The Feldstein-Horioka Puzzle: a Panel Smooth Transition Regression Approach

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Abstract

This paper proposes an original framework to determine the relative influence of five factors on Feldstein and Horioka outcome of a high saving-investment association among OECD countries. Based on panel threshold regression models, we derive country-specific and time-specific saving retention coefficients for 24 OECD countries over 1960-2000. These coefficients are assumed to change smoothly as a function of five threshold variables considered as the most important in the literature devoted to the Feldstein and Horioka puzzle. The results show that degrees of openness, country sizes and ratios of current account to GDP have the greatest influence on investment and saving relationship.

Key words: Feldstein Horioka puzzle, Panel Smooth Threshold Regression models, saving-investment association, capital mobility.

JEL classification: C23, F21, F32.
tions: either implanting different econometric approaches (cross section, panel data models, times series, etc.), splitting the samples according to additional factors, or adding missing variables driving both investment and saving. As regard to the latter, five main factors have been pointed out: (i) economic growth, (ii) demography, in particular dependency ratios, (iii) degree of openness, (iv) size of the country and (v) current account balance. For instance, based on a two steps approach, using five-year averages over the period 1965 to 1989, Taylor (1994) shows that when the FH cross-section regression of the ratio of domestic investment to GDP on the ratio of domestic savings to GDP is controlled for domestic relative prices, age structure of the population and the interaction between the dependency rate and the rate of growth, the standard correlation of saving and investment disappears. Regarding size of countries, Murphy (1984) divides his sample of 17 OECD countries over the period 1960 to 1980 into large countries (the seven biggest) and small ones (the ten remaining). The two groups appear to show significantly different cross-section saving retention coefficient (i.e. FH coefficient). For the set of large countries, FH coefficient was closed to one, while it hardly drew up 0.60 for small ones (versus 0.89 in FH seminal study). This outcome was also found by Feldstein and Horioka (1980), and then confirmed by Tesar (1991), Baxter and Crucini (1993), Obstfeld (1995), Coakley et al. (1998) and Ho (2003). A third method consists in using time-series data (or panel data) instead of cross-section averages. Thus, with annual data, Krol (1996) obtains a small short-run FH coefficient of 0.20, from a fixed effect panel regression, for 21 OECD countries over the period 1962 to 1990. In this context, the main issue is the cross-country heterogeneity of the FH coefficients, even for OECD countries as highlighted by Obstfeld (1995) or Haque et al. (1999).

The purpose of this paper is to propose an original and unified framework to determine the relative influence of five factors on the saving retention coefficient:

3 Feldstein and Bachetta (1991) and Obstfeld (1995) also mention the imperfection of domestic financial markets, while Feldstein and Bachetta (1991) and Tesar (1991) draw attention on budget surpluses/deficits. Unfortunately, the influence of these two variables on FH coefficient is seldom tested due to lack of data for the former and to a symmetric behaviour of private and public savings for the latter.
icient, while explaining cross-country heterogeneity and time variability. For that, we propose to test the existence of threshold effects in the relationships between the ratio of national investment to GDP and the ratio of national savings to GDP on a panel of OECD countries. Indeed, the idea that capital mobility depends on other exogenous variable (openness, size, demography etc.) clearly corresponds to the definition of a threshold regression model: "threshold regression models specify that individual observations can be divided into classes based on the value of an observed variable" (Hansen, 1999, page 346). Thus, at each date the countries are divided into classes with the same FH coefficient according to the value of an observable variable, called the threshold variable. More precisely, we propose here to use a Panel Smooth Threshold Regression (PSTR) model recently developed by Gonzalez, Terasvirta et VanDijck (2005). This threshold regression model authorises a smooth transition mechanism between regimes.

Our approach has two main advantages. Firstly, based on the PSTR estimates, we derive FH parameters (i.e. the saving retention coefficients) that vary between countries but also with time. So, our approach provides a simple parametric approach to capture both cross-country heterogeneity and time instability of the saving retention coefficients\(^4\). Secondly, our approach allows the country-specific FH saving retention coefficients to change smoothly as a function of the threshold variable. Consequently, in such model it is possible (i) to test the existence of thresholds effects and (ii) to evaluate the influence of the five potential threshold variables previously mentioned on saving retention coefficient by comparing the estimated FH parameters in the different regimes.

The rest of the paper is organized as follows. In the next section, we discuss the threshold specification of FH regression and particularly, the cross-country heterogeneity and the time variability of saving retention coefficients. The choice of the threshold variable, linearity tests and the estimation of the

\(^4\) It is a great advantage of our approach. For instance, the use of Bayesian predictors based on Random Coefficient Models (Hsiao and Pesaran, 2004) only authorizes the parameters to change in the individual dimension, but not with time.
parameters are successively presented in a third section. In a fourth section, we present the results of the linearity tests and the estimates obtained from various panel threshold models. Finally, based on these PSTR estimates, we compute the individual FH parameters and discuss the relative influence of the various threshold variables. A last section concludes.

2 The Feldstein-Horioka puzzle: Toward a Threshold Specification

The basis of our empirical approach is exactly the same as that used by many authors since the seminal paper of Feldstein and Horioka (1980). It consists in evaluating the mobility of the capital for a panel of $N$ countries. The corresponding model is then defined as follows:

$$I_{it} = \alpha_i + \beta S_{it} + \epsilon_{it}$$

(1)

where $I_{it}$ is the ratio of domestic investment to GDP observed for the $i^{th}$ country at time $t$, $S_{it}$ is the ratio of domestic savings to GDP and $\alpha_i$ denotes an individual fixed effect. The residual $\epsilon_{it}$ is assumed to be i.i.d. $(0, \sigma^2_{\epsilon})$. Used in particular by Corbin (2001), and more generally in all the cross-section specifications of the FH regression, this model has two major drawbacks. Firstly, it assumes the same degree of international mobility of capital across the $N$ countries of the panel, i.e. $\beta_i = \beta, \forall i = 1, ..., N$. It is obvious that this assumption is unrealistic even when considering only OECD countries. As previously mentioned, many factors have been identified that clearly affect the capital mobility: the size of the country, the age structure of the population, the degree of openness, etc. So, the assumption $\beta_i = \beta$ implies that these factors do not affect the capital mobility. Such an assumption is obviously too restrictive. Besides, when one comes to include these factors in the regression (1) as additional explanatory variables, it does not solve the problem: the conditional relationship between investment and saving is assumed to be homogeneous as long as $\beta_i$ is common for all $i$. Secondly, the equation (1) implies that saving retention coefficient is constant over the estimation period of the model. This assumption is also unrealistic particularly when we consider macro-panel with a sufficiently long time dimension: it is obvious that capital mobility in
a typical OECD country was not the same in the 60’s and in the 90’s. As
capital controls and barriers to the movement of capital across borders have
been removed since mid 70’s in major OECD countries, the FH coefficient is
time-decreasing. Actually, Obstfeld and Rogoff (2000) find a saving retention
coefficient of 0.60 in a cross-country regression for OECD countries in the pe-
riod 1990-1997, compared to 0.89 highlighted by FH in their seminal article
for 16 OECD countries during the period 1960-74. So, there is no reason to
assume that the parameter $\beta$ (the parameters $\beta_i$) is (are) time invariant. Gen-
erally, both issues cannot be tackled with in the same time. For instance, it
is possible to consider a heterogeneous panel model by assuming that the FH
parameters $\beta_i$ are randomly distributed\(^5\). However, in such a random coeffi-
cient model, the mobility of capital is assumed to be time invariant. Besides,
in a simple random coefficient model (Swamy, 1970), the parameters $\beta_i$ are
assumed to be independent of the explanatory variables. In other words, the
FH coefficient is assumed to be independent of the ratio of domestic savings to
GDP. Thus, their variability is the consequence of other unspecified structural
factors.

