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# The role of credibility and fundamentals in a funded pension system: a Markov switching analysis for Australia and Iceland

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*December, 2007*

**Abstract :** Since the turn of the millennium the problem of credibility of the social security system has spread to the private pension funds sector. This is evident for those countries, like Australia and Iceland, that have very large funded pensions assets as a result of strong pension reforms. The problem of trust could prevent pension fund investment from continuing to grow, weakening the privatization of the social security system. The objective of this study is to obtain new insights into the determinants of pension funds. We focus our analysis on the Australian and Icelandic experiences to study the credibility of pension fund performance and, as a consequence, of pension reform. Our credibility indicator is derived from a CAPM time-varying model. It can be used to investigate, using a Markov switching model, the linkages between economic fundamentals and the credibility of pension fund investment and the asymmetric effects of the fundamentals in the two regimes of low and hight credibillity. Our findings make a contribution to modelling policy credibility as a non-linear process with two distinct regimes. We also found large differences in the value of the coefficients for all macroeconomic variables between the low and high credibility regimes. This evidence strongly supports the hypothesis that the effects of macroeconomic fundamental variables on the level of credibility are asymmetric in all countries.

***Keywords***: Credibility, pension funds, Kalman filter, Markov switching model,

***JEL codes***: E21, G23, H55.

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## Introduction

Pension reform is nowadays a necessary ingredient for fiscal reform. In the last two decades the huge amount of concern in the field of pension policy has been related to the credibility of public pension programmes. Such programmes are paying pension benefits that are not financially sustainable at current tax levels. As a consequence, during the 1990s many countries around the globe implemented radical pension reforms, which often involved an increased use of funded pension programmes managed by the private sector. These reforms have encouraged a voluntary (third) pillar through tax incentives, and/or the introduction of a mandatory (second) pillar.

As a consequence of these reforms, in the past 15 years pension funds have emerged as an important component of many institutional investment portfolios. Growth in the percentage of pension fund portfolio assets is also due to the many studies reporting that pension fund returns are comparable to those of other asset classes. Generally they are positively correlated with stock returns, negatively correlated with bond returns and positively correlated with both expected and unexpected inflation. Hence, pension funds offer attractive risk-return characteristics, provide important diversification benefits within mixed-asset portfolios, and act as a hedge against inflation.

But since the turn of the millennium, the problem of credibility has spread to the private pension funds sector, particularly in those countries, such as Netherlands, the UK, Australia and Iceland, that had encouraged private alternatives to public pensions and present very large funded pension assets as a result of major pension reforms.

The desire to achieve a high rate of coverage in private pension provision has led an increasing number of countries, such as Australia and Iceland, to introduce a second, mandatory pillar. Within the next few decades, mandatory and voluntary private pillars are expected to provide a significant share of retirement income in many countries. As a result, there has been growing interest in the institutional and regulatory framework of the pension industry, and in assessing whether the industry will be able to meet the expectations of workers and policy makers. Moreover, the government has the responsibility to ensure that fund management meets some basic rules and is carefully supervised (Vittas, 1998).

These problems of credibility are mostly due to two key facts about pension arrangements. First of all, private pension funds operate within an array of tax and regulatory policies and hence are subject to significant public governance risk. The financial conditions are strictly related to good management by the government and, in addition, pension contributions and benefits may change as a consequence of changes in the tax regulations.

Recent events in international financial sectors have reduced trust in the governance of private money and have raised many questions about the role of pension funds in investment portfolios. Specifically, a number of banks, trust companies and insurance companies heavily exposed their portfolios to housing funds with adverse effects across all financial markets in addition to some corporate scandals such as Enron and Parmalat, and the subsequent collapse of investments. This behaviour has attracted the attention of policy makers, suggesting a lack of clear understanding of pension fund market fundamentals and the relationship between pension funds and other asset classes held in institutional portfolios.

The problem of trust could prevent investment in institutional pension funds from continuing to grow, weakening the privatization of the social security system. The increase in pension fund investment depends critically on two factors linked to the sources of risk in preparing for retirement. The first is the investor's ability to measure pension fund risk and return accurately, hence credibility of a pension reform. In this case it would be important to give guidelines to pension fund managers and ensure that they always act in the interests of beneficiaries. The second major factor is investor understanding of the relationship between pension fund assets and other assets in their portfolios. Investors may be poorly informed while pension fund institutions may have insufficient expertise or poor incentives to manage risk optimally. Both factors lead to the credibility problem of a pension reform designed to give a great role to private pension provision. Although much has been written about issues such as the transition to a funded system and the design of benefits, very little has been said on the crucial issue of credibility of pension funds. Strictly related to credibility, regulation and supervision are crucial to the success of reforms (Besley and Pratt, 2005).

The objective of this study is to obtain new insights into the determinants of pension funds. We focus on experiences in Australia and Iceland because they show the largest pension fund financial assets. In doing so, we analyse the concept of credibility of a pension reform. We use a CAPM time-varying model. The resultant time-varying credibility coefficient can then be used to shift the analysis towards more detailed aspects. It can be used to investigate, using a Markov switching model, the linkages between economic fundamentals and credibility of pension reforms and the asymmetric effects of the fundamentals in the decisions concerning the two regimes.

The remainder of the paper has three main sections. Section 2 presents some definition of credibility, regulation and supervision. Section 3 briefly explains the Australian and Icelandic pension systems. Section 4 presents the data, the methodology applied and the empirical results. Finally, section 4 concludes.

## 2. Credibility, Regulation and Supervision

It is commonly held that mandatory multi-pillar schemes would perform better than traditional pay-as-you-go models, partly because their designers believe that supervision from both authorities and fund members will be more efficient. However, these schemes are not immune to risk, even in the absence of wrongdoing. The government, which forces workers to contribute and aims to ensure a minimum level of welfare to all members of society, must therefore try to reduce such risks. Easy-to-understand credibility, regulations and efficient supervision are a vital part of controlling such risks. Let us now analyse these concepts in brief.

*Credibility*, is defined in the literature as "the extent to which beliefs concerning a policy conform to official announcements about this policy. To achieve credibility, the authorities must precommit themselves to a particular policy rule....Credibility may thus also be viewed as a measure of the degree to which policy-makers tie their hands on future policies by issuing policy announcements"[1]. Credibility is one of the attributes that all policy makers would like to have. To the same extent this concept of credibility can be applied to the regulation and supervision of private pension funds.

As with the other segments of the financial sector, *regulation* of the pension industry is partly driven by the same general objectives. The most important are the promotion of mobilization and allocation of resources in a way that ensures transparency, security, stability and minimizes fees and cost control, and that promotes investment decisions across a range of permissible risk-return combinations (Rocha, Hinz and Gutierrez, 1999). However, in addition to these general objectives, regulation in the case of pension funds has a special characteristic strictly related to the role played by institutions in their social policy: to ensure the provision of retirement income.

In the case of Australia and Iceland, the focus of this paper, participation in a privately managed funded system is mandatory (as in Argentina, Chile, Hungary, Poland, Switzerland, or quasi-mandatory as in Netherlands, and Denmark). Pension funds represent a large portion of household wealth. This provides a strong motivation for the introduction of prudential regulation and supervision.

[1] Weber (1991) p. 62.

As stressed by Queisser (1998), we can distinguish two different regulatory approaches to managing the investment of pension funds: the “prudent-man” rule, which is a behaviourally-oriented standard, or by establishing express quantitative limits on the types of assets in which pension funds may be invested (the so-called Draconian approach).

