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INVESTMENT RISK AND PENSIONS: MEASURING UNCERTAINTY IN RETURNS

Anna d'Addio, José Seisdedos and Edward Whitehouse

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Comment on the series is welcome, and should be sent to the Directorate for Employment, Labour and Social Affairs, 2, rue André-Pascal, 75775 PARIS CEDEX 16, France.

AFFILIATIONS AND ACKNOWLEDGEMENTS

Anna Cristina D'Addio and Edward Whitehouse work in the Social Policy Division of the OECD. José Seisdedos was on secondment to the OECD from the Department of Work and Pensions in the United Kingdom when the paper was prepared.

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The modelling of the pension systems of the three Baltic States that are not currently members of the OECD – Estonia, Latvia and Lithuania – was financed entirely by the European Commission. Many of the results rely on the OECD pension models, which use the APEX (Analysis of Pension Entitlements across Countries) infrastructure originally developed by Axia Economics, with the help of funding from the OECD and the World Bank.

FOREWORD

Pensions are inherently risky because they are long-term contracts. These contracts can involve up to four groups of actors: individuals, governments, employers and financial-services providers. Uncertainty about the future complicates planning for all these actors: if things turn out better than expected, who will reap the gains? If things turn out worse, who will bear the cost? No one wants to bear risk, but, in most cases, someone has to. Risks in pension systems have, in the past, been poorly measured or even just ignored.

This paper is part of a series that examines how different kinds of uncertainty affect retirement incomes. The first of these papers (Whitehouse, 2007) looked at life-expectancy risk: how much of the cost to retirement-income systems of longer lives will be borne by individual retirees, in the form of reduced benefits or later retirement? How should this life-expectancy risk be allocated between generations? The second (Whitehouse, 2009), examined purchasing-power risk: investigating how pension systems react to changes in costs and standards of living.

This, the third paper in the series, analyses investment risk. Using historical data, it attempts to measure the degree of uncertainty in investment returns. A companion paper – Whitehouse, D'Addio and Reilly (2009) – looks in detail at the impact on retirement incomes in countries where defined-contribution pension plans are part of mandatory retirement-income provision or voluntary private pensions are widespread.

Forthcoming OECD work will look at three further kinds of uncertainty – other than life-expectancy, inflation and investment risk – that affect pension systems:

- *Myopia risk*: many individuals are short-sighted and so they consume too much when of working age and save too little for later, especially for retirement. This would lead to low pensions and costs for taxpayers and contributors if these retirees were entitled to safety-net benefits.

- *Social and labour-market risks*: life events – such as persistent low earnings, long-term unemployment, caring for children or older relatives, divorce and widowhood – mean that workers may build up little in the way of retirement income. Again, the cost of these risks could be borne by individuals, by governments or by the contributors to pension systems.

- *Policy risk*: the political process may result in unanticipated changes in pension entitlements before or during retirement, perhaps leaving individuals with little or no time to respond by changing their labour-market or savings decisions.

SUMMARY

This paper explores how uncertainty over investment returns affects pension systems. This issue is becoming more important because of the dramatic spread of defined-contribution pension provision around the world. It has also been highlighted by the recent financial crisis: the OECD estimates that pension funds lost 23% of their value in 2008, worth a heady USD 5.4 trillion.

The scale of investment risk is measured in this paper using historical data on returns on equities and bonds in major OECD economies over the past quarter century. The results show a median real return of 7.3% a year on a portfolio equally weighted between equities and bonds (averaging across the countries studied). It might be expected that, over a very long period, the degree of uncertainty in investment returns is small. After all, a few bad years in the market are likely to be offset by boom years. Nevertheless, the degree of uncertainty, even with the relatively long investment horizons of pensions, is found to be large. In 10% of cases, an annual return of less than 5.5% would be expected, while in 10% of cases, this should exceed 9.0%. Compounded over the time horizon for pension savings of 40 years or more, such differences in rates of return amount to enormous sums of money.

However, there is a series of reasons why returns achieved by individuals on their pension funds are less than the market return (as measured by conventional indices). These factors include administrative charges, agency and governance effects and demographic change, depressing investment returns below the high levels recorded over the past two decades. As a result, a more conservative assumption for future investment returns than the record over the past quarter century is appropriate. Settling on a median of 5.0% annual real return net of charges implies that 80% of the time, the investment return on pension savings should be between 3.2% and 6.7% a year.

AVANT-PROPOS

Les pensions sont assujetties intrinsèquement au risque, parce qu'il s'agit de contrats à long terme. Ces contrats peuvent comporter jusqu'à quatre groupes d'acteurs : les individus, les gouvernements, les employeurs et les fournisseurs de services financiers. L'incertitude sur l'avenir complique la planification pour l'ensemble de ces acteurs : si les choses se révèlent meilleurs que prévu, qui va récolter les gains? Si les choses se révèlent pire encore, qui supportera le coût ? Personne ne veut assumer le risque, mais, dans la plupart des cas, quelqu'un le doit. Les risques dans les systèmes de retraite ont, dans le passé, été mal mesurés ou même tout simplement ignorés.

Ce document fait partie d'une série qui examine comment les différents types d'incertitude affectent les revenus des retraités. Le premier de ces documents (Whitehouse, 2007) a examiné le risque lié à l'espérance de vie: quelle part du coût lié à l'allongement de la vie sera supportée par les retraités, sous la forme d'une réduction des prestations de retraite ou d'un départ postposé à la retraite ? Comment doivent être répartis entre les générations les risques liés à l'allongement de la durée de vie ? Le deuxième (Whitehouse, 2009), a étudié le risque lié au pouvoir d'achat : il a examiné comment les systèmes de retraite réagissent à l'évolution des coûts et du niveau de vie.

Ce document, le troisième de la série sur les risques et les pensions, analyse les risques d'investissement. Utilisant des données historiques, il tente de mesurer le degré d'incertitude dans le rendement des placements. Un autre document – Whitehouse, D'Addio and Reilly (2009) – étudie en détail l'impact de ce risque sur les revenus de retraite dans les pays où sont très répandus soit les régimes de retraite obligatoires à contribution définie soit les régimes de retraite volontaire des pensions privées.

D'autres travaux (à venir) se pencheront sur trois autres types d'incertitude – différents de ceux liés à l'allongement de l'espérance de vie, à l'inflation et aux risques d'investissement – qui affectent les systèmes de retraite :

- *Risques liés à la « Myopie »* : de nombreuses personnes ont une « vue courte » et ils consomment trop quand sont en âge de travailler et mettent trop peu de côté, en particulier pour la retraite. Ces comportements pourraient être associés à de faibles revenus de retraite dans les futurs ainsi qu'à des coûts supplémentaires pour les contribuables et les cotisants aux systèmes de retraite dans le cas où les retraités ayant eu ces comportements avaient droit aux prestations de protection sociale.

- *Risques sociaux et liés au marché du travail* : des événements de la vie – tels que la persistance de faibles revenus, le chômage de longue durée, la garde d'enfants ou de parents âgés, le divorce et le veuvage – peuvent avoir un impact négatif sur les revenus de retraites de travailleurs qui en font l'expérience. Encore une fois, le coût de ces risques pourrait être supporté par les individus, par les gouvernements ou par les cotisants aux systèmes de retraite.

- *Risques politiques* : les processus politiques peuvent amener à des changements imprévus dans les droits à la pension avant ou pendant la retraite, en laissant peu ou pas de temps aux individus pour réagir en changeant leurs décisions de travail ou d'épargne.

RÉSUMÉ

Ce document mesure l'impact de l'incertitude des rendements d'investissement sur les systèmes de retraite. Ce sujet devient de plus en plus important en raison de la propagation spectaculaire des systèmes de retraite à cotisations définies.

Le degré du risque d'investissement est mesuré à l'aide de données historiques sur le rendement des actions et des obligations dans un nombre de pays de l'OCDE au cours du dernier quart de siècle. Les résultats montrent, en moyenne dans les pays étudiés, un rendement réel médian de 7,3% annuel d'un portefeuille composé en parties égales d'actions et d'obligations. On pourrait s'attendre à ce que, sur une très longue période, le degré d'incertitude du rendement des investissements soit faible. Après tout, quelques mauvaises années sont susceptibles d'être compensées par des années de prospérité. Néanmoins, le degré d'incertitude, même en prenant le très long horizon temporel sur lequel se fait l'investissement des pensions, se trouve à être grand. Dans 10% des cas, on devrait s'attendre à un rendement annuel de moins de 5,5%, tandis que dans 10% des cas, il devrait dépasser 9,0%. Les calculs des rendements composés de l'épargne-retraite sur une période de 40 ans, montrent que de telles différences sont équivalentes à d'énormes sommes d'argent.

Toutefois, il existe une série de facteurs qui peuvent expliquer pourquoi les rendements obtenus par les individus sur leurs fonds de pension sont inférieurs aux rendements du marché (tels que ceux mesurés par les indices classiques). Ces facteurs qui incluent les frais administratifs, les effets d'agence et de gouvernance et ceux liés au changement démographique, ont contribué à la baisse des rendements en-dessous du niveau élevé enregistré au cours des deux dernières décennies. Par conséquent, une hypothèse plus conservatrice sur le rendement des investissements futurs est appropriée. En fixant la médiane du rendement annuel net de charges à 5% implique que dans 80% des cas, le rendement sur l'investissement de l'épargne-retraite devrait se situer entre 3,2% et 6,7% par an.

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INVESTMENT RISK AND PENSIONS:

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1. Defined-contribution pensions play a large and growing role in preparing for retirement. In these plans, contributions and investment returns build up in an individual account. The accumulated capital is then used to provide an income stream during retirement. The growing importance of defined-contribution plans in providing for retirement means that individuals' retirement incomes are directly exposed to risk and uncertainty in the return on their investments.[1] Individuals – and governments – may have nice or nasty surprises when actual returns turn out to be higher or lower than expected. Attention has been focused on the question of investment risk as a result of the financial and economic crisis.

2. Investment risk has important implications for pension policy. The current paper aims to measure this risk. This paper's sequel – Whitehouse, D'Addio and Reilly (2009) – examines in detail the impact of uncertain investment returns on individual retirement incomes and on government budgets.

3. Past experience provides the only hard information available to assess future uncertainty over investment returns. While economic models can be used to predict expected (mean) future returns, they are silent on the volatility of returns around that mean. This paper aims to simulate the degree of investment risk over the long horizon involved in saving for retirement using such historical data. The data are based on indices of returns on the two assets that dominate pension-fund portfolios: equities and government bonds.[2] The analysis uses techniques from time-series econometrics. The estimation results, in turn, then form the basis for a simulation of future investment returns. The focus here is on investment *risk*: what is the probability of different outcomes for investment returns over the long horizon involved in pension saving?