One solution to circumvent both issues consists in introducing threshold ef-
fects in a linear panel model. In this context, a first solution consists in using a
simple Panel Threshold Regression (PTR) model (Hansen, 1999) as suggested
by Ho (2003). In this case, the transition mechanism between extreme regimes
is very simple: at each date, if the threshold variable observed for a given coun-
try is smaller than a given value, called the threshold parameter, the capital
mobility is defined by a particular model (or regime) which is different from
the model used if the threshold variable is larger than the threshold parameter.
For instance, let us consider a PTR model with two extreme regimes:

$$I_{it} = \alpha_i + \beta_0 S_{it} + \beta_1 S_{it} g(q_{it}, c) + \epsilon_{it} \quad (2)$$

where $q_{it}$ denotes threshold variables, $c$ a threshold parameter and where the

\(^5\) For a presentation of Random Coefficients Models, see Swamy (1970) or more
recently Hsiao and Pesaran (2004)
transition function $g(q_{it}, c)$ corresponds to the indicator function:

$$g(q_{it}, c) = \begin{cases} 
  1 & \text{if } q_{it} \geq c \\
  0 & \text{otherwise}
\end{cases} \quad (3)$$

In these two extreme regimes model, the FH coefficient is equal to $\beta_0$ if the threshold variable is smaller than $c$ and is equal to $\beta_0 + \beta_1$ if the threshold variable is larger than $c$. However, this PTR model imposes that the value of saving retention coefficient can be divided into a small number of classes. Such an assumption may be unrealistic even for OECD countries and, at least, must be tested. Besides, the transition mechanism between the regimes is too simple to allow interesting non linear effects of capital mobility.

As usual in the literature, the solution to these problems consists in using a model with a smooth transition function. This kind of models has been recently extended to panel data with the Panel Smooth Threshold Regression (PSTR) model proposed by González et al. (2005) and Fok et al. (2004). Let us consider the simplest case with two extreme regimes and a single transition function:

$$I_{it} = \alpha_i + \beta_0 S_{it} + \beta_1 S_{it} g(q_{it}, \gamma, c) + \epsilon_{it} \quad (4)$$

In this case, the transition function is a continuous and bounded function of the threshold variable. González et al. (2005), following the work of Granger and Teräsvirta (1993) for the time series STAR models, consider the following logistic transition function:

$$g(q_{it}; \gamma, c) = \left[ 1 + \exp(-\gamma \prod_{z=1}^{m} (q_{it} - c_z)) \right]^{-1}, \; \gamma > 0, \; c_1 < ... < c_m \quad (5)$$

The vector $c = (c_1, ... c_m)'$ denotes a $m$-dimensional vector of location parameters and the parameter $\gamma$ determines the slope of the transition function. In our context, this PSTR model has a great advantage: it allows parameters (and consequently capital mobility) to vary across countries (heterogeneity issue), but also with time (stability issue). It provides a parametric approach of the cross-country heterogeneity and the time instability of the FH coefficients. It
allows parameters to change smoothly as a function of the threshold variable. More precisely, the FH coefficient is defined as a weighted average of the parameters $\beta_0$ and $\beta_1$. For instance if the threshold variable $q_{it}$ is different from the ratio of domestic savings to GDP, the FH coefficient for the $i^{th}$ country at time $t$ is defined by:

$$e_{it} = \frac{\delta I_{it}}{\delta S_{it}} = \beta_0 + \beta_1 \cdot g(q_{it}, \gamma, c)$$  \ (6)

with by definition of the transition function, $\beta_0 \leq e_{it} \leq \beta_0 + \beta_1$ if $\beta_1 > 0$ or $\beta_0 + \beta_1 \leq e_{it} \leq \beta_0$ if $\beta_1 < 0$. Consequently, this PSTR model allows a precise evaluation of the influence of the variable $q_{it}$ on capital mobility. By comparing various PSTR specifications with various transition variables, it is possible to identify the most important factors that could explain the cross-country heterogeneity of capital mobility.

It is important to note that the degree of capital mobility in a PSTR can be different from the estimated parameters for extreme regimes, i.e. parameters $\beta_0$ and $\beta_1$. As illustrated by equation 6, these parameters do not directly correspond to the FH parameter. The parameter $\beta_0$ corresponds to the FH coefficient only if the transition function $g(q_{it}, \gamma, c)$ tends to 0. The sum of the parameters $\beta_0$ and $\beta_1$ corresponds to the FH coefficient only if the transition function $g(q_{it}, \gamma, c)$ tends to 1. Between these two extremes, the FH coefficient is defined as a weighted average of the parameters $\beta_0$ and $\beta_1$. Therefore, it is important to note that it is generally difficult to directly interpret the values of these parameters (as in a probit or logit model). It is generally preferable to interpret (i) the sign of these parameters which indicates an increase or a decrease of the FH coefficient with the value of the threshold variable and (ii) the time varying and individual coefficient given by the equation 6.

Finally, this model can be analyzed as a generalization of the Panel Threshold Regression (PTR) model used by Ho (2003) and the panel linear model with individual effects used by Corbin (2001). On Figure 1 the transition function is displayed for various values of the parameter $\gamma$ in the case $m = 1$. It can be observed that when the parameter $\gamma$ tends to infinity, the transition function
$g(q_{it}, \gamma, c)$ tends to the indicator function (equation 3). Thus, when $m = 1$ and $\gamma$ tends to infinity the PSTR model corresponds to the PTR model. When $m > 1$ and $\gamma$ tends to infinity, the number of identical regimes remains two, but the function switches between zero and one at $c_1$, $c_2$, etc... When $\gamma$ tends to zero the transition function $g(q_{it}, \gamma, c)$ is constant and the model is the standard linear model with individual effects (so-called "within" model), i.e. with constant and homogenous FH coefficients. The coefficient is then simply defined by $e_{it} = \beta_0, \forall i = 1, ..., N$ and $\forall t = 1, ..., T$.

The PSTR model can be generalized to $r + 1$ extreme regimes as following:

$$I_{it} = \alpha_i + \beta_0 S_{it} + \sum_{j=1}^{r} \beta_j S_{it} g_j(q_{it}, \gamma_j, c_j) + \epsilon_{it}$$

(7)

where the $r$ transition functions $g_j(q_{it}, \gamma_j, c_j)$ depend on the slope parameters $\gamma_j$ and on $m$ location parameters $c_j$. In this generalization, if the threshold variable $q_{it}$ is different from $S_{it}$, the coefficient for the $i^{th}$ country at time $t$ is defined by the weighted average of the $r + 1$ parameters $\beta_j$ associated to the $r + 1$ extreme regimes:

$$e_{it} = \frac{\delta I_{it}}{\delta S_{it}} = \beta_0 + \sum_{j=1}^{r} \beta_j g_j(q_{it}, \gamma_j, c_j)$$

(8)

The expression of the coefficient is slightly different if the threshold variable $q_{it}$ is a function of the ratio of domestic savings to GDP. For instance, if we assume that the threshold variable corresponds to the ratio of domestic savings to GDP, i.e. $q_{it} = S_{it}$, the expression of the FH coefficient is then defined as:

$$e_{it} = \frac{\delta I_{it}}{\delta S_{it}} = \beta_0 + \sum_{j=1}^{r} \beta_j g_j(q_{it}, \gamma_j, c_j) + \sum_{j=1}^{r} \beta_j \frac{\delta g_j(q_{it}, \gamma_j, c_j)}{\delta S_{it}}$$

(9)

Such an expression authorizes a variety of configurations for the relationships between the ratio of domestic investment to GDP and the ratio of domestic savings to GDP as we will discuss in the next part.
The estimation of the parameters of the PSTR model consists in eliminating the individual effects $\alpha_i$ by removing individual-specific means and then in applying non linear least squares to the transformed model (see González et al., 2005) or Colletaz and Hurlin (2006), for more details). González et al. (2005) propose a testing procedure in order (i) to test the linearity against the PSTR model and (ii) to determine the number, $r$, of transition functions, i.e. the number of extreme regimes which is equal to $r + 1$. Let us consider a PSTR model with only one location parameter ($m = 1$) and assume that the threshold variable $q_{it}$ is known. Testing the linearity in a PSTR model (equation 2) can be done by testing $H_0 : \gamma = 0$ or $H_0 : \beta_0 = \beta_1$. But in both cases, the test will be non standard since under $H_0$ the PSTR model contains unidentified nuisance parameters. This issue is well known in the literature devoted to the time series threshold models (Hansen, 1996). A solution consists in replacing the transition function $g_j(q_{it}, \gamma_j, c_j)$ by its first-order Taylor expansion around $\gamma = 0$ and in testing an equivalent hypothesis in an auxiliary regression. Then, we obtain:

$$I_{it} = \alpha_i + \theta_0 S_{it} + \theta_1 S_{it} q_{it} + \ldots + \theta_m S_{it} q_{it}^m + \epsilon_{it}^*$$