Under the prudent man rule[2] there is no restriction to the investment decisions that managers of pension funds make, while there is control by the authority on funding levels and other indicators. This rule and fiduciary diligence should be sufficient to ensure adequate diversification and custodial protection of pension fund assets at least in the case of mature domestic capital markets[3].

Draconian regulation, instead, establishes quantitative limits with respect to the share of assets that a fund may invest per instrument as well as limits per individual issuer. The motivation behind this regulation is the need to safeguard a pension fund’s asset through diversification and, in addition, to secure the pension fund’s demand for government debt[4]. Essentially, the prudent-man rule is applied in the United States, the United Kingdom, Ireland, the Netherlands, Australia, Iceland and Canada.

## 3. Australian and Icelandic Pension Systems

[2] According to Davis (1995) the prudent person rule requires that pension fund money be invested “for the sole benefit of beneficiaries”. Moreover that investment should be made with “the care, skill, prudence and diligence under the circumstances than prevailing that a prudent man acting in a like capacity and familiar with such matters would use in the contact of an enterprise of a like character and with like aims”.

[3] In the case of developing countries initially tight and detailed investment rules would be necessary. This would be justified by the absence of strong and transparent capital markets, the compulsory nature of the pension system, and the little familiarity with capital markets of the members of pension fund. As domestic capital markets grow and mature, such rules should be systematically relaxed until the prudent-man rule applies (Vittas, 1996).

[4] Some governments could be tempted to force pension funds to invest in public debt, above all in the case in which the cost of the transition from the unfunded pension system to the funded one increases the need to place government debt. Latin American countries have resisted this temptation while in Bolivia and Uruguay a limited amount of pension assets must be invested in government bonds (Queisser, 1998)

The largest pension funds in relation to the size of their respective economies are those that have had mandatory or quasi-mandatory pension funds for many years, like Australia, Iceland, the Netherlands and Switzerland[5], while the largest voluntary pension fund systems are those in the United States, United Kingdom and Canada (OECD, 2005).

In this paper we focus on Australia and Iceland which are increasingly meeting the criteria of the prototype three-pillar system. These countries are worth examining in order to identify the key determinants of pensions funds and the linkages between economic fundamentals and credibility of pension reforms.

*Australian Pension System*

The Australian retirement system was reformed in 1993 following the key pension system reforms that most of the industrialized countries are now struggling with. Australia provides a three-pillar system which combines the Age Pension, a flat-rate means-tested first pillar pension financed by general revenues[6], with the second pillar, Superannuation Guarantee Contribution (henceforth SGC) which requires employers to contribute on behalf of their employees to privately managed funds[7].

As documented by Bateman and Piggott (1997), the Australian second pillar began to play an increasing role in the early 1980s. Superannuation coverage reached more than 90 percent after the government act in 1991 requiring that all employers made superannuation contributions on

[5] In Iceland and Australia, however, participation in pension funds, which should be left to individual choice, is instead mandatory in agreements between unions and employers; private pensions receive not only the effective regulation and supervision of financial markets but also of a public guarantee reintroducing elements of PAYG financing (Castellino and Fornero,1996).

[6] The government Age Pension has been in place since 1909. Australia is virtually unique among OECD countries as its social security system is largely based on the social-assistance model (albeit with a growing private provision sector). The role of social assistance payments in Australia is quite different from the role they play in the other OECD countries; they are the normal form of government income support rather than a residual complement to a social insurance system (Bozic and Jackson, 1997).

[7] The initial contribution rate was 3 per cent of earnings in 1986; the rate was 6 per cent in 1997-98 and 9 per cent in 2002-2003.

behalf of their employees. In this new mandated Superannuation Guarantee system, private pensions are compulsory and occupational pensions are automatically vested, funded and preserved[8]. As stressed in Bateman and Piggott (1997) over 90 per cent of employees are now covered by occupational superannuation. In addition, individuals can combine these mandated occupational pensions with voluntary superannuation (third pillar) assisted by generous tax concessions.

Following Disney and Johnson (2001) and Bateman and Piggott (1997) we can distinguish five types of income sources for the Australian retired population: public transfer which is primarily composed by the Age Pension, private pensions, earnings, investment income and other income.

After public transfers, investment income represents on average the major source of income, followed by private pensions and earnings.

The greater role played by Australian superannuation in the provision for retirement income provides an additional argument for government intervention particularly for private pensions, which are mandatory, offer little choice and are eligible for tax relief. Prior to the mid-1980s the pension funds industry was mostly self-regulated. After several specific legislative acts in the regulatory framework and associated Acts starting in 1987, the Australian Prudential Regulatory Authority (APRA) was established in 1998 as the single prudential regulator for the entire financial system, supervising all financial institutions, including pension funds, and applies a sophisticated risk-based supervision system for pension funds. Since it was established it took over the functions that were of the ISC (Insurance and Superannuation Commission), ASC (the Australian Security Commission), the Reserve Bank of Australia and other land regulators[9].

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[8] The term *preservation* means that the individual could not withdraw assets until after age 55. However, later legislation gradually shifted it to age 60. As emphasized by Gallagher, Rothman and Brown (1993), an indicative projection for someone receiving average earnings, contributing to superannuation for 40 years and retiring at age 65 or over, gives an after-tax replacement rate of about 60 per cent.

[9] For a more detailed historical perspective of Australian regulatory arrangements, see Bateman (2003)

*Icelandic Pension System*

The Icelandic pension system is based on three pillars and its dominant feature is the role of occupational pension funds. It is mandatory to pay at least 10 per cent of total wages and salaries to these funds. The first pillar, according to the accepted terminology in this field, is a tax-financed public pension. The second pillar is based on occupational pension funds, which is mandatory as in Australia. The third pillar is voluntary pension saving with tax incentives[10]. A comprehensive pension reform took place in 1997 and 1998 that affected the second and third pillar.

Iceland is not facing the problems of most developed countries due to an aging population. First of all, Icelandic people are younger and, according to the predictions for 2030, its dependency ratio will remain lower than that of other European countries (Bros *et al*., 1994). Moreover, labour participation rates among the elderly are also higher and the effective retirement age is higher than in most industrialized nations. This happens because of the particular Icelandic social security system in which individuals are entitled to receive a public pension only from the age of 67 and pension funds are regulated so that no incentives are given for early retirement.

Leaving out a detailed description of the first pillar we concentrate our attention on private pension provision. Many of the funds were established through a collective labour agreement in 1969. Most of them are managed jointly by representatives from the trade unions and employers. Only in 1998 did comprehensive legislation covering the operation of pension funds come into force[11].

[10] Most of the following is based on Gudmundsson (2001, 2004) and Gudmundsson and Baldursdóttir (2005).

[11] The main elements in the law are the definition of 1) which entities are allowed to call themselves pension funds and receive mandatory contributions for pension rights, 2) minimum pension rights and forms of pension, 3) general requirements for operating pension funds regarding size, risk, internal auditing and funding, 4) guidelines and limits for the funds' investment policies based on the risk diversification principle.

Funds with employer guarantees and ordinary private funds show several differences concerning the amount of contributions and benefits and also regarding risk-bearing. The recent reforms of public sector pension funds imply that all new employees will become members of fully funded schemes with an accumulation of pension rights akin to that prevailing on the private market.