4. The paper goes on to consider the degree to which these simulations based on past data provide a suitable indication of future investment returns and the degree of uncertainty involved in these projections. One thing that we do know about the future is that populations will age. How will this affect financial markets? Administrative charges for running individual accounts mean that effective returns on pension savings will be below the market returns. These are relatively easy to measure. But there are other, more complex, reasons why individuals might not reap the full reward on their savings. These arise from the interaction between market structure, public policy and the different incentives faced by the various actors in the pension system.

5. The analysis begins with a description of historical returns on key assets for eight OECD countries. Sections 2 and 3 set out, first, a methodology for analysing these historical returns using techniques from time-series econometrics and, next, the results. Section 4 sets out the simulation methodology to quantify future investment risks, while section 5 uses these results to simulate the

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1 The literature distinguishes between "risk" – where there is a random outcome with a known probability distribution – and "uncertainty" – where the random outcome has an unknown probability distribution. Since we rarely know these probability distributions with any certainty, most real-world problems involve uncertainty rather than risk. However, the literature typically assumes that probability distributions are known and so it models choices over risky outcomes (Rust, 1999). This paper interchanges the terms "risk" and "uncertainty".

2 See OECD (2006), Table 3.

distribution of future returns, based on past experience, over the typical 45-year investment horizon for a full career spent accumulating assets in a pension fund. Whether past returns are a guide to the future are explored in section 6. The next three sections look at different reasons why the investment returns individuals receive on their retirement accounts are less than the market returns measured by indices, including administrative charges, pension-fund governance and financial regulations. Section 10 summarises the analysis and sets out the implications for the analysis of investment risk and pension policies.

1. Data

6. Historical data on investment returns are taken for eight major OECD economies: the G7 (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) plus Sweden. The data cover the two main assets typically held by pension funds: equities and government bonds. Foreign investments by pension plans are taken into account in the analysis that follows because the simulations use returns averaged over the eight countries. Less liquid and so difficult-to-value investments – such as property, venture capital and private equity – are excluded from the analysis.

7. Country-specific, representative, market indices are used to measure the returns on the two assets. For equities, the analysis uses the national Datastream index, which is constructed using a broad and representative sample of stocks. These national indices cover a minimum of 75-80% of domestic total market capitalisation (see Datastream, 2003). For bonds, the all-maturities, national Datastream government bond indices are used. These cover all traded bonds, irrespective of the issue size, with all maturities of one year and over.

8. Datastream's equity and government-bond indices are widely used in the financial literature. They have the advantage of cross-country comparability (since they are constructed using the same methodology) and can provide relatively long time series of consistent data. This is not the case with the national market indices (FTSE, Dow Jones, S&P, CAC, DAX, etc.) that are commonly cited in the financial press.

9. The indices used reflect the *total* returns on government bonds and equities: they include the change in the value of the asset, dividends (on equities) and interest (on bonds).[3] Real rates of return are obtained by deflating the total return indices by the national consumer price index (CPI).

10. Unfortunately, the data are available for different countries and assets over different time periods. Table 1 shows, for each country, the time frame and number of years over which returns on both equities and bonds are observed. The dataset consists of monthly observations, the number of which is also reported in Table 1. However, annualised returns are generally reported in the analysis that follows. Finally, the Table also gives the number of stocks that make up the equity index, which ranges from 70 in Sweden to nearly 1 000 for Japan and the United States.

11. A second problem is that the time series available at the time of writing only extended to the end of 2006. The data therefore exclude the effect of the current financial crisis on investment returns. The

3 The return index represents the theoretical aggregate growth in value of the constituents of the index. The index constituents are deemed to return an aggregate daily dividend, which is included as an incremental amount to the daily change in price index. The calculation is as follows:

$$RI_t = RI_{t-1} \cdot \frac{PI_t}{PI_{t-1}} \cdot \left(1 + \frac{DY}{100 \cdot n}\right)$$

Where: RI_t= return index a time t; PI_t = price index at time t; DY = dividend yield; n = number of days in the financial year (normally 260).

effect on pension fund returns in 2008 is discussed in Box 1 below. Nevertheless, the period analysed does cover the impact of the stockmarket crash of October 1987 and the bursting of the dotcom bubble in the period 2000-02.

Table 1. Countries and time frame for investment-return data

Country	*Time frame*	*Years*	*Months*	*Number of stocks*
Canada	1985-2006	22	263	246
France	1980-2006	27	323	250
Germany	1985-2006	22	263	246
Italy	1989-2006	18	214	160
Japan	1982-2006	25	298	999
Sweden	1985-2006	22	262	70
United Kingdom	1980-2006	27	323	545
United States	1980-2006	27	323	994

Source: OECD analysis of Datastream information.

12. Most individual pension accounts are invested in a portfolio of assets. In addition to examining the return on equities and government bonds alone, three benchmark portfolios are analysed. The first, dubbed the "conservative" portfolio, holds 75% of assets in government bonds and 25% in equities. The second has equal shares of equities and government bonds and so is called the "balanced" asset allocation. The third is dominated by equities, with a 75% share of assets, and so is named the "risky" portfolio. These terms are merely a convenient shorthand: they should not be interpreted as defining some sort of optimal asset mix which, in any case, would vary between individuals, across countries and over time.

13. Table 2 and Figure 1 show historical mean returns for the three portfolios considered – conservative, balanced and risky – and the statistics for bonds and equities alone.[4] These use the longest time period over which data on both assets are observed, which ranges from 18 years in the case of Italy to 27 years for Germany, the United Kingdom and the United States (Table 1).

14. The annual returns on bonds vary from 4.6% in Japan to 6.6% in Sweden, with an average for the eight countries shown of 5.4%. Equity returns differ much more significantly between countries than those on government bonds, varying from less than 5% in Italy and Japan to more than 12% in Germany and Sweden. For a "balanced" portfolio, with equal shares of equities and bonds, the average return was 7%. Italy and Japan have had relatively low returns, while Germany and Sweden have enjoyed relatively high returns on both bonds and equities.

15. Figure 1 illustrates how the structure of hypothetical portfolios would affect investment performance. In six of the eight countries shown, a higher equity share delivered a higher rate of return, which is the pattern that one would normally predict. Italy is the most prominent exception: government bonds performed better than equities over the past two decades. In Japan, the relatively low return varies little with the composition of the portfolio: a mix of equities and government bonds outperformed portfolios dominated by either of these two assets, but only by a small margin. In contrast, the real return on equities has been around double the return on government bonds in France, Germany, Sweden, the United Kingdom and the United States.

4 Average returns are calculated using the geometric rather than the arithmetic mean, since the latter can produce misleading results. Suppose that in three successive years, the arithmetic returns on an investment are 5%, 15% and -4%. The geometric average rate of return over the three-year period, or compound annual growth rate, is found by computing $\left(\prod(1+r)\right)^{\frac{1}{N}}-1$, *i.e.*, $(((1.05)\times(1.15)\times(0.96))^{\frac{1}{3}})-1$=5.05%, which is different from the arithmetic average (5.33%).

Table 2. Historical investment returns by portfolio

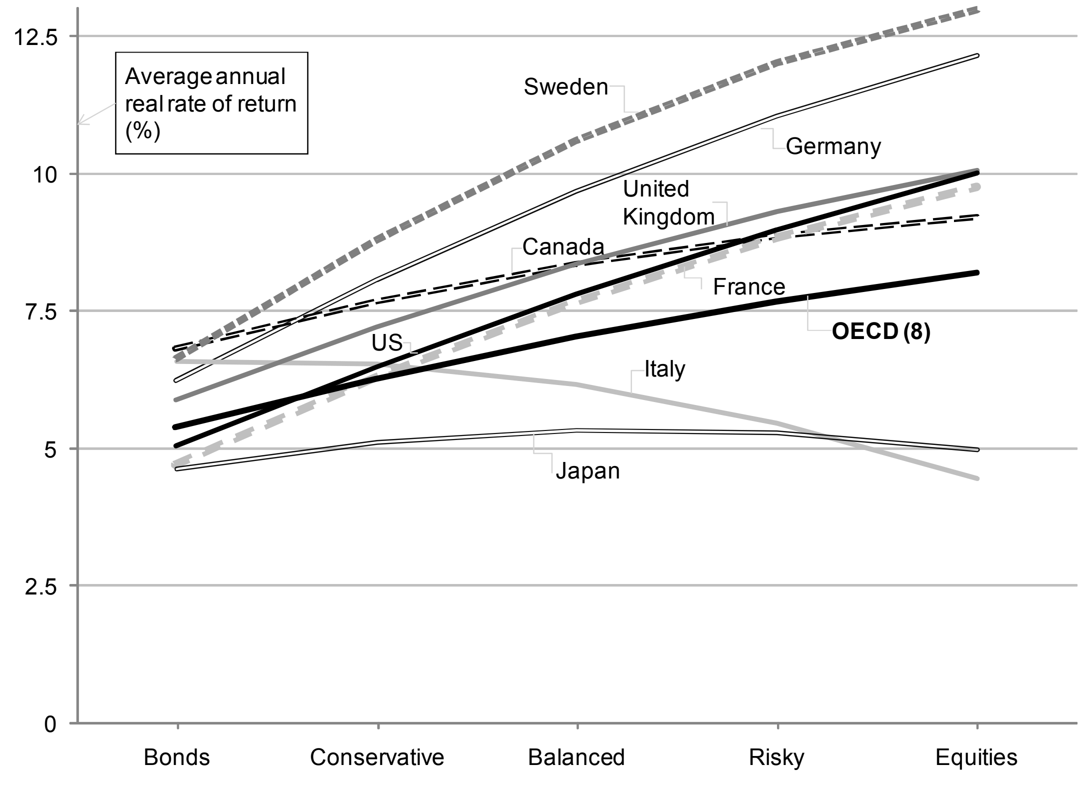
(selected OECD countries over longest period observed for each country to end of 2006)

Portfolio	*Bonds*	*Conservative*	*Balanced*	*Risky*	*Equities*
Equity share	*0%*	*25%*	*50%*	*75%*	*100%*
Bond share	*100%*	*75%*	*50%*	*25%*	*0%*
Canada	6.8	7.7	8.3	8.9	9.2
France	4.7	6.3	7.6	8.8	9.7
Germany	6.2	8.0	9.6	11.0	12.1
Italy	6.6	6.5	6.2	5.5	4.4
Japan	4.6	5.1	5.3	5.3	5.0
Sweden	6.6	8.8	10.6	12.0	13.0
United Kingdom	5.9	7.2	8.3	9.3	10.0
United States	5.0	6.5	7.8	8.9	10.0
Average (OECD-8)	**5.4**	**6.2**	**7.0**	**7.7**	**8.2**

Source: OECD analysis of Datastream information.

