 stochastic trends governing S_{it}^* and I_{it}^*.

Model comparison will be addressed by means of cross validation (CV) techniques which are briefly described subsequently. After determining a most suitable modeling framework we will specify a set of potential economic state variables explaining the cross sectional pattern of empirical SI relations.

4.1 Cross validation

4.1.1 The 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:

$$cv_{(mod)} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}|y_{it} - \hat{y}_{it}(mod)|. \tag{5}$$

In (5) '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.

$$\hat{y}_{it}(mod) = x'_{it}\hat{\boldsymbol{\beta}}_{\underline{}mod,it}, \tag{6}$$

with $\hat{\boldsymbol{\beta}}_{\underline{}mod,it}$, being an estimated parameter vector that is obtained from a particular model, $y_{it} = x'_{it}\hat{\boldsymbol{\beta}}_{\underline{}mod,it} + e_{it}$, 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.

$$cv^2_{(mod)} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}(y_{it} - \hat{y}_{it}(mod))^2. \tag{7}$$

4.1.2 Model specifications

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

$$I^*_{it} = \alpha_{it} + \beta_{it}S^*_{it} + e_{it}. \tag{8}$$

The empirical implementation of the relation in (8) 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

$$pol: \quad I^*_{it} = \alpha + \beta S^*_{it} + e_{it}, \tag{9}$$
$$bet: \quad \overline{I^*_i} = \alpha + \beta\overline{S^*_i} + \overline{e}_i, \tag{10}$$

respectively. As two main competitors of these highly restricted regression designs we regard the parameters of the model in (8) to be either time specific or to vary over the cross section, i.e.

$$tim: \quad I^*_{it} = \alpha_t + \beta_t S^*_{it} + e_{it}, \tag{11}$$
$$cro: \quad I^*_{it} = \alpha_i + \beta_i S^*_{it} + e_{it}. \tag{12}$$

An important 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 for the analysis of the link between domestic saving and investment we will proceed in two steps.

First, we evaluate general panel models as formalized in (8) to explain the changes of investment ratios rather than their levels. The corresponding unrestricted panel representations read as

$$\Delta I^*_{it} = \alpha_{it} + \beta_{it}\Delta S^*_{it} + e_{it}. \tag{13}$$

Note that although not indicated by our notation the parameters α_{it}, β_{it} and error terms e_{it} differ across (8) and (13). As when implementing (8) 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 (13) 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:

$$\begin{aligned}
ecm1_c:\ \ \Delta I^*_{it} &= \alpha_i + \lambda_i(I^*_{i,t-1} - \eta_i S^*_{i,t-1}) + \beta_i \Delta S^*_{it} + e_{it}, && (14)\\
ecm2_c:\ \ \Delta I^*_{it} &= \alpha_i + \lambda_i(I^*_{i,t-1} - S^*_{i,t-1}) + \beta_i \Delta S^*_{it} + e_{it}, && (15)\\
ecm3_c:\ \ \Delta I^*_{it} &= \alpha_i + \lambda_i(I^*_{i,t-1} - S^*_{i,t-1}) + e_{it}, && (16)\\
ecm2_p:\ \ \Delta I^*_{it} &= \alpha + \lambda(I^*_{i,t-1} - S^*_{i,t-1}) + e_{it}, && (17)
\end{aligned}$$

All ECM specifications in (14) to (16) can be derived from the model in (3) introduced by Pelgrin and Schich (2004). Each specification except the pooled model (17) formalizes cross sectional parameter dependence. Whereas the general model in (14) allows the parameter η_i to enter unrestrictedly, (15) and (16) make use of the restriction $\eta_i = 1$ implying that the current account imbalance impacts on the investment ratio.

In the light of the results documented in Section 3.2., it might be criticized that the model family in (14) to (16) does not allow time dependence of its parameters. 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 (13) 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.

4.1.3 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 (13) 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 (8).

4.2 Cross validation results

Cross-validation results are documented in Table 2. 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 (13) and ECMs is feasible. Cross comparison of the model families given in (8) and (13) is feasible by regarding (non-normalized) absolute CV estimates obtained from the benchmark (cross section specific) models.

1) Static vs. weakly dynamic models
   As mentioned comparing the model families in (8) and (13) sheds light on the potential of stochastic trends governing the domestic investment and saving ratios. Moreover, such a comparison hints at the prevalence of individual effects in (8) 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. The latter results support the view that the ratios of domestic saving and investment over GDP are likely stationary.

2) Static panel models
   Concentrating on the model family (8) 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.

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 2, 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 $ecm1_c$ given in (14)) and 74% (F16, model $ecm3_c$ (16)) 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.

4.3 Determinants of the SI relation

4.3.1 Factor dependence

An apparently decreasing trend of the SI relation has been documented in Section 3.2. Moreover, cross section specific features of the SI relation have been worked out in the preceding section. Given these intermediate results it is tempting to investigate if the decrease of empirical SI relations is a purely deterministic feature or could be explained by (measurable) economic conditions. The issue of potential factor dependence of the SI relation is as old as the FH puzzle itself. To find factors governing the SI relation, FH (1980) employed augmented between regressions,

$$\overline{I^*_i} = \alpha + (\gamma_0 + \gamma_1 \bar{w}_i)\overline{S^*_i} + e_i, \tag{18}$$

where $\overline{w}_i = 1/T \sum_{t=1}^{T} \widetilde{w}_{it}$ is a measure of some factor characterizing the i-th member of the cross section. As particular variables $\widetilde{w}_{it}$ entering equation (18), FH (1980) use the rate of population growth, the degree of openness, measured as the sum of exports and imports in relation to GDP, and the logarithm of GDP (large country effect). However, FH (1980) could not find supporting evidence for the view that any of the latter factors significantly influences the link between domestic saving and investment. Numerous factors impacting the SI relation have been suggested in the theoretical literature, such as population growth (Obstfeld 1986), current account targeting (Artis and Bayoumi 1992), or output fluctuations in non-traded goods (Tesar 1993). Apart from FH (1980) the econometric literature has not addressed the issue of factor dependence of the SI relation. In this paper, we will adopt the framework of factor dependent regressions to analyze the SI relation and its determinants empirically. For the selection of factors governing the SI relation we follow the macroeconomic discussion of the potential determinants of saving, investment or the current account balance (group 1) on the one hand and of integration of goods and financial markets (group 2) on the other hand. In addition, we also investigate the scope of variables measuring the dependence of the SI relation on country size (group 3). Most of the chosen factors are motivated in Masson, Bayoumi and Samiei (1998), Edwards (1995), Debelle and Faruqee (1996), Chinn and Prasad (2000), Milesi-Ferretti and Razin (1997) and Milesi-Ferretti and Razin (1998). A list of factors is given in the Appendix.

4.3.2 Profiles of estimated SI relations

Providing a first view at the determinants of empirical SI relations we perform cross sectional regressions of the following type:

$$\hat{\beta}_i = \gamma_0 + \gamma_1 \bar{w}_i + e_i, \quad i = 1, ...N, \tag{19}$$

where $\hat{\beta}_i$ is the slope estimate obtained from cross section specific regressions (12) and $\bar{w}_i$ is defined below (18). In case $\hat{\gamma}_1$ differs significantly from zero we regard the respective factor to affect the SI relation. The regression in (19) takes a cross sectional view at the determinants of the SI relation. The latter is justified in the light of panel heterogeneity diagnosed in Section 4.2 by means of CV criteria. As a particular caveat of the regression in (19) one may point out that the dependent variables are not observed but (unbiased) estimators from some first step regression. As a more direct variant to detect factor dependence using observable regressands, one may regard a model

$$I_{it}^* = \alpha_i + \gamma_0 S_{it}^* + \gamma_1 \bar{w}_i S_{it}^* + e_{it} \tag{20}$$

that is obtained from substituting $\beta_i = \gamma_0 + \gamma_1 \bar{w}_i$ in (12). Running the latter regression we find that the point estimates for γ_1 are rather close to those obtained from (19). We believe, however, that owing to potential cross sectional heterogeneity and autocorrelation of model disturbances e_{it} in (20) estimation uncertainty is easier to control in the cross sectional regression (19). We refrain from providing detailed inference for the disaggregated regression model in (20) for space considerations.

We find two factors for which a significant influence is diagnosed for at least two of the non-overlapping cross sections, L71, O15 and E11. Results from corresponding profile regressions are reported in Table 3. We discuss them in turn:

- A negative impact of the age dependency ratio on the cross sectional SI relation is diagnosed over 4 OECD samples and W97. The higher the ratio of dependents to the working-age population, the less is, ceteris paribus, the domestic saving. This might lead to the disconnection of domestic saving and investment.

- The openness ratio has a significantly negative effect on the SI relation for OECD economies and less developed countries. Not surprisingly, more open economies have more integrated good markets which in turn might lead to a weaker SI relation. Separating the openness ratio into the ratios of exports and imports to GDP, significantly negative effects on the SI relation are confirmed for both components.