At the beginning of 2005 there were 48 pension funds in Iceland. Ten of them were no longer receiving contributions. Ten others had employer guarantees from the government and municipalities. There were 28 fully operational occupational pension funds that had no employer guarantee.

In the 1980s and 1990s pension fund assets grew from 14% to 80% per annum in real GDP terms. This placed Iceland fourth among EU and EFTA countries in terms of the size of second-pillar pension fund assets as a percentage of GDP, after the Netherlands, Switzerland and the UK.

The main feature of the *third* pillar consists of voluntary private pension savings for which in 1998 tax incentive legislation was adopted as part of the general pension reform. Employees are currently allowed to deduct from their taxable income a contribution to authorised individual pension schemes comprising up to 4% of wages. The pension schemes have to be authorised by the Ministry of Finance. The pension saving is not redeemable until the age of 60 and has to be paid in equal payments over a period of at least seven years.

In 2003 and 2004 the *assets* of Icelandic pension funds and life insurance were respectively 138.4 and 146.2 % of GDP (OECD, 2005). The reason is that contributions to pension funds exceed benefits paid by them since there are few pensioners in proportion to working fund members. Furthermore, as most of them have contributed to the fund only for a short period of their working lives, they are entitled only to relatively small benefits.

Regulation and supervision of Icelandic pension funds is very low. Pension funds are regulated by the Ministry of Finance and supervised by the Financial Supervisory Authority (FME) which is also responsible for supervising the credit, securities and insurance markets. According to the Pension Act in Iceland, pension funds should maintain net assets, together with the present discounted value of future contributions, equal to the present discounted value of expected pensions arising from contributions already paid and future contributions. Every year the financial situation of the fund should be actuarially assessed. If there is a mismatch between the assets of the fund and pension obligations, the benefits level is usually changed at discrete intervals by changing the Statutes of the pension fund.

## 3. Methodology and empirical results

Starting from the milestone papers of Sharpe (1964), Lintner (1965), and Black (1972), the Capital Asset Pricing Model (CAPM hereafter) has been one of the cornerstones of modern finance theory for the last four decades. The CAPM is funded on a simple and stable linear relationship between an asset's systematic risk and its expected return.

However, since the 1980s, several studies like Basu (1983), Bhandari (1988), and Fama and French (1992), have found weak or no statistical evidence in support of this simple relationship. Stimulated by these findings, a number of researchers have sought alternative explanations for the risk and return trade off. The new line of research argues that since “beta” and market risk premium vary over time, static CAPM would be improved by incorporating time variation in beta in the models (Ferson, 1989, Ferson and Harvey, 1991, 1993, Ferson and Korajczyk, 1995, and Jaganathan and Wang, 1996).

Although there is now considerable empirical evidence on time variation in betas, it is not clear how this variation should be captured. Many researchers model the variation in betas by using continuous approximation and the theoretical framework of the conditional CAPM. However, Ghysels (1998) shows that this approximation fails to capture the dynamics of beta risk. He argues that betas change through time very slowly and linear factor models like the conditional CAPM may have a tendency to overstate the time variation. Empirically documented large pricing errors could be due to the linear approach used in the above models. Treating a non-linear relationship as a linear one can lead to serious prediction problems in estimation. Thus, we will test for the existence of significant evidence of non-linearity in the time series relationship of pension fund asset returns with market returns. Nevertheless, there are very few non-linear asset-pricing models in the finance literature, as they are cumbersome to analyze and interpret. In this paper we take a non-linear approach to estimate betas over time, as we believe that acknowledging non-linearity is an important step towards capturing the dynamics of beta. In this first step of the analysis, due to the well known instability of the beta coefficient, we propose a time-varying version of the CAPM.

Following Hallet et al. (1997) and Sarantis and Piard (2005) we construct a time varying CAPM model to analyse the credibility of the pension reforms implemented in Australia and Iceland. Groenewold and Fraser (1999), for instance, investigate the nature of the time-variation in betas using monthly Australian data from 1979 to 1994 for 23 sectors using the Kalman Filter and they found considerable time-variation in the estimated betas.

### *3.1 Description of the Data*

The data used in this paper largely follow previous studies on CAPM and credibility and therefore cover the two countries: Australia and Iceland, respectively.

The choice of the 1988-2006 sample for Australia using quarterly observations and 1997-2006 for Iceland using monthly observations was essentially based on the need to analyse the credibility variables in both countries after substantial reforms to the pension systems had taken place. For the estimation of the equations used in this work, the variables considered are[12]: the Superannuation data based on a joint Australian Prudential Regulation Authority (APRA) and the Australian Bureau of Statistics (ABS), which currently collects quarterly information from the largest 340 superannuation funds in Australia. For Iceland the private pension fund variable is that available from the Icelandic Central Bank; "i" is the nominal interest rate. We use the money market rate (called *money rate*) as reported by the IMF-Financial Statistics. However, since we are interested in identifying the effects of tight monetary policy, we construct two monetary policy innovation variables (one per country), that is, $r_{i,t}^{+}$ referring to positive changes in monetary policy (tight monetary policy); $R_{j,t}$ is the observed rate of return for the pension fund asset; $R_{f,j,t}$ is the risk-free rate that is, the three-month T-bond interest rate; $R_{m,j,t}$ is the observed rate of return for the aggregate stock market. As fundamental variables we use: public government deficit (gd), the US/home currency nominal exchange rate (e), and the stock market index (sm). Most of the macroeconomic data we used are from the International Financial Statistics databases (IFS), while the sources for the interest rates are from each single Central Bank database. All fundamental variables are calculated as first differences with the previous period.

*3.2 Modelling time-varying β*

We define the following important variables below which will be used in our model.

$$\left(R_{j,t} - R_{f,j,t}\right) = \beta_0 + \beta_t \left(R_{m,j,t} - R_{f,j,t}\right) + \mu_t \qquad \mu_t \sim N\left(0, \sigma^2\right) \tag{1}$$

[12] Data source: IMF - Financial Statistics, Reserve Bank of Australia, Iceland Central bank and OECD statistics.

where $R_{j,t}$ is the observed rate of return for portfolio ***j,*** $R_{m,j,t}$ is the observed rate of return for the market portfolio and $R_{f,j,t}$ is the risk free rate in period ***t***. The subscript ***j*** =1,2 denotes the country portfolio, while ***t*** denotes the period.

In our application of the CAPM, $R_{i,,t}$ *is* the observed rate of return of the private pension asset, $R_{f,i,t}$ is the risk-free rate measured by the interest rate on treasury bills and $R_{m,i,t}$ is the observed rate of return for the market portfolio measured as the return of the whole stock market.

Equation (1) can be re-written in the following form:

$$r_{j,t} = \alpha + \beta_t r_{m,j,t} + \varepsilon_t \qquad \varepsilon_t \sim N\left(0,\sigma^2\right) \tag{2}$$

where $\left(R_{j,t} - R_{f,j,t}\right) = r_{j,t}$ is the excess rate of return for portfolio ***j,*** and $\left(R_{m,j,t} - R_{f,j,t}\right) = r_{m,j,t}$ is the excess rate of return for the market portfolio.

In this context, $\beta$ measures the risk or consistency of the credibility of holding a pension asset up to a given maturity, relative to the performance of the whole market. Values of the $\beta$ coefficient greater (smaller) than one imply that the credibility of national pension reform is lower (higher) than the average market "credibility". Since $\beta$ is constructed as time-varying, the consistency of a country's pension reform credibility will evolve over time as a result of changes either in the credibility of the pension reform itself or in the credibility of the entire asset market.