Figure 1. Historical investment returns by portfolio

(selected OECD countries over longest period observed for each country to end of 2006)



Note: 'Conservative' portfolio is 25% equities, 75% bonds. 'Balanced' portfolio is 50:50 equities and bonds. 'Risky' portfolio is 75% equities.

Source: OECD analysis of Datastream information.

Box 1. Short-term investment performance of pension funds

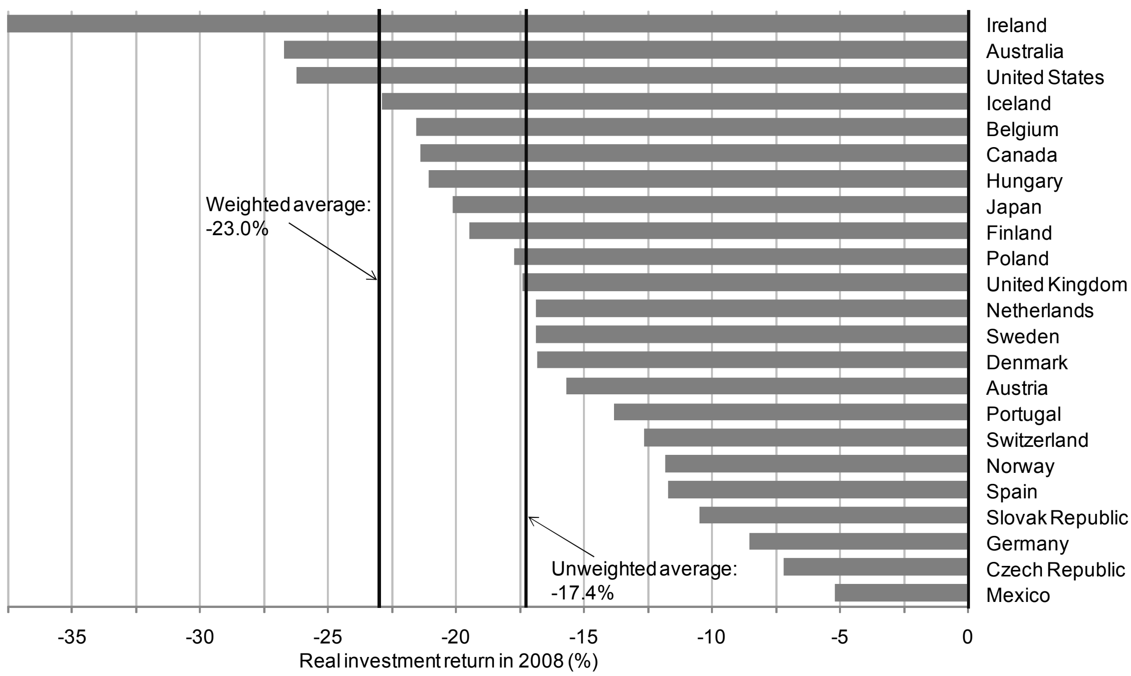
In 2008 as a whole, world stock markets (as measured by the MSCI index) fell by nearly a half and markets were much more volatile. In contrast, the world government-bond index (Citigroup) increased by around 7%. Property markets in many OECD economies weakened, in some cases dramatically. These assets, along with corporate bonds and deposits, account for nearly all of pension funds' investments. However, pension funds' portfolios differ significantly between countries and so their investment performance last year also varied between countries.

Figure 2 presents investment returns of pension funds in real terms (allowing for price inflation) for the 2008 calendar year. Data are shown for 23 OECD countries where private pension funds are large relative to the economy (with assets worth at least 4% of national income at the end of 2007, that is before the crisis gained momentum). The weighted average real return – of minus 23% – reflects the importance of the United States in the figures. The unweighted average (including each of the 23 countries equally) was minus 17%.

The United States, which accounts for around a half of all private-pension assets in OECD countries, showed the third largest decline: around 26%. Only Ireland, where the loss was nearly 38%, and Australia, with losses of 27%, showed a worse investment performance in 2008. In another five countries – Belgium, Canada, Hungary, Iceland and Japan – real investments fell by more than 20%.

At the other of the scale, losses were only around 10% in Germany, the Slovak Republic, Norway, Spain and Switzerland. They were smaller still in the Czech Republic and Mexico.

Figure 2. Pension funds' real investment returns, 2008



Note: Returns are shown only for countries where pension-fund assets exceeded 4% of gross domestic product (GDP) in 2007. Data are from official sources for Austria, Belgium, Finland, Hungary, Ireland, Mexico, Norway, Poland, Slovak Republic, Spain and Switzerland. Where data on actual pension-fund performance were not available, investment returns were estimated using data on pension funds' asset allocation and the returns on different asset classes. See OECD (2009b), *Private Pensions Outlook*, footnote on p. 23.

Belgium: Data are for the year to end September 2008. Finland: data relate to the mandatory, public-sector occupational plans. Sweden: figures are for occupational schemes. Hungary and Slovak Republic: data are for mandatory private pensions only.

Source: OECD (2009a).

2. Estimation: Methodology

16. The procedure used to quantify future investment risk known as "filtered historical simulation" (Barone-Adesi, Giannopoulos and Vosper, 1999) involves two steps: (i) the calibration of the historical data to the model; and (ii) the simulation itself, based on the filtered series of residuals.

17. The first step of the procedure assesses past levels and volatility of investment returns. This exercise uses techniques from time-series econometrics to analyse the historical data, breaking down the pattern of returns into a number of components. Typically, there can be up to three main types: (1) annual random shocks, which are either positive or negative (but centred on zero); (2) year-to-year correlations in annual values; and (3) random changes in the central tendency of the annual values. However, because many variables seem to have no random change in central tendency over long periods, analysts frequently need to model only the first two sources of change. This is also the case with both the data and the model used here.

18. The calibration of the model involves the estimation of the return process (R_t) which is assumed to be generated as

$$R_t = \mu + \varepsilon_t \qquad (1.)$$

with μ, the conditional mean, including a moving average term ($\theta_1 \varepsilon_{t-1}$) and a constant *c,* defined as follows

$$\mu = c + \theta_1 \varepsilon_{t-1}$$

ε_t and ε_{t-1} are the residuals at time *t* and *t-1,* respectively . The monthly continuously compounded return (R_t) is thus modeled as a "moving-average" process (MA) of order 1.[5] An intuitive explanation of a moving-average process is that it captures the persistence of random shocks. In this case, the effect of a random shock is assumed to persist for just one period after it occurred (eq. 1). Hence, it is called a first-order moving average or MA(1).

19. In view of the simulation, much of interest of the estimation procedure lies in the dynamics of the conditional variance. In financial applications, in fact, it happens very often that the observed volatility of variables do not appear to be constant over time (*i.e.* they are heteroskedastic) and tend to cluster together, and therefore do not fulfill one of the underlying assumptions of classical linear regression models, *i.e.* constant variance in the errors (homoskedasticity). In other words, the error terms may reasonably be expected to be larger for some points or ranges of the returns. The reasons for this behaviour of the conditional variance are multiple: there may be various small shocks to some specific industries, or there may be large shocks (*e.g.* crash of the stock market, changes of governments) that all affect the volatility of the returns. In all these case, conditional heteroskedasticity is a key issue because the variance of the rate of return (*i.e.* the volatility) represents the risk of the return or portfolio. In addition, the conditional variance may affect the conditional mean.

20. A Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model can account for this kind of heteroskedasticity (Engle, 1982; Bollerslev, 1986). The key point of a GARCH model is that it allows for the conditional variance to vary, while the unconditional (global) variance is constant. GARCH

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5 To determine whether AR process or MA process are present we have used specific time series graphs called autocorrelation functions (ACFs) and partial autocorrelation functions (PACFs). The ACFs assess the raw correlations between y_t and y_{t-S}, and the confidence band around zero; if the correlation is outside of this band, then the correlation between y_t and y_{t-S} is statistically significant. The PACFs compute correlations taking into account all correlations with prior lags: in a MA process the lags will continue to be significantly (partially) correlated with each other for a while.

models allow for the variance of today's return to depend conditionally on (a) the variance of yesterday's return, and (b) the square of yesterday's return. To this end, the error term of equation 1 is defined as

$$\varepsilon_t = z_t \sigma_t$$

where z_t is iid(0,1) and σ_t is the volatility of the return process.

21. After fitting a number of different models to the data, the process that seems to fit the data best is a GARCH(1,1). This defines the volatility (conditional variance) formally as a linear function of past squared residual (ε_{t-1}^2) and past conditional variance (σ_{t-1}^2).

$$\sigma_t^2 = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \qquad (2.)$$

where ε_{t-1} represents the residuals of equation (1) at time *t-1*, σ_{t-1}^2 is the conditional variance or volatility at time *t*, w_0 is a constant, α_1 is the coefficient on the past squared residuals at time (*t-1*) and β_1 is the coefficient on the past conditional variance at time t-1. The β_1 and α_1 coeffecients will be referred to as GARCH and ARCH coefficients, respectively.

22. It is interesting to note that $\alpha_1 + \beta_1$ measures the persistence of a shock to the conditional variance σ_t^2 with half-life decay, measuring how long it takes to a half shock to decay, defined as $\frac{\log(0.5)}{\log(\alpha_1 + \beta_1)}$. The unconditional variance is linked to the conditional variance through the following expression $\sigma^2 = \frac{\omega_0}{1 - \alpha_1 - \beta_1}$.

23. The parameters are constrained to be non-negative, *i.e.* $\alpha_1, \beta_1 \geq 0$ and $\omega_0 > 0$. In order for a finite unconditional variance to exist it is necessary and sufficient that the sum $\alpha_1 + \beta_1 < 1$. The non-negativity conditions on the parameters is required to have a nonnegative variance, while the condition on the sum of the β_1 and α_1 is required for stationarity. When $\beta_1 = 0$ the above model reduces to ARCH(1), as proposed by Engle (1982).