(10)

In this first-order Taylor expansion, the parameters $\theta_i$ are proportional to the slope parameter $\gamma$ of the transition function. Thus, testing the linearity of the FH model against the PSTR simply consists in testing $H_0 : \theta_1 = \ldots = \theta_m = 0$ in this linear panel model. If we denote $SSR_0$ the panel sum of squared residuals under $H_0$ (linear panel model with individual effects) and $SSR_1$ the panel sum of squared residuals under $H_1$ (PSTR model with two regimes), the corresponding F-statistic\(^6\) is then defined by:

$$LM_F = [(SSR_0 - SSR_1)/m][SSR_0/(TN - N - m)]$$

(11)

Under the null hypothesis, the F-statistic has an approximate $F(m, TN - N - m)$ distribution. The logic is similar when it comes to test the number

\(^6\) Since previous studies have documented that the F-version of the test has better size properties in small sample than the asymptotic $\chi^2$ based statistic (Dijk et al., 2002), we only report the results of the F-version.
of transition functions in the model or equivalently the number of extreme regimes. The idea is as follows: we use a sequential approach by testing the null hypothesis of no remaining nonlinearity in the transition function. For instance let us assume that we have rejected the linearity hypothesis. The issue is then to test whether there is one transition function ($H_0 : r = 1$) versus there is at least two transition functions ($H_0 : r = 2$). Let us assume that the model with $r = 2$ is defined as:

$$I_{it} = \alpha_i + \beta_0 S_{it} + \beta_1 S_{it} g_1(q_{it}, \gamma_1, c_1) + \beta_2 S_{it} g_2(q_{it}, \gamma_2, c_2) + \epsilon_{it} \quad (12)$$

The logic of the test consists in replacing the second transition function by its first-order Taylor expansion around $\gamma_2$ and then in testing linear constraints on the parameters. If we use the first-order Taylor approximation of $g_2(q_{it}, \gamma_2, c_2)$, the model becomes:

$$I_{it} = \alpha_i + \beta_0 S_{it} + \beta_1 S_{it} g_1(q_{it}, \gamma_1, c_1) + \theta_1 S_{it} q_{it} + ... + \theta_m S_{it} q_{it}^m + \epsilon_{it} \quad (13)$$

and the test of no remaining nonlinearity is simply defined by $H_0 : \theta_1 = ... = \theta_m = 0$. Let us denote $SSR_0$ the panel sum of squared residuals under $H_0$, i.e. in a PSTR model with one transition function. Let us denote $SSR_1$ the sum of squared residuals of the transformed model (equation 13). As in the previous cases, the F-statistic $LM_f$ can be computed according to the same definitions by adjusting the number of degrees of freedom. The testing procedure is then the following. Given a PSTR model with $r = r^*$, we will test the null $H_0 : r = r^*$ against $H_1 : r = r^* + 1$. If $H_0$ is not rejected the procedure ends. Otherwise, the null hypothesis $H_0 : r = r^* + 1$ is tested against $H_0 : r = r^* + 2$. The testing procedure continues until the first acceptance of $H_0$. Given the sequential aspect of this testing procedure, at each step of the procedure the significance level must be reduced by a constant factor $0 < \rho < 1$ in order to avoid excessively large models. We postulate $\rho = 0.5$ as suggested by González et al. (2005).
4 Data and Results

In this study, we consider a panel of 24 OECD countries\(^7\) over the period 1960-2000. We consider annual data\(^8\) (instead of five-year or eight-year averaged cross-section estimation\(^9\)) in order to stress the time instability of the saving retention coefficient. In view of the results of Krol (1996), our sample excludes Luxembourg as suggested by Coiteux and Olivier (2000) and Jansen (2000)\(^10\). Our data are issued from the Penn World Tables, World Development Indicator and the World Perspective database. As recommended by Hansen (1999), we consider balanced panels. For that, we consider only data after 1960. The two exceptions relate to models with the share of the GDP\(^11\) and the current account\(^12\) for transition variable.

We consider six “candidates” for the threshold variable. In the first model (called Model A), we assume that the transition mechanism in the domestic investment equation is determined by GDP per capita growth rate. We are expecting that the stronger the growth, the higher the FH coefficient. The

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\(^7\) Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Portugal, South Korea, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.


\(^9\) The latter method has been applied by Feldstein and Horioka (1980), Murphy (1984), Feldstein and Bachetta (1991) and Taylor (1994).

\(^10\) Jansen (2000) and Coiteux et al. (2000) showed Krol’s outcome of a short-run FH coefficient of 0.20 essentially resulted from the presence of Luxembourg in the panel. When Luxembourg is excluded, an unrestricted fixed-effect model estimation, even with annual data, confirms Feldstein and Bachetta (1991)’s result: two-thirds of domestic investment are financed by national saving.

\(^11\) For the share of the GDP, the data start in 1965 for Canada and in 1968 for Turkey.

\(^12\) For the current account, data start in 1970 for: Australia, Austria, Canada, Italy, Netherlands, Sweden, United Kingdom, United States; in 1972 for: New Zealand; in 1974 for: Ireland and Turkey; in 1975: for Belgium, Denmark, Finland, France, Norway, Portugal, Spain; in 1977: for Switzerland; and in 1979 for: Mexico
intuition is as follows: in business cycles' expansion phases, investment exceed national saving and has to rely on foreign saving, while the converse holds in recession (Taylor, 1994). In the second specification (Model B), the transition mechanism is based on the degree of openness defined as the ratio of the sum of imports and exports to GDP. That is to say that the more open a country, the more it can borrow from abroad and thus the less domestic investment depends on national saving. The third model (Model C) takes into account the impact of the size of a country on international mobility of capital. The size of the $i^{th}$ country is approximated by the share of its GDP in current dollars in total GDP of our sample countries. The larger a country, the higher its saving retention coefficient, as large countries' behaviour influence world interest rate, a rise in saving can involve a fall in world interest rate and an increase in domestic investment$^{13}$. We also consider two models (Models D and E) in which the transition variable reflects the dependency ratios in the population. We divide the dependency ratio in two sub-ratios: the share of the population that is under 16 and over 65 to total population. The more numerous dependent people (young and old), the smaller is the saving rate. But, while ageing decreases investment, the younger a population, the more investment it makes. Thus, raising youth dependency is expected to decrease the saving retention coefficient, whereas it will increase with ageing. Finally, we consider (Model F) the ratio of current account to GDP as the threshold variable. Introducing this variable tackles in both the intertemporal budget constraint and economic policies of current account targeting$^{14}$. Considering this solvency problem, current account cannot diverge too much. As balance of payments imbalances reflect gaps between domestic investment and national savings, we expect that the greater the absolute value of the current transaction balance, the smaller the FH coefficient.

For each model (i.e. each threshold variable), the first step consists of test-

$^{13}$Feldstein Horioka (1980), Obstfeld (1995), Coakley et al. (1998) and Ho (2003) have pointed out the influence of the size of the country on the value of the FH coefficient.

$^{14}$This point was raised by Baxter and Crucini (1993), Obstfeld (1995)) and Coakley et al. (1996).
ing the linear specification of the capital mobility against a specification with
threshold effects. If the linearity hypothesis is rejected, it will be necessary,
in a second step, to determine the number of transition functions required
to capture all the non-linearity, or equivalently all the heterogeneity of FH
coefficient. The results of these linearity tests and specification tests of no
remaining non-linearity are reported on Table 1. For each definition of the
threshold variable \(q_t\), we consider two specifications with one or two location
parameters. For each specification, we compute the statistics for the linearity
tests \(LM_f (H_0: r = 0 \text{ versus } H_1: r = 1)\) and for the tests of no remaining non-
linearity \(LM_f (H_0: r = a \text{ versus } H_1: r = a+1)\). The values of the statistics are
reported until the first acceptance of \(H_0\). The linearity tests clearly lead to the
rejection of the null hypothesis of linearity of the relationships between saving
rate and investment rate. Whatever the choice made for the threshold vari-
able, the number of location parameters, the \(LM_f\) statistics lead to strongly
reject the null \(H_0: r = 0\). For model C, the lowest value of the \(LM_f\) statistic
is obtained with one location parameter, but even in this case the value of the
test statistic is largely above the critical value at standard levels. This first
result confirms the non-linearity of the FH relation, but more originally shows
the presence of strong threshold effects determined by all considered transition
variables. The stronger rejection of the linearity hypothesis is obtained when
the openness variable (model B) is used as threshold variable. So, if we want
to choose a particular model among the six models proposed, the “optimal”
model would correspond to this model. Indeed, as suggested by González et
al. (2005), the ”optimal” threshold variable corresponds to the variable which
leads to the strongest rejection of the linearity hypothesis.