Apart from parameter significance documented in Table 3, the detected cross section patterns are mostly uniform in the sense that the diverse profile regressions indicate the same direction of potential state variables affecting the SI relation. As a further result it is worthwhile to point out that specific factors suggested by economic theory as, for instance, population growth, country size or fiscal variables, fail to describe the cross sectional pattern of SI relations significantly. The latter failure of significance, however, may also be addressed to a false presumption of time homogeneity of the SI relation or the factor state ($\bar{w}_i$) or both. When performing a surface regression by regressing $\hat{\beta}_i$ simultaneously on the explanatory factors listed in Table 3, it turns out that owing to multicollinearity only two factors remain to have significant explanatory power. Such surface regressions detect the age dependency ratio and one of the trade related measures (openness, exports, imports) to explain estimates $\hat{\beta}_i$ significantly.

5 Functional coefficient models

The preceding analyses have shown that the link between domestic saving and investment has likely country specific features. Moreover, the SI relation exhibits some downward trending behavior and, finally, profile regressions reveal that the correlation between domestic saving and investment may be explained conditional on some economic factor variables. Given the likelihood of parameter variation over two data dimensions, all empirical approaches followed so far carry the risk of providing spurious results since at most one dimension of potential parameter dependence has been taken into account. From the latter observations, one may refrain from modeling the SI relation by means of econometric specifications presuming some restrictive form of (cross sectional or time) homogeneity or state invariance. As a consequence one may alternatively opt for local models where the parameters of interest are given conditionally on some economic state variable measured over both dimensions of the panel. For the latter reasons we will adopt semiparametric models that can be seen as a bivariate generalization of functional coefficient models as introduced by Cai, Fan and Yao (2000). A further merit of this approach and its local implementation is that it might give valuable information on the accuracy of the restrictive nature of parametric models. In the following we briefly sketch model representation, bandwidth selection and parameter estimation in turn.

5.1 Model representation

To discuss model representation we start, for convenience, with a one dimensional factor model fitting into the framework introduced by Cai, Fan and Yao (2000). In a second step the bivariate state dependent model, as employed in this work, will be provided.

Consider the following semiparametric extension of a pooled regression:

$$\begin{aligned} I^*_{it} &= \alpha(w^{(i)}_{it}) + \delta(w^{(i)}_{it})t + \beta(w^{(i)}_{it})S^*_{it} + e_{it} \\ \equiv y_{it} &= x'_{it}\boldsymbol{\beta}(w^{(i)}_{it}) + e_{it},\ \boldsymbol{\beta}(\bullet) = (\alpha(\bullet), \delta(\bullet), \beta(\bullet))'. \end{aligned} \tag{21}$$

The model in (21) formalizes the view that the SI relation responses to (changes of) some underlying factor, $w^{(i)}_{it}$, characterizing the state of economy i. The inclusion of a deterministic trend term in (21) is thought to disentangle deterministic features of the SI relation from factor dependence. To measure economic states it is natural to represent the factor in some standardized form so that cross sectional comparisons are facilitated. Owing to potential nonstationarity of the time path of a particular factor variable measured for a specific cross section member, we consider standardized factors

$$w^{(i)}_{it} = (\widetilde{w}_{it} - \hat{w}^{(hp)}_{it})/\sigma_i(gap(w)). \tag{22}$$

In (22) $\hat{w}^{(hp)}_{it}$ is the long-run time path of a particular factor variable as obtained from applying the Hodrick-Prescott (HP) filter (Hodrick and Prescott 1997) to $\widetilde{w}_{it}$, $t = 1, \ldots, T$. Accordingly, the process $\widetilde{w}_{it} - \hat{w}^{(hp)}_{it}$ describes the 'factor gap' for economy i having unconditional (cross section specific) variance $\sigma^2_i(gap(w))$. To implement (22) with yearly factor observations we set the HP smoothing parameter to 6.25 as recommended by Ravn and Uhlig (2001). Note that the standardized 'factor gap' as defined in (22) has an unit unconditional variance. As an alternative for $\hat{w}^{(hp)}_{it}$ to measure a factor's long-run time path, one may a-priori also consider a cross sectional mean, i.e. $\bar{w}_i = 1/T \sum_{t=1} \widetilde{w}_{it}$. In case a particular factor variable is nonstationary, however, it is not clear what $\bar{w}_i$ actually measures and, as such, it will not be representative for the factor over the entire sample period. In the opposite case of a stationary factor variable, $\bar{w}_i$ is an efficient approximation of the factor's 'steady state' but the efficiency loss implied by applying the HP filter might be moderate. Since controlling the time series features of diverse factor variables over a cross section as large as W97 is not at the core of our analysis, we prefer the HP filter as an approximation of a factor's long-run time path.

Along the latter lines one may evaluate local SI relations conditional on scenarios where a particular factor variable for the i-th cross section member is above, close to or below its long-run time path. Regarding, for instance, the ratio of exports plus imports over GDP as a factor, states of lower vs. higher 'openness' observed for a given economy over time could be distinguished to evaluate the SI relation locally. From the empirical features of the SI relation uncovered in Section 3.2.2, however, one may regard the model not only to depend on the location of the country specific factor relative to its long-run time path but also on the factor's time features measured against other economies comprising the cross section. In a standardized fashion, the latter measure is $w_{it}^{(t)} = (\widetilde{w}_{it} - \bar{w}_t)/\sigma_t(\widetilde{w})$, where $\bar{w}_t$ and $\sigma_t(\widetilde{w})$ denote the empirical (time dependent) cross sectional mean, $\bar{w}_t = 1/N \sum_{i=1}^{N} \widetilde{w}_{it}$, and time specific standard error of $\widetilde{w}_{it}$, respectively. Note that $\bar{w}_t$, $t = 1, \ldots, T$, might be interpreted as a factor's long-run time path measured over the cross section. In case the latter is as large as W97, $\bar{w}_t$ approximates a factor's global evolution over time. For instance, with regard to the openness variable, $\bar{w}_t$ is suitable to reflect the world wide trend towards global specialization and an intensified international exchange of goods. Since $\bar{w}_t$ is defined as an arithmetic mean over the cross section its local interpretation does not suffer from the potential of stochastic trends governing country specific factor processes. Generalizing the model in (21), both dimensions of a particular factor variable could be used to formalize a local view at the pooled regression model as

$$\begin{aligned} I_{it}^{*} &= \alpha(w^{(i)} = w_{it}^{(i)}, w^{(t)} = w_{it}^{(t)}) && (23)\\ &+ \delta(w^{(i)} = w_{it}^{(i)}, w^{(t)} = w_{it}^{(t)})t + \beta(w^{(i)} = w_{it}^{(i)}, w^{(t)} = w_{it}^{(t)})S_{it}^{*} + e_{it} \\ \equiv y_{it} &= x_{it}'\boldsymbol{\beta}(w^{(i)}, w^{(t)}) + e_{it} \\ &= x_{it}'\boldsymbol{\beta}(\omega) + e_{it}, && (24) \end{aligned}$$

with $x_{it} = (1, t, S_{it}^{*})'$ and $\omega = (w^{(i)}, w^{(t)})$.

5.2 Estimation

To estimate the factor dependent parameter vector $\boldsymbol{\beta}(\omega)$ in (24) we proceed similar to a trivariate version of the Nadaraya Watson estimator (Nadaraya 1964, Watson 1964). The latter builds upon the following weighted sums of cross products of observations:

$$\mathcal{Z}(w^{(i)}, w^{(t)}) = \sum_{i=1}^{N}\sum_{t=1}^{T} x_{it}x_{it}' K_{i,h}(w_{it}^{(i)} - w^{(i)})K_{t,h}(w_{it}^{(t)} - w^{(t)}), \qquad (25)$$

$$\mathcal{Y}(w^{(i)}, w^{(t)}) = \sum_{i=1}^{N}\sum_{t=1}^{T} x_{it}y_{it} K_{i,h}(w_{it}^{(i)} - w^{(i)})K_{t,h}(w_{it}^{(t)} - w^{(t)}), \qquad (26)$$

where the components of the bivariate factor variable $\omega_{it} = (w_{it}^{(i)}, w_{it}^{(t)})$ have been defined previously as

$$w_{it}^{(i)} = (\widetilde{w}_{it} - \hat{w}_{it}^{(hp)})/\sigma_i(gap(w)),\ w_{it}^{(t)} = (\widetilde{w}_{it} - \bar{w}_t)/\sigma_t(\tilde{w}).$$

In (25) and (26) we denote $K_{\bullet,h}(u) = K_{\bullet}(u/h)/h$, where $K(\cdot)$ is a kernel function and h is the bandwidth parameter. From the moments given in (25) and (26), the semiparametric estimator is obtained as

$$\hat{\boldsymbol{\beta}}(\omega) = \hat{\boldsymbol{\beta}}(w^{(i)}, w^{(t)}) = \mathcal{Z}^{-1}(\omega)\mathcal{Y}(\omega). \qquad (27)$$

As it is typical for Kernel based estimation, the choice of the bandwidth parameter is of crucial importance for the factor dependent estimates given in (27) (Härdle, Hall and Marron 1988). For bandwidth selection, we use Scott's rule of thumb (Scott 1992). Since the unconditional standard deviation of the factor variables over both data dimensions is (close to) unity by construction, the rule of thumb bandwidth is $h =$

$(NT)^{-1/6}$. With regard to the Kernel function, we use the Gaussian Kernel, $K(u/h) = (2\pi)^{-1/2}\exp(-0.5(u/h)^2)$. Generally, NT is the number of observations available for the factor variable. For the practical implementation of the bivariate Kernel estimator in the present case, we have to point out that owing to missing observations the actual panel used for estimation is unbalanced for numerous factor variables. For convenience, the latter feature of the panel is suppressed by the employed notation.