3. Estimation: Results

24. Table 3 shows the estimates of the MA(1)-GARCH(1,1) model on monthly historical returns averaged across OECD countries. Annex A.1 provides results for single countries. For each series, the goal was to find the specification the more closely matches the characteristics of the historical series and employs a limited number of variables to yield a plausible fit for the rate-of-return variable.[6]

25. Concerning the estimates of the conditional mean, coefficients are all significant and positive, implying that a random shock one period away significantly affects present returns. The GARCH parameters are significant and satisfy non-negativity, with the estimated degree of persistence to a shock

6 Estimations were carried out with the MATLAB package. Ljung-Box-Pierce portmanteau tests for up to twentieth order serial correlation in the standardized and the squared standardized residuals indicate no serial correlation and suggest that the GARCH(1,1) model is successful in explaining the time-varying volatility in the data.

varying from 0.93 for the conservative portfolios, to 0.95 for the balanced portfolio and to 0.96 for the risky portfolio.[7] In sum, these GARCH model results support the usual finding of long-memory volatility.

Table 3. Estimates from the GARCH model of monthly historical investment returns

(OECD averages)

		Conservative		Balanced		Risky	
Constant	c	0.0051 (0.0010)	***	0.0069 (0.0016)	***	0.0085 (0.0022)	***
MA(1)	θ_1	0.2651 (0.0827)	***	0.2170 (0.0862)	**	0.1972 (0.0840)	**
Constant	ω_0	9.5E-06 (1.5E-05)		2.1E-05 (2.3E-05)		4.2E-05 (4.6E-05)	
GARCH coefficient	β_1	0.8540 (0.1446)	***	0.8088 (0.1097)	***	0.7776 (0.1128)	**
ARCH coefficient	α_1	0.0808 (0.0527)	*	0.1424 (0.0782)	*	0.1821 (0.0940)	**

Note: * indicates significance at the 10% level, ** at 5% and *** at 1%. The cells give coefficient values first and standard error in parentheses. The aim of the estimation is to provide parameters values from a specification the more closely matches the characteristics of the historical series and employs a limited number of variables to yield a plausible fit for the rate-of-return variable. The process that fits the data best is MA(1), GARCH(1,1).

Source: OECD analysis of Datastream information.

4. Simulation: Methodology

26. It has been shown that historical simulation has a number of limitations, for example a limited set of outcomes and unresponsiveness to changes in market volatility. These issues can be solved with Filtered Historical Simulation (FHS).

27. After the calibration of the model described in section 2, stochastic simulation techniques are thus used to generate probability distributions for future outcomes. The residuals arising from the estimation of the return process, set up as a MA(1)- GARCH(1,1) processes, are collected. At this point, to remove serial correlation and volatility clusters they are filtered to become identically and independently distributed (i.i.d.) by dividing them by the corresponding volatility estimate (*i.e.* they are “standardized”). In fact, before filtered returns are used as innovations they are scaled (multiplied) by the current conditional forecast of volatility; thus they reflect current market conditions At this stage, simulation consists in taking a number of random draws from the series of standardized residuals (here 10 000), which lead to bootstrapped residuals. The bootstrapped residuals together with the coefficients’ estimates are used to build simulated returns over a 45-year period.

28. Naturally, these results must be interpreted with caution, especially because of the long time horizon involved in retirement savings. Over such long periods, the uncertainties in variables that will significantly affect rates of return – such as economic growth, labour-force growth, technological change, etc. – are huge.

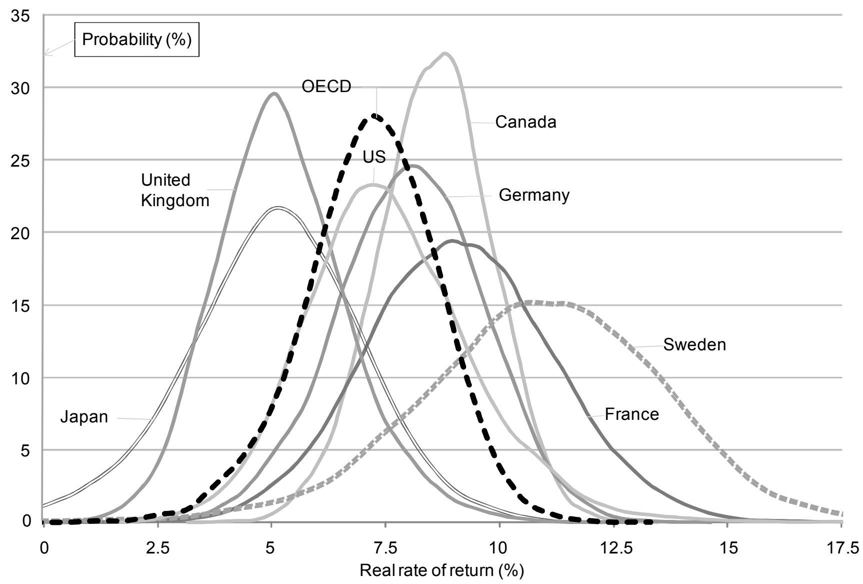
7 According to the formula $\frac{\log(0.5)}{\log(\alpha_1 + \beta_1)}$ this corresponds to a half-life decay of 10, 14 and 17 months respectively.

5. Results: Simulated probability distributions

29. Each simulation yields a possible set of annual outcomes over the 45-year assumed investment horizon for the returns on the different portfolios. To move from that set of annual outcomes to a probability distribution for the outcomes in a given year, the process must be repeated many times (here, 10 000 times). The most likely annual outcomes (those near the central tendency) will be realised in many more simulations than unlikely annual outcomes (those far away from the central tendency).

30. Table 4 reports the selected percentiles of the geometric mean rate of return across the 45-year period (in fact, these are the deciles of the distribution). The results are also illustrated graphically in Figure 3 for the balanced portfolio, which has equal shares of equities and government bonds.[8]

Figure 3. Kernel density estimates: balanced portfolios



Note: The OECD figure shows the simple average for the G7 countries plus Sweden. Italy has a very compact distribution and so is excluded from this chart for reasons of scale.

Source: OECD analysis of Datastream information.

31. Italy is very obviously an outlier. The bottom decile return on the balanced portfolio is 5.3%, very close to the OECD average of 5.5% at the same point of the distribution of returns. The top decile of simulated returns is, however, 7.0% in Italy compared with 9.0% for the OECD average. Italy seems to exhibit a much smaller degree of investment risk than found in other OECD economies. At the other end of the spectrum, investment risk seems to be largest in Sweden, with returns ranging from 7.6% at the bottom decile to 14.1% at the top. The range between these two points of the simulated distribution of returns is therefore 6.5 percentage points in Sweden compared with just 1.7 points in Italy.

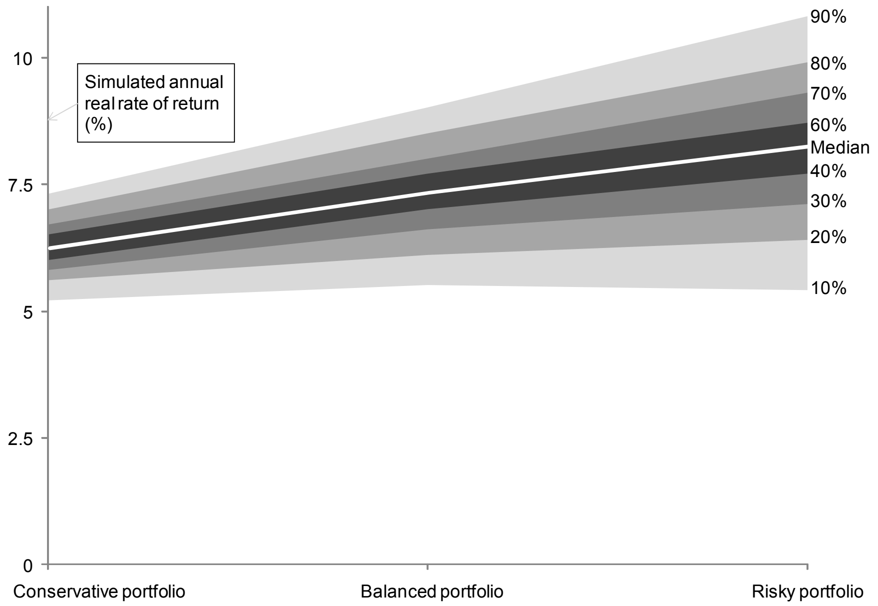
32. The degree of investment risk is fairly similar in the other six countries studied: slightly lower than the average in Canada and the United Kingdom and slightly higher in Germany. Overall, therefore, one would expect average returns over a 45-year investment horizon between 5.5% and 9.0% a year 90%

8 The distribution of returns has been smoothed using a non-parametric technique known as "kernel-density estimation" (see Wand and Jones, 1995). Estimates are based on an Epanechnikov kernel.

of the time on average across the eight major OECD countries and between 6.7% and 12.8% excluding Italy from the average. (Country-specific analyses are provided in Annex A.2.)

33. Turning to the different portfolios, the results indeed confirm the prejudices underlying the shorthand names adopted here: conservative, balanced and risky. This can be seen clearly in Figure 4, which shows the expected returns by portfolio. Again, the chart averages over the G7 plus Sweden. The distribution is much tighter for the conservative, bond-dominated portfolio than for the balanced and again for the balanced relative to the risky portfolio (where equities have the larger asset share). However, median returns are highest with the risky portfolio: this reflects the expected "reward" for taking on more risk.

Figure 4. Distribution of returns simulated over 45 years in selected OECD countries by portfolio



Note: OECD-8 is the G7 countries plus Sweden.

Source: OECD analysis of Datastream information.