The specification tests of no remaining non-linearity (see Table 1) lead to
identify an optimal number of transition functions (or extreme regimes) in all
cases. The optimal number of transition functions is always inferior or equal
to two. In other words, in a PSTR model, a small number of extreme regimes
is sufficient to capture the non-linearity of the saving retention coefficient, or
equivalently the cross-country heterogeneity and the time variability of the
FH coefficient. However, recall that a smooth transition model, even with two
extreme regimes \(r = 1\), can be viewed as a model with an infinite number
of intermediate regimes. The FH coefficients are defined at each date and for each country as weighted averages of the values obtained in the two extreme regimes. The weights depend on the value of the transition function. So, even if \( r = 1 \), this model allows a "continuum" of coefficient value (or regimes), with each one associated with a different value of the transition function \( g(.) \) between 0 and 1.

Finally, in the PSTR model, it is necessary to choose the number of location parameters used in the transition functions, that is the value of \( m \). In Table 2, for each assumed value of \( m \) we report the corresponding optimal number of transition functions deduced from the \( LM_F \) tests of remaining non-linearity. We estimate the PSTR models for each potential specification \( m, r(m) \), and report the number of parameters and the residual sum of squares. We suggest here the use of a Schwarz information criteria in order to choose a benchmark specification for each specification of the saving retention coefficient. Consequently, we consider the specification with \( m = 1 \) and \( r = 1 \) as optimal for the model A, B, D, E, and the specification with \( m = 2 \) and \( r = 2 \) as optimal for the model C.

5 PSTR Estimates of Capital Mobility

Table 3 contains the parameter estimates of the final PSTR models. Firstly, we can observe that for all models (except for the model C), the estimated slope parameters \( \gamma \) are relatively small. It implies that the transition function \( g(q_{it}, \gamma, c) \) cannot be reduced to an indicator function as in a simple PTR model: the transition between extreme regimes is smooth, except when the size is used as threshold variable. In other words, the estimated values of the capital mobility in this OECD panel cannot be divided into a small number of classes. The estimated FH parameter for these 24 countries over 1960-2000 are distributed according to a "continuum" of values. The great heterogeneity of OECD countries of our sample and the time-decreasing nature of saving retention coefficients lead to this outcome. This result also points out the fact that the solution which consists in grouping countries in sub-panel panels and
estimating a homogenous relationship between savings and investment may be unsatisfactory. The only exception is the model C. When the size of the country is used to discriminate the countries, the estimated slope parameter is particularly high. In this particular case, the transition function is sharp and corresponds to an indicator function. These estimates confirm the results of Ho (2003) based on a PTR model.

Secondly and more fundamentally, we can evaluate the influence of the six threshold variables on capital mobility. Recall that the estimated parameters $\beta_j$ cannot be directly interpreted as FH coefficients. As in logit or probit models, the value of the estimated parameters is not directly interpretable, but their sign can be interpreted. For instance, let us consider the model B. The parameter $\beta_1$ is negative: it only implies that when the threshold variable (Openness) increases, the FH coefficient decreases. Then, we can check here the influence of the various threshold variables on the FH parameters. Given the sign of the $\beta_1$ parameters, our model confirms that the stronger GDP growth, the larger the country, the younger the population, the higher is the saving retention coefficient (models A, C and D) and thus the less capital is mobile. On the contrary, we confirm that openness, ageing and current account balances tend to decrease FH coefficient (models B, E and F) and thus to signal greater international mobility of capital. However, the main difference with the previous studies is that our model makes it possible to assess the relative quantitative importance of these various variables on capital mobility.

The relative importance of the different threshold variables on the FH coeffi-

This observation can be generalized in a model with more than one transition function ($r > 1$) even if things are slightly more complicated. In a model with two transition functions, if parameter $\beta_1$ is positive and parameter $\beta_2$ is negative, this implies that an increase of the threshold variable has two opposite effects on the income elasticity. The results of these two opposite effects will depend on the value of the (i) slope parameters $\gamma_j$ and (ii) the location parameters $c_j$. But in model C, both parameters $\beta_1$ and $\beta_2$ are positive, so an increase in the threshold variable induces an increase in the FH parameter.
cient is clearly pointed out on the Figures 2. On these figures, FH coefficients, derived from the six considered PSTR models, are displayed for all the possible values of the transition variable. For each PSTR model (i.e. transition variable), the FH parameter is computed from equation (6) for any possible theoretical value of \( q_{it} \). In each sub-figure, we report the average of the threshold variable over the 1960-2000 period for 5 countries (France, Netherlands, Spain, United Kingdom and USA) in order to evaluate their corresponding estimated FH coefficient (evaluated at the mean of \( q_{it} \)). These figures clearly point out the fact that three variables have the greatest influence on capital mobility: the openness, the size of the country and the ratio of current account to GDP. For instance, when the degree of openness is inferior to 20%, our model shows that the FH coefficient is equal to 0.85, whereas it is slightly larger than 0.25 when the openness exceeds 100%. Thus, in figure 2, Netherlands appear to have a sensibly smaller saving retention coefficient with 0.477 not only than the USA (0.840), but also France (0.792) and United Kingdom (0.752) in line with a higher degree of openness, which confirm the intuition that the more open a country, the easier it gains access to international capital markets. Like openness, the ratio of current account to GDP has an important impact on capital mobility: the estimated FH coefficient ranges from 0.75 to 0.35 when the ratio of current account varies from \(-20\%\) to 15\%. This outcome underlines the importance of the intertemporal budget constraint. On the contrary, the FH coefficient is slightly dependent on the value of the GDP growth rate. For instance, the estimated FH coefficient ranges from 0.49 to 0.61 when the annual GDP growth rate varies from -10\% to more than 10\%. The results of the model C (threshold equal to size) are more surprising, but they confirm Ho’s results. When the relative size of the country is inferior to 4\%, the estimated FH coefficient is found to be roughly equal to 0.15, but when the size exceeds this threshold the FH is roughly equal to 0.70 (as in homogenous models in panel). As for dependency ratios, our outcomes confirm the intuition. The more important the share of young in population, the higher the FH coefficient, as Brooks (2003) put it, younger population invest more and save less. In opposite, ageing drives down saving retention coefficient, illustrating that, as national saving reduces, investment has to rely more on foreign saving.
The average estimated FH parameters\textsuperscript{16} are reported in Table 4 for the six PSTR models. In order to compare our model with linear specifications, we also report the results obtained in time series and in a linear homogenous panel with fixed individual effects. Let us consider the PSTR estimates derived from the optimal model B. The average corresponding FH estimates are largely different from one country to another: the average estimate is only equal to 0.39 in Belgium but is near to 0.85 for the USA. This result clearly points out the heterogeneity of saving retention coefficients. On the contrary, the use of a homogenous linear panel leads to an estimate of 0.655 (valuable for all countries), the two thirds of the Feldstein and Bachetta (1991): this value is roughly equivalent to the mean of our individual PSTR estimates (0.71), but hides the great heterogeneity of the sample. On the contrary, using time series reduces the information set and leads to unrealistic and nonsensical values (negative or larger to one) of the FH regression parameters for some countries. This result clearly illustrates the advantage of our panel approach.

With our model, it is also possible to analysis the time dynamics (over the period 1960-2000) of the estimated FH parameters for the 24 OECD countries of our sample. For that we only consider the ”optimal” model, \textit{i.e.} the model with the threshold variable that leads to the strongest rejection of the null linearity hypothesis. This model corresponds to the threshold variable openness. The individual estimated FH parameters are displayed on Figure 3. These estimates have also been derived from equation (6), but the difference with the previous case (Figure 2) is that we consider here the historical value of the threshold variable $q_{it}$ (openness) observed for each country between 1960 and 2000. Our results confirm the intuition of a move towards greater capital mobility. For most of the countries of our sample, the estimated FH parameters are decreasing between 1960 and 2000. However, we can observe that the fall is generally moderate except for Austria, Belgium, Canada and Ireland.