To be able to capture the dynamics of the parameters of the model we start writing Eq. (2) in its state-space form. The state-space representation can then be used to compute the estimates of a state vector for t = k + 1; k + 2; …; T using the Kalman filter. This recursive algorithm computes the linear least square of the predicted state vector given data observed at time t. To illustrate the evolution of the coefficients, we estimated a time-varying parameter (TVP) model of the following form in compact matrix notation:

$$r_{j,t} = \mathbf{Z}\beta_t + \varepsilon_t \qquad \textit{(transition equation)} \qquad (3)$$

$$\beta_t = F\beta_{t-1} + \eta_t \qquad \textit{(measurement equation)} \qquad (4)$$

$$\mathbf{Z} = \begin{pmatrix} \alpha^1 & z^1_{t-1} & \cdots & \cdots & z^k_{t-1} \\ \vdots & \vdots & \cdots & \cdots & \vdots \\ \vdots & \vdots & \cdots & \cdots & \vdots \\ \vdots & \vdots & \cdots & \cdots & \vdots \\ \alpha^k & z^1_{t-n} & \cdots & \cdots & z^k_{t-n} \end{pmatrix} \quad r_{j,t} = \left[ r_{j,t-1}, r_{j,t-2}, \ldots, r_{j,t-n} \right]$$

$$\beta_t = \left[ \beta_{t-1}, \beta_{t-2}, \ldots, \beta_{t-n} \right] \qquad \varepsilon_t = \left[ \varepsilon_{t-1}, \varepsilon_{t-2}, \ldots, \varepsilon_{t-n} \right]$$

The $Z_t$ matrix, of dimension (Txk), contains the fundamental variable. We now have the state vector $\beta_t$, a (kx1) vector that contains all the slope coefficients, which are now varying through time. The F matrix, of dimension (kxk), contains the autoregressive coefficients of $\beta_t$. We allow the coefficient $\beta_t$ to follow a random walk process. The error terms are assumed to be independent white noise $Var(\varepsilon_t) = Q; \quad Var(\eta_s) = R; \quad Var(\varepsilon_t \eta_s) = 0$ for all $t$ and $s$.

For each endogenous variable of the model it is therefore possible to observe how the respective coefficients are changing over time due to changes in market assessment. If we calculate for every coefficient the first difference, we can simply quantify how "market sentiments" about the credibility of the pension reform are modified by each independent variable.

$$\underset{t-2,t-1}{\Delta}\beta_i = \beta_i^{t-1} - \beta_i^{t-2} \tag{5}$$

Eq. (5) expresses how the credibility has changed in successive times, attributed and deduced by the market, relative to the expectations of the *i-inth* variable. The second graphs in figure 1a and 1b present the patterns of $\underset{t-2,t-1}{\Delta}\beta_i$ for Australia and Iceland, respectively. This can be seen as a sort of intuitive component of the "market sentiment" about the reform.

### *3.3 Modelling the Markov switching process*

The Markov-switching process is frequently used nowadays in finance and economics. This kind of process takes account of the changes in state of a time series. In finance, for instance, it is well known that the volatility of a time series could change, say, because of a depression. One of its properties is that the change in state has a unique probability. This is due to the Markov definition of the model. Unfortunately, a consequence of this is that it is difficult to control the changes of state. In this respect, our work can be regarded as an extension of the studies by Maheu and McCurdy (2000), Perez-Quiros and Timmermann (2000), Akifumi Isogai *et* al (2004) and Shiu-Sheng Chen (2005).

In this section we describe a general econometric framework which allows for regime switching in the dynamics of credibility of pension fund returns.

A Markov regime-switching model enhances traditional performance measures by allowing assessment of the investment strategy when exposed to dynamic factors through time. The regime-switching model combines several sets of model parameters (coefficients) into one system, and which set of parameters should be applied depends on the regime the system is likely to be in at a certain time.

We investigate the ability of the Markov switching model to explore whether there are different regimes in the credibility index and to capture the potential influence of fundamental variables on the credibility level. The first specification is:

$$\beta_{j,t} = \phi_0 s_t + \phi_i s_t \beta_{j,t-n} + \mu_t \tag{6}$$

where $\beta_t$ is the credibility variable of country "j", $s_t$ is governed by an unobservable, discrete, first-order Markov chain that can assume *k* values (states), $\mu_t \sim i.i.d.\mathrm{N}(0, \sigma^2_{s_t})$. .

The second specification is given by:

$$\beta_{j,t} = \phi_0 s_t + \phi_{j}, s_t \beta_{j,t-n} + \phi_{r}, s_t X_{j,t} + \varepsilon_t \tag{7}$$

where $s_t$ is governed by an unobservable, discrete, first-order Markov chain that can assume *k* values (states), $\varepsilon_t \sim i.i.d.\mathrm{N}(0, \sigma^2_{s_t})$. , and $X_t$ is a vector of fundamental variables.

In what follows, we define a univariate switching model (eq. (6)) to examine whether the credibility series is subject to a discrete shift in regimes and a multivariate switching model (eq. (7)) which allows the effect of macroeconomic variables on credibility to be asymmetric.

The introduction of Markov switching allows the coefficients $\phi_i$ in equations (6) and (7) and $\phi_r$ to switch between the two different states $S_t = 0$ and $S_t = 1$. If our conjecture that the credibility variable at times has specific effects is correct, the unobserved state variable $S_t$ is a latent dummy variable equal either to 0 or 1, which indicates bull/bear markets.

Nevertheless, we do not impose either different signs on the coefficients *a priori* or force the process to switch into the other regime at a certain time. The only restriction we impose is that there are two different regimes, while everything else is determined from the data in the estimation.

The series $S_t$, $t = 1, 2, \ldots, T$ provides information about the regime the economy is in at date $t$. If $S_t$ were known before estimating the model, we could apply a dummy variable approach. In the Markov-switching approach, however, we assume $S_t$ to be not observed, and we estimate the evolution of the regimes endogenously from the data. It is assumed that the transition between the two states is governed by a first-order Markov process with the transition probabilities $p$ and $q$, which can be summarised in the form of a transition matrix $P$:

$$\begin{bmatrix} p & 1-q \\ 1-p & q \end{bmatrix}$$

The transition probabilities are defined as follows:

$$\begin{aligned} p &= \Pr\left[S_t = 1 \middle| S_{t-1} = 1\right] \\ 1-p &= \Pr\left[S_t = 0 \middle| S_{t-1} = 1\right] \\ q &= \Pr\left[S_t = 0 \middle| S_{t-1} = 0\right] \\ 1-q &= \Pr\left[S_t = 1 \middle| S_{t-1} = 0\right] \end{aligned}$$

Here we assume a first-order Markov process, i.e., the probability of being in a particular state in period $t$ only depends on the state in period $t$ - 1. To force $p$ and $q$ to lie between 0 and 1, and to keep the model set-up for the constant transition probabilities similar to the case of the time-varying transition probabilities, we employ the following specification in the estimation:

$$p = \frac{\exp(p_1)}{1 + \exp(p_1)} \text{ and } q = \frac{\exp(q_1)}{1 + \exp(q_1)}$$

The model can be estimated using an iterative Maximum Likelihood procedure, maximising the following likelihood function:

$$\ln L = \sum_{t=1}^{T} \ln \sum_{t=0}^{1} \Pr\left[S_t = i \middle| \Psi_{t-1}\right] \frac{1}{\sqrt{2\pi\sigma(S_t)}} \exp \frac{-\mu^2(S_t)}{2\sigma^2(S_t)}$$

with $\Pr = \left[S_t = i \middle| \Psi_{t-1}\right]$ denoting the probability of being in state 0 or 1 in period $t$ and $\psi_{t-1}$ denoting all available information up to period $t - 1$. In general, equation (6) is called a MS-AR(k) model.