Table 4. Distribution of returns in selected OECD countries by portfolio: 45-year simulated mean returns by percentile of the distribution of returns

Conservative portfolio (25% equities, 75% bonds)

Percentile:	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*
Canada	6.7	7.1	7.4	7.6	7.8	8.1	8.3	8.6	8.9
France	2.6	2.9	3.2	3.4	3.7	4.0	4.3	4.7	5.4
Germany	5.2	5.6	5.9	6.2	6.4	6.7	6.9	7.2	7.6
Italy	4.5	4.9	5.2	5.5	5.7	5.9	6.2	6.5	6.9
Japan	3.7	4.2	4.5	4.8	5.0	5.2	5.5	5.8	6.2
Sweden	7.6	7.9	8.1	8.3	8.4	8.6	8.7	8.9	9.2
United Kingdom	3.0	3.4	3.7	4.0	4.3	4.5	4.9	5.3	5.9
United States	2.7	3.0	3.3	3.5	3.7	4.0	4.3	4.9	5.2
OECD-8	5.2	5.6	5.8	6.0	6.2	6.5	6.7	7.0	7.3

Balanced portfolio (50% equities, 50% bonds)

Percentile:	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*
Canada	7.1	7.6	8.0	8.4	8.7	9.0	9.3	9.7	10.2
France	6.7	7.5	8.1	8.7	9.2	9.7	10.2	10.9	11.8
Germany	6.1	6.8	7.3	7.7	8.1	8.5	8.9	9.4	10.1
Italy	5.3	5.7	5.9	6.1	6.2	6.4	6.6	6.8	7.0
Japan	3.2	3.9	4.5	4.9	5.3	5.8	6.2	6.7	7.5
Sweden	7.6	8.8	9.6	10.3	11.0	11.6	12.3	13.1	14.1
United Kingdom	3.9	4.4	4.7	5.1	5.4	5.7	6.1	6.5	7.2
United States	5.6	6.2	6.7	7.1	7.5	.8.0	8.5	9.1	10.0
OECD-8	5.5	6.1	6.6	7.0	7.3	7.7	8.0	8.5	9.0

Risky portfolio (25% equities, 75% bonds)

Percentile:	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*
Canada	7.0	7.8	8.4	8.8	9.3	9.7	10.2	10.7	11.5
France	6.9	8.1	9.0	9.7	10.4	11.1	119	12.8	14.0
Germany	6.7	7.8	8.5	9.2	9.7	10.3	10.9	11.7	12.7
Italy	5.2	5.8	6.2	6.4	6.7	6.9	7.1	7.3	7.7
Japan	2.1	3.2	4.0	4.7	5.3	5.9	6.6	7.4	8.6
Sweden	7.6	9.4	10.7	11.7	12.6	13.6	14.6	15.7	17.3
United Kingdom	6.6	7.6	8.3	8.9	9.4	9.9	10.5	11.1	11.9
United States	6.6	7.5	8.1	8.6	9.2	9.8	10.5	11.3	12.6
OECD-8	5.4	6.4	7.1	7.7	8.2	8.7	9.3	9.9	10.8

Note: Based on 10 000 simulations. OECD-8 is the G7 countries plus Sweden. See text for further explanation.

Source: OECD analysis of Datastream information.

6. Investment returns: Past and future

34. Over the quarter century ending in 2006, financial markets delivered large, albeit often volatile, returns on investments. For example, government bonds delivered a real return averaging 5.4% a year, ranging from just over 4.5% in France and Japan to over 6.5% in Canada, Italy and Sweden. Equities performed relatively poorly in Italy and Japan, although real returns were 4.5-5.0% a year. In the other six countries studied, annual real returns on equities ranged from 9.2% in Canada to 13% in Sweden.

35. Market rates of return over 25 years ending in 2006 have undoubtedly been very strong. The 5.4% average real return on government bonds means that the value of assets would double every 13 years. The real return on equities, which averages 8.2% a year, would double investments in real terms every nine years. A study of long-term investment returns (since 1900) shows average annual real returns on equities of 5.2% for the United Kingdom and 6.3% for the United States and (Dimson, Marsh and Staunton, 2002). The authors note that this is 1-2 percentage points below previous studies, which they attribute to the longer time frame of their study and correcting biases in early 20th century market indices. The returns on bonds over the century was 1.3% in the United Kingdom and 1.9% in the United States.

36. The current financial and economic crisis is not included in this time series. A rough calculation of an average of 8.2% annual returns on equities for 25 years followed by a 50% decline in asset values in 2008 yields an annual average real return of 5.8% on equities. Nevertheless, the analysis does cover previous stockmarket crashes (in 1987 and 2000-02). The back-of-the-envelope figure therefore overstates the impact of the current crisis. Moreover, the increase in the bond index in 2008 suggests that bond returns were close to their long-term average.

37. Turning to the future, retirement savings are clearly a long-term issue. When (and if) markets recover, what is the long-term outlook? Much of what may happen in the future is clearly speculative. But one future development is both predictable and well documented: the ageing of the population as the baby-boom generation begins to retire. Some commentators have argued that the accumulation of retirement savings of this cohort has driven up financial returns over the past two decades. As the baby-boomers begin to retire in a decade's time, its members will sell at least some of the financial assets that they accumulated when working. The younger generations are much smaller in size and so may have less demand for financial assets. Also, there will be an increase in the amount of physical capital per worker. Both of these mechanisms will tend to drive down rates of return and the value of financial assets (see OECD, 1998). The most alarmist interpretation of this possibility is the "asset-meltdown hypothesis".[9]

38. However, there are many counter-arguments to this hypothesis. First, the observed consumption behaviour of older people does not match the pattern required to deliver asset meltdown. Secondly, the phenomenon of ageing is known in advance and so, with rational expectations, the adjustment will be spread over many years. Thirdly, there are many ways in which savings and retirement behaviour might adjust to offset the effect on asset prices.

39. Several empirical studies have used inter-temporal general equilibrium models to investigate how a changing age structure of the population might affect equilibrium asset returns and asset prices. Yoo (1994) simulates the effect of a baby boom using an overlapping-generations model (OLG) and concludes that equilibrium asset returns change by between 40 basis points and 85 basis points per year as the baby boom boosts first the number of workers and then the number of pensioners. Brooks (2000) presents simulation evidence of the effects of a baby boom roughly based on the post-war population pattern of the United States in a model that incorporates both risky and risk-free assets. The results show a fall in risk-free returns from 4.5% to 4.1% a year when the baby boomers retire, with a fall in returns on

9 See, for example, Sterling and Waite (1998) and Siegel (1998).

risky assets of about half that size. Brooks (2002) estimates a 100 basis point fall in asset returns for the United States using a real business-cycle model with OLG.

40. Börsch-Supan, Ludwig and Winters (2006) extend the OLG approach to a multi-country setting in which they allow for several capital-mobility scenarios. They predict that the annual rate of return on capital will fall by slightly less than one percentage point if capital moves freely between OECD countries. However, substantial *gains* in the rate of return would be possible if capital were globally mobile. They conclude that closed-economy models, which are often used in the literature, miss the important role that international capital flows might play. They accept, however, that the advantages of diversification will fall over time.

41. A second approach to estimating the effects of demographic change on capital-market returns uses time-series econometric techniques to analyse historical data (akin to the method used above). For example, Bakshi and Chen (1994) included population data for the United States in an equation relating consumption growth to returns on Treasury bills or equities, finding significant effects on equilibrium returns. Poterba (2001) examined the historical relationship between demographic structure and real returns on Treasury bills, long-term government bonds and equities using data for Canada, the United Kingdom and the United States. He concluded that “neither the findings on the level of asset prices, nor the findings on the level of asset prices, are consistent with the view that asset returns will decline sharply when the baby boom cohort reaches retirement age”.

42. A range of studies, using different modelling strategies, concur that shocks to the rate of population growth are likely to affect equilibrium asset returns. However, the fall in the rate of return as the population ages is far less than would merit the sobriquet of a “meltdown in asset prices”. Nonetheless, it seems reasonable for projecting the future to make a conservative assumption that the returns on assets over the past quarter century may not be repeated.

7. Impact of administrative charges

43. Measures of market investment returns, such as those analysed above, do not take account of administrative charges for managing retirement savings. Analysis of the impact of administrative charges on investment returns available to individuals’ pensions is complicated. An important reason for this is the complexity and diversity of the institutional arrangements for managing retirement savings.

44. In many of the countries with mandatory defined-contribution plans – the three Baltic States, Hungary, Poland, the Slovak Republic and Mexico – existing financial-services companies established new pension vehicles to manage individual accounts. In Denmark and Norway, the individual accounts are mainly organised by employers, although some or all of the management is often contracted out to specialist companies. In Australia, many employers offer pensions through industry-based plans. However, individuals can choose instead to buy an individual account from a financial-services company. In Sweden, the mandatory contribution is invested by the clearing house in individuals’ choice of mutual fund, although most people do not exercise this choice and leave their money with the default fund. The quasi-mandatory occupational pensions for private-sector workers also involve defined-contribution provision.[10]

10 The scheme for blue-collar workers has been entirely defined-contribution for some time and the white-collar scheme shifted to defined contribution in 2007. However, as the modelling in this paper is based on 2004 parameters and rules, the white-collar scheme modelled is a mix of defined-benefit and defined-contribution components.

45. In the six countries where voluntary private pension coverage is widespread – Belgium, Canada, Germany, Ireland, the United Kingdom and the United States – there is again a mixture of institutional arrangements. For example, employers are involved in sponsoring and managing these schemes to varying degrees.

7.1 Measuring charges

46. There are other reasons – apart from institutional complexity – why measuring the price of financial services is more difficult than comparing the cost of other goods or services. First, providers can levy many different kinds of fees. There are examples of both one-off and ongoing charges. Some fees are proportional and some are fixed rate. Some are levied on contributions, some on the value of assets in the fund, some on investment returns.

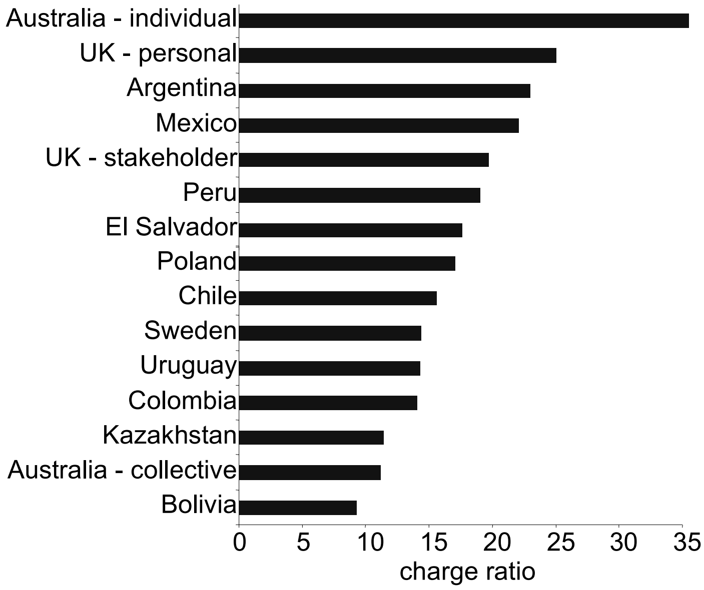
47. These different kinds of charge accumulate and interact in complicated ways over the lifetime of membership of a pension plan. This leads to the second problem: how to summarise these charges in a single number to compare charge levels, both between different providers in a single country and across countries.