Finally, we can observe that when ratios of under 15 years and over 65 to

\textsuperscript{16}Contrary to the previous values, these estimated FH parameters are based on the historical values of the transition variable $q_{it}$ observed for the 21 countries.
total population are used as threshold variable (Models D and E), the PSTR model gives similar average estimated coefficient for all the countries. This result could let suppose that the transition mechanism is not well specified. It is important to note that when the threshold variable is not well chosen, it implies associating countries according to fallacious criteria. Consequently, at each date the countries are split into a small number of randomly constituted groups and associated with different slope parameters, according to the value of the fallacious threshold variable. Therefore, the estimated slope parameters obtained in this context on random groups shouldn’t be different from those estimated for the whole sample. However, here we notice that this interpretation is not justified. The individual estimated parameters obtained are different from the within coefficient in linear panel. In addition, this conclusion is reinforced by the fact that the linearity tests lead to a strong rejection of the linearity. These threshold variables make it possible to take into account the unstability of the FH coefficient but not of the cross section heterogeneity. This result is confirmed by the high individual standard errors. We obtained similar conclusion for the ratio of current account used in threshold variable (Model F).

6 PSTR Estimates and Endogeneity

In order to assess the robustness of our PSTR estimates to potential endogeneity biases, we propose to consider an instrumental variable (IV) extension of the estimation method generally used in this context. Recall that the parameters of a PSTR model are estimated with non linear least squares. For a given threshold parameter and a given value of the threshold variable, the model is linear and the IV estimator can be adapted in order to take into account the potential endogeneity of savings. Let us consider a simple PSTR model with one transition function \( r = 1 \) :

\[
I_{it} = \alpha_i + \beta_0 S_{it} + \beta_1 g(q_{it}, \gamma, c) + \epsilon_{it} \tag{14}
\]

The estimation of the parameters is carried out in two steps. In the first step,
the individual effects $\mu_i$ are eliminated by removing individual-specific means to the variables of the model. This first step is standard in linear models (within transformation) but it requires more careful treatment in the context of a threshold model. Let us denote $\tilde{I}_{it} = I_{it} - \bar{I}_i$, where $\bar{I}_i = T^{-1} \sum_{t=1}^{T} I_{it}$. The explanatory and instrumental variables must be transformed as follows. In the first extreme regime, the variable $S_{it}$ is simply transformed as $\tilde{S}_{it} = S_{it} - \bar{S}_i$ and the instrumental variable as $\tilde{z}_{it} = z_{it} - \bar{z}_i$. But the transformed explanatory and instrumental variables in the second regime depends on the parameters $\gamma$ and $c$ of the transition function since:

\[
\tilde{w}_{it}(\gamma, c) = S_{it} g(q_{it}; \gamma, c) - \bar{w}_i(\gamma, c) \quad \text{with} \quad \bar{w}_i(\gamma, c) = T^{-1} \sum_{t=1}^{T} S_{it} g(q_{it}; \gamma, c) \tag{15}
\]

\[
\tilde{z}_{it}(\gamma, c) = z_{it} g(q_{it}; \gamma, c) - \bar{z}_i(\gamma, c) \quad \text{with} \quad \bar{z}_i(\gamma, c) = T^{-1} \sum_{t=1}^{T} z_{it} g(q_{it}; \gamma, c) \tag{16}
\]

Consequently, the matrix of transformed explanatory variables $x^*_it(\gamma, c) = [\tilde{S}_{it} : \tilde{w}_{it}(\gamma, c)]$ and the matrix of instrumental variables $\eta^*_it(\gamma, c) = [\tilde{z}_{it} \tilde{z}_{it}(\gamma, c)]$ depend on the parameters of the transition function. So, it has to be recomputed at each iteration. More precisely, given a couple $(\gamma, c)$, the FH parameter can be estimated by IV, which yields:

\[
\hat{\beta}_{IV}(\gamma, c) = \left[ \sum_{i=1}^{N} \sum_{t=1}^{T} x^*_it(\gamma, c) \eta^*_it(\gamma, c) (\eta^*_it(\gamma, c) \eta^*_it(\gamma, c))^{-1} \eta^*_it(\gamma, c) x^*_it(\gamma, c) \right]^{-1}
\]

\[
= \left[ \sum_{i=1}^{N} \sum_{t=1}^{T} x^*_it(\gamma, c) \eta^*_it(\gamma, c) (\eta^*_it(\gamma, c) \eta^*_it(\gamma, c))^{-1} \eta^*_it(\gamma, c) \tilde{y}_{it} \right] \tag{17}
\]

with $\hat{\beta}_{IV}(\gamma, c) = [\hat{\beta}_0(\gamma, c) \hat{\beta}_1(\gamma, c)]'$. In a second step, conditionally to $\hat{\beta}_{IV}(\gamma, c)$, the parameters of the transition function $\gamma$ and $c$ are estimated by NLS according to the program:

\[
(\hat{\gamma}, \hat{c}) = \text{ArgMin} \sum_{i=1}^{N} \sum_{t=1}^{T} \left[ \tilde{y}_{it} - \hat{\beta}_{IV}(\gamma, c)x^*_it(\gamma, c) \right]^2 \tag{18}
\]

Given $\hat{\gamma}$ and $\hat{c}$, it is then possible to estimate the elasticities of the production function in the extreme regimes as follows: $\hat{\beta}_{IV} = \hat{\beta}_{IV}(\hat{\gamma}, \hat{c})$. 

In Table 5, we report the results of this IV estimation for three models (Mod-
els B, D and E). For each model, we consider two other instrumental variables which correspond to the threshold “candidates” not used as threshold variable. For instance, in the model B the threshold is the openness, and we use two instrumental variables: ratio of population under 15 and the ratio of population over 65. We can observe that the estimated parameters are similar to the parameters reported in Table 3. More precisely, we can observe that the individual average FH coefficients (Table 6) derived from these PSTR estimates corrected for endogeneity are relatively close to the estimated FH coefficients based on non corrected PSTR. So, our results seem to be robust to endogeneity. This result can be interpreted as follows: the use a PSTR limits the potential endogeneity bias since for each level of the threshold variable there is a “particular” value of the estimated FH regression parameter.

7 Conclusion

In this paper we propose an empirical evaluation of the influence of various threshold variables on the saving-retention coefficient. This assessment is based on a Panel Smooth Transition Regression Model. Our main results can be summarized in three main points. Firstly the relationship between domestic investment and saving is non linear and strong threshold effect can be identified. This conclusion is robust to changes in the threshold variable and to potential endogeneity biases. More precisely, we found that three variables have the greatest influence on capital mobility: the degree of openness, the size of the country and the ratio of current account to GDP. In addition, for five out of six models, it seems that the saving retention coefficient cannot be reduced to a small number of regimes and must be studied through a model allowing a "continuum" of regimes. This result reveals the strong heterogeneity in the degree of mobility of OECD countries. Secondly in line with the literature, we can observe that the estimated FH parameters are decreasing between 1960 and 2000 for most of the countries of our sample. Thirdly, we propose an original method for specifying the heterogeneity and the time variability of the FH coefficient.
Table 1
LM\textsubscript{f} Tests for Remaining Nonlinearity