5.3 Implementation

The trivariate model formalized in (24) offers a local view at the SI relation conditional on a particular economic variable describing the state of an economy in two directions. As a consequence estimation results could be provided in terms of three dimensional graphs. Since our interest here is focussed on some overall impact of a particular factor on the SI relation, however, we will display estimation results from the model in (24) along particular paths of the state variables. The latter perspective has the advantage that estimation results can be provided in the familiar form of two dimensional functional estimates. To be explicit, estimates of the following local SI relations will be shown:

$$\begin{array}{ll} (i) & \hat{\beta}(w^{(i)} = v, w^{(t)} = -1, 0, 1), \\ (ii) & \hat{\beta}(w^{(i)} = 0, w^{(t)} = v),\ v = -2 + 0.1k,\ k = 0, 1, 2, \ldots, 40. \end{array}$$

Conditioning the evaluation of local estimates on states with either $w^{(i)} = 0$ or $w^{(t)} = 0$ provides different insights into the determinants of the SI relation that allow a classification into short- and long-run impacts. To get an intuition for the latter interpretations, we discuss the Kernel based weighting schemes in (25) and (26) in some more detail.

- Short-run determinants
  Conditional on $w^{(t)} = 0$ local SI relations are evaluated with putting higher weights on those members of a particular cross section that follow closely the cross sectional time trend ($\bar{w}_t$), as, for instance, the globally trending behavior towards an intensified exchange of goods. Similarly, conditional on positive (+1, say) or negative (−1) values of $w^{(t)}$, local SI relations are evaluated with those economies getting the highest weight which are above or below the factor specific trend. As a particular merit of the semiparametric approach it is noteworthy that the composition of the latter 'artificial' cross sections is time dependent, i.e. the weighting scheme picks up effects of a country falling behind or keeping up with the global perspective. Apart from the time varying Kernel weight, $K_{t,h}(\bullet)$, it is the 'inner factor variation' around its country specific trend that enters the local weighting scheme for the given country ($K_{i,h}(\bullet)$). In the latter sense, conditional estimates of the SI relation exploit short-run factor variation. Since short-run factor dependence might differ according to a countries' position relative to the cross sectional average, it is tempting to compare various local estimates, conditioned upon $w^{(t)} = -1,\ 0,\ 1$ say.

- Long-run determinants
  Conditional on $w^{(i)} = 0$, country specific weights $K_{i,h}(\bullet)$ are the highest for those

observations where a particular factor realization in country i is close to the long-run time path characterizing this particular economy. Varying in the same time the location of $w^{(t)} = -2, \ldots, 2$ allows to exploit 'outer factor variation' for quantifying local states of the SI relation. In this case, the chosen support of $w^{(t)}$ will subsequently put high Kernel weight, $K_{t,h}(\bullet)$, on those economies which are below, close to or above a factor's overall time path. Since changes of the latter relative positions are likely to reflect long term economic conditions or policy strategies, local SI relations conditional on $w^{(i)} = 0$ are interpreted here as long-run characteristics of the SI relation.

- An illustration
  The latter perspectives of factor variation are illustrated for the case of the openness ratio (measured in %) in Figure 2. The left hand side panel shows time series of the openness ratio (dashed line) for all countries in O26 jointly with the time path of the average openness degree. The latter corresponds to $w^{(t)} = 0$. For three particular economies, Germany, the US and Japan, the openness ratio and it's corresponding country specific trend ($w^{(i)} = 0$) are shown in the medium panel as dashed and solid curves, respectively. When evaluating long run dependence of the SI on openness, factor realizations close to the latter trend enter the Kernel regression with the highest weight. To estimate short run impacts of openness on the SI relation, factor variation around the long run trend (shown in right hand side panel of Figure 2) contributes to Kernel based weighting while in the same time the relative location of a particular economy within the cross section is fixed. Given the openness measure as displayed in the medium panel of Figure 2, it is likely that inner German variations get a higher/lower kernel based weight than factor variations measured for Japan or the US conditional on a relatively high/low degree of openness ($w^{(t)} = 1/w^{(t)} = -1$).

5.4 Bootstrap inference in the two factor model

Inference on state dependence of the SI relation may proceed conditional on some (approximation of) asymptotic properties of the Nadaraya Watson estimator (Nadaraya 1964, Watson 1964). Alternatively, state dependent and invariant model representations could be contrasted by means of CV criteria. As proposed by Cai, Fan and Yao (2000), the latter may also be used for factor selection from a set of alternative state variables. In semi- and nonparametric modeling, bootstrap approaches have become a widely used toolkit for inferential issues. For univariate factor dependent regressions, Cai, Fan and Yao (2000) advocate a residual based resampling scheme to infer on factor dependence against a structurally invariant model specification. Owing to the relatively small sized available samples, residual based resampling might suffer from the instance that, in the boundaries of the factor support, functional estimates could become wiggly and at the same time residual estimates unreliably small. Moreover, residual estimation could be adversely affected by possible over- or undersmoothing as a consequence of rule of thumb based bandwidth selection. In the light of the latter caveats, we decide in favor of some resampling from the data which, similar to pairwise bootstrapping (Freedman 1981), promises valid significance levels even in case of local under- or oversmoothing. For a systematic comparison of residual based resampling and the latter procedure, the reader may consult Herwartz and Xu (2006). The adopted approach to contrast a structurally invariant model against the local formalization is implemented along the following lines:

1) The local estimate in (27) can be seen as a function of the data and the chosen bandwidth parameter, i.e.

$$\hat{\boldsymbol{\beta}}(\omega) = f\{y_{it}, x'_{it}, \omega_{it} = (w_{it}^{(i)}, w_{it}^{(t)}), h,\ i = 1, \ldots, N,\ t = 1, \ldots, T\}. \quad (28)$$

2) To distinguish the cases of factor dependence and factor invariance of the SI relation we compare local estimates as given in (28) with bootstrap counterparts

$$\hat{\boldsymbol{\beta}}^*(\omega) = f\{y_{it}, x'_{it}, \omega^*_{it} = (w_{it}^{(i*)}, w_{it}^{(t*)}), h,\ i = 1, \ldots, N,\ t = 1, \ldots, T\}, \quad (29)$$

where bivariate tuples $\omega^*_{it} = (w_{it}^{(i*)}, w_{it}^{(t*)})$ are drawn with replacement from the set of bivariate variables $w_{it} = (w_{it}^{(i)}, w_{it}^{(t)})$. Since sample information on the y_{it} and x'_{it} is not affected by the bootstrap the adopted scheme will disconnect any potential link between the selected factor variable on the one hand and the SI relation on the other hand. If the true underlying SI relation is state invariant estimates $\hat{\boldsymbol{\beta}}(\omega)$ and $\hat{\boldsymbol{\beta}}^*(\omega)$ are likely to differ only marginally over the support of the state variable.

3) Drawing a large number, $R = 1000$ say, of bootstrap estimates $\hat{\boldsymbol{\beta}}^*(\omega)$ allows to decide if the null hypothesis of a state invariant SI relation can be rejected at some state $\omega = (w^{(i)}, w^{(t)})$. For this purpose, estimates $\hat{\beta}(\omega)$ are contrasted with a confidence interval constructed from its bootstrap distribution $\hat{\beta}^*(\omega)$. For this study, we will use the 2.5% and 97.5% quantiles of in $\hat{\beta}^*(\omega)$ as a 95% confidence interval to hold for the true (functional) parameter $\beta(\omega)$ under the null hypothesis of state invariance. Accordingly, we regard the actual estimate to differ locally from the unconditional relation with 5% significance if $\hat{\beta}(\omega)$ is not covered by the bootstrap confidence interval.

6 Results for state dependent modeling

In this section, we report results obtained from the state dependent model (24) outlined in Section 5. Our discussion will not cover local estimates of the intercept ($\alpha(\omega)$) and trend parameter ($\delta(\omega)$) of the model. Rather we will concentrate on the empirical features of the SI relation, i.e. on local estimates $\hat{\beta}(\omega)$. As mentioned, the inclusion of the a deterministic trend term in (24) was meant to allow an evaluation of factor impacts on the SI relation conditional on deterministic time features. We also estimated the local model excluding the deterministic trend term. Instead of providing any explicit results obtained from these exercises for space considerations, we confirm that functional relationships turn out to be invariant in shape under inclusion or exclusion of a deterministic trend variable. For most factors, however, slopes of functional forms were more pronounced for the model without deterministic trend. In addition, evaluating estimation uncertainty by means of resampling schemes obtains confidence intervals for the SI relation which are throughout wider for the functional regression model including the deterministic trend term.