48. The measure of administrative charges most familiar to investors and policy-makers alike is the "reduction in yield". This adds together all the charges over the lifetime of a pension policy, and expresses them all as a percentage of assets. An alternative approach is to measure charges as a proportion of contributions. This is the same as calculating the charges over the lifetime of the fund as a proportion of the balance accumulated at retirement. This second measure is known as the "reduction in premium" or the "charge ratio".

7.2 Empirical evidence

49. Figure 5 summarises data on administrative charges for 13 countries with mandatory funded pension systems. The measure illustrated is the charge ratio. It is calculated assuming 40 years of contributions to the individual account at the OECD's baseline assumption of a 3.5% return on investments.

Figure 5. Paying for pensions: the charge ratio for individual accounts in 13 countries



Note: charge ratio: total charges over the lifetime of the pension as percentage of accumulated balance at retirement. The calculations assume 40 years' contributions and 3.5% annual real return. Australia: 'collective': industry-wide funds; 'individual': 'master trusts' (provided by financial-services companies)

Source: Whitehouse (2000a, b, c; 2001).

50. Even very similar pension systems with similar approaches to charges deliver very different levels of fees in practice. Among Latin American countries with individual accounts, the average charge ratio varies from under 15% in Colombia to nearly 25% in Argentina. Looking at all systems, average charges range from under 10% in Bolivia to 35% in Australia's retail superannuation funds. It is important to note that the three cheapest systems offer very limited choice of provider and/or investments.

51. As a rough rule-of-thumb, a charge ratio of 20% over a 40-year pension plan is equivalent to a reduction in yield of 1% per year at the rate of return of 3.5% assumed in the source study.

7.3 Paying for annuities

52. The focus so far has been on administrative charges during the "accumulation" phase of a defined-contribution pension, when contributions are collected and the money is invested. However, a complete analysis must also take account of the burden of administrative charges during the "decumulation" or withdrawal phase, when retirement benefits are paid out. Usually, individuals have to use the balance accumulated in their pension account at the time of retirement to buy an annuity.

53. Friedman and Warshawsky (1988, 1990) developed a methodology for analysing annuity markets that allows the calculation of the implicit administrative charge. The analysis begins with data on annuity prices offered by financial-services companies. Typically, these are in the form of an annuity rate: the annual pension as a percentage of the capital sum used to buy the annuity. The next step uses standard actuarial techniques to calculate the expected present value of this flow of pension payments, discounted using a market riskless interest rate and allowing for population mortality (including any expected improvements during the retirement period). However, the difference between the two values – the capital used to buy the annuity and its expected present value – conflates two factors. The first is the impact of

"adverse selection": the people who buy annuities tend to be longer lived than the population as a whole. The second is more akin to an administrative charge.

54. To isolate these two factors, Friedman and Warshawsky recomputed the expected present value of the annuity using the (lower) mortality rates of people who bought annuities rather than those of the population as a whole. The difference between this and the value of the capital used to buy the annuity reflects the administrative expenses. The difference between this and the expected present value of the annuity calculated using population rather than annuitant mortality rates shows the impact of adverse selection.

55. Table 5 shows a selection of results from a number of recent studies that have implemented the Friedman and Warshawsky methodology. Mitchell *et al.* (1999) show that the average annuity rate offered in the United States to 65-year-old men would deliver discounted benefits worth just 81.6% of capital to a hypothetical person with population-average mortality. However, once account is taken of the fact that people who buy annuities live longer than average, the pay-out ratio increases to 91.6%. This is the relevant number for considering administrative charges because this reflects the experience of people who actually buy annuities. The 10-percentage-point difference between this and the money's-worth ratio calculated at population mortality is a measure of the cost of a "missing market". It is borne by people who *do not* buy annuities because their life expectancy is relatively short.

Table 5. Money's-worth ratios from annuities, population and annuitant mortality rates

(65-year-old men)

	Population mortality	*Annuitant mortality*
Mitchell *et al.* – United States		
All	0.816	0.916
Ten best	0.895	1.006
Ten worst	0.745	0.837
Finkelstein and Poterba – United Kingdom		
Compulsory	0.900	0.962
Voluntary	0.865	0.988
Poterba and Warshawsky – United States		
Qualified	0.835	0.953
Non-qualified	0.850	0.970
James and Vittas – various countries		
Nominal		
Australia	0.914	0.986
Canada	0.925	1.014
Switzerland	0.965	1.169
United Kingdom	0.897	0.966
Real		
Chile	0.868	0.939
Israel	0.799	0.921
United Kingdom	0.801	0.878

Source: Mitchell *et al.* (1999), Finkelstein and Poterba (2002, 2004); Poterba and Warshawsky (1999); James and Vittas (1999).

56. Mitchell *et al.* also report a huge variation in annuity prices offered by different providers, with the 10 best paying out 20% more than the 10 worst. Studies of the United Kingdom have found similar differences between providers. (The degree to which consumers can and do shop around for the best deal in the annuity market clearly has an important effect on retirement incomes but is not the subject of this paper.)

57. The United Kingdom's dual market of compulsory and voluntary annuities offers insights into the development of pension systems in countries that have recently introduced mandatory defined-contribution plans. Tax and social-security regulations require that some retirement savings are annuitised, while other people choose to convert capital sums into income streams. The terms offered by providers differ. Based on population mortality (left-hand column of Table 5), a better deal is offered to compulsory annuitants, confirming the adverse-selection story. But the reverse is true once the mortality of the relevant groups of annuitants is taken into account.

58. Table 5 suggests that a reasonable assumption for the administrative costs of annuitising retirement capital in defined-contribution pension plans is around 5-10 percentage points of the accumulated balance. Using the same methodology that was applied to the accumulation phase, this is equivalent to a 0.25-0.50 percentage point reduction in annual returns.

8. Agency and governance risks

59. Pension-fund investments are rarely managed by individual members directly: funds are invested by professional managers. This gives rise to an "agency" problem, because the interests of the members and the managers may not be aligned. Moreover, professional fund managers are better informed than members: it is difficult and expensive for the members to monitor the manager's performance.[11]

60. The agency problem is closely linked with the issue of pension-fund governance. The agency problem results from misaligned interests and incentives and high costs of monitoring the agent's behaviour. Governance is built around a framework of laws and internal controls that manage the relationships between pension-fund stakeholders and the management. This structure determines the objectives of the pension plan, how the managers propose to achieve the objectives and the means of monitoring performance to hold managers to account.[12]

61. In a pioneering empirical study, Lakonishok, Shleifer and Vishny (1992) found evidence of investment underperformance of pension funds in the United States relative both to market indices and to the performance of mutual funds. They argued that much of this effect was due to agency problems. Similarly, Blake, Lehman and Timmermann (2000) found that the median pension fund in the United Kingdom underperformed market benchmarks by 15 basis points a year. Comparable data for the United States suggested much greater underperformance at the median: 130 basis points a year. However, the dispersion of pension fund returns around the median was far greater in the United States than in the United Kingdom. Indeed many pension funds in the United States outperformed the benchmark, a rarity in the United Kingdom. Blake *et al.* concluded: "The narrow dispersion of returns around the median and the slight underperformance of the median fund compared with the market average appear to be the result of the incentive effects of fee structures, the performance evaluation environment operating, and the degree of concentration in the UK pension fund industry during the sample period".

11 This is the "principal-agent" problem of the economics literature. The problem arises when a principal compensates an agent for performing certain acts that are useful to the principal and costly to the agent and where there are elements of the performance that are costly to observe. This is the case, to some extent, with all contracts concluded in a world of information asymmetry, uncertainty and risk.

12 See OECD (2005b) and Marossy and Yermo (2002).

62. Other researchers have investigated the relationship between pension-fund governance and investment performance directly. Much of this literature, however, concerns pension funds managed by the public sector: either schemes for public-sector employees or public pension reserves.[13] (These plans are not the focus of this paper.) Studies of privately managed pension plans are rarer and, often, less rigorous. Ambachtsheer, Capelle and Lum (2006) asked a group of pension-fund managers around the world to rate the quality of pension-fund governance. They then compared this variable with a proxy measure of fund performance for the period 1992-2004, finding that better governed funds outperformed the worse governed schemes by 1-2% a year.

63. There is much evidence to suggest that agency and governance have an important effect on pension-fund performance but the impact is difficult to quantify.

9. Impact of regulatory policies

64. There is one kind of regulatory policy that can impinge particularly strongly on the investment performance of defined-contribution pension plans: quantitative restrictions on the assets that pension funds can hold.

65. OECD countries generally adopt one of two approaches to investment regulation. The first relies on "prudent-person" rules. The United States, for example, requires fund managers to invest "with the care, skill, prudence and diligence under the circumstances then prevailing that a prudent person, acting in a like capacity and familiar with such matters would use in the conduct of an enterprise of a like character and with like aims". Similar regulations apply in other English-speaking countries and in Austria, the Netherlands and Spain, among others. Investments in these countries are not entirely deregulated: for example, there are often rules to prevent self-investment or concentration of the portfolio in the securities of a particular issuer.

66. The alternative policy of quantitative asset limits requires funds to hold a minimum amount of safe assets, such as government bonds, or restricts the share of riskier assets, such as equities, foreign securities, unlisted securities, etc. This approach is common in European countries and is also the policy adopted in Mexico.

67. To show the impact of investment restrictions, Figure 6 compares the returns on pension funds' actual portfolios with the return on a "balanced portfolio". This benchmark is based on a fund invested half in equities and half in bonds. Pension funds in the four countries at the top, with relatively liberal investment regimes, earned 9.5% a year between 1984 and 1996 (the bars on the chart). In the six countries that restrict asset allocations, returns were around 6.5% a year on average.

68. There are many possible explanations for this difference. One important reason for differences in pension fund performance might be differences in financial market performance. But we can reject this conjecture. The lines in the chart show the returns on a balanced portfolio. This measure of the market return is actually lower on average in the countries with fewer investment restrictions: 3.5% compared with 4% a year.