<table>
<thead>
<tr>
<th>Model</th>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold Variable</td>
<td>Growth</td>
<td>Openness</td>
<td>Size</td>
</tr>
<tr>
<td>Number of Location Parameters</td>
<td>$m = 1$</td>
<td>$m = 2$</td>
<td>$m = 1$</td>
</tr>
<tr>
<td>H0 : $r = 0$ vs H1 : $r = 1$</td>
<td>73.08 (0.00)</td>
<td>36.89 (0.00)</td>
<td>293.1 (0.00)</td>
</tr>
<tr>
<td>H0 : $r = 1$ vs H1 : $r = 2$</td>
<td>0.637 (0.42)</td>
<td>0.0945 (0.90)</td>
<td>0.071 (0.79)</td>
</tr>
<tr>
<td>H0 : $r = 2$ vs H1 : $r = 3$</td>
<td>- - -</td>
<td>56.17 (0.00)</td>
<td>-</td>
</tr>
<tr>
<td>H0 : $r = 3$ vs H1 : $r = 4$</td>
<td>- - -</td>
<td>46.39 (0.00)</td>
<td>-</td>
</tr>
<tr>
<td>H0 : $r = 4$ vs H1 : $r &gt; 4$</td>
<td>- - -</td>
<td>36.72 (0.00)</td>
<td>-</td>
</tr>
<tr>
<td>Model</td>
<td>Model D</td>
<td>Model E</td>
<td>Model F</td>
</tr>
<tr>
<td>Threshold Variable</td>
<td>$pop&lt;_{15years}$</td>
<td>$pop&gt;_{64years}$</td>
<td>CA/GDP</td>
</tr>
<tr>
<td>Number of Location Parameters</td>
<td>$m = 1$</td>
<td>$m = 2$</td>
<td>$m = 1$</td>
</tr>
<tr>
<td>H0 : $r = 0$ vs H1 : $r = 1$</td>
<td>186.5 (0.00)</td>
<td>114.5 (0.00)</td>
<td>211.1 (0.00)</td>
</tr>
<tr>
<td>H0 : $r = 1$ vs H1 : $r = 2$</td>
<td>3.21 (0.07)</td>
<td>2.59 (0.08)</td>
<td>0.075 (0.78)</td>
</tr>
<tr>
<td>H0 : $r = 2$ vs H1 : $r = 3$</td>
<td>- - -</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H0 : $r = 3$ vs H1 : $r = 4$</td>
<td>- - -</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>H0 : $r = 4$ vs H1 : $r &gt; 4$</td>
<td>- - -</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: For each model (i.e. for each threshold variable), the testing procedure works as follows. First, test a linear model ($r = 0$) against a model with one threshold ($r = 1$). If the null hypothesis is rejected, test the single threshold model against a double threshold model ($r = 2$). The procedure is continued until the hypothesis no additional threshold is not rejected. The corresponding LM\textsubscript{f} statistic has an asymptotic $F[mK, TN - N - (r+1)mK]$ distribution under $H_0$ where $m$ is the number of location parameters and $K$ the number of explicative variables. In our specifications we have $K=1$. The corresponding p-values are reported in parentheses.
Table 2
Determination of the Number of Location Parameters

<table>
<thead>
<tr>
<th>Model</th>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
<th>Model D</th>
<th>Model E</th>
<th>Model F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Location Parameters</td>
<td>( m = 1 )</td>
<td>( m = 2 )</td>
<td>( m = 1 )</td>
<td>( m = 2 )</td>
<td>( m = 1 )</td>
<td>( m = 2 )</td>
</tr>
<tr>
<td>Optimal Number of Threshold</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Residual Sum of Squares</td>
<td>7558</td>
<td>7523</td>
<td>6378</td>
<td>5834</td>
<td>7437</td>
<td>6566</td>
</tr>
<tr>
<td>AIC Criterion</td>
<td>2.102</td>
<td>2.101</td>
<td>1.907</td>
<td>1.871</td>
<td>2.068</td>
<td>1.952</td>
</tr>
<tr>
<td>Schwarz Criterion</td>
<td>2.123</td>
<td>2.127</td>
<td>1.927</td>
<td>2.081</td>
<td>2.068</td>
<td>1.997</td>
</tr>
<tr>
<td>Number of obs.</td>
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<td>960</td>
<td>960</td>
<td>960</td>
<td>947</td>
<td>947</td>
</tr>
<tr>
<td>Number of Location Parameters</td>
<td>( m = 1 )</td>
<td>( m = 2 )</td>
<td>( m = 1 )</td>
<td>( m = 2 )</td>
<td>( m = 1 )</td>
<td>( m = 2 )</td>
</tr>
<tr>
<td>Optimal Number of Threshold</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Residual Sum of Squares</td>
<td>6707</td>
<td>6713</td>
<td>6584</td>
<td>6589</td>
<td>3891</td>
<td>3861</td>
</tr>
<tr>
<td>AIC Criterion</td>
<td>1.957</td>
<td>1.962</td>
<td>1.939</td>
<td>1.943</td>
<td>1.700</td>
<td>1.720</td>
</tr>
<tr>
<td>Schwarz Criterion</td>
<td>1.978</td>
<td>1.987</td>
<td>1.959</td>
<td>1.968</td>
<td>1.730</td>
<td>1.770</td>
</tr>
<tr>
<td>Number of obs.</td>
<td>960</td>
<td>960</td>
<td>960</td>
<td>960</td>
<td>639</td>
<td>639</td>
</tr>
</tbody>
</table>

Notes: For each model (each specification), the optimal number of locations parameters used in the transitions functions can be determined as follows. For each value of \( m \), the corresponding optimal number of thresholds, denoted \( r^\ast(m) \), is determined according to a sequential procedure based on the LMF statistics of the hypothesis of non remaining nonlinearity. Thus, for each couple \((m, r^\ast)\), the value the RSS of the model is reported. The total number of parameters is determined by the formula \( K(r^\ast + 1) + r^\ast(m + 1) \), where \( K \) denotes the number of explicative variables, i.e. \( K = 1 \) in our specifications.
Table 3. Parameter Estimates for the Final PSTR Models

<table>
<thead>
<tr>
<th>Specification</th>
<th>Model A</th>
<th>Model B</th>
<th>Model C</th>
<th>Model D</th>
<th>Model E</th>
<th>Model F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold Variable</td>
<td>Growth</td>
<td>Openness</td>
<td>Size</td>
<td>pop&lt;15years</td>
<td>pop&gt;64years</td>
<td>CA/GDP</td>
</tr>
<tr>
<td>$(m, r^*)$</td>
<td>(1,1)</td>
<td>(1,1)</td>
<td>(2,2)</td>
<td>(1,1)</td>
<td>(1,1)</td>
<td>(1,1)</td>
</tr>
<tr>
<td>Parameter $\beta_0$</td>
<td>0.487 (0.04)</td>
<td>0.885 (0.02)</td>
<td>0.017 (0.04)</td>
<td>0.378 (0.03)</td>
<td>0.600 (0.04)</td>
<td>0.893 (0.08)</td>
</tr>
<tr>
<td>Parameter $\beta_1$</td>
<td>0.126 (0.01)</td>
<td>-0.678 (0.03)</td>
<td>0.705 (0.04)</td>
<td>0.215 (0.01)</td>
<td>-0.371 (0.02)</td>
<td>-0.676 (0.07)</td>
</tr>
<tr>
<td>Parameter $\beta_2$</td>
<td>-</td>
<td>-</td>
<td>0.1154 (0.02)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Location Parameters $c_j$

First Transition Function | 2.74 | 87.2 | [0.049 0.536] | 20.7 | 14.2 | -2.63 |
Second Transition Function | - | - | [0.816 2.081] | - | - | - |
Slopes Parameters $\gamma$ | 0.774 | 0.037 | [345 2319] | 0.579 | 0.547 | 0.109 |