6.1 Cross validation

Since semiparametric estimates could become quite wiggly in the boundaries of the factor support, we provide CV measures only for those observations which correspond to 'regular' factor realizations such that

$$cv_{(mod)} = \frac{1}{NT} \sum_{i=1}^{N} \sum_{t=1}^{T} |y_{it} - \hat{y}_{it}(mod)| I(-2 \leq w_{it}^{(t)} \leq 2) I(-2 \leq w_{it}^{(i)} \leq 2), \tag{30}$$

where $I(\bullet)$ is an indicator function. To obtain jackknife estimators, $\hat{y}_{it}(mod)$, all available sample information is used.

For the three groups of factors mentioned in Section 4.3.1, CV criteria comparing the merits of local estimates (27) against pooled regressions are reported in Table 4. Since the results from model comparison based on squared and absolute forecast errors are very similar, we only provide CV criteria for the latter. With regard to CV criteria, it turns out that invariant versions of the model in (24) deliver CV measures coming very close to those provided in Table 2 for the time dependent regression model in (11). CV estimates for the semiparametric model are given in Table 4 as a fraction of the pooled regression (time invariant version of (24)) CV statistics.

As can be seen from Table 4, the relative performance of the local (24) against the pooled regression differs over the alternative cross sections as well as over the selected factor variables. For instance, used as a measure for capital market segmentation, an economies' real interest rate differential measured against some world index (for details see Section 6.4.2) does not help to improve the pooled model since the relative CV measures are close to unity throughout. With only a very few exceptions, all relative CV estimates are less than unity and thereby indicate some gain in jackknife forecasting offered by the local model. To assess the significance of the relative measure, one should take into account that, depending on the cross section, CV criteria are determined on the basis of a very large number of observations (up to 3100 for W97). Thus, moderate relative measures, varying between 0.90 and 0.97 say, may already signal a significant improvement of the invariant regression achieved by the local model. In some cases, the relative CV measures are clearly in favor of the local model. Conditioning, for instance, the SI relation on (the natural logarithm of) GDP when modeling F16 or E14 relative CV estimates are 0.74 and 0.75, respectively. The corresponding absolute CV estimates (not listed for the space considerations) are 1.63 and 1.82. These quantities, in turn, are even smaller than the respective estimates obtained for the best performing static panel model with cross section specific parameters (12) in Table 2. Taking the large parameter space of the latter model into account, the jackknife forecasting performance of the local model is quite accurate. With regard to the larger cross sections W97 and L71, it is in particular the ratio of imports over GDP that provides the strongest improvement of the pooled model.

For this factor variable the relative CV measures are 0.90 and 0.88 for W97 and L71, respectively.

With regard to model evaluation by means of CV criteria, it is worthwhile mentioning that the latter statistics indicate overall model performance. Even if relative CV estimates are smaller than but close to unity it is still possible that over particular areas of the factor space local estimates differ significantly from corresponding quantities computed under an assumption of global homogeneity. We turn now to the provision and discussion of local estimates of the SI relation.

6.2 Results for Functional Estimation

6.2.1 Factors impacting on saving, investment or the current account

Age dependency ratio
As displayed in the left hand side panels of Figure 3, the age dependency ratio affects significantly the SI relation in the long run for all displayed cross sections of developed countries (E11, F16, O26). Conditional on country specific long-run trends ($w^{(i)} = 0$), the empirical SI relation is decreasing in the time specific age dependency ($w_{it}^{(t)} = (\widetilde{w}_{it} - \bar{w}_t)/\sigma_t(\tilde{w})$).

According to the "Life Cycle Hypothesis" (LCH) (Modigliani and Brumberg 1954), consumption or saving is affected by the age distribution of the population. Most households do not have a constant flow of income over their lifetimes. In order to smooth their consumption path, young agents should borrow and retired agents shall finance themselves from their past savings. Therefore, if the age dependency ratio, the ratio of the dependent population to the working-age population, is high, the aggregate saving rate shall be low. The latter might disconnect the links between domestic saving and investment. In the empirical literature (Modigliani 1970, Masson et al. 1998) the influence of the age dependency ratio on the saving ratio has been mainly confirmed by means of studies with cross-country or pooled data.

Regarding the level of the functional SI relations, it is worthwhile to point out that the between estimates given in Table 1 are likely not representative for the entire cross sections. For instance, the estimated between coefficient for E11, $\hat{\beta} = -0.11$, is far below the SI relation measured over states of a relatively low age dependency ratio. As such, homogeneous models like (8) run the risk of providing biased approximations of the link between domestic saving and investment. Note that the latter caveat of a homogeneous model formalization may also be illustrated with other potential factor variables.

For less developed economies (L71), the estimated SI relation shows a U-shaped behavior when interpreted as a function of the age dependency ratio. To explain the latter, one may conjecture that for less developed economies age dependency affects saving (consumption smoothing) and investment (growth prospect) in a more symmetric fashion than implied by the LCH for developed economies. As the most comprehensive cross section, the results for the long-run SI relation given for W97 can be seen as an aggregate over the features of developed (O26) and less developed (L71) economies with the latter introducing some mild, i.e. insignificant, U-shaped pattern. In sum, the results for W97 underscore that the negative impact of age dependency on the SI relation dominates.

Effects of short-run variations in the age dependency on the SI relation are not observed (medium panels of Figure 3). Conditional on ($w^{(t)} = -1, 0, 1$) the estimated functional forms are more or less constant. However, comparing conditional estimates for $w^{(t)} = 1$ and $w^{(t)} = -1$, it turns out that the former are almost uniformly above the latter for developed economies (E11, F16, O26). The right hand side panels show the difference between these two estimated short-run effects, i.e. $\hat{\beta}(w^{(i)} = v, w^{(t)} = 1) - \hat{\beta}(w^{(i)} = v, w^{(t)} = -1)$, and the corresponding 95% confidence intervals. The significantly negative difference is confirmed for E11 and F16 over the supports $-1 \leq w^{(i)} \leq 1$ and for O26 given $-2 \leq w^{(i)} \leq 1.6$.

Similar to the latter results on the short-run behavior of the SI relation conditional on age dependency, analyses conditional on other factors also reveal that the link between domestic saving and investment is mostly stable in response to inner country factor variation. For this reason, we will concentrate in the following on the functional relations characterizing the SI relation in the long run.

Population growth
Following Obstfeld (1986), population growth might govern saving as well as investment and thereby explain a high positive correlation between the latter variables. Long-run effects of population growth on the SI relation for W97 are shown in the medium panel of Figure 6. Apart from boundary effects, the conditional estimates are well stabilized around the between estimates $\hat{\beta} = 0.43$ documented in Table 1. A clear trending pattern of the functional estimates cannot be diagnosed.

Per capita income
As a potential measure of an economies' state of development, the impact of global variation (W97) of per capita income on the SI relation is shown in the left hand side panel of Figure 6. From a-priori reasoning one may expect that for a less developed country, the domestic investment ratio is high in response to high rates of return, and the domestic saving ratio is lower owing to a high growth prospect. In contrast, for rich industrial economies with high per capita income, the domestic investment ratio is low because of low rates of return, and the domestic saving ratio is high owing to a low growth prospect. Hence, a hump-shaped SI relation is expected conditional on an increase of per capita income. Our empirical evidence on the impact of per capita income on the SI relation confirms the latter considerations merely to some extent. Conditional on economies having per capita income above the cross sectional average (W97), a significantly decreasing trend is visible from Figure 6. Functional estimates, similar to W97 in shape as well as in level, are found for L71. For the remaining cross sections a hump like pattern cannot be detected which might be addressed to a higher degree of factor homogeneity within these subsamples. For space considerations we do not show detailed estimation results obtained for per capita income.

Fiscal variables
Firstly, the government budget balance is considered as a fiscal variable which might

have an influence on the SI relation. A full offset of private saving to government deficits (Ricardian equivalence) is generally rejected in the empirical literature. Bernheim (1987) shows that a unit increase in the government deficit is related with a decrease in consumption of 0.5 to 0.6. This evidence supports the view that government deficits might be positively correlated with current account deficits, thereby describing so-called “Twin Deficits”. Based on this argument, we shall expect a hump-shaped SI relation conditional on an increasing government budget balance since a high current account imbalance is consistent with a low SI relation. As can be seen in the left hand side panels of Figure 4, hump-shaped functional estimates of the SI relation are only observed to some extent. While a significant left part of a hump shape is found for developed economies (O26), the right part is found to be significant for less developed economies (L71). However, a significant influence of the government budget balance on the SI relation is not observed for W97.