*3.4 Empirical results from the Kalman filter*

Since we consider of great importance the time variation in parameters and its implication in defining a more reliable credibility index, we first need to test three hypotheses regarding the constancies of all or part of the parameters in eq. (3). Accordingly, we test the following hypotheses:

1. $H_0^1 : \sigma_v^2 = \sigma_{v1}^2 = 0$ which implies that all parameters in eq. 3 are constant;
2. $H_0^2 : \sigma_v^2 = 0$ which implies a constant intercept but time variation in the persistence parameters;
3. $H_0^3 : \sigma_{v1}^2 = 0$ which implies a time-varying intercept but a constant $r_{m,j,t}$ parameter.

In order to test these hypotheses, we next estimate the restricted versions of the model; the hypotheses in 1), 2) and 3) can then be tested using the likelihood ratio test (LR test). This test statistic follows a $\chi^2$ distribution with R degrees of freedom under the null hypothesis. The results from these three tests are given in Table 1b.

First, it can be noted that $H_0^1 : \sigma_v^2 = \sigma_{v1}^2 = 0$ is forcefully rejected for the two countries and we conclude that some kind of time-variation in coefficients seems important. The tests also support that the constant intercepts for all the countries are time-varying. Rejecting $H_0^2 : 0$ and $H_0^3 : 0$ it connotes that the intercept and $r_{m,j,t}$ are not constant, respectively. In conclusion, the null hypotheses are rejected for both countries and for all the three tests.

Based on the above tests, we conclude that the unrestricted models in equations (3) and (4) are preferred and we need impose no restriction on them. The models in equations (3) and (4) were initially estimated by maximum likelihood and the estimated variances are presented in Table 1a. However, as our attention is directed towards the issue of time-variation in the parameters, we wish to establish the relevance of this modelling choice.

The main results and estimates are reported in Figure 1a and 1b and in Table 2 for Australia and Iceland, respectively. In order to specify the state-space model appropriately, we add lags to the dependent and independent variables such that the serial correlation can be removed from the equation. We found that the AR(1) process was enough to tackle the problem of serial correlation. The variance of the transition function, $\sigma_{\mu,t}^2$ is statistically significant for the two countries (table 2), hence confirming the time-varying behaviour of credibility coefficients.

Moreover, the pattern of credibility coefficients "$\beta_t$" seems to capture well the economic dynamic of the period. The most important result is that the framework "works" in the sense that figures 1a and 1b show that the behaviours of pension fund credibility for the two countries vary over time. All betas exhibit noticeable variation over time and are characterised by different movements which reflect different credibility phases.

In particular, both coefficients are smaller than one. The coefficients "$\beta_t$" in figure 1a and 1b illustrate for Australia a shift upward before the launch of reforms in 1993, implying that economic agents felt strong uncertainty about the success of the reform. Once established, the pattern of the coefficient shows a stable and consistent decline. This can be interpreted as substantial success of the reform itself. The pattern of the coefficient for Iceland is somewhat different compared to the Australian one. At the beginning it fluctuated for two years before the launch of the reform. It then rose sharply and, soon after the start of the reform, it began to decrease. However, the magnitude differs in the two countries. The beta coefficient for Australia reached the peak value of about 0.5 in 2000, while the same coefficient for Iceland peaked around 0.2 before the reform.

### *3.5 Empirical results from Markov switching*

We first test for the existence of significant evidence of non-linearity in the time series relationship of pension fund asset returns with market returns. The null hypothesis of linearity against the alternative of Markov regime-switching cannot be tested directly using a standard likelihood ratio (LR) test[13].

Unfortunately, testing for the number of regimes in an MS model is difficult. The main problem arises from the presence of unidentified nuisance parameters under the null of linearity, which invalidates the conventional testing procedures (Krolzig, 1997).

[13] This is due to the fact that standard regularity conditions for likelihood-based inference are violated under the null hypothesis of linearity, as some parameters are unidentified and scores are identically zero. However, appropriate test procedures that overcome the former or both of these difficulties do exist (Hansen, 1992,1996; Garcia, 1998).

The nuisance parameters give the likelihood surface sufficient freedom such that one cannot reject the possibility that the apparently significant parameters could simply be due to sampling variation. The scores associated with parameters of interest under the alternative may be identically zero under the null.

Davies (1987) derived an upper bound for the significance level of the likelihood ratio test statistic under nuisance parameters. Formal tests of the Markov switching model against the linear alternative employing a standardized likelihood ratio test designed to deliver an (asymptotically) valid inference have been proposed by Hansen (1992, 1996), Garcia (1998), but are computationally demanding.

Alternatively, one may use the results of Ang and Bekaert (2002) which indicate that critical values of the $\chi^2_{\cdot}$ $(r+n)$ distribution can be used to approximate the LR test, where $r$ is the number of restricted parameters and $n$ is the number of nuisance parameters.

In this work the null hypothesis of linearity against the alternative of Markov switching will be tested using the Hansen test (linearity versus the two-state Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes[14]. Our findings exhibit that there exists statistically significant non-linearity in this relationship with respect to credibility variables. LR test results are presented in the bottom row of Tables 3 and 4.

We first estimate the model without multiple equilibria using ordinary least squares, in order to test a purely linear model. The parameter estimates, together with associated p-values, likelihood function values and diagnostic statistics of eq.(6), are reported in table 3. The results provide strong evidence in favour of a two-state regime-switching specification. The explanatory powers

[14] See Hansen, 1992 for details.

of the linear models seem to be poor. Although the coefficients have the expected signs, some of them are statistically not significant. As shown in Table 3, the relation improves when the model is estimated, taking into account an additional state. The fits of the models are considerably better, as evidenced by a lower $\sigma^2_u$ and a higher log likelihood. Moreover, the plots in figures 2 and 4 show that the models with multiple equilibria seem to capture the episode of reform implementation well in both countries.

The second relevant issue is how to determine the number of states required by each model to be an adequate characterisation of the observed data. Our empirical procedure follows Psaradakis and Spagnolo (2003) who select the number of regimes using Akaike Information Criterion (AIC hereafter). Using Monte Carlo experiments they show that selection procedures based on the AIC are generally successful in choosing the correct dimension, provided that the sample size and parameter changes are not small. We compute the value of the Akaike information criterion for the linear models and the corresponding Markov switching models in tables 3 and 4. The reported values indicate that a switching model is preferred for the two countries. Moreover, the two regime models outperform the corresponding single regime models in terms of the residuals diagnostic for linear and non-linear dependence.

Table 3 also reports estimation results for the model in its first specification as described in eq. (6), where $s_t$ is governed by an unobservable, discrete, first-order Markov chain that can assume k values (states), $\mu_t \sim i.i.d.\mathrm{N}(0, \sigma^2_{s_t})$. P-values are reported in parentheses.