Notes: The standard errors in parentheses are corrected for heteroskedasticity. For each model and each value of $m$ the number of transition functions $r$ is determined by a sequential testing procedure (see Table 1). For the $j^{th}$ transition function, with $j = 1, \ldots, r$, the estimated location parameters $c_j$ and the corresponding estimated slope parameter $\gamma_j$ are reported. The PSTR parameters cannot be directly interpreted as elasticities.
<table>
<thead>
<tr>
<th>Model</th>
<th>Threshold Variable</th>
<th>OLS / Within</th>
<th>Model A Growth</th>
<th>Model B Openness</th>
<th>Model C Size</th>
<th>Model D pop&lt;15years</th>
<th>Model E pop&gt;64years</th>
<th>Model F CA/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>β</td>
<td>σ</td>
<td>β</td>
<td>σ</td>
<td>β</td>
<td>σ</td>
<td>β</td>
</tr>
<tr>
<td>Australia</td>
<td>0.874 (5.85)</td>
<td>0.546 (3.43)</td>
<td>0.808 (1.19)</td>
<td>0.722 (0.00)</td>
<td>0.562 (3.61)</td>
<td>0.564 (2.57)</td>
<td>0.570 (3.07)</td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>0.933 (6.49)</td>
<td>0.554 (3.67)</td>
<td>0.668 (6.60)</td>
<td>0.722 (0.00)</td>
<td>0.484 (6.79)</td>
<td>0.407 (4.48)</td>
<td>0.532 (3.14)</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>0.897 (10.3)</td>
<td>0.553 (3.59)</td>
<td>0.394 (10.4)</td>
<td>0.722 (0.00)</td>
<td>0.485 (6.35)</td>
<td>0.423 (5.62)</td>
<td>0.481 (5.36)</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>0.615 (7.66)</td>
<td>0.550 (3.86)</td>
<td>0.740 (5.93)</td>
<td>0.837 (0.00)</td>
<td>0.54 (3.53)</td>
<td>0.565 (2.92)</td>
<td>0.549 (2.96)</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>1.044 (20.6)</td>
<td>0.543 (3.90)</td>
<td>0.690 (2.89)</td>
<td>0.722 (0.00)</td>
<td>0.478 (7.25)</td>
<td>0.436 (7.35)</td>
<td>0.549 (2.96)</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>1.723 (23.9)</td>
<td>0.555 (4.19)</td>
<td>0.735 (4.11)</td>
<td>0.837 (0.00)</td>
<td>0.502 (6.41)</td>
<td>0.516 (6.60)</td>
<td>0.523 (6.49)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>1.077 (9.72)</td>
<td>0.550 (3.62)</td>
<td>0.792 (2.34)</td>
<td>0.837 (0.00)</td>
<td>0.526 (5.26)</td>
<td>0.451 (5.13)</td>
<td>0.503 (2.10)</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>0.956 (3.13)</td>
<td>0.554 (4.78)</td>
<td>0.787 (2.80)</td>
<td>0.832 (0.01)</td>
<td>0.514 (7.10)</td>
<td>0.478 (8.68)</td>
<td>0.569 (3.40)</td>
<td></td>
</tr>
<tr>
<td>Iceland</td>
<td>1.022 (12.3)</td>
<td>0.554 (4.76)</td>
<td>0.642 (3.86)</td>
<td>0.793 (0.02)</td>
<td>0.586 (0.95)</td>
<td>0.568 (1.84)</td>
<td>0.553 (4.69)</td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>0.091 (4.20)</td>
<td>0.564 (4.02)</td>
<td>0.479 (13.2)</td>
<td>0.132 (0.00)</td>
<td>0.587 (1.44)</td>
<td>0.544 (0.71)</td>
<td>0.558 (8.61)</td>
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</tr>
<tr>
<td>Italy</td>
<td>1.099 (6.54)</td>
<td>0.553 (3.95)</td>
<td>0.788 (2.37)</td>
<td>0.837 (0.00)</td>
<td>0.496 (8.13)</td>
<td>0.465 (9.85)</td>
<td>0.509 (3.31)</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>0.850 (5.87)</td>
<td>0.565 (4.21)</td>
<td>0.833 (0.68)</td>
<td>0.837 (0.00)</td>
<td>0.514 (7.73)</td>
<td>0.540 (8.29)</td>
<td>0.471 (2.28)</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>-0.152 (19.8)</td>
<td>0.540 (3.92)</td>
<td>0.805 (4.46)</td>
<td>0.722 (0.00)</td>
<td>0.594 (0.00)</td>
<td>0.599 (0.03)</td>
<td>0.553 (5.70)</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>1.313 (20.1)</td>
<td>0.546 (3.25)</td>
<td>0.477 (6.51)</td>
<td>0.783 (0.06)</td>
<td>0.514 (7.50)</td>
<td>0.527 (4.26)</td>
<td>0.455 (3.03)</td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.526 (20.3)</td>
<td>0.534 (4.27)</td>
<td>0.737 (3.14)</td>
<td>0.132 (0.00)</td>
<td>0.578 (1.93)</td>
<td>0.565 (2.13)</td>
<td>0.603 (5.98)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>-0.067 (28.6)</td>
<td>0.557 (3.42)</td>
<td>0.631 (2.43)</td>
<td>0.837 (0.00)</td>
<td>0.516 (5.73)</td>
<td>0.414 (7.73)</td>
<td>0.504 (9.24)</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>0.342 (10.2)</td>
<td>0.569 (4.32)</td>
<td>0.717 (5.07)</td>
<td>0.145 (0.03)</td>
<td>0.539 (7.18)</td>
<td>0.520 (7.34)</td>
<td>0.568 (7.61)</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>0.600 (4.72)</td>
<td>0.591 (3.51)</td>
<td>0.719 (7.43)</td>
<td>0.780 (0.06)</td>
<td>0.584 (1.94)</td>
<td>0.599 (0.12)</td>
<td>0.515 (8.18)</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>1.074 (13.8)</td>
<td>0.557 (4.50)</td>
<td>0.804 (2.87)</td>
<td>0.837 (0.00)</td>
<td>0.532 (7.91)</td>
<td>0.509 (8.77)</td>
<td>0.531 (3.27)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>1.031 (15.1)</td>
<td>0.543 (3.55)</td>
<td>0.713 (5.62)</td>
<td>0.722 (0.00)</td>
<td>0.457 (3.73)</td>
<td>0.361 (8.89)</td>
<td>0.516 (3.37)</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.327 (11.0)</td>
<td>0.532 (3.49)</td>
<td>0.677 (3.81)</td>
<td>0.765 (0.06)</td>
<td>0.478 (7.25)</td>
<td>0.466 (6.91)</td>
<td>0.425 (4.77)</td>
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</tr>
<tr>
<td>Turkey</td>
<td>1.049 (7.95)</td>
<td>0.549 (4.57)</td>
<td>0.821 (3.39)</td>
<td>0.823 (0.03)</td>
<td>0.594 (0.03)</td>
<td>0.599 (0.05)</td>
<td>0.536 (3.33)</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.720 (11.1)</td>
<td>0.541 (3.25)</td>
<td>0.752 (2.69)</td>
<td>0.837 (0.00)</td>
<td>0.501 (5.43)</td>
<td>0.414 (6.99)</td>
<td>0.521 (3.49)</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>1.280 (13.6)</td>
<td>0.550 (3.66)</td>
<td>0.840 (0.78)</td>
<td>0.837 (0.00)</td>
<td>0.554 (3.26)</td>
<td>0.539 (3.13)</td>
<td>0.527 (2.30)</td>
<td></td>
</tr>
<tr>
<td>All Countries</td>
<td>0.655 (2.15)</td>
<td>0.552 (4.06)</td>
<td>0.710 (12.5)</td>
<td>0.711 (0.22)</td>
<td>0.529 (6.86)</td>
<td>0.502 (8.95)</td>
<td>0.526 (6.17)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: For each country, the average $\bar{\beta}$ and standard deviation $\bar{\sigma}$ (in percentages) of the individual capital mobility are reported. The two first column of the line All countries corresponds to the within estimates.
Table 5
Parameter Estimated for the Final PSTR Models corrected of endogeneity

<table>
<thead>
<tr>
<th>Specification</th>
<th>Model B</th>
<th>Model D</th>
<th>Model E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold Variable</td>
<td>Openness</td>
<td>pop&lt;15years</td>
<td>pop&gt;64years</td>
</tr>
<tr>
<td>Instrumental variables</td>
<td>pop&lt;15years, pop&gt;64years</td>
<td>Openness, pop&gt;64years</td>
<td>Openness, pop&lt;15years</td>
</tr>
<tr>
<td>(m, r*)</td>
<td>(1,1)</td>
<td>(1,1)</td>
<td>(1,1)</td>
</tr>
<tr>
<td>Parameter β₀</td>
<td>0.787 (0.04)</td>
<td>0.391 (0.06)</td>
<td>3733</td>
</tr>
<tr>
<td>Parameter β₁</td>
<td>-0.559 (0.04)</td>
<td>0.211 (0.02)</td>
<td>-7464</td>
</tr>
<tr>
<td>Location Parameters c₁</td>
<td>98.1 (0.04)</td>
<td>21.2 (0.02)</td>
<td>3.94</td>
</tr>
<tr>
<td>Slopes Parameters γ</td>
<td>0.058</td>
<td>0.566</td>
<td>1.6 * 10⁻⁵</td>
</tr>
</tbody>
</table>