In the second place, we consider the influence of the composition of government expenditures on the SI relation. As can be seen from the upper right hand side panel of Figure 4, a significantly decreasing estimated SI relation is obtained for W97 conditional on increasing total government expenditure. For the remaining cross-sections, similar effects are found. A high government spending might lower private saving by reducing the resources available to the private sector. On the other side, a permanent rise in government spending might lower the interest rate and induce an increase in the domestic investment. Therefore, high government spending might be related with a low SI relation. When we decompose total government expenditures to government capital, current and consumption expenditure for W97, significantly decreasing functional estimates are also obtained for the latter two components (the lower right hand side panels in Figure 4). Since government capital expenditure is generally viewed as productive, increasing future taxes might not be expected, which leaves private saving unaffected. Therefore, no significant influence of the government capital expenditure on the SI relation is observed.

6.2.2 Factors measuring integration of goods and financial markets

Openness

Conditioning the SI relation on the long-run path of an economies' openness measured as the sum of imports and exports over GDP obtains significantly decreasing functional estimates for W97 (Figure 5). The latter reflects that domestic investment is naturally bounded by domestic saving for a closed economy. Separating W97 in its two divisions O26 and L71, we find that the overall trend is most obvious for the group of less developed economies. The latter impression might mirror that the L71 is likely more heterogenous with regard to country specific degrees of openness. When alternatively decomposing the openness measure in its two components, exports over GDP and imports over GDP, we obtain that the common factor results documented for more closed economies ($-2 < w^{(t)} < -1$) are most obvious for the import over GDP measure. At the opposite, for more open economies ($1 < w^{(t)} < 2$), it appears to be the export over GDP component having the strongest impact on the SI relation evaluated conditional on openness. By construction, the ‘openness’ variable is a measure reflecting good markets integration. As such, our results for the conditional

SI relation motivate the view that the SI relation is perhaps not only reflecting capital market separation as stated by FH (1980) but also barriers of international trade (Obstfeld and Rogoff 2000).

Interest rate parity

Having discussed the impact of openness as a measure of good markets integration on the SI relation it is also tempting to relate the latter to some measure approximating capital market integration. For this purpose we use the absolute real interest rate differential measured for a particular economy towards a world real interest rate index. Country specific real interest rates are the lending rates charged by banks on loans to prime customers adjusted for inflation. To approximate the real world interest rate we construct a GDP weighted average of real interest rates among the US, Germany and Japan. Instead of using the interest rate differential directly we presume that positive and negative realizations are equally informative for the prevalence of capital market frictions. Therefore we investigate the impact of the absolute real interest differential on the SI relation. As documented in the right hand side panel of Figure 6, a significant impact of the real interest rate differential on the SI relation for W97 is not found in our analysis for the global perspective which is also representative for all remaining cross sections (not shown for space considerations). Still, however, one may regard the different unconditional levels of empirical SI relations as reported in Table 1, for E11 against O15 say, to signal a mitigating impact of market integration on the SI relation.

By using the real interest rate differential, we are aware that this measure might not only correspond to capital mobility, as argued by Frankel (1992). As another potential measure of capital mobility, we consider the nominal interest rate differential. However, significant impacts of this measure on the SI relation are not obtained.

6.2.3 Large country effect

As can be seen in Figure 7, significantly positive long-run impacts of the log GDP on the SI relation can be diagnosed for E11, O26 and W97, thereby supporting a large country effect. A large country might have a higher SI relation than a small country owing to an endogenous domestic interest rate. For the cross section of less developed economies we cannot confirm a large country effect which might be expected given that L71 collects small economies by definition.

6.3 Policy implications

As has been shown in the last subsection, the degree of the trade openness, the age dependency ratio, government current and consumption expenditure and country size influence the SI relation significantly. These results might induce the following policy implications.

Firstly, it might be questionable to use the SI relation merely as a measure of capital mobility upon which the optimal savings policy and tax rate is determined. As has been argued by Feldstein and Horioka (1980), the national return on additional saving is equal to the pre-tax marginal product of capital for a closed economy, but is only equal to the after-tax return for an open economy. As such the optimal saving ratio shall be higher for a closed economy than for an open economy. Furthermore, countries with high capital mobility have an incentive to cut the rate of capital taxation in order to prevent the outflow of domestic capital. For a developed country that is largely engaged in international trade and shows a high age dependency ratio, it's actual state of capital market integration might be overestimated via the SI relation. The latter in turn may lead to an underestimated optimal saving ratio and tax rate.

Secondly, since the SI relation reflects not only the financial market integration but also the goods market integration (the openness ratio), no unique economic policy might be developed conditional on the SI relation alone. Garrett (1995) points out that the impact of increasing capital mobility and trade on the economic policy might be different. On one side, financial integration may lead to cross-national convergence in monetary policy, especially in fixed exchange rate regimes, and cuts in government spending. On the other side, goods market integration might lead to different fiscal policies to achieve long-run competitiveness of national producers in international markets. Therefore, it is difficult to develop economic policy based on the SI relation which might signal financial market integration or goods market integration.

Thirdly, because a low SI relation is corresponding to a high current account imbalance, determinants of SI relation can also be regarded as determinants of current account. Based on our results, high government current and consumption expenditure may induce a high current account imbalance for most economies. For OECD countries, a high current account imbalance might also be caused by a high age dependency ratio. Furthermore, the increasing degree of openness in good markets might provide countries with the possibility to sustain long-run current account imbalances.

7 Conclusions

In this paper we investigate the relation between domestic saving and investment for seven cross sections covering the sample period 1971 to 2002. Firstly, 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. Secondly, through between regressions and time dependent SI models, an overall decreasing trend of the SI relation is confirmed. Potential factor dependence of the SI relation is detected by cross-sectional profile regressions explaining empirical SI relation. The latter confirm the view that the trending behavior of the SI relation is rather influenced by economic factors than by a deterministic trend.

In the light of time and cross sectional heterogeneity of the SI relation on the one hand and possible factor dependence on the other hand, we apply a new framework of bivariate functional coefficient models to estimate conditional SI relations. We propose a resampling scheme to address inferential issues for the new model. Our bivariate functional approach allows to separate factor dependence of the SI relation in the short and long run. In the short run, the factor dependent SI relations are found to be rather stable. In the long run, however, a set of economic factors is found to impact the SI relation. The latter are an economies' openness ratio, the age dependency ratio and government expenditures. Supporting evidence for the large country effect on the SI relation is also found. Since the SI relation is not merely influenced by the financial market integration according to our results, it might be inappropriate to develop strategies of fiscal and monetary policies relying only on the SI relation as a measure of capital mobility.

Appendix 1. List of Factors

Group 1:

AGE: Ratio of the dependent population (younger than 15 and older than 64) to the working-age population (between 15 and 64) (%)

GDPC: Natural logarithm of GDP per capita

POPG: Growth rate of the population (%)

GVBB: Ratio of government overall budget balance (including grants) to GDP (%)

GVTT: Ratio of government total expenditure to GDP (%)

GVIVM: Ratio of government capital expenditure to GDP (%)

GVCE: Ratio of government current expenditure to GDP (%)

GVCON: Ratio of government consumption expenditure to GDP (%)

Group 2:

OPN: Ratio of export plus import to GDP (%)

EXPT: Ratio of exports of goods and services to GDP (%)

IMPT: Ratio of imports of goods and services to GDP (%)

INTD: Absolute real interest rate differential measured for a particular economy towards a world real interest rate index (%)

Group 3:

GDP: Natural logarithm of GDP

Appendix 2. 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

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Table 1: **Between Regression**

$$\overline{I_i^*} = \alpha + \beta \overline{S_i^*} + e_i$$

Samples	W97	L71	O26	O15	F16	E14	E11
			Panel A: 1971 - 2002				
$\widehat{\beta}$	**0.43**	**0.42**	**0.59**	**0.77**	**0.62**	0.13	-0.16
	(11.24)	(9.37)	(5.11)	(7.96)	(4.44)	(0.53)	(-0.71)
R^2	0.57	0.56	0.52	0.83	0.58	0.02	0.05
			Panel B: 1971 - 1986				
$\widehat{\beta}$	**0.44**	**0.42**	**0.69**	**0.86**	**0.66**	0.36	0.18
	(9.44)	(7.54)	(6.58)	(10.43)	(4.50)	(1.46)	(0.78)
R^2	0.48	0.45	0.64	0.89	0.59	0.15	0.06
			Panel C: 1987 - 2002				
$\widehat{\beta}$	**0.38**	**0.39**	**0.39**	**0.65**	**0.30**	-0.02	-0.14
	(9.96)	(8.76)	(3.27)	(5.23)	(2.24)	(-0.10)	(-0.90)
R^2	0.51	0.53	0.31	0.68	0.26	0.00	0.08

This table reports slope estimates from the between regressions of the investment ratio on the saving ratio. t-statistics appear in parentheses below the coefficient estimates. Coefficients which are significant at the 5% level are highlighted in bold face.