69. A second reason for the differences is that this simple comparison ignores risk. The portfolios of equity-dominated pension funds, such as those in the countries with more liberal investment rules, are more volatile. As a result, the standard deviation (a simple measure of variability) of the returns on a pension fund's average portfolio in countries with liberal investment regimes is 11%, compared with 8% in more restrictive systems. So, some of the extra return is being bought at the price of greater risk. But only

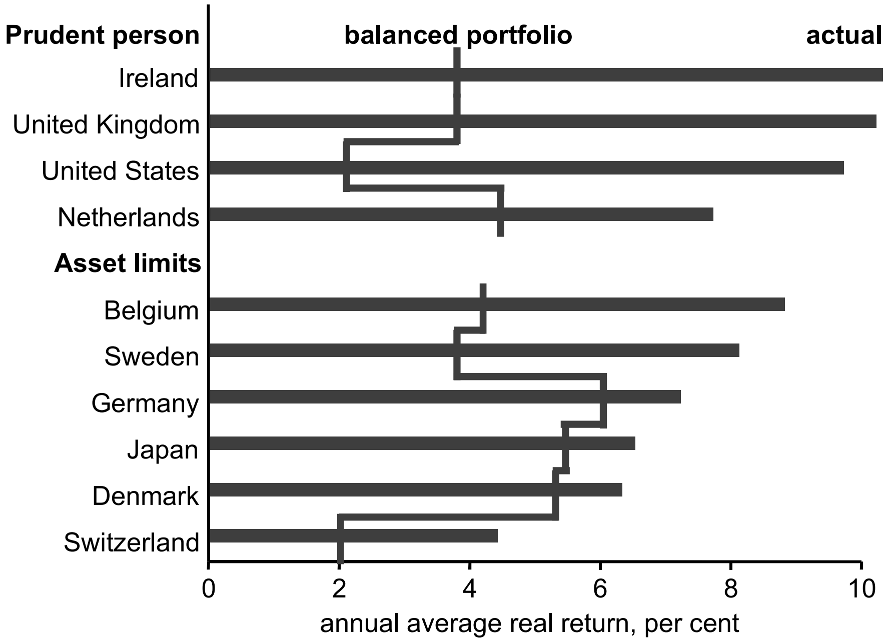
13 Iglesias and Palacios (2000) and Palacios (2002) look at the international experience.

investors extremely adverse to risk would choose to forego returns three percentage points a year better for this comparatively small increase in volatility.

70. There are many other factors that might be at work in determining these cross-country differences: macroeconomic policies, taxation, etc. It is too simplistic to attribute the whole of underperformance to investment regulations (Srinivas, Whitehouse and Yermo, 2000). However, Figure 6 offers some compelling evidence that investment restrictions do compromise pension fund performance.

71. Nevertheless, pension-fund investment regulations have been liberalised over the past decade since this analysis was carried out. For example, only 12 OECD countries still set quantitative limits on equity investments. Even these are set at relatively high levels, an average of 52% of portfolios.[14] This allows pension fund managers greater ability to diversify portfolios.

Figure 6. Investment returns on pension-fund and benchmark portfolios



Note: the data cover the period 1967-1990.

Source: OECD (1998); Davis (1998).

10. Implications for analysis of investment risk and pensions

72. The degree of investment risk was measured in this paper using historical data on returns on equities and bonds in major OECD economies. It might be expected that over a long period, the degree of uncertainty in investment returns would be small. After all, a few bad years in the market are likely to be offset by a boom. Nevertheless, the degree of uncertainty, even with the relatively long investment horizons of pensions, is found to be large.

14. The tightest restrictions on equity investments are in Korea and Mexico (30%) and Germany and Norway (35%). See OECD (2009b), Figure 2.18. In some countries, pension managers must offer a range of funds with different risk-return characteristics. The equity limit for the central or balanced fund is used to compute the cross-country average.

73. Table 6 shows the simulated distribution of future investment returns based on past market returns over the 25 years ending in 2006. The median real annual return is 7.3% for the eight OECD countries studied. The compound-interest effect means that differences in returns imply very large differences in retirement benefits. This is illustrated using a simple model. It assumes 40 years of contributions of 10% of earnings a year. The results are calculated with the OECD average mortality rates projected for 2040. With median returns, the replacement rate – pension relative to earnings – would be 87%. But the lower bound for the replacement rate (in 10% of cases) is 55% or less. Returns at the higher end of expectations would deliver, again in 10% of cases, a replacement rate of 139% or more.

Table 6. Distribution of simulated future investment returns: balanced portfolio

	Percentile of distribution								
	10	20	30	40	50	60	70	80	90
Market data									
Rate of return	5.5	6.1	6.6	7.0	7.3	7.7	8.0	8.5	9.0
Replacement rate	54.8	63.7	72.3	80.2	86.9	96.7	104.9	120.4	138.6
Rescaled									
Rate of return	3.2	3.8	4.3	4.7	5.0	5.4	5.7	6.2	6.7
Replacement rate	32.2	36.8	41.2	45.2	48.6	53.5	57.6	65.3	74.2

Note: based on unisex mortality rates of the OECD average projected for 2040. Assumes a contribution of 10% of earnings over a 40-year term.

Source: OECD pension models and OECD analysis of Datastream information.

74. However, this paper has also suggested that individuals will not be able to achieve the investment returns measured by market indices. The most readily quantifiable effect is the impact of administrative charges. A reasonable estimate would be that one percentage point (or slightly more) of the return goes in fees to pay for the management of the individual account during the accumulation phase. During the decumulation phase, further charges are incurred for managing annuities. A range of 5-10% of the fund balance seems a reasonable, conservative compromise between different studies' results. This is equivalent to a reduction in the rate of return during the accumulation phase of between 0.25% and 0.5% a year.

75. The other factors that depress the returns open to individuals relative to the market return (as measured by an index) are still more difficult to quantify. Tracking error, which has a number of causes, is an inevitable part of the process of managing indexed pension funds. The scale of agency and governance effects on investment shortfalls depends on the structure and norms of the pension-fund management industry. Regulation also matters if portfolio structures are restricted.

76. A reasonable estimate is that individuals should be able to achieve median returns of 5.0% rather than the 7.3% shown in historical data. Rescaling all the data to this level gives a range of returns from 3.2% to 6.7% (bottom panel of Table 6). The replacement rate with these rescaled returns is 49% in the median case. The range between low and high returns is 32% to 74%, encompassing a "comfortable" retirement and "borderline old-age poverty". The scale of investment risk measured here has important implications for pension policy. These are explored further in the companion paper, Whitehouse, D'Addio and Reilly (2009).

ANNEXES

A.1 Estimation results for GARCH model of investment returns: single countries

Table A.1.1. GARCH estimates of monthly historical results – selected OECD countries

	Canada		France		Germany		Italy	
	coeff	se	coeff	se	coeff	se	coeff	se
	25% equities - 75% bonds							
C	0.0062***	0.0009			0.0054***	0.0009	0.0045***	0.0014
θ_1			0.1890***	0.0629				
ω_0	0.0002***	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
β_1			0.9639***	0.0307	0.8361***	0.0798	0.9206***	0.0322
α_1	0.2107***	0.0560	0.0315	0.0214	0.0911**	0.0405	0.0700**	0.0284
	50% equities - 50% bonds							
C	0.0070***	0.0014			0.0068**	0.0016	0.0053**	0.0024
θ_1			0.1398**	0.0688				
ω_0	0.0004***	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
β_1			0.8095**	0.1444	0.8145**	0.0591	0.9346***	0.0301
α_1	0.1710*	0.0922	0.1022	0.0611	0.1144**	0.0406	0.0631**	0.0265
	75% equities - 25% bonds							
C	0.0082***	0.0021			0.0077***	0.0022	0.0058*	0.0035
θ_1			0.1279*	0.0697				
ω_0	0.0008***	0.0000	0.0003	0.0002	0.0001*	0.0001	0.0000	0.0000
β_1			0.7401***	0.1785	0.8097***	0.0493	0.9292***	0.0346
α_1	0.13591**	0.0632	0.1296	0.0781	0.1315**	0.0420	0.0693**	0.0300

Table A.1.1. cont.

	Japan		Sweden		UK		US	
	coeff	se	coeff	se	coeff	se	coeff	se
				25% equities - 75% bonds				
C	0.0042***	0.0010	0.0066***	0.0016				
θ_1	0.1162*	0.0690	0.2176***	0.0665	0.2302***	0.0515	0.1403**	0.0590
ω_0	0.0000**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
β_1	0.6651***	0.1217	0.9413***	0.0386	0.9781***	0.0230	0.9747***	0.0146
α_1	0.1608**	0.0550	0.0565*	0.0302	0.0188	0.0138	0.0214**	0.0109
				50% equities - 50% bonds				
C	0.0052**	0.0018	0.0091**	0.0028				
θ_1	0.1253*	0.0692	0.1703**	0.0685	0.15987**	0.0592	0.1133*	0.0625
ω_0	0.0002**	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
β_1	0.5916**	0.1405	0.87522***	0.0496	0.9831***	0.0202	0.9154***	0.0371
α_1	0.1601**	0.0534	0.096791**	0.0403	0.0147	0.0094	0.0645**	0.0282
				75% equities - 25% bonds				
C	0.0060**	0.0027	0.0105**	0.0042	0.0070**	0.0021		
θ_1	0.1291*	0.0699	0.1584**	0.0687			0.0994*	0.0652
ω_0	0.0004*	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
β_1	0.6035***	0.1467	0.8596***	0.0599	0.8681***	0.0523	0.8901***	0.0351
α_1	0.1482**	0.0517	0.0981**	0.0433	0.0824**	0.0308	0.0876**	0.0324

Note: The aim of the estimation is to provide parameters values from a specification the more closely matches the characteristics of the historical series and employs a limited number of variables to yield a plausible fit for the rate-of-return variable. For the average portfolios, the specification used for Japan and Sweden is MA(1) GARCH(1,1) with constant; for Canada, the process that best fits the return is a ARCH(1); for France, the United Kingdom and the United States is a MA(1) GARCH (1,1) without constant; and for Germany and Italy a GARCH(1,1) process fits best the data.