Table 4 reports estimation results for the model in its first specification as described in eq. (7), where $s_t$ is governed by an unobservable, discrete, first-order Markov chain that can assume k values (states), $\mu_t \sim i.i.d.\mathrm{N}(0, \sigma^2_{s_t})$, $X_t$ is the vector of the fundamental variables that we assume can have some impact on the credibility of the pension reform.

Whereas the coefficients $\phi_{r+,1}$ indicate how the credibility variables respond to a positive impact of monetary policy innovation in a period of high credibility, the coefficients $\phi_{r+,2}$ can be interpreted as the same monetary policy effect on credibility variables in a period of low credibility. The coefficients show (table 4) that a contractionary monetary policy leads to a decrease in credibility coefficient, no matter whether the economy is in state 1 or 2. Both countries with low credibility (state 2) show a stronger reaction as a result of a positive monetary policy innovation. Hence we can look at the asymmetric effects of policy innovation on the credibility variables. The asymmetric effects of monetary policy emerge in the estimations since we have $\left|\phi_{r^+,2}\right| > \left|\phi_{r^+,1}\right|$. From table 4 it is also discernible that the asymmetric effect, $\left|\phi_{r^+,2}\right| > \left|\phi_{r^+,1}\right|$, holds in both cases, implying that positive changes in monetary policy instrument have a stronger impact during a lower credibility state.

The coefficients $\phi_{e,1}$ and $\phi_{e,2}$ indicate how the credibility variables respond to a change in the exchange rate in a period of high or low credibility. They are all statistically significant. For Iceland $\phi_{e,1}$ and $\phi_{e,2}$ have negative signs, implying that an increase in the exchange rate difference (that is an appreciation of the domestic currency) contributes to a reduction in the beta coefficient in both states. For Australia, however, the signs of $\phi_{e,1}$ and $\phi_{e,2}$ are different. The first is positive while the second is negative, implying a different reaction of this explanatory variable under different states. The question arises as follows: is there a link between the exchange rate and asset markets? Desislava Dimitrova (2005) asserts that this link is positive when asset prices are the lead variable and probably negative when exchange rates are the lead variable. She found some support for these propositions in the literature. In our case we established an indirect link between the exchange rate and a specific asset (pension fund) that make the explanation even more difficult.

One of the last two fundamental variables (government deficit and stock market) was used for each country's Markov-switching regression. This was due to the problem we encountered of convergence failure when all fundamental variables were included in the regression.

The coefficients $\phi_{gd,1}$ and $\phi_{gd,2}$ indicate how the credibility variables respond to a change in the government deficit in a period of high or low credibility for Iceland. The signs are positive as expected and statistically significant. The coefficients' value is greater when the economy is in state 1. In other words, high credibility means that negative signals coming from the government deficit can lead to a stronger loss of credibility.

Finally, the coefficients $\phi_{sm,1}$ and $\phi_{sm,2}$ indicate how the credibility variables respond to a change in the stock market in a period of high or low credibility for Australia. They are statistically significant with the expected negative signs. Indeed, we found support for the proposition that stock market is positively correlated with pension fund assets and hence negatively correlated with the beta coefficient in the literature (see Davis, 1995, Vittas, 1999 and Catalan *et al*., 2000).

Figures 2 and 4 plot the smoothing probability of state 1 (high credibility), using estimation of equation (6) while figures 3 and 5 plot the smoothing probability of state 1 using the multivariate Markov-switching estimations. Simply taking 0.5 as the cut-off value for State 1 or 2, we use the smoothing probability to infer the low and high states. Hence, the periods with smoothing probabilities greater than 0.5 are associated to low credibility, while periods with smoothing probabilities less than 0.5 are related to higher credibility. In most cases, the smoothing probabilities estimated from beta coefficients (figures 2 to 5) imply consistent periods of low and high credibility.

The main thing to notice about the probabilities is that, for Australia using univariate Markov switching, there are seemingly periodic 2–4-quarter regime shifts (state 1 or 2) during the period 1989 – 1993; after that the prevalent state is state 2 with a periodic 4-5 quarter regime shift.

Figure 3 shows the smoothing probability of state 1 or 2 (high credibility/low credibility), using the estimation of equation (7). It is worth noting that, in a Markov model with fundamentals, the probabilities of switching from state 1 to 2 and vice versa are reduced. Moreover, after 1998 the probability of being in state 1 (high credibility) increases considerably.

This historical pattern of regime changes for Iceland is shown in figures 4 and 5 under univariate and multivariate Markov switching models. In these cases the two regimes and the relative switches are well defined. Univariate Markov switching shows a period from 1998 to 2000 with three switches from high to low credibility and a long period of high credibility (state 1) after the implementation of the reform with the only exception of the period from the end of 2005 to the beginning of 2006. The multivariate Markov switching model presents a similar pattern without the peak in 2006 of state 2 and a more persistent state 2 in the period 2000-end of 2001.

## 4. Conclusions

The current literature on credibility of monetary and fiscal policies generally uses a linear framework for modelling credibility. However, assumption of linearity can be restrictive and sometimes unrealistic, leading to misleading inferences. Therefore empirical and theoretical studies should consider the probability that the credibility variable can be subject to discrete regime shifts, with countries switching between states of low and high credibility. In this paper we use the Markov regime switching framework to describe and analyse directly the credibility of pension funds and indirectly the validity of social security reform in which an important role is played by pension programmes managed by the private sector.

The Markov switching model enables us to answer a number of important questions: under different credibility regimes, how do credibility variables respond to macroeconomic fundamentals as a tight monetary policy innovation, a change in the exchange rate and a change in government deficit? Do macroeconomic fundamentals affect the level of credibility or the probability of switching between regimes?

A number of important conclusions follow from the empirical estimates obtained in the paper. First of all, it is shown that a restrictive monetary policy shock has a positive impact on the credibility of pension funds. Investors should be concerned with the unanticipated monetary policy because they will be surprised and the immediate effect of monetary policy shock will be large. Moreover, our findings show that these effects will be larger with state 2. This means that a monetary policy shock, under a low credibility regime, increases the probability of a future switch to the regime of high credibility.

Another interesting feature of the results is that, at first glance, it appears that an increase in the exchange rate variation displays a prevalent positive effect on credibility in both countries except in Australia under the state of initial high credibility. Government deficit variation seems to have a stronger influence on credibility of pension fund assets. In addition, our findings show that the effect in the two regimes is asymmetric with different magnitude. Finally, we found that the variable stock market is negatively correlated with credibility for Australia in both regimes.

A major innovation of our paper is the use of a time varying CAPM for the pension asset returns that enable us to generate a new variable as a proxy of credibility. Our findings, using a Kalman filter algorithm, show that for each endogenous variable of the model it was possible to observe how the respective coefficients changed over time due to changes in market sentiment.

The second important innovation of our paper is the use of a multivariate Markov switching model which makes the effects of macroeconomic variables on pension fund credibility state-dependent. We found large differences in the value of the coefficients for all macroeconomic variables between the low and high credibility regimes. This evidence strongly supports the hypothesis that the effects of macroeconomic variables on the level of credibility are asymmetric in all countries.

From a modelling perspective, our findings contribute to the literature given the need to model policy credibility as a non-linear process with distinct regimes. From a policy perspective, the empirical findings suggest that the credibility of pension fund assets depends not only on management policy, but also on a wider set of macroeconomic fundamentals, especially the stance of fiscal and monetary policy.