Table 2: **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	$ecm1_c$	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	$ecm2_c$	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	$ecm3_c$	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	$ecm2_p$	10.44	197.62	2.45	5.08
						Cross-Section: L71							
bet	4.99	46.39	1.39	1.84	6.65	75.65	1.34	1.54	$ecm1_c$	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	$ecm2_c$	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	$ecm3_c$	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	$ecm2_p$	11.47	234.86	2.31	4.77
						Cross-Section: O26							
bet	2.87	14.45	1.38	1.83	3.33	19.26	1.41	1.80	$ecm1_c$	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	$ecm2_c$	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	$ecm3_c$	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	$ecm2_p$	5.02	54.49	2.13	5.11
						Cross-Section: O15							
bet	2.51	11.94	1.16	1.36	3.72	22.46	1.43	1.72	$ecm1_c$	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	$ecm2_c$	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	$ecm3_c$	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	$ecm2_p$	6.29	79.31	2.42	6.06
						Cross-Section: F16							
bet	2.55	11.61	1.43	1.99	2.47	9.69	1.37	1.69	$ecm1_c$	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	$ecm2_c$	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	$ecm3_c$	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	ecm_p	3.36	20.44	1.87	3.55
						Cross-Section: E14							
bet	3.05	15.26	1.55	2.32	2.82	13.82	1.46	2.08	$ecm1_c$	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	$ecm2_c$	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	$ecm3_c$	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	$ecm2_p$	3.60	25.48	1.87	3.84
						Cross-Section: E11							
bet	3.30	17.96	1.69	2.70	3.02	15.94	1.49	2.16	$ecm1_c$	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	$ecm2_c$	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	$ecm3_c$	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	$ecm2_p$	3.65	27.02	1.81	3.67

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.

Table 3: **Cross-Sectional Features of SI relation**

Factor	W97	L71	O26	O15	F16	E14	E11
			$\hat{\gamma}_1$ in $\hat{\beta}_i = \gamma_0 + \gamma_1 \bar{w}_i + u_i$				
AGE	**−0.006** (−2.51)	0.001 (0.15)	**−0.026** (−2.41)	−0.018 (−1.48)	**−0.052** (−2.52)	**−0.060** (−2.26)	**−0.068** (−2.57)
OPN	**−0.004** (−3.84)	**−0.004** (−3.41)	−0.005 (−1.53)	0.000 (0.06)	−0.006 (−2.10)	**−0.009** (−2.68)	**−0.009** (−2.93)
EXPT	**−0.007** (−3.53)	**−0.007** (−3.23)	−0.009 (−1.54)	−0.000 (−0.03)	−0.011 (−2.04)	**−0.016** (−2.55)	**−0.017** (−2.68)
IMPT	**−0.009** (−4.05)	**−0.007** (−3.50)	−0.010 (−1.50)	0.002 (0.16)	−0.012 (−2.14)	**−0.019** (−2.79)	**−0.020** (−3.18)
t-critical value at 5%	1.985	1.994	2.064	2.131	2.145	2.179	2.262

OLS slope estimates for profile regressions (19). t-statistics appear in the parentheses below the coefficient estimates. Coefficient estimates which are significant at the 5% level are highlighted in bold face. A list of abbreviations for the employed factor variables is given in the Appendix.

Table 4: **Factor Dependent Model Comparison**

Factor	W97	L71	O26	O15	F16	E14	E11
			Group 1				
AGE	0.97	0.98	0.92	0.93	0.94	0.96	0.94
GDPC	0.95	0.93	0.79	0.89	0.86	0.75	0.74
POPG	0.99	1.00	0.98	0.91	0.95	0.91	0.93
GVBB	0.99	0.99	0.96	0.97	0.92	0.96	1.02
GVTT	0.96	0.96	0.91	0.91	0.87	0.87	0.86
GVIVM	0.96	0.96	0.97	0.97	0.95	0.92	0.92
GVCE	0.97	0.98	0.90	0.92	0.87	0.86	0.85
GVCON	0.96	0.97	0.87	0.89	0.82	0.84	0.91
			Group 2				
OPN	0.93	0.93	0.94	0.86	0.83	0.98	0.91
EXPT	0.94	0.93	0.90	0.81	0.81	0.97	0.96
IMPT	0.90	0.88	0.89	0.82	0.84	0.93	0.87
INTD	1.01	1.00	1.00	1.04	0.98	1.00	1.02
			Group 3				
GDP	0.95	0.98	0.89	0.92	0.74	0.75	0.78

This table reports CV criteria (absolute forecast errors) comparing of local estimates (27) against the factor invariant trivariate regression. Semiparametric CV estimates are given as a fraction of the pooled regression CV statistics.

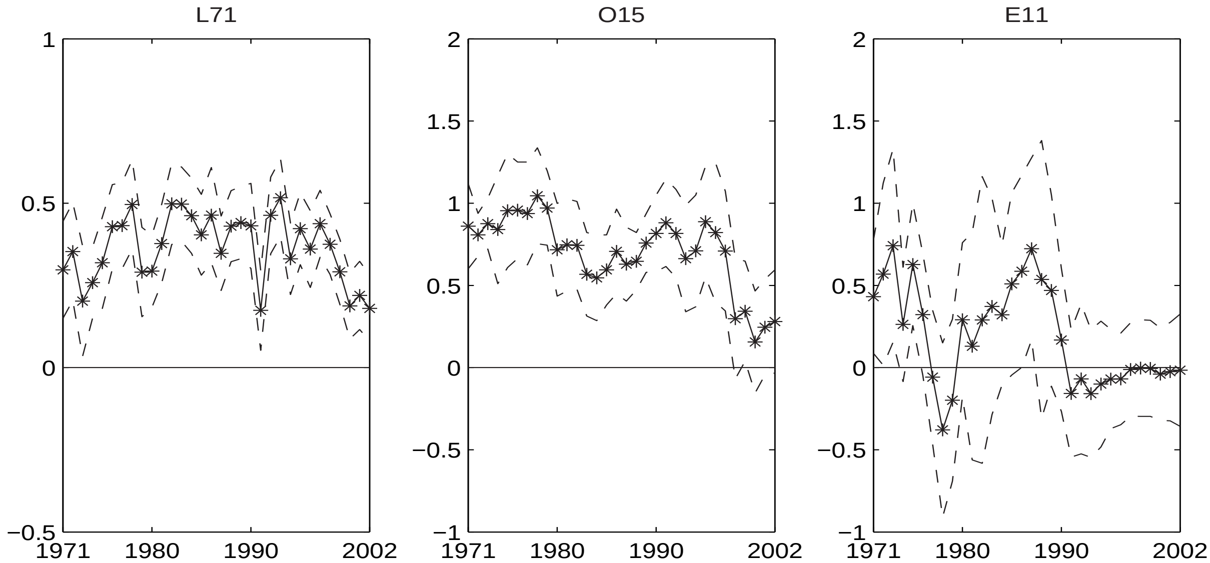

Figure 1: Estimated time varying SI relations obtained from model (4) for the three non-overlapping cross sections. The solid line with stars shows the point estimates and the two dashed lines are the corresponding 95% confidence intervals.

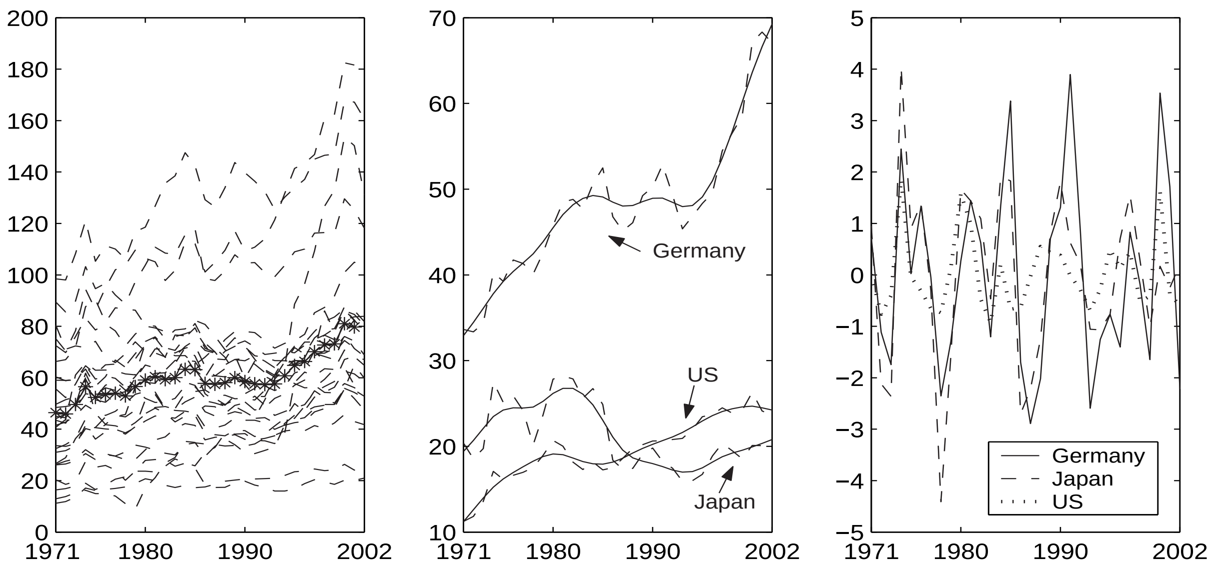

Figure 2: Dynamics of the openness ratio. The left hand side panel shows the observations for the countries in O26 (dashed line) and the corresponding cross-sectional averages (solid line with stars). The medium panel displays the openness degree of Germany, the US and Japan (dashed line), and the corresponding long-run trend (solid line). The right hand side panel illustrates the deviations from the long-run trend for the given three countries.