A.2. Probability distribution of simulated returns by portfolio and country

Figure A.2.1. Probability density of mean (simulated) returns: conservative portfolio

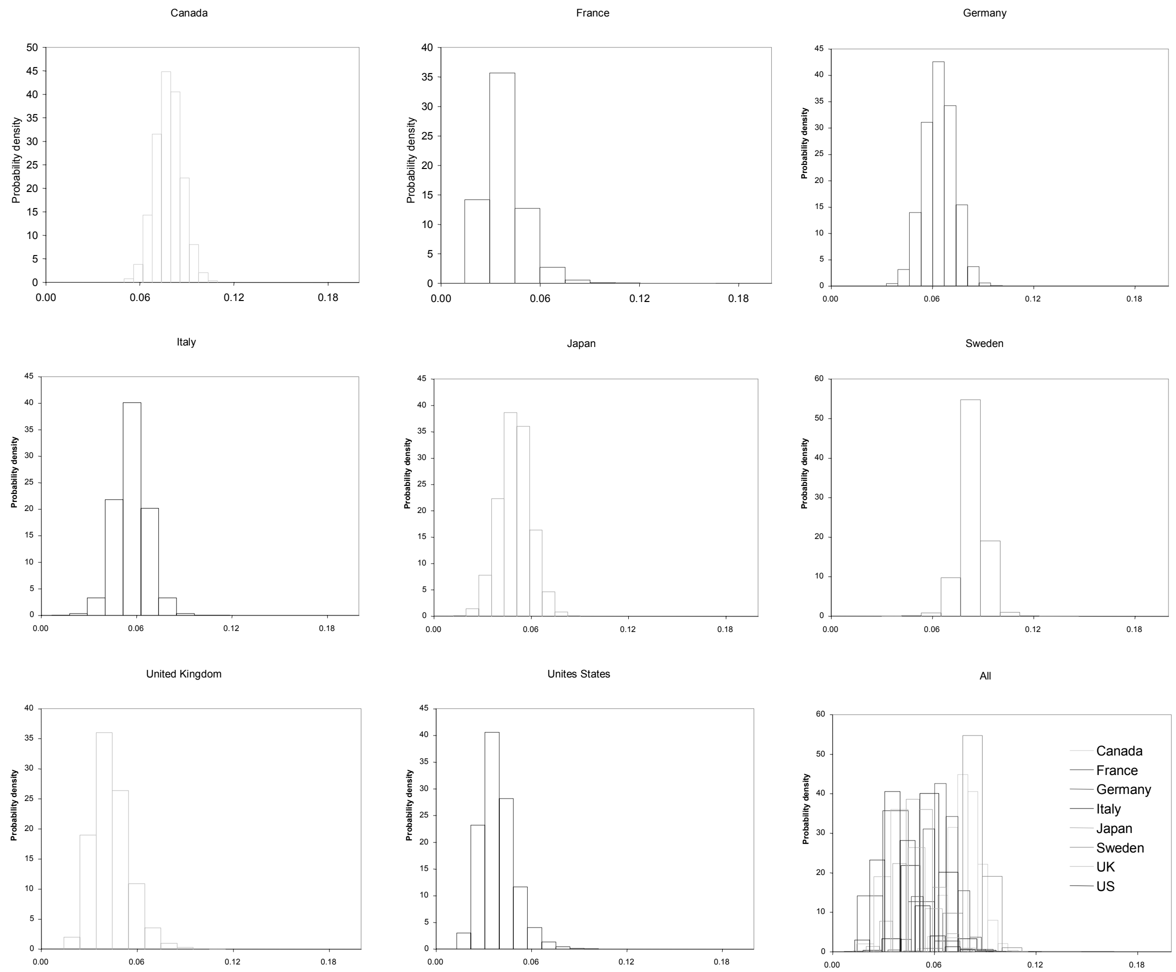


Figure A.2.2. Probability density of mean (simulated) returns: balanced portfolio

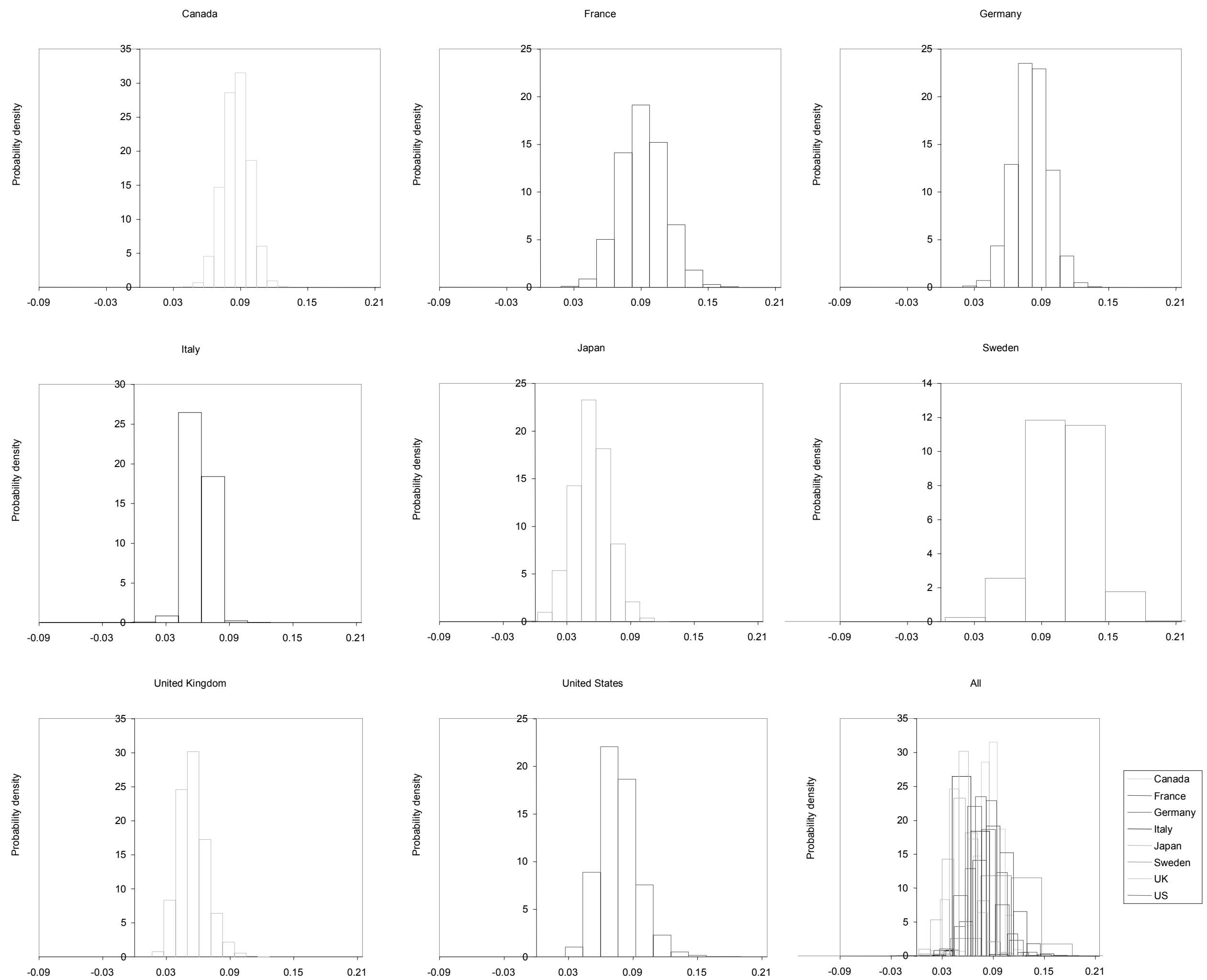
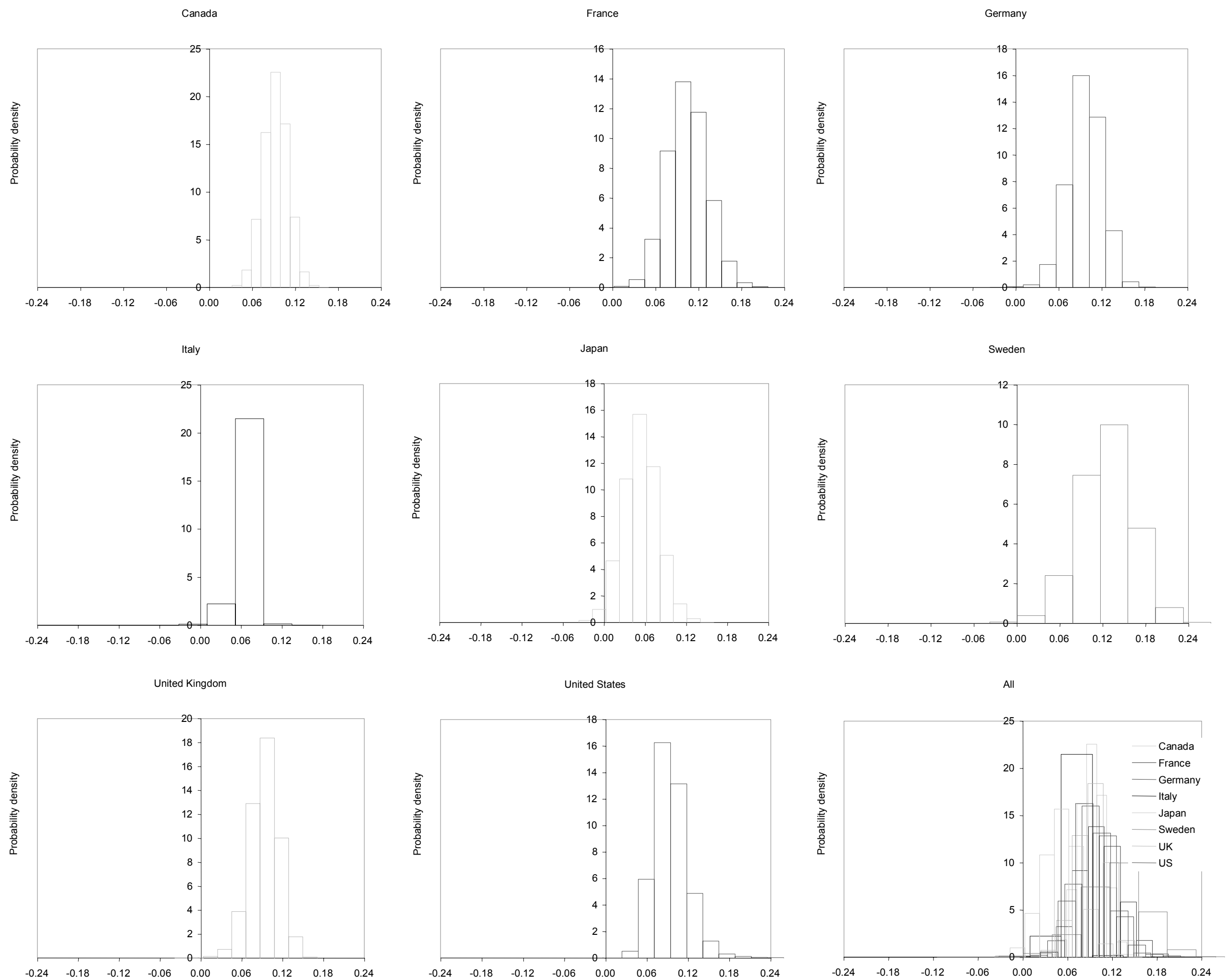


Figure A.2.3. Probability density of mean (simulated) returns: risky portfolio



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