## Appendix

*Table 1a Variance of the parameters from Kalman filter of equations (3) and (4).*

| Variance | Australia | Iceland |
|---|---|---|
| $\sigma^2_v$ | $3.457\text{x}10^{-7}$ | $6.577\text{x}10^{-8}$ |
| $\sigma^2_{v1}$ | $2.386\text{x}10^{-6}$ | $3.151\text{x}10^{-5}$ |

*Table 1b Likelihood Ratio Test (LR test)*

| | | Australia | Iceland |
|---|---|---|---|
| $H_0^1 : \sigma_v^2 = \sigma_{v1}^2 = 0$ | $\chi^2_{LR}(2)$ ♦ | 534.74** | 409.96** |
| $H_0^2 : \sigma_v^2 = 0$ | $\chi^2_{LR}(1)$ | 458.11** | 316.25** |
| $H_0^3 : \sigma_{v1}^2 = 0$ | $\chi^2_{LR}(1)$ | 435.47** | 287.43** |
| Sample | | 1989:01<br>2006:04 | 1997:07<br>2006:12 |

**♦ $\chi^2_{LR}(R)$ are the test statistics from the likelihood ratio tests of whether the variances in the equations for the parameters of the model are zero. ** significant at the 1% level;**

**Table 2 Kalman filter estimations**

| *(Australia)* | $\alpha_t$ | $\beta_{j,t}$ | $\sigma^2_{\mu,t}$ |
|---|---|---|---|
| | -2.378** | 0.893** | 0.287** |
| AIC=6.102 | (-3.2264 ) | (18.551) | (4.8942) |
| Schwarz=6.166 | [ 0.001] | [ 0.000] | [ 0.000] |
| Obs. 72(Q) | | | |
| ***(Iceland)*** | $\alpha_t$ | $\beta_{j,t}$ | $\sigma^2_{\mu,t}$ |
| | -6.196** | 0.982** | 0.172** |
| AIC=4.071 | (-30.571 ) | (7.280) | (7.726) |
| Schwarz=4.122 | [ 0.000] | [ 0.0213] | [ 0.000] |
| Obs. 108 (M) | | | |

*significant at the 0.05 level; **significant at the 0.01 level ; z-statistics in brackets; p-value in squared brackets; (M)=monthly, (Q)= quarterly

**Table 3 Estimates of the univariate Regime Switching Model**

| | ***Australia*** | | ***Iceland*** | |
|---|---|---|---|---|
| ***Parameter*** | Linear | Markov | Linear | Markov |
| $\phi_{0,1}$ | 0.02588 (0.215) | 0.18399** (0.000) | 0.00453 (0.283) | 0.01277** (0.000) |
| $\phi_{0,2}$ | | 0.00292 (0.613) | | -0.0109** (0.047) |
| $\phi_{\beta,1}$ | 0.93034** (0.000) | 0.60486** (0.000) | 0.97284** (0.000) | 0.92863** (0.000) |
| $\phi_{\beta,2}$ | | 0.98488** (0.000) | | 0.89377** (0.003) |
| $p_{11}$ | | 0.967 | | 0.954 |
| $p_{22}$ | | 0.988 | | 0.819 |
| $\sigma^2_u$ | 0.0003 | 0.000125 | 0.00011 | 0.000039 |
| $\sigma^2_{S1}$ | | 0.00552 | | 0.19757 |
| $\sigma^2_{S2}$ | | 0.02604 | | 0.34348 |
| **Log-likelihood** | 187.65 | 250.05 | 342.24 | 356.28 |
| **AIC** | 185.52 | 242.06 | 335.25 | 354.29 |
| **LR test** | | 13.55 (0.027) | | 11.24 (0.048) |

The bottom row concerns the Hansen test (linearity versus two-state Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The asymptotic p-values are calculated according to the Hansen (1992) method. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes (see Hansen, 1992 for details).

*significant at the 0.05 level; **significant at the 0.01 level ; p-value in squared brackets.

**Table 4 Estimates of the multivariate Regime Switching Model**

| | | *Australia* | | *Iceland* |
|---|---|---|---|---|
| ***Parameter*** | | Markov | | Markov |
| $\phi_{0,1}$ | | -0.0073*<br>(0.059) | | 0.00877**<br>(0.000) |
| $\phi_{0,2}$ | | 0.04091<br>(0.369) | | 0.03862<br>(0.117) |
| $\phi_{\beta,1}$ | | 1.02131**<br>(0.000) | | 0.95171**<br>(0.000) |
| $\phi_{\beta,2}$ | | 0.89304**<br>(0.000) | | 0.92463**<br>(0.000) |
| $\phi_{r+,1}$ | | -0.00042**<br>(0.004) | | -0.00101**<br>(0.003) |
| $\phi_{r+,2}$ | | -0.00558**<br>(0.001) | | -0.01592**<br>(0.000) |
| $\phi_{e,1}$ | | 0.00548*<br>(0.073) | | -0.02547**<br>(0.001) |
| $\phi_{e,2}$ | | -0.00143**<br>(0.035) | | -0.07215**<br>(0.022) |
| $\phi_{gd,1}$ | | | | 0.0445**<br>(0.000) |
| $\phi_{gd,2}$ | | | | 0.00101**<br>(0.000) |
| $\phi_{sm,1}$ | | -0.00076**<br>(0.004) | | |
| $\phi_{sm,2}$ | | -0.00558**<br>(0.001) | | |
| $p_{11}$ | | 0.956 | | 0.939 |
| $p_{22}$ | | 0.835 | | 0.0073 |
| $\sigma^2_u$ | | 0.000074 | | 0.000027 |
| $\sigma^2_{S1}$ | | 0.0018 | | 0.0036 |
| $\sigma^2_{S2}$ | | 0.0025 | | 0.01557 |
| **Log-likelihood** | | 241.11 | | 440.78 |
| **AIC** | | 231.10 | | 430.77 |
| **LR test** | | 14.24<br>(0.019) | | 12.87<br>(0.021) |

The bottom row concerns the Hansen test (linearity versus two-state Markov switching model). It represents standardised likelihood ratio statistics for the model of each country. The asymptotic p-values are calculated according to the Hansen (1992) method. The p-value is calculated according to the method described in Hansen (1992, 1996), using Rats procedures based on 1,000 random draws from the relevant limiting Gaussian processes (see Hansen, 1992 for details).

*significant at the 0.05 level; **significant at the 0.01 level ; p-value in squared brackets.