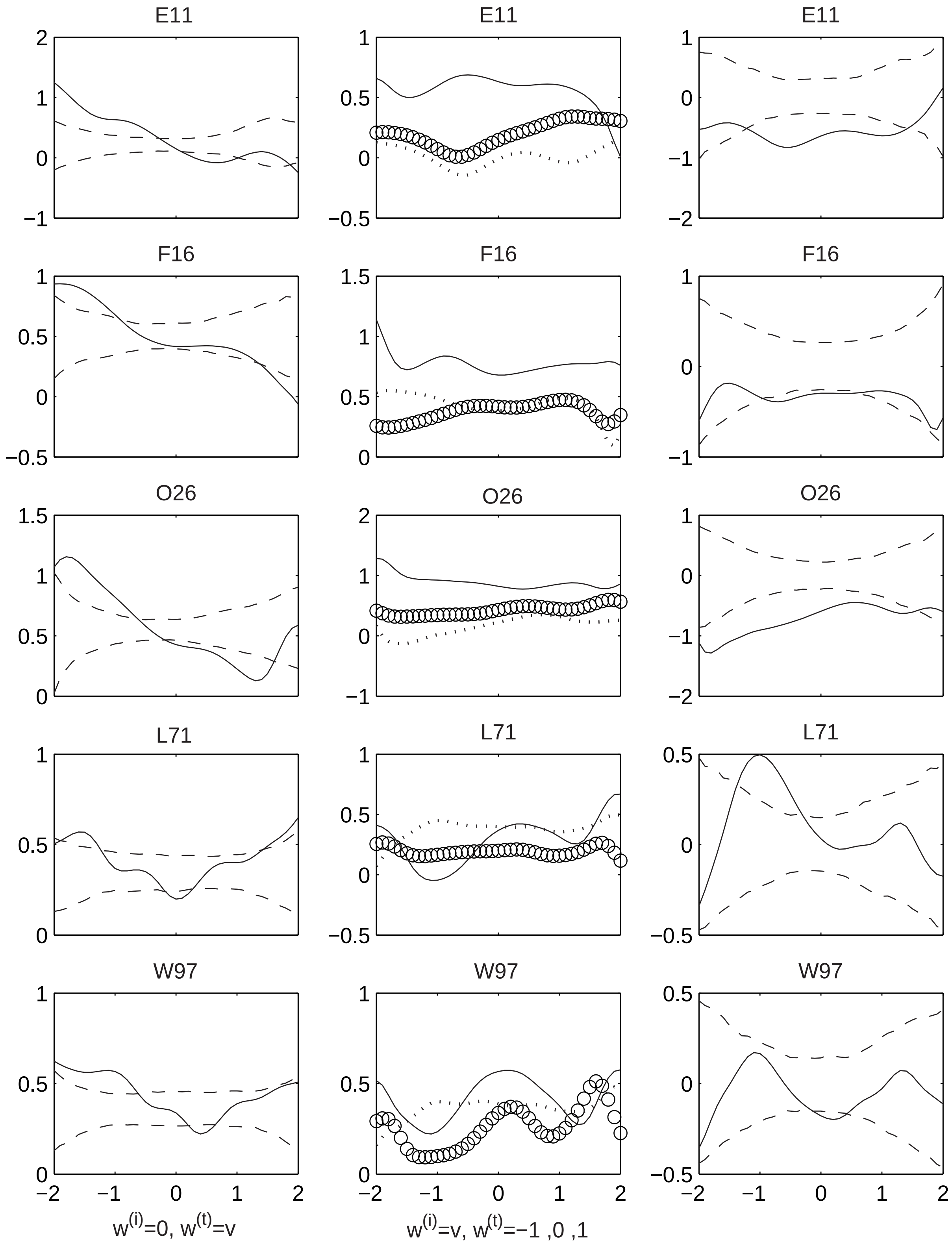

Figure 3: Functional estimates of the SI relation conditional on the age dependency ratio for five selected cross sections. The left hand side panels show the estimated long-run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ (solid). Dashed lines are the corresponding 95% confidence intervals. The medium panels display the short-run effects for three local paths, i.e. $\hat{\beta}(w^{(i)} = v, w^{(t)} = 0)$ (circled line), $\hat{\beta}(w^{(i)} = v, w^{(t)} = -1)$ (solid) and $\hat{\beta}(w^{(i)} = v, w^{(t)} = 1)$ (dotted). The right hand side panels show the difference between two estimated short-run effects (solid), i.e. $\hat{\beta}(w^{(i)} = v, w^{(t)} = 1) - \hat{\beta}(w^{(i)} = v, w^{(t)} = -1)$, and the corresponding 95% confidence intervals (dashed).

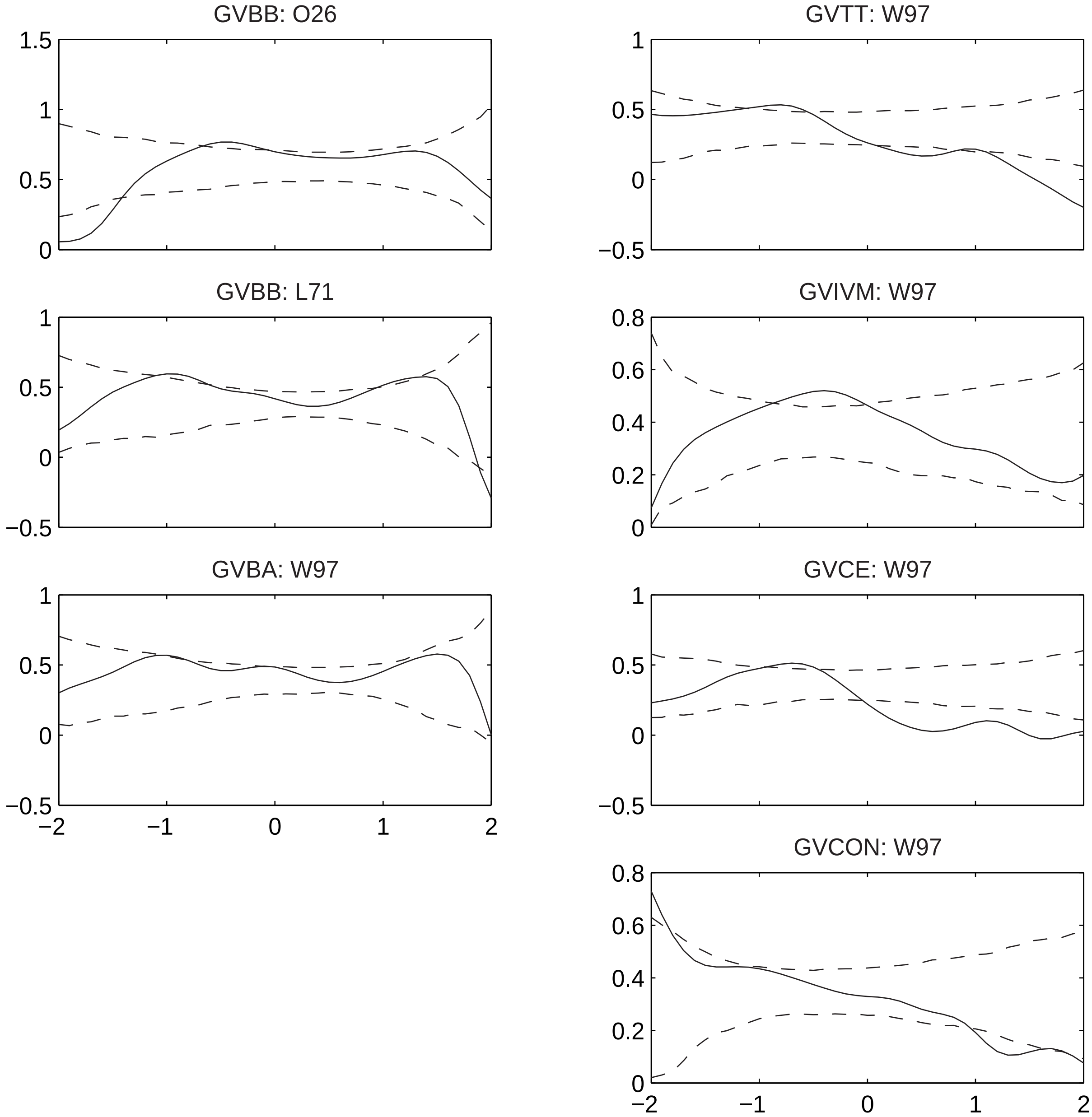

Figure 4: Functional estimates of the SI relation conditional on fiscal variables. The long-run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ are displayed. The solid line shows the point estimates and the dashed lines are the corresponding 95% confidence intervals.