Notes: The standard errors in parentheses are corrected for heteroskedasticity. For each model and each value of m the number of transition functions r is determined by a sequential testing procedure (see Table 1). For the jth transition function, with j = 1..r, the m estimated location parameters c_j and the corresponding estimated slope parameter γ_j are reported. The PSTR parameters can not be directly interpreted as elasticities.
<table>
<thead>
<tr>
<th>Model</th>
<th>OLS / Within</th>
<th>Model B</th>
<th>Model D</th>
<th>Model E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transition variable</td>
<td>-</td>
<td>Openness</td>
<td>pop&lt;15years</td>
<td>pop&gt;64years</td>
</tr>
<tr>
<td>Instrumental variables</td>
<td>Openness, pop&lt;15years, pop&gt;64years</td>
<td>Openness, pop&lt;15years, pop&gt;64years</td>
<td>Openness, pop&gt;64years</td>
<td>Openness, pop&lt;15years</td>
</tr>
<tr>
<td></td>
<td>$\beta$</td>
<td>$\sigma$</td>
<td>$\bar{\beta}$</td>
<td>$\bar{\sigma}$</td>
</tr>
<tr>
<td>Australia</td>
<td>0.931 (7.15)</td>
<td>0.776 (0.33)</td>
<td>0.563 (4.19)</td>
<td>0.550 (4.08)</td>
</tr>
<tr>
<td>Austria</td>
<td>0.962 (7.81)</td>
<td>0.702 (4.92)</td>
<td>0.483 (6.41)</td>
<td>0.412 (2.76)</td>
</tr>
<tr>
<td>Belgium</td>
<td>1.380 (19.2)</td>
<td>0.402 (13.13)</td>
<td>0.484 (6.07)</td>
<td>0.421 (3.55)</td>
</tr>
<tr>
<td>Canada</td>
<td>0.59 (9.78)</td>
<td>0.746 (3.73)</td>
<td>0.540 (5.87)</td>
<td>0.556 (5.03)</td>
</tr>
<tr>
<td>Denmark</td>
<td>3.382 (97.3)</td>
<td>0.724 (1.84)</td>
<td>0.479 (6.83)</td>
<td>0.433 (4.98)</td>
</tr>
<tr>
<td>Finland</td>
<td>1.706 (34.8)</td>
<td>0.747 (2.11)</td>
<td>0.502 (6.62)</td>
<td>0.506 (7.19)</td>
</tr>
<tr>
<td>France</td>
<td>1.132 (13.2)</td>
<td>0.771 (0.70)</td>
<td>0.524 (5.49)</td>
<td>0.439 (3.29)</td>
</tr>
<tr>
<td>Greece</td>
<td>0.979 (3.96)</td>
<td>0.769 (0.88)</td>
<td>0.515 (6.94)</td>
<td>0.468 (7.47)</td>
</tr>
<tr>
<td>Iceland</td>
<td>1.147 (13.3)</td>
<td>0.688 (3.32)</td>
<td>0.591 (1.28)</td>
<td>0.552 (3.35)</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.095 (4.47)</td>
<td>0.503 (15.5)</td>
<td>0.593 (1.82)</td>
<td>0.510 (0.83)</td>
</tr>
<tr>
<td>Italy</td>
<td>1.192 (7.47)</td>
<td>0.770 (0.74)</td>
<td>0.498 (7.70)</td>
<td>0.456 (7.48)</td>
</tr>
<tr>
<td>Japan</td>
<td>0.969 (26.0)</td>
<td>0.782 (0.14)</td>
<td>0.516 (7.52)</td>
<td>0.553 (9.49)</td>
</tr>
<tr>
<td>Mexico</td>
<td>-0.883 (35.9)</td>
<td>0.773 (1.72)</td>
<td>0.602 (0.00)</td>
<td>0.717 (0.95)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2.986 (57.6)</td>
<td>0.506 (8.47)</td>
<td>0.517 (7.67)</td>
<td>0.502 (4.30)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>-0.976 (110)</td>
<td>0.749 (1.52)</td>
<td>0.581 (2.44)</td>
<td>0.549 (3.83)</td>
</tr>
<tr>
<td>Norway</td>
<td>0.470 (40.9)</td>
<td>0.680 (2.13)</td>
<td>0.514 (5.85)</td>
<td>0.417 (5.04)</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.146 (53.2)</td>
<td>0.737 (2.75)</td>
<td>0.543 (7.35)</td>
<td>0.509 (7.00)</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.559 (5.16)</td>
<td>0.733 (4.00)</td>
<td>0.590 (2.40)</td>
<td>0.715 (2.97)</td>
</tr>
<tr>
<td>Spain</td>
<td>1.311 (21.0)</td>
<td>0.774 (0.92)</td>
<td>0.537 (7.91)</td>
<td>0.499 (7.55)</td>
</tr>
<tr>
<td>Sweden</td>
<td>1.622 (28.6)</td>
<td>0.733 (3.50)</td>
<td>0.455 (3.27)</td>
<td>0.376 (6.27)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.648 (15.1)</td>
<td>0.714 (2.64)</td>
<td>0.479 (6.83)</td>
<td>0.454 (5.14)</td>
</tr>
<tr>
<td>Turkey</td>
<td>1.419 (24.3)</td>
<td>0.778 (0.96)</td>
<td>0.602 (0.05)</td>
<td>0.707 (1.29)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.914 (16.0)</td>
<td>0.756 (1.13)</td>
<td>0.498 (5.35)</td>
<td>0.417 (4.46)</td>
</tr>
<tr>
<td>USA</td>
<td>1.480 (19.8)</td>
<td>0.783 (0.13)</td>
<td>0.554 (3.89)</td>
<td>0.512 (3.63)</td>
</tr>
<tr>
<td>All Countries</td>
<td>0.683 (0.04)</td>
<td>0.712 (10.9)</td>
<td>0.531 (6.99)</td>
<td>0.510 (10.5)</td>
</tr>
</tbody>
</table>

Notes: For each country, the average $\bar{\beta}$ and standard deviation $\bar{\sigma}$ (in percentages) of the individual capital mobility are reported. The two first column of the line All countries corresponds to the within estimates.
Figure 1. Transition Function with $m=1$ et $c=0$. Sensivity Analysis to the Slope Parameter
1 Introduction

In their seminal article of 1980, Feldstein and Horioka put in evidence a strong correlation between countries’ national saving and domestic investment. Their result has been confirmed in most studies on EU and OECD countries, although not for other samples. It has led to huge literature as there is no reason for an increase in national saving to raise domestic investment, in a world of capital mobility. This outcome, known as the Feldstein – Horioka (FH thereafter) puzzle, could be explained under unalloyed mobility of capital, but also by the existence of other factors that simultaneously drive both investment and savings. Indeed, as Taylor (1994) put it: “For the FH condition to hold a strong assumption must be made that all determinants of a country’s rate of investment other than its real interest rate are uncorrelated with its saving rates” (Taylor, 1994, page 3).

In the literature, attempts to solve FH puzzle have turned in three main direc-

1 According to Frankel (1992) only covered interest parity holds and withstands an unalloyed criterion of capital mobility. This point solves the FH puzzle: remaining exchange risk premium plus expected real currency depreciation generate large gap in real interest rate across countries. Baxter and Crucini (1993) find robust positive time-series’ associations between saving and investment, with free international asset transactions, in their simulations of a two-country, one-good neoclassical general equilibrium model. Furthermore, small open economies exhibit high investment and high saving, whereas real interests remain low, in line with real appreciation highlighted by Balassa (1964) with a permanent shock of productivity in the traded sector, while productivity remains steady in the non-traded activities (Obstfeld, 1995). Besides, due to hysteresis of factor supplies, in spite of the liberalisation of capital movements, high-saving countries maintained their specialisation in capital-intensive industries, while low-saving nations kept on producing more labour-intensive products. So high-capital countries having high-saving, a high cross-sectional correspondence between saving and investment rates aroused (Obstfeld, 1995).

2 Frankel (1992), Coakley et al. (1998) shared Taylor’s idea of a positive covariance between domestic investment and national saving as long as existed common factors affecting both saving and investment.
Figure 2. Estimated FH Coefficients PSTR Models

Gross Rate of Real GDP per Capita in Percent

Openness in Percent

Population Rate Older than 65 Years in Percent

Population Rate Younger than 15 Years in Percent

Size in Percent

Ratio Current Account / GDP in Percent
Figure 3. Estimated FH Individual Coefficients: PSTR Model B
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