**Figure 1 a**

***β Credibility for Australia***

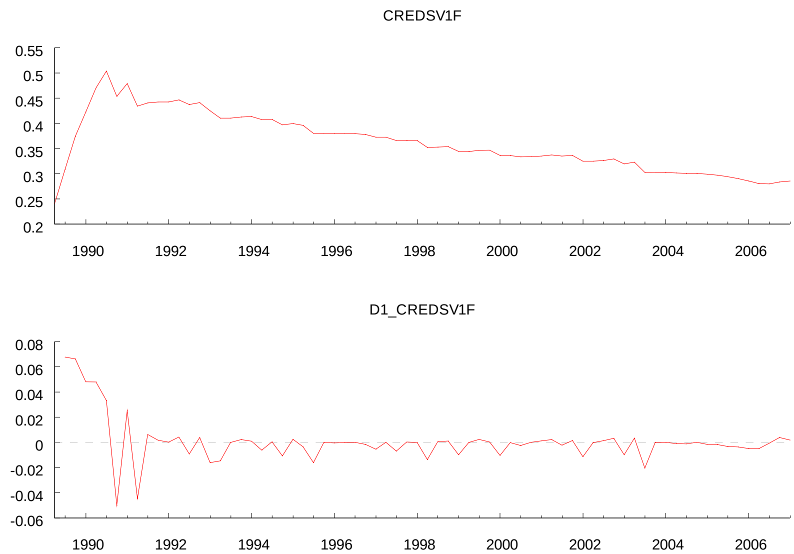



**Figure 1 b**

***β Credibility for Iceland***

**Figure 2 Markov switching credibility for Australia without fundamentals (non-dynamic model)**

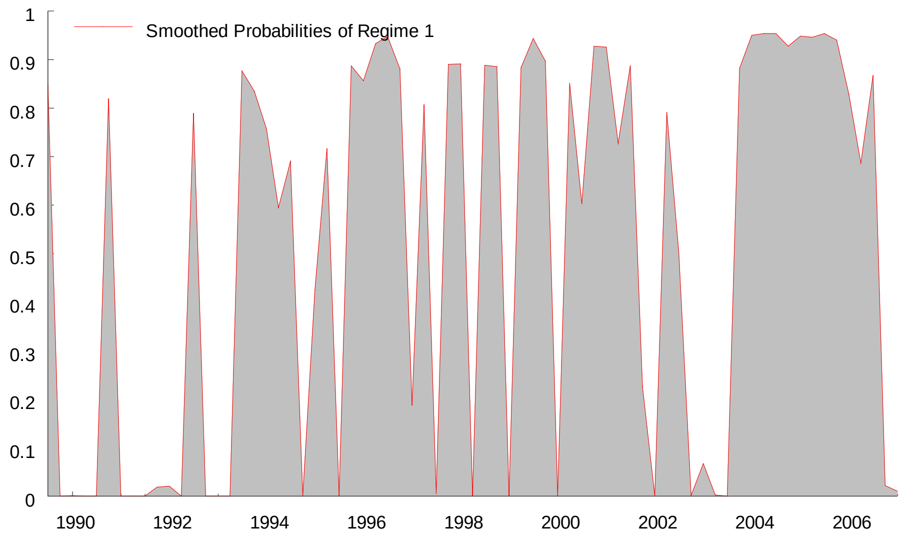



**Figure 3 Markov switching credibility for Australia with fundamentals**

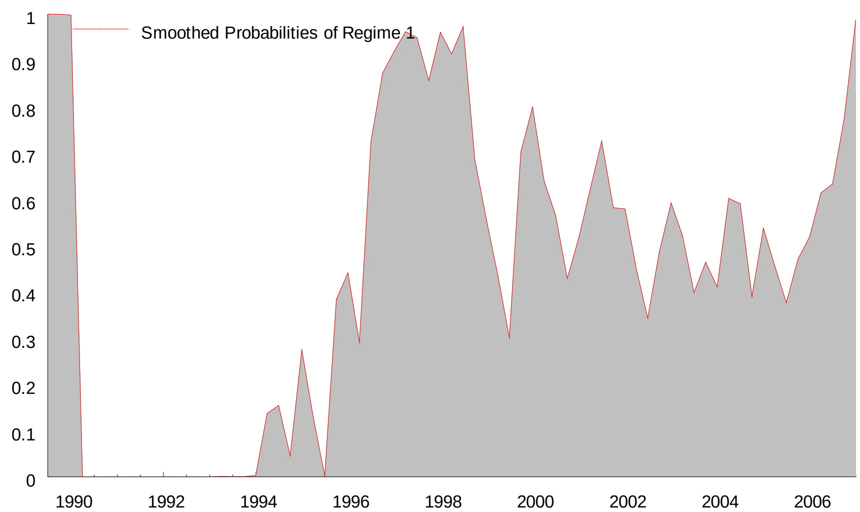


**Figure 4 Markov switching credibility for Iceland without fundamentals**

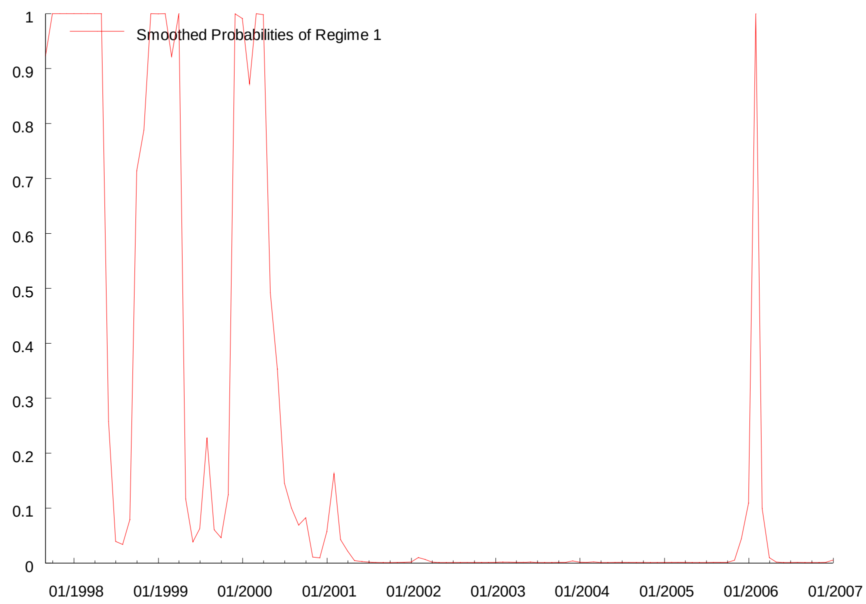
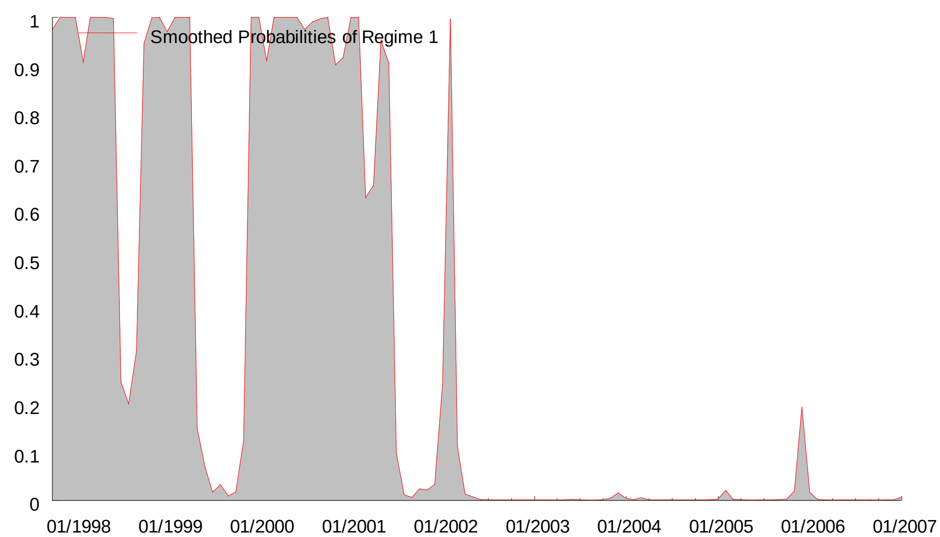



**Figure 5 Markov switching credibility for Iceland with fundamentals**



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