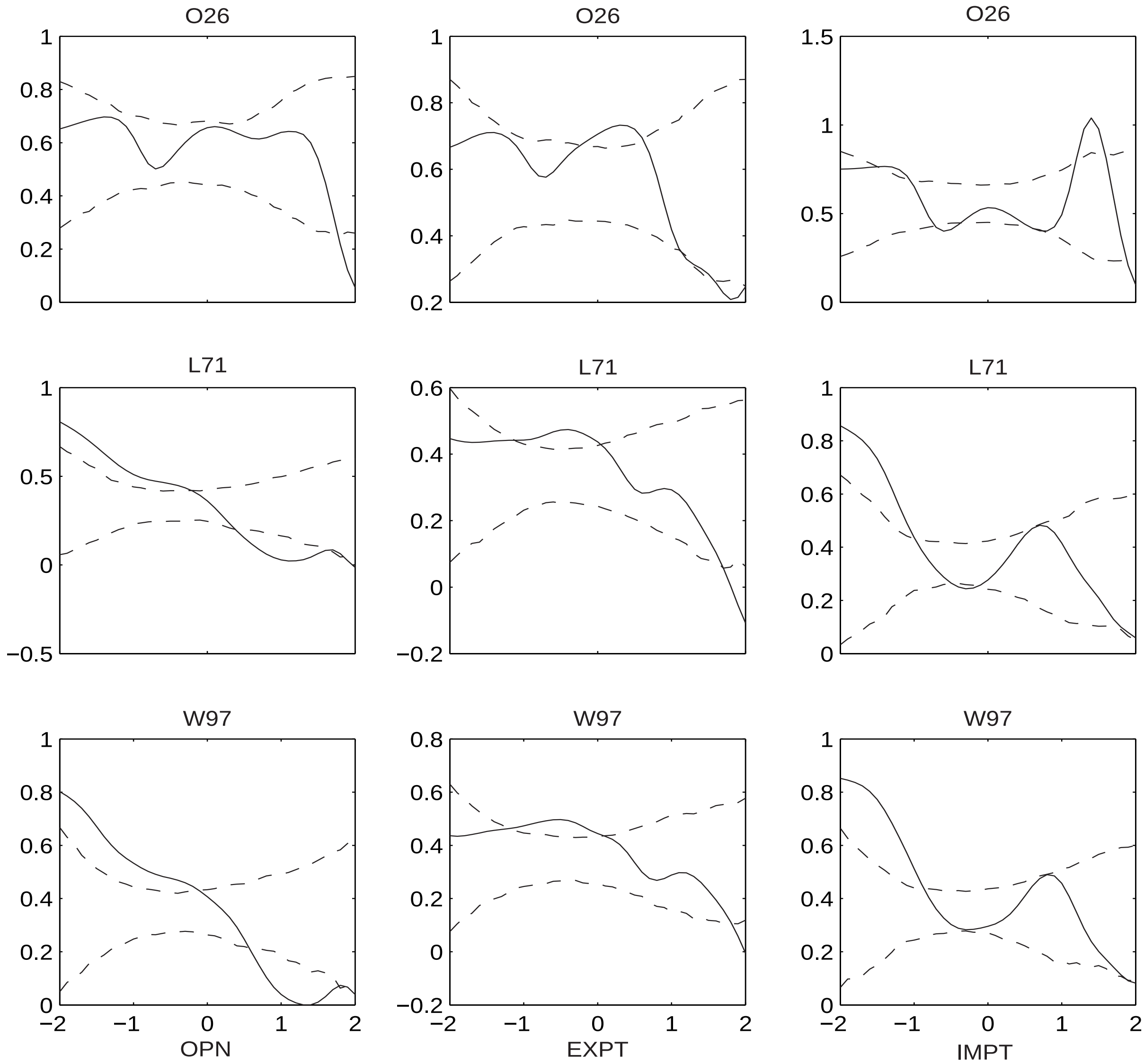

Figure 5: Functional estimates of the SI relation conditional on the openness ratio, the ratio of exports and imports to GDP for three selected cross sections. Estimated long-run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ are displayed. The solid line shows the point estimates and the two dashed lines are the corresponding 95% confidence intervals.

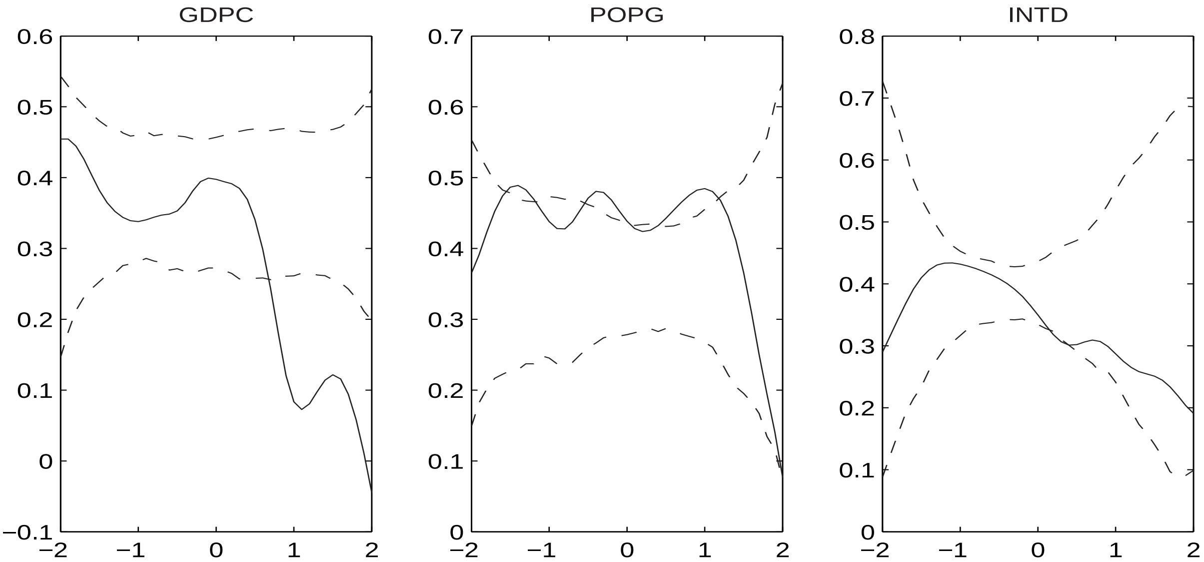

Figure 6: Functional estimates of the SI relation conditional on per capita income, the population growth rate and the absolute real interest rate differential. Estimated long-run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ are displayed for W97. The solid line shows the point estimates and the two dashed lines are the corresponding 95% confidence intervals.

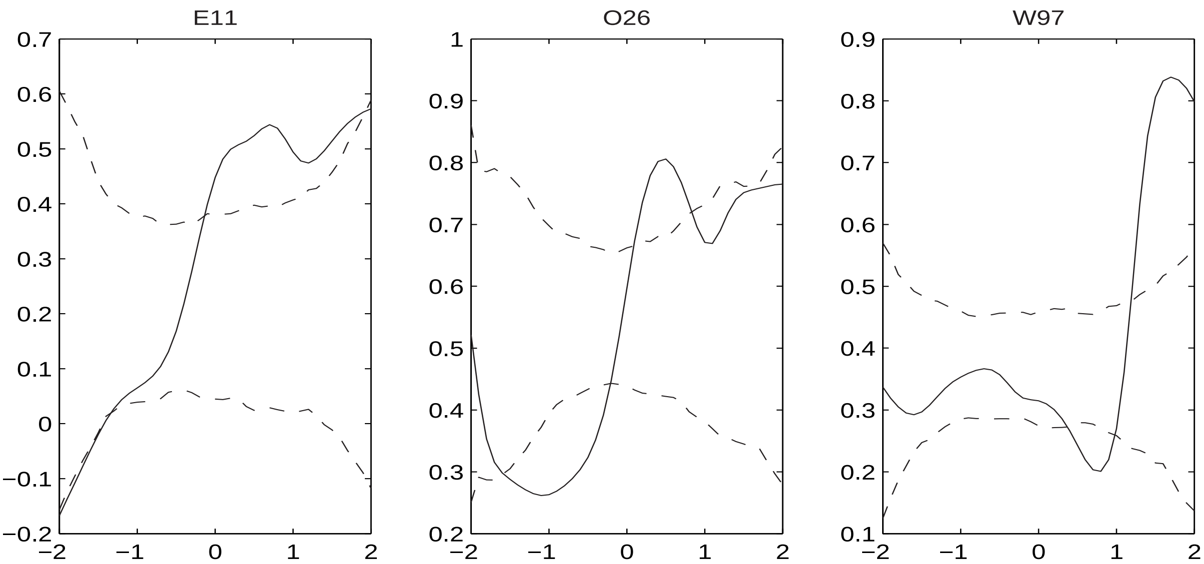

Figure 7: Functional estimates of the SI relation conditional on the logarithm of GDP. Estimated long-run effects $\hat{\beta}(w^{(i)} = 0, w^{(t)} = v)$ are displayed. The solid line shows the point estimates and the two dashed lines are the corresponding 95% confidence intervals.